United States Department of the Interior

FISH AND WILDLIFE SERVICE
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Sacramento, California 95825-1846

In Reply Refer to:
08ESMF00-
2014-F-0518

SEP 1 1 2015

Ms. Alicia E Kirchner
Chief, Planning Division
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814

Subject: Formal Consultation on the American River Common Features (AFRC) Project, Sacramento County, California

Dear Ms. Kirchner:

This letter is in response to the U.S. Army Corps of Engineers (Corps) April 3, 2015, request for consultation with the U.S. Fish and Wildlife Service (Service) on the proposed American River Common Features General Reevaluation Report (ARCF GRR) project in Sacramento County, California. You request was received by the Service on April 7, 2015. The Corps originally initiated consultation on June 30, 2014; however, the Service responded on July 23, 2014, with a request for additional information regarding the project description and the effects analysis the Corps had completed. The April 3, 2015, letter and biological assessment began the formal consultation period. This response is provided under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

The Federal action on which we are consulting is the ARCF GRR, which includes levee improvements and bank protection along the Sacramento River, levee improvements along Arcade, Magpie, and Dry/Robla Creeks, widening the Sacramento Bypass and Weir, and bank protection along the lower American River. Pursuant to 50 CFR 402.12(j), you submitted a biological assessment for our review and requested concurrence with the findings presented therein. These findings conclude that the proposed project may affect and is not likely to adversely affect the vernal pool fairy shrimp (*Branchinecta lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*); may affect likely to adversely affect the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), delta smelt (*Hypomesus transpacificus)* (smelt) and its critical habitat; the giant garter snake (*Thamnophis gigas*); and the yellow-billed cuckoo (*Coccyzus americanus occidentalis*). The project is outside of critical habitat designated for the valley elderberry longhorn beetle and critical habitat proposed for the yellow-billed cuckoo.

The Corps previously consulted with the Service on the Magpie Creek Flood Control Project and on September 15, 2004 a biological opinion regarding effects to the vernal pool fairy shrimp, vernal pool tadpole shrimp, and giant garter snake (File # 1-1-04-F-0132) was provided. The project described in the 2004 biological opinion is exactly the same as the Magpie Creek portion of the project description in the Common Features biological assessment. Because the environmental baseline for vernal pool fairy shrimp and vernal pool tadpole shrimp has not changed from the baseline that was analyzed in the 2004 biological opinion and the project description remains the same, effects to and take of vernal pool fairy shrimp and vernal pool tadpole shrimp are addressed in the September 15, 2004, biological opinion. More recent information regarding the status of the habitat along Magpie Creek for giant garter snake has changed from the 2004 biological opinion. This opinion addresses those changes and any potential effects to the giant garter snake.

Seasonal wetlands, which may provide suitable habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp, occur in the vicinity of the Robla Creek woodland mitigation site A, however any vernal pools in this area would be avoided by these activities. The Corps will implement a 250-foot buffer between vernal pools and vegetation planting. Planting activities will be done in the fall when the wetlands are dry and will use best management practices to ensure that sediment does not enter the seasonal wetlands. The Service concurs that with your determination of may affect, not likely to adversely affect vernal pool fairy shrimp and vernal pool tadpole shrimp at the Robla Creek woodland mitigation site A.

This biological opinion is based on information provided in the Corps' letter requesting consultation and the biological assessment. A complete administrative record is on file at the Service's Sacramento Fish and Wildlife Office.

CONSULTATION HISTORY

September 4, 2013: The Service commented on the April 2013 draft biological assessment.

April 8, 2014: The Service commented on the October 2013 draft biological assessment.

June 30, 2014: The Corps initiated section 7 consultation with the Service.

July 23, 2014: The Service sent a letter in response to the Corps initiation requesting additional information.

April 3, 2015: The Corps provided an updated biological assessment with responses to the Service's July 23, 2014, request for additional information.

August 31, 2015: The Corps provided a revised biological assessment that addressed questions the Service had regarding the project description.

BIOLOGICAL OPINION

Description of the Action

Congress directed the Corps to investigate the feasibility of reducing flood risk of the city of Sacramento. The Corps completed feasibility studies in 1991 and 1996, recommending a concrete gravity flood detention dam on the north fork of the American River at the Auburn site along with levee improvements downstream of Folsom Dam. Other plans evaluated in the report were Folsom Dam improvements and a stepped release plan for Folsom Dam releases. These additional plans also included levee improvements downstream of Folsom Dam. Congress recognized that levee improvements were "common" to all candidate plans in the report and that there was a Federal interest in participating in these "common features." Thus, the ARCF Project was authorized in the Water Resources Development Act (WRDA) of 1996 and a decision on Auburn Dam was deferred to a later date. Major construction components of ARCF in the WRDA 1996 authorization included construction of seepage remediation along about 22 miles of American River levees and construction of levee strengthening and raising of 12 miles of Sacramento River levee in Natomas.

Following the 1986 flood, significant seepage was experienced on the Sacramento River from Verona (upstream end of Natomas) at River Mile (RM) 79 to Freeport at RM 45.5. In addition, both the north and south bank of the American River from RM 0 to about RM 11.4 experienced seepage. Seepage on the Sacramento River was so extensive that Congress, soon after the 1986 flood event, funded remediation in the Sacramento Urban Levee Improvement Project (Sac Urban). The Sac Urban Project constructed shallow seepage cutoff walls from Powerline Road in Natomas at approximately RM 64 down to Freeport.

Shortly thereafter, the Sacramento Valley experienced a flood event in 1997. Considerable seepage occurred on the Sacramento River as well as on the American River. Seepage on the American River was expected because remediation measures had yet to be constructed, but the occurrence of significant seepage on the Sacramento River in the reach remediated as part of the Sac Urban Project was alarming and confirmed that deep underseepage was also of significant concern. As a result, seepage remediation on the American River (then in the late 1990s in the design phase) would need to be designed to remediate both through- and deep underseepage.

In 1999, Congress decided not to authorize Auburn Dam, but instead authorized improvements for Folsom Dam. By doing this, improvements to levees downstream of Folsom Dam could be fine-tuned to work closely with the Folsom improvements being discussed by Congress. Therefore, the ARCF project was modified by WRDA 1999 to include additional necessary features for the American River so that it could safely convey the proposed emergency release of 160,000 cubic feet per second (cfs) from Folsom Dam. Major construction components for the ARCF project in the WRDA 1999 authorization include construction of seepage remediation and levee raise along four stretches of the American River, and construction of levee strengthening and raising of 5.5 miles of Natomas Cross Canal levee in Natomas. All American River features authorized in WRDA 1996 and 1999 have been constructed or are in design analysis for construction within a year or two.

The purpose of the ARCF project is to reduce the flood risk for the city of Sacramento. The following problems were identified within the Sacramento levee system:

- Seepage and underseepage;
- Levee erosion;
- Levee stability;
- Levee overtopping;
- Access for maintenance and flood fighting;
- Vegetation and encroachments;
- Releases from Folsom Dam;
- Floodplain management; and
- Additional upstream storage from existing reservoirs.

In order to evaluate the effects to listed species, the Corps looked at the largest foreseeable footprint. As the Corps moves into the design phase of the project, footprint changes will likely reduce the effects to listed species.

The project is designed to allow for the release of 160,000 cubic feet per second (cfs) from Folsom Dam. The levees along the American River are unable to withstand these maximum flows for extended periods of time without increased risk of erosion and potential failure. The exact location where erosion will occur and to what extent erosion will occur during any given event is unknown. Erosion within the American River Parkway will be addressed as part of the Folsom Dam Water Control Manual Update currently under evaluation and a biological assessment is being prepared to initiate section 7 consultation with both the Service and National Marine Fisheries Service (NMFS). Therefore, the effects of erosion along the lower American River and effects of increased Yolo Bypass flooding frequency due to changes in operations from Folsom Dam are not analyzed in this project description. This is because construction of the American River and Sacramento Bypass measures, which are dependent on releases from Folsom Dam, will not occur until after a biological opinion is received for the Water Control Manual Update. Sacramento River and East Side Tributaries measures are necessary to improve the flood risk management system in the Sacramento area regardless of the change in operation at Folsom Dam and are not dependent on Folsom Dam operations for their implementation. As a result, construction in these areas could occur regardless of the Folsom Dam Water Control Manual Update schedule.

The Corps' project involves the construction of fix-in-place levee remediation measures to address seepage, stability, erosion, and height concerns identified for the Sacramento River and American River levees, Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks (Figure 1). Most height concerns along the Sacramento River will be addressed by a widening of the Sacramento Weir and Bypass to divert more flows into the Yolo Bypass. Due to the urban nature and proximity of existing development within the American River North and South basins the Corps is planning fix in place remediation. This would improve the flood damage reduction system to safely convey flows to a level that maximizes net benefits. Table 1 summarizes the levee problems discussed above and the proposed measure for each waterway.

Sacramento Area Flood Control Agency (SAFCA), the project's local sponsor, will complete some portions of the Federal project. SAFCA is seeking permission from the Corps pursuant to 33 USC §408 (Section 408) for alteration of the Federal levees along the NEMDC and Arcade Creek.

In addition to the proposed levee improvements measures shown in Table 1, the following measures and policies would be addressed during construction:

- The non-Federal (Department of Water Resources (DWR)) will bring the levees into compliance with the Corps' standard levee footprint using a System Wide Implementation Framework (SWIF) process. A SWIF is a plan developed by the levee sponsor(s) and accepted by the Corps to implement system-wide improvements to a levee system (or multiple levee systems within a watershed) to address system-wide issues, including correction of unacceptable inspection items, in a prioritized way to optimize flood risk reduction. The standard levee footprint consists of a 20 foot crown width, 3:1 waterside

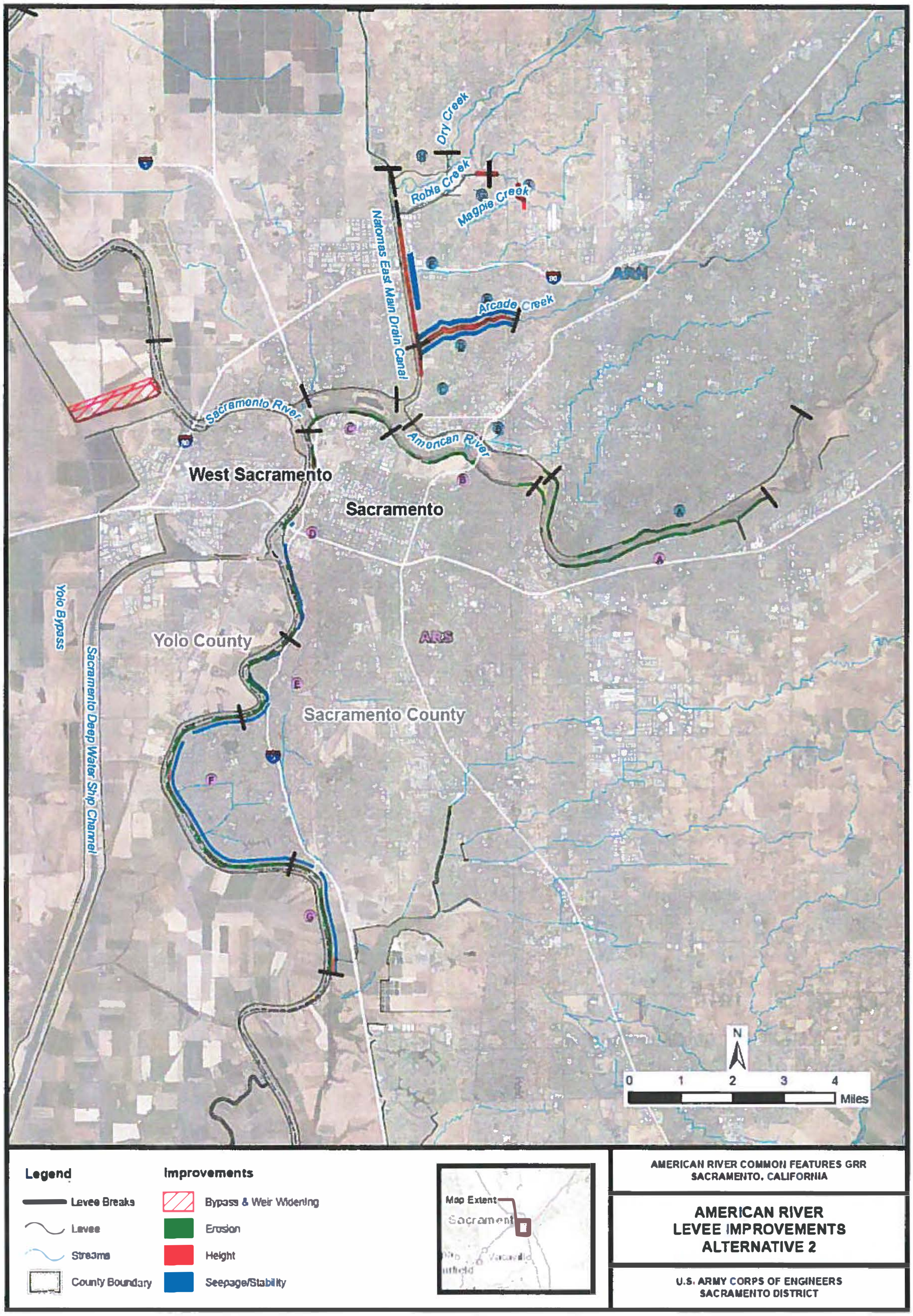

Figure 1. American River Common Features Project Area

Table 1. Remediation by Waterway.

Waterway	Seepage Measures	Stability Measures	Erosion Protection Measures	Overtopping Measures
American River[1]	---	---	Bank Protection, Launchable Rock Trench (31,000 linear feet)	---
Sacramento River	Cutoff Wall (50,300 linear feet)	Cutoff Wall (50,300 linear feet)	Bank Protection (50,300 linear feet)	Sacramento Bypass and Weir Widening, Levee Raise (1,500 feet)
NEMDC	Cutoff Wall (6,000 linear feet)	Cutoff Wall	---	Floodwall (15,600 linear feet)
Arcade Creek	Cutoff Wall (22,000 linear feet)	Cutoff Wall	---	Floodwall (22,000 linear feet)
Dry/Robla Creeks	---	---	---	Floodwall (2,500 linear feet)
Magpie Creek[2]	---	---	---	Floodwall, Levee Raise

[1]American River seepage, stability, and overtopping measures were addressed in a previous construction project.
[2]In addition to the floodwall, Magpie Creek will include construction of a new levee (3,100 linear feet) along Raley Boulevard south of the creek, and construction of a detention basin on both sides of Raley Boulevard (79 acres). In addition, some improvements would need to occur on Raley Boulevard, including widening of the Magpie Creek Bridge, raising the elevation of the roadway, and removing the Don Julio Creek culvert.

slope and 2:1 landside slope, when possible. If the 3:1 waterside slope is not possible, then a minimum 2:1 waterside slope would be established instead.

- Engineering Technical Letter 1110-2-583 (ETL) vegetation compliance would occur under a SWIF by the local maintaining agency (LMA). The intent of the SWIF is to collaboratively work with the resource agencies and levee sponsors to transition existing levees to Corps standards while maintaining Public Law (PL) 84-99 rehabilitation assistance and adhering to the Act and other environmental laws. The SWIF is a two-step process completed by the applicant that is composed of a letter of intent, which is followed by submission of a SWIF plan. The SWIF process allows eligible local sponsors to implement levee improvements in a prioritized "worst first" way to optimize the achievement of risk reduction. The Corps acknowledges that implementing system-wide improvements will need to be done within a collaborative intergovernmental framework and that it will take time to develop and implement improvements in complex situations. Challenges including ensuring that both environmental and levee safety considerations are adequately served.
- The vegetation requirements for the SWIF include a 15-foot waterside, landside, and vertical vegetation-free zone. Trees that pose an unacceptable risk to levee integrity will be removed and the root balls and roots will be remediated. Trees that do not pose a threat will not be removed. Vegetation on the landside slope would only be removed within the construction

footprint (up to ½ levee degrade) and the remaining vegetation would be dealt with under the SWIF process.

- Utility encroachments will be brought into compliance with Corps policy. Utilities that penetrate the levee would be removed and replaced with one of two fixes: (1) a surface line over the levee prism, or (2) a through-levee line equipped with positive closure devices.
- Private encroachments shall be removed by the non-Federal sponsor prior to construction.
- The Sacramento District of the Corps will pursue a vegetation variance which will allow vegetation on the lower ½ of the levee slope to 15 feet waterward of the waterside levee toe to remain in place. The Sacramento District has conducted an evaluation which examined the safety, structural integrity, and functionality of the levees that will be retained and not compromised if a tree were to fall and result in scouring of the root ball area. The results show that the tree fall and scour did not significantly affect levee performance, and the levee meets Corps seepage and slope stability criteria assuming the entire project is constructed.

American River

Levees along the American River require improvements to address erosion. The proposed measures for these levees consist of waterside armoring to prevent erosion to the river bank and levee, which could potentially undermine the levee foundation. There are two measures proposed for the American River levees: (1) a maximum of 31,000 linear feet (LF) of bank protection, and (2) a maximum of 65 acres/45,000 LF of launchable rock trench. Both of these measures are described in detail in the subsections below. These numbers are maximized because there is some overlap identified to account for the uncertainty of site-specific conditions. For example, for some reaches both bank protection and launchable rock trench impacts were estimated even though both measures will not be constructed in the same reach.

Bank Protection

This measure consists of placing rock revetment on the river's bank to prevent erosion. It entails installing revetment along the stream bank based on site-specific analysis (Figure 2). When necessary, the eroded portion of the bank will be filled and compacted prior to the rock placement. The sites will be prepared by clearing and stripping of loose material and understory growth prior to construction. In most cases, large vegetation will be permitted to remain at these sites. Temporary access ramps will be constructed, if needed, using imported borrow material that would be trucked on site.

The placement of rock onto the bank will occur from a land based staging area using long reach excavators and loader. The loader brings rock from a permitted source and stockpiles it near the levee in the construction area. The excavator then moves the rock from the stockpile to the waterside of the levee.

The revetment will be placed on the existing bank at a slope varying from 2V:1H to 3V:1H depending on site specific conditions. After revetment placement has been completed, a planting berm will be constructed in the rock to allow for revegetation of the site. The planting berm varies in width from 5 to 15 feet. In all cases the planting will occur outside the vegetation free zone as required by the ETL.

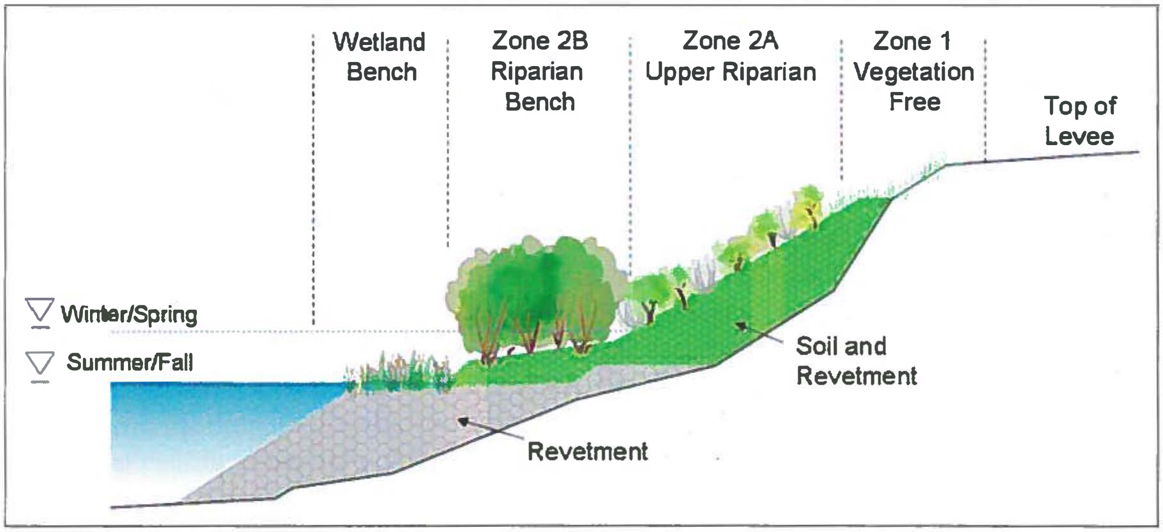

Figure 2. Bank Protection with Planting Bench.

Launchable Rock Trench

For the purposes of this project description, it is assumed that 65 acres of the lower American River will have a launchable rock trench fix. The remainder will be the bank protection described above. This measure includes construction of a launchable rock filled trench, designed to deploy once erosion has removed the bank material beneath it (Figure 3). All launchable rock trenches will be constructed outside of the natural river channel. The vegetation will be removed from the footprint of the trench and the levee slope prior to excavation of the trench. The trench configuration will include a 2:1 landside slope and 1:1 waterside slope and will be excavated at the toe of the existing levee. All soil removed during trench excavation will be stockpiled for potential reuse. The bottom of the trench will be constructed close to the summer mean water surface elevation in order to reduce the rock launching distance and amount of rock required.

After excavation, the trench will be filled with revetment that will be imported from an offsite commercial location. After rock placement the trench will be covered with a minimum of 3 feet of the stockpiled soil for a planting berm. Rock placed on the levee slope will be covered with 2 feet of stockpiled soil. All disturbed areas will be reseeded with native grasses and small shrubs where appropriate. Trees and shrubs could be permitted on the trench if planted outside the specified vegetation free zone as required by the ETL.

Sacramento River

Levees along the Sacramento River require improvements to address seepage, stability, and erosion. About 50,300 LF of bank protection and cutoff wall or slope stability work is proposed for the Sacramento River. In addition, these levees require a total of one mile of intermittent height improvements in order to convey additional flows that exceed current design levels.

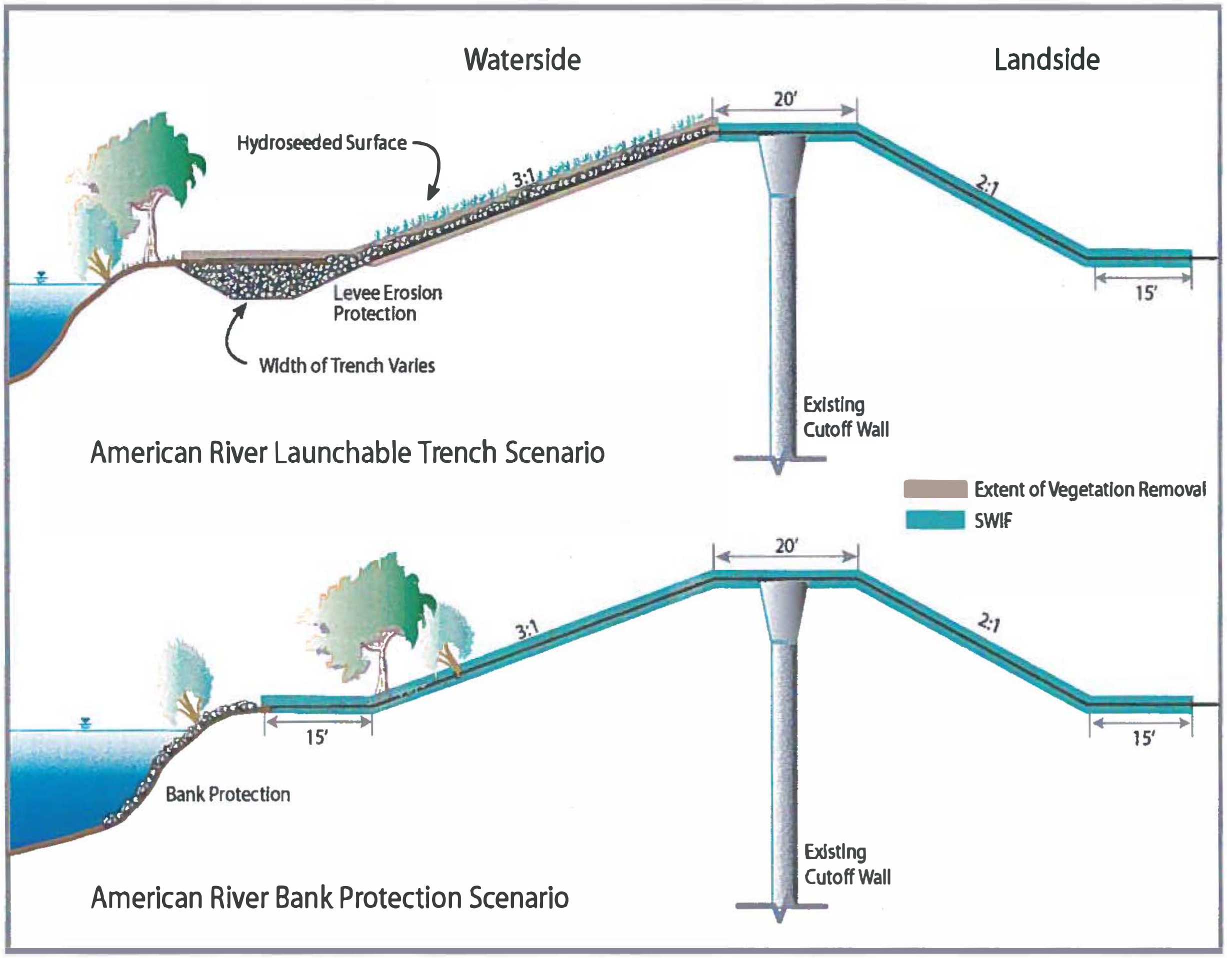

Figure 3. Launchable Rock Trench and Bank Protection.

Where the existing levee does not meet the levee design requirements, as discussed above, slope flattening, crown widening, and/or a minimal amount of levee raise is required. This improvement measure addresses problems with slope stability, geometry, height and levee crest access and maintenance. To begin levee embankment grading, loose material and vegetation understory will be cleared, grubbed, stripped, and where necessary, portions of the existing embankment will be excavated to allow for bench cuts and keyways to tie in additional embankment fill. Excavated and borrow material (from nearby borrow sites) will be stockpiled at staging areas. Haul trucks and front end loaders will bring borrow materials to the site, which will then be spread evenly and compacted according to levee design plans.

The levee will be raised about 1 to 2 feet resulting in the levee footprint extending out a maximum of 5 feet on the landside from the existing levee. The levee crown patrol road will be re-established at the completion of construction.

Cutoff Walls

To address seepage concerns, a cutoff wall will be constructed through the levee crown. The cutoff wall will be installed by one of two methods: (1) conventional open trench cutoff walls, or (2) deep soil mixing (DSM) cutoff walls. The method of cutoff wall selected for each reach will depend on the depth of the cutoff wall needed to address the seepage. The open trench method can be used to install a cutoff wall to a depth of about 85 feet. For cutoff walls of greater depth the DSM method will be utilized.

Prior to any cutoff wall construction method, the construction site and any staging areas will be cleared, grubbed, and stripped. The levee crown will be degraded up to half the levee height to create a large enough working platform (about 30 feet) and to reduce the risk of hydraulically fracturing the levee embankment from the insertion of slurry fluids. This method of slurry wall installation will also reduce the risk of slurry mixture following seepage paths and leaking into the river or into landside properties.

Open Trench Cutoff Wall

Under the open trench method, a trench about 3 feet wide will be excavated at the top of levee centerline and into the subsurface materials up to 85 feet deep with a long boom excavator. As the trench is excavated, it is filled with low density temporary bentonite water slurry to prevent cave in. The soil from the excavated trench is mixed nearby with hydrated bentonite, and in some applications cement. The soil bentonite mixture is backfilled into the trench, displacing the temporary slurry. Once the slurry was hardened, it will be capped and the levee embankment will be reconstructed with impervious or semi-impervious soil.

DSM Cutoff Wall

The DSM method involves a crane supported set of two to four mixing augers used to drill through the levee crown and subsurface to a maximum depth of about 140 feet. As the augers are inserted and withdrawn, a cement bentonite grout will be injected through the augers and mixed with the native soils. An overlapping series of mixed columns will be drilled to create a continuous seepage cutoff barrier. A degrade of up to one half the levee height will be required for construction of the DSM wall. For both methods, once the slurry has hardened it will be capped and the levee embankment will be reconstructed with impervious or semi-impervious soil.

Bank Protection

Proposed bank protection along the Sacramento River will address erosion concerns. Studies have shown that the Sacramento River levees have a medium to high risk of breach due to erosion. Bank protection will be addressed by standard bank protection with planting berm. The standard bank protection measure for the Sacramento River consists of placing rock protection on the bank to prevent erosion. This measure entails filling the eroded portion of the bank, where necessary, and installing revetment along the waterside levee slope and streambank from streambed to a height determined by site-specific analysis. Large trees on the lower half of the waterside slope will be protected in place to retain shaded riverine aquatic (SRA) habitat. The sites will be prepared by removing vegetation along the levee slopes at either end of the site for construction of a temporary access ramp, if needed. The ramp will then be constructed using imported commercial borrow material that will be trucked on site.

The placement of rock onto the levee slope will occur from atop the levee and/or from the waterside by means of barges. Rock required within the channel, both below and slightly above the water line at the time of placement, will be placed by an excavator located on a barge. Construction will require two barges: one barge would carry the excavator, while the other barge will hold the stockpile of rock to be placed on the channel slopes. Rock required on the upper portions of the slopes will be placed by an excavator located on top of the levee. Rock placement from atop the levee will require one excavator and one loader for each potential placement site. The loader brings the rock from a permitted source and stockpiles it near the levee in the construction area. The excavator then moves the rock from the stockpile to the waterside of the levee.

The revetment will be placed via the methods discussed above on existing bank at a slope varying from 2V:1H to 3V:1H depending on site specific conditions. After revetment placement has been completed, a small planting berm will be constructed in the rock to allow for some revegetation of the site.

Natomas East Main Drain Canal

The east levee of the NEMDC requires 6,000 LF of improvements to address seepage and stability at locations where historic creeks had intersected the current levee alignment. A cutoff wall will be constructed at this location to address the seepage and stability problems. The cutoff wall will be constructed by one of the methods described in the Sacramento River section above. SAFCA is proposing to construct 1,700 LF of cutoff wall beginning just south of the confluence of Arcade Creek and extending south along the NEMDC. The Corps will construct the remaining 4,300 LF of cutoff wall.

Arcade Creek

The Arcade Creek levees require improvements to address seepage, slope stability, and overtopping when the event exceeds the current design. A centerline cutoff wall will be constructed to address seepage along 22,000 LF of the Arcade Creek levees. Levees from Rio Linda Boulevard to Marysville Boulevard will have a cutoff wall constructed at the waterside toe of the levee. Construction of the waterside toe cutoff wall will require constructing a work bench along the toe of the levee. Excavation for the bench will extend deep enough below existing grade to remove organic material and soft, unsuitable foundation soils. Bench excavation will also extend into the existing waterside slope of the levee as needed. Riprap will be placed on the waterside benches after construction of the waterside toe cutoff wall. Some portions of the Arcade Creek north levee will require more substantial excavation and reconstruction of the waterside slope to provide a low permeable seepage levee slope barrier. Bench fill material will be integrated with the slope reconstruction fill to provide an integral seepage barrier with the cutoff wall over the full height of the levee slope. A small section of levee will have a sheet pile cutoff wall at the centerline of the levee, rather than the waterside toe cutoff wall.

There is a ditch adjacent to the north levee at the landside toe which provides a shortened seepage path, and could affect the stability of the levee. The ditch will be replaced with a conduit or box culvert and then backfilled. This will lengthen the seepage path and improve the stability of the levee. Additionally, pressure relief wells will be installed along the landside toe of the levee along the north levee west of Norwood Avenue.

The majority of the Arcade Creek levees have existing floodwalls, however there remains a height issue in this reach. A 1 to 4-foot floodwall will allow the levees to pass flood events greater than the current design level. The floodwall will be placed on the waterside hinge point of the levee and will be designed to disturb a minimal amount of waterside slope and levee crown for construction. The waterside slope will be re-established to its existing slope and the levee crown will grade away from the wall and be surfaced with aggregate base.

Dry and Robla Creeks

The Dry and Robla Creeks levees require improvements to address overtopping when flood events exceed the design level. Height improvements will be made with a new floodwall constructed to a height of 4 to 6 feet along 2,500 LF of the south levee. The floodwall will be placed at the waterside hinge point of the levee and will be designed to disturb a minimal amount of waterside slope and levee crown for construction. Construction of the floodwall will be consistent with the description for Arcade Creek above. The waterside slope will be re-established to its existing slope and the levee crown will grade away from the wall and be surfaced with aggregate base.

Magpie Creek Diversion Canal

The Magpie Creek Diversion Canal project description is the same as was described in the September 15, 2004 biological opinion.

Sacramento Weir and Bypass

The Sacramento Weir was completed in 1916. It is the only weir in the Sacramento River Flood Control Project that is manually operated; all others overflow by gravity on their own. It is located along the right bank of the Sacramento River about 4 miles upstream of the Tower Bridge, and about 2 miles upstream from the confluence with the American River. Its primary purpose is to protect the city of Sacramento from excessive flood stages in the Sacramento River channel downstream of the American River. The weir limits flood stages (water surface elevations) in the Sacramento River to project design levels through the Sacramento/West Sacramento area. Downstream of the Sacramento Weir, the design flood capacity of the American River is 5,000 cfs higher than that of the Sacramento River. Flows from the American River channel during a major flood event often exceed the capacity of the Sacramento River downstream of the confluence. When this occurs, floodwaters flow upstream from the mouth of the American River to the Sacramento Weir.

The project design capacity of the weir is 112,000 cfs. It is currently 1,920 feet long and consists of 48 gates to divert floodwaters to the west through the mile-long Sacramento Bypass to the Yolo Bypass. Each gate has 38 vertical wooden plank "needles" (4 inches thick by 1 foot wide by 6 feet long).

Though the weir crest elevation is 24.75 feet, the weir gates are not opened until the river reaches 27.5 feet at the I Street gage with a forecast to continue rising. This gage is about 1,000 feet upstream from the I Street Bridge and about 3,500 feet upstream from the mouth of the American River. The number of gates to be opened is determined by the National Weather Service/DWR river forecasting team to meet either of two criteria: (1) to prevent the stage at the I Street gage from exceeding 29 feet, or (2) to hold the stage at the downstream end of the weir to 27.5 feet (DWR 2010). The weir gates are then closed as rapidly as practicable once the stage at the weir drops below 25 feet. This provides "flushing" flows to re-suspend sediment deposited in the Sacramento River between the Sacramento Weir and the American River during the low flow periods when the weir is open during the peak of the flood event (DWR 2010).

The Sacramento Weir and Bypass will be expanded to roughly twice their current width to accommodate increased bypass flows. The existing north levee of the Sacramento Bypass will be degraded and a new levee would be constructed 1,500 feet to the north. The existing Sacramento Weir will be expanded to match the wider bypass. At this time, it is not known whether the new segment of weir will be constructed consistent with the 1916 design described above, or whether it will be designed to be a gravity-type weir. The new north levee of the bypass will be designed to be consistent with the existing Sacramento Bypass north levee; however, it will also include a 300-foot-wide seepage berm on the landside with a system of relief wells. A hazardous, toxic, and radiological waste site near the existing north levee will be remediated by the non-Federal sponsor prior to construction.

Operation of the new segment of the Sacramento Weir will occur during high water situations only, when the American River flows exceed 115,000 cfs. The existing Sacramento Weir will be operating at the pre-existing conditions described above. There are not expected to be any water quality impacts, though this has not been specifically modeled. The approximate change in water diversions, which are shown in Table 2, will vary based on the size of the flood event. The frequency of water diversion is expected to be the same, dependent on the stream gage at the I Street Bridge reaching 27.5 feet.

The widened portion of the Sacramento Weir will only be operated when the release from Folsom Dam is above 115,000 cfs. With the Folsom Dam improvements in place, releases from Folsom Dam will be above 115,000 cfs for flood events greater than the 100-year event. Therefore, for events up to and including the 100-year event, only the existing weir will be operated per the criteria previously established. For events greater than the 100-year event, when the release from Folsom Dam will go above 115,000 cfs, the new weir will be opened. Therefore, for events up to the 100-year event there will be no change in flow conditions in the Sacramento and Yolo Bypasses.

Table 2. Comparison of 10-, 100-, and 200-year Frequency Flows under Various Conditions

10-Year Event	Existing Condition	Future Without Project Condition	Future With Project Condition
American River	43,000 cfs	72,000 cfs	72,000 cfs
Sacramento Bypass	50,000 cfs	66,000 cfs	66,000 cfs
Yolo Bypass below Sacramento Bypass	270,000 cfs	296,000 cfs	296,000 cfs
100-Year Event	**Existing Condition**	**Future Without Project Condition**	**Future With Project Condition**
American River	145,000 cfs	115,000 cfs	115,000 cfs
Sacramento Bypass	131,000 cfs	115,000 cfs	115,000 cfs
Yolo Bypass below Sacramento Bypass	555,000 cfs	535,000 cfs	535,000 cfs
200-Year Event	**Existing Condition**	**Future Without Project Condition**	**Future With Project Condition**
American River	320,000 cfs	160,000 cfs	160,000 cfs
Sacramento Bypass	183,000 cfs	149,000 cfs	164,000 cfs
Yolo Bypass below Sacramento Bypass	656,000 cfs	631,000 cfs	643,000 cfs

For the 200-year event, there will be an increase in flows in the Sacramento Bypass of about 15,000 cfs. In the Yolo Bypass, this equates to an increase of about 0.10-foot of water surface elevation. During the 200-year event, the Yolo Bypass is already flooded from levee to levee. The addition of these flows will equate to about 0.5-foot of additional width on the Yolo Bypass levee slopes.

High Hazard Levee Encroachment and Vegetation Removal

The National Flood Insurance Program (NFIP) standards for levee accreditation and the State's ULDC both require removal or modification of encroachments that pose an unacceptably high risk to the performance and safety of a levee either by undermining its structural integrity or by interfering with necessary inspection, operation, and maintenance activities. To address this requirement, SAFCA has identified and evaluated all of the encroachments in the NEMDC, Robla Creek, and Arcade Creek area. Each of these encroachments has been evaluated and based on this evaluation the encroachments have been classified as either:

- High-risk – poses a threat to levee integrity, removable prior to the levee being accredited;
- High-risk – impedes operation, maintenance, and inspection, removable within 3 years after the levee is accredited; or
- Low-risk – not identified as high hazard.

High-risk encroachments to be removed are limited to residential landscaping located at 10 locations along the landside of the south and north levees of Arcade Creek and along the Robla Creek south levee.

Vegetation on levees must be modified or removed if it presents an unacceptable risk to the structural integrity or impedes operation and maintenance of the levee. Eight high-risk trees along Arcade Creek have been identified for removal. All of the trees are either nonnative (7) or snags (1). Five are located on the waterside of the levees. These trees are in addition to any trees that will be removed as a result of implementation of levee improvements in the Arcade Creek area.

Utility Relocation

Existing encroachments and penetrations within the NEMDC and Arcade Creek have been inventoried by SAFCA. Many utilities will be avoided, however some utilities may need to be temporarily removed or relocated prior to construction. Temporary bypass pumping may be required for sanitary sewers. SAFCA and the construction contractors will coordinate with utility owners to manage the utilities in advance of construction. Disturbed utilities will be restored after construction consistent with Central Valley Flood Protection Board requirements.

Stormwater Pollution Prevention

Temporary erosion/runoff best management control measures would be implemented during construction to minimize stormwater pollution resulting from erosion and sediment migration from the construction, borrow, and staging areas. These temporary control measures may include implementing construction staging in a manner that minimizes the amount of area disturbed at any one time; secondary containment for storage of fuel and oil; and the management of stockpiles and disturbed areas by means of earth berms, diversion ditches, straw wattles, straw bales, silt fences, gravel filters, mulching, revegetation, and temporary covers as appropriate. Erosion and stormwater pollution control measures will be consistent with National Pollutant Discharge Elimination System (NPDES) permit requirements and included in a Stormwater Pollution Prevention Plan (SWPPP).

After completion of construction activities, the temporary facilities (construction trailers and batch plants) will be removed and the site would be restored to pre-project conditions. Site restoration activities for areas disturbed by construction activities, including borrow areas and staging areas, will include a combination of regrading, reseeding, constructing permanent diversion ditches, using straw wattles and bales, and applying straw mulch and other measures deemed appropriate.

Borrow Sites, Haul Routes, and Staging Areas

Borrow Sites - It is estimated that a maximum of 1 million cubic yards (cy) of borrow material will be needed to construct the project. Detailed studies of the borrow needs have not been completed. Actual volumes exported from any single borrow site will be adjusted to match demands for fill. Borrow sites will be selected that avoid effects to endangered species or their habitat.

To identify potential locations for borrow material soil maps and land use maps were obtained for a 20-mile radius surrounding the project area. Except as discussed below for Arcade Creek and NEMDC, eventual borrow site selection will include the following criteria: avoid threatened and endangered species effects and habitat, current land use patterns, and soil types.

Excavation limits on the borrow sites will provide a minimum buffer of 50 feet from the edge of the borrow site boundary. From this setback, the slope from existing grade down to the bottom of the excavation will be no steeper than 3:1. Excavation depths from the borrow sites will be determined based on available suitable material. The borrow sites will be stripped of top material and excavated to appropriate depths. Once material is extracted, borrow sites will be returned to their existing use whenever possible, or these lands could be used to mitigate for project effects, if appropriate.

Because SAFCA has completed more detailed design and studies for work along NEMDC and Arcade Creek the borrow site has been selected. Borrow site 2 is located along the east side of the NEMDC north of where the levee repairs will occur. About 27,000 cubic yards of material will be excavated from the 5.5-acre borrow site in order to construct levee improvements along the NEMDC and Arcade Creek. Following borrow activities the site will be contoured to create about 0.5 acre of tule bench, set an elevation the will provide aquatic habitat all year, 1.0 acre of higher bench with seasonal wetlands, that will flood in the winter and spring, and 3.5 acres of native grassland.

Clean rock will be commercially acquired in order to construct the American and Sacramento River bank protection sites. For the Sacramento River, rock will be acquired from a commercial source in the Bay Area and barged up the Sacramento River to the construction sites. Rock for the American river sites will be acquired from a commercial source within a 50-mile radius and will be hauled in trucks to the construction sites.

Haul Routes – Haul routes will be determined during the design phase and will depend on what borrow sites and staging areas are selected. Haul routes will be selected based on existing commercial routes and levee roads. Haul routes will be selected that avoid effects to federally listed species.

For Arcade Creek and NEMDC, haul trucks will leave borrow site 2 and use East Levee Road from the borrow site down to a point just north of the existing Del Paso/Main Avenue Bridge over NEMDC. Temporary bridges crossing the NEMDC and Arcade Creek will be used to allow haul trucks to reach repair sites. Railroad car undercarriages on temporary abutment supports will be one option for temporary bridge crossings.

Staging Areas – Staging areas will be selected that do not require the removal of vegetation or habitat that is used by threatened or endangered species or effect threatened or endangered species. Four potential staging areas have been identified for improvements along Arcade Creek. All four areas will require little preparation other than surface striping and temporary connection roads and ramps to the levee crown. The primary use of staging areas will be for temporary trailers, parking, and material staging. Additionally, there will need to be space to process material and an area where excavated soils and imported soils will be spread out and processed material. Importing, processing, and exporting material for levee reconstruction will be continuous activities once the work flow is established during the start of the construction season. Staging areas will be returned to pre-project conditions following construction activities unless the owner agrees to some grade raising to help dispose of excess construction soils.

Operation and Maintenance

Operation and maintenance (O&M) of the levees in the Sacramento area are the responsibility of the local maintaining agencies, including the American River Flood Control District, the DWR, and the City of Sacramento. The applicable O&M Manual for the Sacramento area levees is the Standard Operation and Maintenance Manual for the Sacramento Flood Control Project. Typical levee O&M in the Sacramento in the Sacramento area currently includes the following actions:

- Vegetation maintenance up to four times a year by mowing or applying herbicide.
- Control of burrowing rodent activity monthly by baiting with pesticide.
- Slope repair, site-specific and as needed, by re-sloping and compacting.
- Patrol road reconditioning up to once a year by placing, spreading, grading, and compacting aggregate base or substrate.
- Visual inspection at least monthly, by driving on the patrol road on the crown and maintenance roads at the base of the levee.
- Post-construction, groundwater levels will be monitored using the piezometers.

The Corps will work with local maintaining agencies to develop the maintenance activities necessary for long-term operations and maintenance. This will occur during the preconstruction engineering and design phase of the project. The Corps will evaluate if these maintenance activities will affect any Federally-listed species and reinitiate section 7 consultation if there will be adverse effects to listed species. Currently, the Corps only has a project description for activities that will affect valley elderberry longhorn beetle habitat. This is included below.

Following construction, the O&M manual for these reaches will be adjusted to reflect the vegetation variance and the SWIF plan. Under the adjusted O&M manual, large trees that are protected in place under the variance will be allowed to remain on the waterside slopes and additional vegetation will be planted on the planting benches.

Vegetation maintenance includes keeping maintenance roads clear of overhanging branches. Some of the vegetation along the levees includes elderberry shrubs. As part of long-term O&M, elderberry shrubs will be trimmed by the three levee maintenance districts. Table 3 describes the maximum amount of elderberry acreage that will be trimmed each year as a result of O&M. Trimming consists of cutting overhanging branches along the levee slopes on both the landside and waterside. Some shrubs may be located adjacent to the levee with branches hanging over the levee maintenance road. Up to a third of a shrub will be trimmed in a single season. Trimming will occur between November 1 and March 15. Loss of habitat will be offset through the development of a conservation area as described in the conservation measures below. Each year the local maintaining agency will document the amount of valley elderberry longhorn beetle habitat that they have trimmed and report that number to the Corps to ensure compliance with this biological opinion. If the local maintaining agency has a need to exceed the amount of valley elderberry longhorn beetle habitat which needs to be trimmed or affected due to routine maintenance, then they will request the Corps reinitiate consultation on this biological opinion for those actions.

Table 3. O&M by Maintaining Agency

Local Maintaining Agency	Levee Systems Covered	Annual Acreage of Trimmed Elderberry Shrubs*	Total Acreage of Elderberry Shrubs Trimmed over the 50 Year Life of the Project
American River Flood Control District	Lower American River, Dry/Robla Creek, Arcade Creek, NEMDC	0.5	25
Maintenance Area 9	Sacramento River east levee between Sutterville Road and the Beach Lake Levee	0.2	10
City of Sacramento	Sacramento River East Levee between the confluence of the American River and Sutterville Road	0.1	5

*acreage based on an estimated average shrub of 0.027 acre and no more than 1/3 of a shrub trimmed any given year.

Valley Elderberry Longhorn Beetle Habitat

Valley elderberry longhorn beetles are closely associated with elderberry shrubs. In 2011, the Corps conducted surveys and mapped all of the elderberry shrubs on the levees and 15 feet on either side of the levee. Elderberry shrubs were located along the American River and Sacramento River. The Corps counted shrub clusters and used elderberry stem counts from previous projects in the area to estimate a standard number and size of elderberry stems per shrub cluster. Tables 4 and 5 list the stem counts for shrubs along the American River and Sacramento River respectively. While shrubs exist along Arcade Creek or Magpie Creek, the Corps and SAFCA will avoid effects to the beetle by following the conservation measures below.

Table 4. American River Elderberry Shrub Effects and Compensation

Location	Stems	Exit Holes	No. of Stems	Elderberry Ratios	Elderberry Plantings	Associated Native Planting	Associated Native Ratios
riparian	> or = 1" & < or = 3"	no	1,998	2	3,996	3,996	1
		yes	0	4	0	0	2
riparian	> 3" & < 5"	no	790	3	2,370	2,370	1
		yes	16	6	96	192	2
Riparian	> or = 5"	no	312	4	1,248	1,248	1
		yes	23	8	184	368	2
TOTAL			**3,139**		**7,894**	**8,174**	
				total basins or credits=	1,606.8		
				total acres for compensation	66.40		

Table 5. Sacramento River Elderberry Shrub Effects and Compensation

Location	Stems	Exit Holes	No. of Stems	Elderberry Ratios	Elderberry Plantings	Associated Native Plantings	Associated Native Ratios
riparian	> or = 1" & < or = 3"	no	104	2	208	208	1
		yes	0	4	0	0	2
riparian	> 3" & < 5"	no	40	3	120	120	1
		yes	1	6	6	12	2
riparian	> or = 5"	no	16	4	64	64	1
		yes	2	8	16	32	2
TOTAL			**163**		**414**	**436**	
				total basins or credits=	85		
				total acres need for compensation	3.51		

Delta Smelt Habitat

The American River lacks suitable turbidity making it unsuitable for delta smelt. Due to the higher temperatures within Arcade Creek, Magpie Creek, and NEMDC it is also unlikely that delta smelt will use these tributaries. Therefore, suitable delta smelt habitat occurs within the Sacramento River in the reach where erosion protection will occur. The Corps has calculated that there will be a complete loss of 14 acres of shallow water habitat due to the placement of riprap and a change of substrate from natural soil to riprap on 32 acres.

Giant Garter Snake Habitat

Giant garter snakes are not known to use large rivers such as the American and Sacramento Rivers. Given the close proximity to urban development, high level of human disturbance, presence of riparian vegetation along the banks of most channel reaches, and lack of extensive marsh or rice to the east, giant garter snakes are unlikely to occur in Arcade Creek, Dry Creek, Robla Creek, Magpie Creek, or the southern section of the NEMDC (south of where Dry Creek enters). North of Dry Creek, the NEMDC has less woody vegetation, less urban development, and large areas of open grassland along the landside of the levee with rice farming occurring to the west of the grasslands. Therefore, there is potential for the snake to occur either in the upland or within the NEMDC north of where Dry Creek enters. Work in this location will involve removal of borrow material at borrow site 2 (5.5 acres of upland habitat).

Habitat for the giant garter snake also exists north of the existing Sacramento Bypass north levee. The land north of the Sacramento Bypass is currently agricultural fields producing row crops and nut orchards. Existing giant garter snake aquatic habitat occurs in drainage ditches and farm canals and the surrounding upland habitat. About 15 acres of aquatic habitat will be filled making it and the associated 30 acres of upland habitat unavailable to the giant garter snake. The Sacramento Bypass also has a toe drain along the levee with 25 acres of aquatic and 50 acres of upland habitat that will be relocated to the toe of the new Sacramento Bypass levee.

Yellow-billed Cuckoo Habitat

Yellow-billed cuckoos use riparian habitat for foraging and nesting. Suitable habitat occurs within the lower American River. The project will affect 65 acres of riparian habitat that could be used by the yellow-billed cuckoo. While riparian habitat occurs along Arcade Creek, Magpie Creek, and NEMDC it is very narrow and cuckoos are not likely to use these areas. Riparian habitat occurs along the Sacramento River and in some areas may be of such a width that a cuckoo could stop and use it during migration, but it is not wide enough to support a nesting pair of cuckoos. The Corps will remove 110 acres of riparian habitat along the Sacramento River and disturb an additional 50 acres of riparian habitat by removing the understory and placing rock around the large trees. The Sacramento Bypass does not have suitable habitat for the yellow-billed cuckoo. But riparian habitat does exist north of the existing Sacramento Weir along the Sacramento River (8 acres). Cuckoos have been observed in the Yolo Bypass in recent years (Ebird 2015).

Conservation Measures

Valley Elderberry Longhorn Beetle

- The Corps assumes complete avoidance of the valley elderberry longhorn beetle when a 100-foot (or wider) buffer is established and maintained around elderberry shrubs.
- When work will occur within the 100-foot buffer, a setback of 20 feet from the dripline of each elderberry shrub will be maintained whenever possible.
- During construction activities, all areas to be avoided will be fenced and flagged.
- Contractors will be briefed on the need to avoid damaging elderberry shrubs and the possible penalties for not complying with these requirements.
- Signs will be erected every 50 feet along the edge of the avoidance area, identifying the area as an environmentally sensitive area.
- Any damage done to the buffer area will be restored.
- Buffer areas will continue to be protected after construction.
- No insecticides, herbicides, fertilizers, or other chemicals that might harm the beetle or its host plant will be used in the buffer areas.
- Elderberry shrubs that cannot be avoided would be transplanted to an appropriate riparian area at least 100 feet from construction activities.
- Elderberry shrubs will be surveyed prior to construction to ensure that the actual effects match the estimated effects of this biological opinion. If the Corps will effect more valley elderberry longhorn beetle habitat than estimated than they will reinitiate consultation with the Service.
- If possible, elderberry shrubs would be transplanted during their dormant season (November through the first two weeks in February). If transplantation occurs during the growing season, increased mitigation will apply.
- Elderberry compensation will be planted in the American River Parkway. The Corps has six existing sites which are offsetting previous Corps flood control projects along the lower American River and near Folsom Dam. The Corps will find areas within the lower American River parkway which will either expand existing compensation areas or provide for connectivity between conserved valley elderberry longhorn beetle habitat. Sites within the lower American River parkway will be coordinated with Sacramento County Parks and the Service during the design phase of the project. Sites will be designed and developed prior to any effects to valley elderberry

longhorn beetle habitat. The Corps will create 69.91 acres of riparian habitat which supports valley elderberry longhorn beetle within the lower American River parkway for the transplantation of elderberry shrubs. In addition, the local sponsors will create an additional 40 acres of land to benefit the valley elderberry longhorn beetle or purchase 40 acres of credits at a Service approved conservation bank to offset the loss of habitat due to trimming of elderberry shrubs along the lower American River, Sacramento River, Dry/Robla Creeks, Arcade Creek, Magpie Creek, and NEMDC.

- Management of these lands will include all measures specified in the Service's conservation guidelines (1999a) related to weed and litter control, fencing, and the placement of signs.
- Monitoring will occur for 10 consecutive years or for 7 non-consecutive years over a 15-year period. Annual monitoring reports will be submitted to the Service.
- Compensation areas will be protected in perpetuity and have a funding source for maintenance (endowment).

<u>Giant Garter Snake</u>

- Unless approved otherwise by the Service, construction will be initiated only during the giant garter snakes' active period (May 1–October 1, when they are able to move away from disturbance).
- Construction personnel will be given a Service-approved worker environmental awareness program.
- A survey for giant garter snakes will be conducted within 24 hours prior to construction beginning in potential giant garter snake habitat. Should there be any interruption in work for greater than 2 weeks, a biologist will resurvey the area within 24 hours prior to the restart of construction.
- Giant garter snakes encountered during construction will be allowed to move away from construction activities on their own.
- Movement of heavy equipment to and from the construction site will be restricted to established roadways. Stockpiling of construction materials will be restricted to designated staging areas, which will be located more than 200 feet away from giant garter snake aquatic habitat.
- Giant garter snake habitat within 200 feet of construction activities will be designated as an environmentally sensitive area and delineated with signs or fencing. This area will be avoided by all construction personnel.
- Habitat temporarily affected for one season (the 5.5 acre borrow site along the NEMDC and the 75 acres along the toe drain of the Sacramento Bypass levee) will be restored after construction by applying appropriate erosion control techniques and replanting/seeding with appropriate native plants. If for any reason construction extends into another active season the Corps will replace the habitat on-site and purchase credits at a ratio of 1:1 at a Service approved conservation bank.
- Habitat temporarily affected for more than three or more seasons will be restored and twice as much habitat will be created.
- Habitat permanently affected in the Sacramento Bypass in the form of drainage ditches and irrigation canals will be compensated for through the purchase of 135 acres of credits at a Service approved conservation bank.
- One year of monitoring will be conducted for the 80.5 acres that are temporarily affected.

- The Corps will purchase credits at a conservation bank prior to any permanent disturbance of giant garter snake habitat.
- A biological monitor will be on-site during all ground disturbing activities at borrow site 2.
- Exclusionary fencing will be placed, at least 10 days prior to the beginning of ground disturbing activities after May 1, to exclude giant garter snakes from entering areas where upland disturbance (borrow site 2 and Sacramento Bypass) will occur during the active season (May 1 to October 1). Prior to fencing installation, the fence line will be mowed (with a minimum height of 6 inches) in order to conduct a surface survey of potential burrows. Fencing will be installed with a minimum of 6 inches buried in the ground and a minimum of 24 inches above ground. Fence staking will be installed on the inside of the exclusion area. One-way escape funnels will be installed every 50 to 100 feet and sealed along the fence line to provide an escape for any giant garter snake that may be within the exclusion area. The fencing will enclose the entirety of the site, or additional exclusionary fencing can be extended 200 to 400 feet beyond the proposed entrance area. The fencing will be inspected before the start of each work day and maintained by the contractor until completion of the project. The fencing will be removed only when project activities are completed.

<u>Yellow-Billed Cuckoo</u>

- Prior to construction, surveys will be conducted to determine the presence of yellow-billed cuckoos within the project area in accordance with any required Service survey protocols and permits at the time of construction.
- If surveys find cuckoos in the area, vegetation removal will be done outside of the cuckoo nesting season.
- Riparian habitat that is removed due to project construction along the American River will be replanted within the American River parkway. The Corps intends to expand existing conserved riparian lands within the parkway that could support the yellow-billed cuckoo. The design of replacement riparian areas will be coordinated with the Service to ensure that the habitat benefits both valley elderberry longhorn beetles and yellow-billed cuckoos.

<u>Fisheries Conservation Measures</u>

- In-water construction activities (e.g., placement of rock revetment) will be limited to the work window of August 1 through November 30. If the Corps wants to work outside of this window they will consult with National Marine Fisheries Service (NMFS) and/or the Service.
- The Corps will purchase 42 acres of delta smelt credits from a Service-approved conservation bank to off-set the loss of 14 acres of shallow water habitat.
- The Corps will purchase an additional 32 acres of delta smelt credits from a Service-approved conservation bank to off-set the loss of spawning habitat due to the placement of riprap on the river bed.
- Erosion control measures (BMPs), including Storm Water Pollution Prevention Program and Water Pollution Control Program, that minimize soil or sediment from entering the river shall be installed, monitored for effectiveness, and maintained

throughout construction operations to minimize effects to federally listed fish and their designated critical habitat.

- Screen any water pump intakes, as specified by NMFS and the Service 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.
- The Corps shall include as part of the project, a Riparian Corridor Improvement Plan with the overall goal of maximizing the ecological function and value of the existing levee system within the Sacramento Metropolitan area.

Additional Minimization and Conservation Measures

- Obtain an ETL approved vegetation variance exempting sites from vegetation removal prior to final design and construction phase for the Sacramento River.
- Construction will be scheduled when listed terrestrial and aquatic species will be least likely to occur in the project area. If construction needs to extend into the timeframe that species are present, then coordination/reinitiation with the Service will occur.
- Compensation for impacts to native riparian habitat will occur on a 2:1 basis on-site or in close proximity to the impact area. Riparian vegetation impacted under the SAFCA 408/404 actions will be replaced on a 3:1 canopy cover acreage basis.
- Stockpile all liquid chemicals and supplies at a designated impermeable membrane fuel and refueling station with a 110% containment system.
- Stockpile construction materials such as portable equipment, vehicles, and supplies, at designated construction staging areas and barges, exclusive of any riparian and wetland areas.
- Implement BMPs to prevent slurry from seeping out to the river and require piping systems on the landside of the levee.
- Project related vehicles will observe a 20-mile-per-hour speed limit within construction areas, except on County roads and on State and federal highways.
- Site access will be limited to the smallest area possible in order to minimize disturbance. Litter, debris, unused materials, equipment, and supplies will be removed from the project area daily. Such materials or waste will be deposited at an appropriate disposal or storage site.
- Immediately (within 24 hours) cleanup and report 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 Service approved biologist as a 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.

Action Area

The action area is defined in 50 CFR § 402.02, as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." For the purposes of the effects assessment, the action area encompasses the Sacramento River from the Sacramento Bypass downstream to River Mile 45, the Yolo Bypass south the confluence of the Sacramento Bypass, the lower American River from Arden Way to the confluence of the Sacramento River, Arcade Creek from Marysville Boulevard to the confluence of the NEMDC, the NEMDC from the south Dry

Creek levee to just south of the NEMDC Arcade Creek confluence, the southern Dry Creek levee between Dry Creek Road and Rose Street, the borrow site along the NEMDC, and any borrow sites. Additionally, we are including a buffer of 300 feet from construction to account for effects to listed species due to dust and noise.

Analytical Framework for the Jeopardy Analysis

The following analysis relies on four components to support the jeopardy determination for the giant garter snake, valley elderberry longhorn beetle, yellow-billed cuckoo, and delta smelt: (1) the *Status of the Species*, which evaluates the species' range-wide condition, the factors responsible for that condition, and their survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the role of the action area in the species' survival and recovery; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on these species; and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on these species.

In accordance with the implementing regulations for section 7 and Service policy, the jeopardy determination is made in the following manner: the effects of the proposed Federal action are evaluated in the context of the aggregate effects of all factors that have contributed to the current status of the delta smelt, valley elderberry longhorn beetle, giant garter snake, and yellow-billed cuckoo. Additionally, for non-Federal activities in the action area, we will evaluate those actions likely to affect the species in the future, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both its survival and recovery in the wild.

The following analysis places an emphasis on using the rang-wide survival and recovery needs of the delta smelt, valley elderberry longhorn beetle, giant garter snake, and yellow-billed cuckoo, and the role of the action area in providing for those needs as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Analytical Framework Adverse Modification

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.2. Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this biological opinion relies on four components: (1) the *Status of the Critical Habitat*, which evaluates the range-wide condition of critical habitat for the delta smelt in terms of primary constituent elements (PCE)s, the factors responsible for that condition, and the intended recovery function of the critical habitat at the provincial and range-wide scale; (2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units and; (4) *Cummulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on the delta smelt critical habitat are evaluated in the context of the range-wide condition of the critical habitat at the provincial and range-wide scales, taking into account any cumulative effects, to determine if the critical habitat range-wide would remain functional (or would retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for the delta smelt.

The analysis in this biological opinion places an emphasis on using the intended range-wide recovery function of delta smelt critical habitat and the role of the action area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

Status of the Species and Environmental Baseline

Valley Elderberry Longhorn Beetle Status of the Species

Please refer to the *Withdrawl of the Proposed Rule to Remove the Valley Elderberry Longhorn Beetle from the Federal List of Endangered and Threatened Wildlife* (Service 2014) for the current status of the species. Ongoing threats to the valley elderberry longhorn beetle include habitat loss due to flood control projects, development projects, and invasive species. While these threats continue to affect the valley elderberry longhorn beetle throughout its range, to date no project has proposed a level of effect for which the Service has issued a biological opinion of jeopardy for the valley elderberry longhorn beetle.

Valley Elderberry Longhorn Beetle Environmental Baseline

The project footprint along both the Sacramento River and the American River contain riparian vegetation. The beetle is known in numerous locations along the American River parkway (CNDD 2015). Suitable habitat for the beetle in the form of elderberry shrubs occurs within the action area along the Sacramento River, the American River, and Arcade Creek.

Sacramento River - Riparian habitat along the Sacramento River, south of the city of Sacramento, occurs in narrow bands along the riverbank and levee. Generally an overstory layer is present composed of cottonwood, sycamore, and oak trees. Shrubs occur as a mid-story layer including buttonbush, blue elderberry, white alder, and Oregon ash. Elderberry shrubs occur randomly along the reach of river proposed for improvements. The Corps has documented at least 73 elderberry shrubs along the Sacramento River reach where construction is proposed. Natural river processes of erosion and accretion effect elderberry shrubs which is the host plant of the valley elderberry longhorn beetle by eroding away bank and potentially elderberry shrubs. Levee maintenance can adversely affect elderberries within this stretch of the Sacramento River either by pruning or drift of herbicides used along the levee slope.

American River – The valley elderberry longhorn beetles have been identfied along the lower American River Parkway in the CNDDB (2015). Additionally, the Corps has designed and built six sites along the lower American River as habitat for the valley elderberry longhorn beetle. These sites extend from RM 0.9 up to RM 21. Levee maintenance can adversely affect elderberry shrubs, though the largest threat to valley elderberry longhorn beetle is fires that have been started in the parkway and burned habitat that supports valley elderberry longhorn beetles.

Delta Smelt Status of Species

Listing Status: The Service proposed to list the delta smelt as threatened with proposed critical habitat on October 3, 1991 (56 FR 50075). The Service listed the delta smelt as threatened on March 5, 1993 (58 FR 12854), and designated critical habitat for this species on December 19, 1994 (59 FR 65256). The delta smelt was one of eight fish species addressed in the *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* (Service 1996). This recovery plan is currently under revision. A 5-year status review of the delta smelt was completed on March 31, 2004 (Service 2004). The 2004 review affirmed the need to retain the delta smelt as a threatened species. A 12-month finding on a petition to reclassify the delta smelt was completed on April 7, 2010 (75 FR 17667). After reviewing all available scientific and commercial information, the Service determined that re-classifying the delta smelt from a threatened to an endangered species was warranted, but precluded by other higher priority listing actions (Service 2010).

Distribution: The delta smelt is endemic to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta) in California, and is restricted to the area from San Pablo Bay upstream through the Delta in Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties (Moyle 2002). Their range extends from San Pablo Bay upstream to Verona on the Sacramento River and Mossdale on the San Joaquin River. The delta smelt was formerly considered to be one of the most common pelagic fish in the upper Sacramento-San Joaquin Estuary.

Description: Live delta smelt are nearly translucent with a steely-blue sheen to their sides and have been characterized to have a pronounced odor reminiscent of cucumber (Moyle 2002). Although delta smelt have been recorded to reach lengths of up to 120 millimeters (mm) (4.7 in) (Moyle 2002), mean fork length of the delta smelt from 1974 to 1991 was measured to be 64.1 ± 0.1 mm. Since then, catch data from 1992 - 2004 showed mean fork length decreased to 54.1 ± .01 mm (Bennett 2005; Sweetnam 1999). Delta smelt are also identifiable by their relatively large eye to head size (Moyle 2002). Delta smelt have a small, translucent adipose fin located between the dorsal and caudal fins.

The delta smelt is one of six species currently recognized in the *Hypomesus* genus (Bennet 2005). Genetic analyses have confirmed that *H. transpacificus* presently exists as a single intermixing population (Stanley *et al.* 1995; Trenham *et al.* 1998; Fisch *et al.* 2011). Within the genus, delta smelt is most closely related to surf smelt (*H. pretiosis*), a species common along the western coast of North America. Despite morphological similarities, the delta smelt is less-closely related to the wakasagi (*H. nipponensis*), an andadromous western Pacific species introduced to Central Valley reservoirs in 1959, and may be seasonally sympatric with delta smelt in the estuary (Trenham *et al.* 1998). Allozyme studies have demonstrated that wakasagi and delta smelt are genetically distinct and presumably derived from different marine ancestors (Stanley *et al.* 1995).

Life History and Biology

Adult-Spawning: Adult delta smelt spawn during the late winter and spring months, with most spawning occurring during April through mid-May (Moyle 2002). Spawning occurs primarily in sloughs and shallow edge areas in the Delta. Delta smelt spawning has also been recorded in Suisun Marsh and the Napa River (Moyle 2002). Most spawning occurs at temperatures between 12-18°C. Although spawning may occur at temperatures up to 22°C, hatching success of the larvae is very low (Bennett 2005).

Fecundity of females ranges from about 1,200 to 2,600 eggs, and is correlated with female size (Moyle 2002). Moyle *et al.* (1992) considered delta smelt fecundity to be "relatively low." However, based on Winemiller and Rose (1992), delta smelt fecundity is fairly haigh for a fish its size. Captive delta smelt can spawn up to 4-5 times. While most adults do not survive to spawn a second season, a few (<5 percent) do (Moyle 2002; Bennett 2005). Those that do survive are typically larger (90-110 mm Standard Length[sdl]) females that may contribute disproportionately to the population's egg supply (Moyle 2002 and references therein). Two-year-old females may have 3-6 times as many ova as first year spawners.

Most of what is known about delta smelt spawning habitat in the wild is inferred from the location of spent females and young larvae captured in the California Department of Fish and Wildlife Spring Kodiak Trawl (SKT) and 20-mm Survey, respectively. In the laboratory, delta smelt spawned at night (Baskerville-Bridges *et al.* 2000; Mager *et al.* 2004). Other smelts, including marine beach spawning species and estuarine populations and the landlocked Lake Washington longfin smelt, are secretive spawners, entering spawning areas during the night and leaving before dawn. If this behavior is exhibited by delta smelt, then delta smelt distribution based on the SKT, which is conducted during daylight hours in offshore habitats, may reflect general regions of spawning activity, but not actual spawning sites.

Delta smelt spawning has only been directly observed in the laboratory and eggs have not been found in the wild. Consequently, what is known about the mechanics of delta smelt spawning is derived from laboratory observations and observations of related smelt species. Delta smelt eggs are 1 mm diameter and are adhesive and negatively buoyant (Moyle 1976, 2002; Mager *et al.* 2004; Wang 1986, 2007). Laboratory observations indicate that delta smelt are broadcast spawners, discharging eggs and milt close to the bottom over substrates of sand and/or pebble in current (DWR and Reclamation 1994; Brown and Kimmerer 2002; Lindberg *et al.* 2003; Wang 2007). Spawning over gravel or sand can also aid in the oxygenation of delta smelt eggs. Eggs that may have been laid in silt or muddy substrates might get buried or smothered, preventing their oxygenation from water flow (Lindberg pers. comm. 2011). The eggs of surf smelts and other beach spawning smelts adhere to sand particles, which keeps them negatively buoyant but not immobile, as the sand may move ("tumble") with water currents and turbulence (Hay 2007). It is not known whether delta smelt eggs "tumble incubate" in the wild, but tumbling of eggs may moderately disperse them, which might induce predation risk within a localized area.

The locations in the Delta where newly hatched larvae are present, most likely indicates spawning occurrence. The 20-mm trawl has captured small (~5 mm sdl) larvae in Cache Slough, the lower Sacramento River, San Joaquin River, and at the confluence of these two rivers (e.g., 20-mm trawl survey 1 in 2005). Larger larvae and juveniles (size > 23 mm sdl), which are more efficintly sampled by the 20-mm trawl gear, have been captured in Cache Slough and the Sacramento Deep Water Ship Channel in July (e.g. 20-mm trawl survey 9 in 2008). Because they are small fish inhabiting pelagic habitats with strong tidal and river currents, delta smelt larval distribution depends on both the spawning area from which they originate and the effect of transport processes caused by flows. Larval distribution is further affected by water salinity and temperature. Hydrodynamic simulations reveal that tidal action and other factors may cause substantial mixing of water with variable salinity and temperature among regions of the Delta (Monson *et al.* 2007). This could result in rapid dispersion of larvae away from spawning sites.

The timing of spawning may affect delta smelt population dynamics. Lindberg (2011) has suggested that smelt larvae that hatch early, around late February, have an advantage over larvae hatched during late spawning in May. Early season larvae have a longer growing season and may be able to grow larger faster during more favorable habitat conditions in the late winter and early spring. An early growing season may result in higher survivorship and a stronger spawning capability for that generation. Larvae hatched later in the season have a shorter growing season which effectively reduces survivorship and spawning success for the following spawning season.

Larval Development: Mager *et al.* (2004) reported that embryonic development to hatching takes 11-13 days at 14-16° C for delta smelt, and Baskerville-Bridges *et al.* (2000) reported hatching of delta smelt eggs after 8-10 days at temperatures between 15-17° C. Lindberg *et al.* (2003) reported high hatching rates of delta smelt eggs in the laboratory at 15° C, and Wang (2007) reported high hatching rates at temperatures between 14-17° C. Hatching success peaks near 15°C (Bennett 2005) and swim bladder inflation occurring at 60-70 days post hatch at 16-17°C (Mager *et al.* 2004). At hatching and during the succeeding three days, larvae are buoyant, swim actively near the water surface, and do not react to bright direct light (Mager *et al.* 2004). As development continues, newly hatched delta smelt become semi-buoyant and sink in stagnant water. However, larvae are unlikely to encounter stagnant water in the wild.

Growth rates of wild-caught delta smelt larvae are faster than laboratory-cultured individuals. Mager *et al.* (2004) reported growth rates of captive-raised delta smelt reared at near-optimum temperatrues (16-17°C). Their fish were about 12 mm long after 40 days and about 20 mm long after 70 days. In contrast, analyses of otoliths indicated that wild delta smelt larvae were 15-25 mm, or nearly twice as long at 40 days of age (Bennett 2005). By 70 days, most wild fish were 30-40 mm long and beyond the larval stage. This suggests there is a strong selective pressure for rapid larval growth in nature, a situation that is typical for fish in general (Houde 1987). Successful feeding seems to depend on a high density of food organisms and turbidity, and increases with stronger light conditions (Baskerville-Bridges *et al.* 2000; Mager *et al.* 2004; Baskerville-Bridges *et al.* 2004). The food available to larval fishes is constrained by mouth gape and status of fin development. Larval delta smelt cannot capture as many kinds of prey as larger individuals, but all life stages have small gapes that limit their range of potential prey. Prey availability is also constrained by habitat use, which affects what types of prey are encountered. Larval delta smelt are visual feeders. They find and select individual prey organisms and their ability to see prey in the water is enhanced by turbidity (Baskerville-Bridges *et al.* 2004). Thus, delta smelt diets are largely comprised of small crustacea that inhabit the estuary's turbid, low-salinity, open-water habitats (i.e., zooplankton). Larval delta smelt have particularly restricted diets (Nobriga 2002). They do not feed on the full array of zooplankton with which they co-occur; they mainly consume three copepods, *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and freshwater species of the family Cyclopidae. Further, the diets of first-feeding delta smelt larvae are largely restricted to the larval stages of these copepods; older, larger life stages of the copepods are increasingly targeted as the delta smelt larvae grow, their gape increases, and they become stronger swimmers.

The triggers for and duration of delta smelt larval movement from spawning areas to rearing areas are not known. Hay (2007) noted that eulachon larvae are probably flushed into estuaries from upstream spawning areas within the first day after hatching, but downstream movement of delta smelt larvae occurs much later. Most larvae gradually move downstream toward the two parts per thousand (ppt) isohaline (X2). X2 is scaled as the distance in kilometers from the Golden Gate Bridge (Jassby *et al.* 1995).

At all life stages, delta smelt are found in greatest abundance in the water column and usually not in close association with the shoreline. They inhabit open, surface waters of the Delta and Suisun Bay, where they presumably aggregate in loose schools where conditions are favorable (Moyle 2002). In years of moderate to high Delta outflow (above normal to wet water years), delta smelt larvae are abundant in the Napa River, Suisun Bay and Montezuma Slough, but the degree to which these larvae are produced by locally spawning fish versus the degree to which they originate upstream and are transported by tidal currents to the bay and marsh is uncertain.

Juveniles: Young-of-the-year delta smelt rear in the low-salinity zone (LSZ) from late spring through fall and early winter. Once in the rearing area growth is rapid, and juvenile fish are 40-50 mm sdl long by early August (Erkkila *et al.* 1950; Ganssle 1966; Radtke 1966). They reach adult size (55-70 mm sdl) by early fall (Moyle 2002). Delta smelt growth during the fall months slows considerably (only 3-9 mm total), presumably because most of the energy ingested is being directed towards gonadal development (Erkkila *et al.* 1950; Radtke 1966).

Delta Smelt Population Dynamics and Abundance Trends

As a consequence of channelization, water operations, and agriculture in the Delta there has been a change to the physical appearance, water salinity, water clarity, and hydrology in the Delta such that most life stages of the delta smelt are now distributed across a smaller area than historically (Arthur *et al.* 1996; Feyrer *et al.* 2007). Wang (1991) noted in a 1989 and 1990 study of delta smelt larval distribution that, in general, the San Joaquin River was used more intensively for spawning than the Sacramento River. Nobriga *et al.* (2008) found that delta smelt capture probabilities in the Summer Townet Survey (TNS) are highest at specific conductance levels of 1,000 to 5,000 $\mu S\ cm^{-1}$ (approximately 0.6 to 3.0 practical salinity unit [psu]). Similarly, Feyrer *et al.* (2007) found a decreasing relationship between abundance of delta smelt in the Fall Midwater Trawl (FMWT) and specific conductance during September through December. The location of the low salinity zone (LSZ) and changes in delta smelt habitat quality in the San Francisco Estuary can be indexed by changes in X2. The LSZ historically had the highest primary productivity and is where zooplankton populations (on which delta smelt feed) were historically most dense (Knutson and Orsi 1983; Orsi and Mecum 1986). However, this has not always been true since the invasion of the overbite clam (Kimmerer and Orsi 1996). The abundance of many local aquatic species has tended to increase in years when winter-spring outflow has high and Z2 was pushed seaward (Jassby *et al.* 1995), implying that the quantity and quality (overall suitability) of estuarine habitat increases in years when outflows are high. However, delta smelt is not one of the species whose abundance has statistically covaried with winter-spring freshwater flows (Stevens and Miller 1983; Moyle *et al.* 1992; Kimmerer 2002a; Bennett 2005).

The distribution of juvenile delta smelt has also changed over the last several decades. During the years 1970 through 1978, delta smelt catches in the TNS survey declined rapidly to zero in the Central and South Delta and have remained near zero since. A similar shift in FMWT catches occurred after 1981 (Arthur *et al.* 1996). This portion of the Delta has also had a long-term trend increase in water clarity during July through December (Arthur *et al.* 1996; Feyrer *et al.* 2007; Nobriga *et al.* 2008).

The CDFW has conducted several long-term monitoring surveys that have been used to index the relative abundance of delta smelt. The 20-mm Survey has been conducted every year since 1995. This survey targets late-stage delta smelt larvae. Most sampling has occurred April-June. The TNS has been conducted nearly every year since 1959. This survey targets 38-mm striped bass, but collects similar-sized juvenile delta smelt. Most sampling has occurred June-August. The Fall Midwater Trawl Survey has been conducted nearly every year since 1967. This survey also targets age-0 striped bass, but collects delta smelt > 40 mm in length. The FMWT samples monthly, September-December. The relative abundance index data and maps of the sampling stations used in these surveys are available at http://www.CDFW.ca.gov/delta/. The methods that underlie the surveys have been described previously (Stevens and Miller 1983; Moyle *et al.* 1992; Dege and Brown 2004). The delta smelt catch data and relative abundance indices derived from these sampling programs have been used in numerous publications (e.g., Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995; Kimmerer 2002b; Dege and Brown 2004; Bennett 2005; Feyrer *et al.* 2007; Sommer *et al.* 2007; Kimmerer 2008; Newman 2008; Nobriga *et al.* 2008; Kimmerer *et al.* 2009; Mac

Nally *et al.* 2010; Thomson *et al.* 2010; Feyrer *et al.* 2011; Maunder and Deriso 2011). These abundance index time series document the long-term decline of the delta smelt.

Early statistical assessments of delta smelt population dynamics concluded that at best, the relative abundance of the adult delta smelt population had only a very weak influence on subsequent juvenile abundance (Sweetnam and Stevens 1993). Thus, early attempts to describe abundance variation in delta smelt ignored stock-recruit effects and researchers looked for environmental variables that were directly correlated with interannual abundance variation (e.g., Stevens and Miller 1983; Moyle *et al.* 1992; Sweetnam and Stevens 1993; Herbold 1994; Jassby *et al.* 1995). Because delta smelt live in a habitat that varies in size and quality with Delta outflow, the authors cited above searched for a linkage between Delta outflow (or X2) and the TNS and FMWT indices. Generally, these analyses did not find strong support for an outflow-abundance linkage. These analyses led to a prevailing conceptual model that multiple interacting factors had caused the delta smelt decline (Moyle *et al.* 1992; Bennett and Moyle 1996; Bennett 2005). It has also recently been noted that delta smelt's FMWT index is partly influenced by explanation for why few analyses could consistently link springtime environmental conditions to delta smelt's fall index.

One published exception to the multi-factor hypothesis was proposed by Gilbert (2010), who posited that nutrient pollution was the root cause of all the food web and fish assemblage changes that caused the decline of delta smelt and other pelagic fishes. However, the statistical approach she used to support her hypothesis was not appropriate and the untransformed data sets do not support this hypothesized chain of consequences stemming solely from wastewater inputs to the Delta (Jassby *et al.* in press). It is now recognized that delta smelt abundance plays an important role in subsequent abundance (Bennett 2005; Maunder and Deriso 2011). Bennett (2005) assessed (1) the influence of adult stock as indexed by the FMWT versus the next generation of juveniles indexed by the following calendar year's TNS; (2) the influence of the juvenile stock indexed by the TNS versus the subsequent adult stock indexed a few months later in the FMWT; (3) the influence of the FMWT on the following year's FMWT and on the FMWT two years later, and (4) he did the same for the TNS data. He concluded that (1) two-year-old delta smelt might play an important role in delta smelt population dynamics, (2) it was not clear wheter juvenile production was a density-independent or density-dependent function of adult abundance, and (3) adult production was a density-dependent function of juvenile abundance and the carrying capacity of the estuary to support this life-stage transition had declined over time. These conclusions are also supported by Maunder and Deriso (2011).

The concept of density-dependence and how it has affected the delta smelt is important because it may be used as a reason not to protect particular life stages from sources of mortality. Bennet (2005) concluded it was (statistically) unclear whether density-dependence occurs between generations. He also noted that the delta smelt indices strongly suggest that density-dependence has occurred, at least over the long-term, during the juvenile stage. The uncertainty about density-dependence between generations results because statistical assessments of the relationship between the adult stock and the next generation of recruits (juveniles_ result in similar fits for linear (density-independent) and nonlinear (density-dependent) relationships (Bennett 2005; Maunder and Deriso 2011).

One reason for this is that delta smelt population dynamics may have changed over time. Previous papers have reported a delta smelt step-decline during 1981-1982 (Kimmerer 2002a; Thomson *et al.* 2010). Prior to this decline, the stock-recruit data are consistent with "Ricker" type density-dependence where increasing adult abundance resulted in decreased juvenile abundance. Since the decline, recruitment has been positively and essentially linearly related to prior adult abundance, suggesting that reproduction has been basically density-independent for about the past 30 years.

This means that since the early 1980s, more adults translates into more juveniles and fewer adults translates into fewer juveniles without being 'compensated for' by density-dependence. In contrast to the transition among generations, the weight of scientific evidence strongly supports the hypothesis that, at least over the history of Interagency Ecological Program (IEP) fish monitoring, delta smelt has experienced density-dependence during the juvenile stage of its life cycle, i.e., between the summer and fall (Bennett 2005; Maunder and Deriso 2011). This has been inferred because, statistically, the FMWT index does not increase linearly with increases in the summer townet index. Rather, the best-fitting relationships between the summer townet index and the FMWT index show that the FMWT indices approach an asymptote as the summer townet increases or possibly even declines at the highest summer townet indices.

From a species conservation perspective, the most relevant aspect of this juvenile density dependence is that the carrying capacity of the estuary for delta smelt has declined (Bennett 2005). Thus, the delta smelt population decline has occurred for two basic reasons. First, the compensatory density-dependence that historically enabled juvenile abundance to rebound from low adult numbers stopped happening. This change had occurred by the early 1980s as described above. The reason is still not known, but the consequence of the change is that for the past several decades, adult abundance drives juvenile production in a largely density-independent manner. Thus, if numbers of adults or adult fecundity decline, juvenile production will also decline (Kimmerer 2011). Second, because juvenile carrying capacity has declined, juvenile production hits a 'ceiling' at a lower abundance than it once did. This limits adult abundance and possibly per capita fecundity, which cycles around and limits the abundance of the next generation of juveniles. The mechanism causing carrying capacity to decline is likely due to the long-term accumulation of deleterious habitat changes, both physical and biological, during the summer-fall (Bennett *et al.* 2008; Feyrer *et al.* 2007; 2011; Maunder and Deriso 2011).

Habitat

The existing physical appearance and hydrodynamics of the Delta have changed substantially from the environment in which native fish species like delta smelt evolved. The Delta once consisted of tidal marshes with networks of diffuse dendritic channels connected to floodplains of wetlands and upland areas (Moyle 2002). The in-Delta channels were further connected to drainages of larger and smaller rivers and creeks entering the Delta from the upland areas. In the absence of upstream reservoirs, freshwater inflow from smaller rivers and creeks and the Sacramento and San Joaquin Rivers were highly seasonal and more strongly and reliably affected by precipitation patterns than they are today. Consequently, variation in hydrology, salinity, turbidity, and other characteristics of the Delta aquatic ecosystem was greater in the past than it is today (Kimmerer 2002a). For instance, in the early 1900s, the location of maximum salinity intrusion into the Delta during dry periods varied from Chipps Island in the lower Delta to Stockton along the San Joaquin River and Merritt Island in the Sacramento River. Operations of upstream reservoirs have reduced spring flows while releases of water for Delta water export and increased flood control storage have increased late summer and fall inflows (Knowles 2002), though Delta outflows have been tightly constrained during late summer-fall for several decades. The following is a brief description of the changes that have occurred to delta smelt's habitat that are relevant to the environmental baseline for this consultation.

Changes to the LSZ: There have been documented changes to the delta smelt's LSZ habitat that have led to present-day, baseline habitat conditions. The close association of delta smelt with the San Francisco estuary LSZ has been known for many years (Stevens and Miller 1983; Moyle *et al.* 1992). Peterson (2003) developed a conceptual model that hypothesized how, "stationary and dynamic components of estuarine habitats" interacted to influence fisheries production in tidal river estuaries.

Peterson's model suggests that when the dynamic and static aspects of estuarine habitat sufficiently overlap, foraging, growth, density, and survival are all high, and that enables fish production to outpace losses to predators. The result is high levels of successful recruitment of new individuals. The model also hypothesizes that when the dynamic and static aspects of an estuarine habitat do not sufficiently overlap, foraging, growth, density, and survival are impaired such that losses to predators increase and recruitment of new individuals decreases. This model was developed specifically for species spawned in marine environments that were subsequently transported into estuaries. However, the concept of X2, which was developed in the San Francisco estuary to describe how freshwater flow affected estuarine habitat (Jassby *et al.* 1995), played a role in the intellectual development of Peterson's model. The Peterson model also provides a useful framework to conceptualize delta smelt's LSZ habitat.

Currently available information indicates that delta smelt habitat is most suitable for the fish when low-salinity water is near 20°C, highly turbid, oxygen saturated, low in contaminants, supports high densities of calanoid copepods and mysid shrimp (Moyle *et al.* 1992; Lott 1998; Nobriga 2002), and occurs over comparatively static 'landscapes' that support sandy beaches and bathymetric variation that enables the fish and their prey to aggregate (Kimmerer *et al.* 2002a; Bennett *et al.* 2002; Hobbs *et al.* 2006). Almost every component listed above has been degraded over time (see below). The Service has determined that this accumulation of habitat change is the fundamental reason or mechanism that has caused delta smelt to decline.

Alterations to estuarine bathymetry and salinity distribution (~ 1850-present): The position of the LSZ, where delta smelt rear, has changed over the years. The first major change in the LSZ was the conversion of the landscape over which tides oscillate and river flows vary (Moyle *et al.* 2010). The ancestral Delta was a large tidal marsh-floodplain habitat totaling approximately 700,000 acres. Most of the historic wetlands within the system were diked and reclaimed for agriculture or other human uses by 1920 (Atwater *et al.* 1979). Channels were dredged deep (~12 meters[m]) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the confluence of the Sacramento-San Joaquin Rivers as the largest and most bathymetrically variable places in the LSZ. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995). However, the deepened channels created to support shipping and flood control, requires more freshwater outflow to maintain the LSZ in the large Suisun Bay and River confluence than was once required (Gartrell 2010). The construction of the CVP and SWP not only provided water supply for urban, agricultural and industrial users, but also provided water needed to combat salinity intrusion into the Delta, which was observed by the early 20th century. California's demand for freshwater (keeps) continues to increase, thus seasonal salinity intrusion perpetually reduces the temporal overlap of the LSZ (indexed by X2) within the Suisun Bay (region), especially in the fall (Feyrer *et al.* 2007; 2011). Consequently, the second major habitat change in the Delta has been in the frequency with which the LSZ is maintained in Suisun Bay for any given amount of precipitation. There was a step-decline in the LSZ in 1977 from which it has never recovered for more than a few years at a time. Based on model forecasts of climate change and water demand, this trend is expected to continue (Feyrer *et al.* 2011).

Summer and fall environmental quality has decreased overall in the Delta because outflows are lower and water transparency is higher. These changes may be due to increased upstream water diversions for flooding rice fields (Kawakami *et al.* 2008). The confluence of the Sacramento and San Joaquin Rivers has, as a result, become increasingly important as a rearing location for delta smelt, with physical environmental conditions constricting the species range to a relatively narrow area (Feyrer *et al.* 2007; Nobriga *et al.* 2008). This has increased the likelihood that most of the juvenile population is exposed to chronic and cyclic environmental stressors, or catastrophic events. For instance, all seven delta smelt collected during the September 2007 FMWT survey were captured at statistically significantly higher salinities than what would be expected based upon historical distribution data generated by Feyrer *et al.* (2007). During the same year, the annual bloom of toxic cyanobacteria (Microcystis aeruginosa) spread far downstream to the west Delta and beyond during the summer (Peggy Lehman, pers comm). This has been suggested as an explanation for the anomaly in the distribution of delta smelt relative to water salinity levels (US Bureau of Reclamation 2008).

Bank Protection (Levees): The placement of riprap bank protection has led to the loss of riparian habitat, large woody debris, shallow water habitat, and natural channel migration. Bank stabilization and riprapping has been shown to change natural river processes such as erosion and accretion which reduces habitat complexity; creates a smooth, hydraulically enhanced surface that is not conducive to the habitat requirements of fish including delta smelt; stops woody vegetation from entering the river and reduces the long-term recruitment of large woody debris; inhibits plant growth through a change is substrate; lowers the amount of outside food sources because of the lack of riparian and wetland vegetation for aquatic invertebrates; and increases stream edge velocities which decreases available refuge areas for fish (Service 2000). More than half of the Sacramento River's lower 194 miles have been riprapped, mostly under the Corps Sacramento River bank Protection Project. Today most of the riparian forests and wetlands have been removed and the Sacramento River has been constrained to not allow natural erosion and accretion to occur.

Turbidity: From 1999 to present, the Delta experienced a change in estuarine turbidity that culminated in an estuary-wide step-decline in 1999 (Schoellhamer 2011). For decades, the turbidity of the modified estuary had been sustained by very large sediment deposits resulting mainly from gold mining in the latter 19th century. Sediments continued to accumulate into the mid-20th century, keeping the water relatively turbid even as sediment loads from the Sacramento River basin declined due to dam and levee construction (Wright and Schoellhamer 2005). The flushing of the sediment deposits may also have made the estuary deeper overall and thus a less suitable nursery from the 'static' bathymetric perspective (Schroeter 2008).

Delta smelt are associated with highly turbid waters; there is a negative correlation between the frequency of delta smelt occurrence in survey trawls during the summer, fall and early winter and water clarity. For example, the likelihood of delta smelt occurrence in trawls at a given sampling station decreases with increasing Secchi depth at the stations (Feyrer *et al.* 2007, Nobriga *et al.* 2008). This is very consistent with behavioral observations of captive delta smelt (Nobriga and Herbold 2008). Few daylight trawls catch delta smelt at Secchi depths over 0.5 m and capture probabilities for delta smelt are highest at 0.40 m depth or less. First-feeding delta smelt larvae require relatively turbid (muddy) waters to capture prey, but older fish do not require turbidity to capture prey and very high turbidity may even have some inhibitory effect on prey consumption (Hasenbein *et al.* 2013). Delta smelt may also use turbidity as cover from predators; this was hypothesized based on long-term monitoring of the distribution of fish in the wild (e.g., Feyrer *et al.* 2007) and recently supported by a laboratory experiment (Ferrari *et al.* 2014).

Temperature: Temperature also affects delta smelt distribution. Swanson and Cech (1995) and Swanson *et al.* (2000) indicate delta smelt tolerate temperatures (<8° C to >25° C), however warmer water temperatures >25° C restrict their distribution more than colder water temperatures (Nobriga and Herbold 2008). Delta smelt of all sizes are found in the main channels of the Delta and Suisun Marsh and the open waters of Suisun Bay where the water is well oxygenated and temperatures are usually less than 25° C in summer (Nobriga *et al.* 2008). Currently, delta smelt are subjected to thermally stressful temperatures every summer, and all available regional climate change projections predict central California will be warmer still in the coming decades (Dettinger 2005). We expect warmer estuary temperatures to be yet another significant conservation challenge based on climate change models. Warmer water temperatures would increase delta smelt mortality and constrict suitable habitat throughout the Delta during the summer months. Higher temperatures would shrink delta smelt distribution into the fall, limiting their presence to Suisun Bay and in waters with less than optimal salinities (Brown *et al.* 2013). Water temperatures are presently above 20°C for most of the summer in core habitat areas, sometimes even exceeding the nominal lethal limit of 25°C for short periods. Coldwater fishes begin to have behavioral impairments (Marine and Cech 2004) and lose competitive abilities (Taniguchi *et al.* 1998) prior to reaching their thermal tolerance limits. Thus, the estuary can already be considered thermally stressful to delta smelt and can only become more so if temperatures warm in the coming decades.

Foraging Ecology: Delta smelt feed primarily on small planktonic crustaceans, and occasionally on insect larvae (Moyle 2002). Juvenile-stage delta smelt prey upon copepods, cladocerans, amphipods, and insect larvae (Moyle 2002). Historically, the main prey of delta smelt was the euryhaline copepod *Eurytemora affinis* and the euryhaline mysid *Neomysis mercedis.* The slightly larger *Pseudodiaptomus forbesi* has replaced *E. affinis* as a major prey source of delta smelt since its introduction into the Bay-Delta, especially in summer, when it replaces *E. affinis* in the plankton community (Baxter *et al.* 2008; Moyle 2002). The most common copepod in the estuary now is a small nonnative species, *Limnoithona tetraspina.* It has been suggested that *L. tetraspina* may be an inferior food for pelagic fishes including delta smelt because of its small size and generally sedentary behavior (Bouley and Kimmerer 2006). Experimental studies addressing this issue have suggested that smelt larvae will attack *L. tetraspina* until they grow large enough to successfully capture larger copepods; also, growth rate of delta smelt fed *L. tetraspina* was lower than that of smelt fed the larger copepods (Sullivan *et al.*, unpublished). *L. tetraspina* is sometimes consumed in large numbers by juvenile delta smelt during late summer when this copepod is abundant in the LSZ (Slater and Baxter 2014). *Acartiella sinensis*, a calanoid copepod species that invaded the Delta at the same time as *L. tetraspina*, also occurs at high densities in Suisun Bay and in the western Delta over the last decade. Delta smelt eat these newer copepods, but *Pseudodiaptomus* remains their dominant prey (Baxter *et al.* 2008).

River flows influence estuarine salinity gradients and water residence times and thereby affect both habitat suitability for benthos and the transport of pelagic plankton upon which delta smelt feed. High tributary flow leads to lower residence time of water in the Delta, which generally results in lower plankton biomass (Kimmerer 2004). In contrast, higher residence times, which result from low tributary flows, can result in higher plankton biomass but water diversions, overbite clam grazing (Jassby *et al.* 2002) and possibly contaminants (Baxter *et al.* 2008) remove a lot of plankton biomass when residence times are high. These factors all affect food availability for planktivorous fishes that utilize the zooplankton in Delta channels. Delta smelt cannot occupy much of the Delta anymore during the summer (Nobriga *et al.* 2008). Thus, there is the potential for mismatches between regions of high zooplankton abundance in the Delta and delta smelt distribution now that the overbite clam has decimated LSZ zooplankton densities.

The delta smelt compete with and are prey for several native and introduced fish species in the Delta. The introduced Mississippi silverside may prey on delta smelt eggs and/or larvae and compete for copepod prey (Bennett and Moyle 1996; Bennett 2005). Young striped bass also use the LSZ for rearing and may compete for copepod prey and eat delta smelt. Centrarchid fishes and coded wire tagged Chinook salmon smolts released in the Delta for survival experiments since the early 1980s may potentially also prey on larval delta smelt (Brandes and McLain 2001; Nobriga and Chotkowski 2000). Studies during the early 1960s found delta smelt were only an occasional prey fish for striped bass, black crappie and white catfish (Turner and Kelley 1966). However, delta smelt were a comparatively rare fish even then, so it is not surprising they were a rare prey. Striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they historically did, following severe declines in the abundance of mysid shrimp (Feyrer *et al.* 2003). Nobriga and Feyrer (2008) showed that Mississippi silverside, which is similar in size to delta smelt, was only eaten by subadult striped bass less than 400-mm fork length. While largemouth bass are not pelagic, they have been shown to consume some pelagic fishes (Nobriga and Feyrer 2007).

Other Stressors

Aquatic Macrophytes: For many decades, the Delta's waterways were turbid and growth of submerged plants was apparently unremarkable. That began to change in the mid-1980s, when the Delta was invaded by the non-native plant, *Egeria densa*, a fast-growing aquatic macrophyte that has now taken hold in many shallow habitats throughout the Delta (Brown and Michnuik 2007; Hestir 2010). *Egeria densa* and other non-native species of submerged aquatic vegetation (SAV) grow most rapidly in the summer and late fall when water temperatures are warm (> 20°C) and outflow is relatively low (Hestir 2010). The large canopies formed by these plants have physical and biological consequences for the ecosystem (Kimmerer *et al.* 2008). First, the dense nature of SAV promotes sedimentation of particulate matter from the water column, which increases water transparency that then limits the amount of habitat available for delta smelt (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Second, dense SAV canopies provide habitat for a suite of non-native fishes that occupy the littoral and shallow habitats of the Delta, displacing native fishes (Nobriga *et al.* 2005; Brown and Michniuk 2007). Finally, the rise in SAV colonization over the last three decades has led to a shift in the dominant trophic pathways that fuel fish production in the Delta. Until the latter 1980s, the food web of most fishes was often dominated by mysid shrimp (Feyrer *et al.* 2003) that were subsidized by phytoplankton food sources (Rast and Sutton 1989). Now, most littoral and demeral fishes of the Delta have diets dominated by the epibenthic amphipods that eat SAV detritus or the epiphytic algae attached to SAV (Grimaldo *et al.* 2009).

E. densa and other non-native submerged aquatic vegetation (e.g., *Myriophyllum spicatum*) can affect delta smelt in direct and indirect ways. Directly, submerged aquatic vegetation can over whelm littoral habitats (inter-tidal shoals and beaches) where delta smelt may spawn making them unsuitable for spawning. Indirectly, submerged aquatic vegetation decreases turbidity (by trapping suspended sediment) which has contributed to a decrease in both juvenile and adult smelt habitat (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Increased water transparency may delay feeding and may also make delta smelt more susceptible to predation pressure.

Predators: Delta smelt is a rare fish and has been a rare fish (compared to other species) for at least the past several decades (Nobriga and Herbold 2008). Therefore, it has also been rare in examinations of predator stomach contents. Delta smelt were occasional prey fish for striped bass, black crappie, and white catfish in the early 1960s (Turner and Kelly 1966) but went undetected in a recent study of predator stomach contents (Nobriga and Feyrer 2007). The predator with the highest historical documentation of predation on delta smelt is striped bass (*Morone saxatilis*; Stevens 1963; 1966; Thomas 1967). In these studies, striped bass were confirmed to prey on both juvenile and adult delta smelt. Striped bass are widely distributed in pelagic areas of the San Francisco Bay-Delta and parts of its watershed, and thus striped bass distribution fully encompasses the distribution of delta smelt juveniles and adults (Nobriga *et al.* 2013). Striped bass also tend to aggregate in the vicinity of water diversion structures, where delta smelt are frequently entrained (Nobriga and Feyrer 2007). No inverse correlations between the abundance of striped bass and the relative abundance of delta smelt have been found to date using a variety of statistical approaches (Mac Nally et al 2010; Thomson *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012; Nobriga et al 2013). Although the relative rarity of delta smelt in the estuary food web would presumably make them an incidental prey item for striped bass, it is possible that striped bass abundance and demand for prey are always high enough to limit delta smelt population growth rate (Nobriga *et al.* 2013).

Fish eggs and larvae can be opportunistically preyed upon by many invertebrate and vertebrate animals. There has always been a very long list of potential predators of delta smelt's eggs and larvae. One of these is the nonnative Mississippi silverside (*Menidia audens*), which like delta smelt is and annual fish with a maximum length near 100 mm (4 inches). Mississippi silversides may be both predators and competitors of delta smelt (Bennett 2005). Mississippi silversides were first introduced to the San Francisco Bay-Delta in the mid-1970s, and have increased dramatically in numbers since the mid-1980s. They forage in schools around the shoreline habitats and tidal marsh channels of the San Francisco Bay-Delta, where they are exceptionally common (Matern *et al.* 2002); Nobriga *et al.* 2005; Gewant and Bollens 2012). They readily consume delta smelt larvae in aquarium tests Bennett (20025_ concluded that "delta smelt are at high risk of eggs or larvae co-occur with schools of foraging silversides."

Another known predator is the largemouth bass are freshwater fish that prefer clear waters along shorelines (littoral habitat) with relatively dense water plants (Nobriga and Feyrer 2007; Brown and Michniuk 2007; Baxter *et al.* 2008). This is a suite of habitat characteristics that is distinctly different from those described above for delta smelt. Thus, unlike delta smelt and striped bass, delta smelt and largemouth bass have different habitat requirements (e.g., Nobriga *et al.* 2005) and their distributions do not strongly overlap. However, there has been a major increase in the Delta's largemouth bass population since the early 1990's that is believed to have been facilitated by the spread of the introduced plant *Egeria densa*, which provides rearing habitat for the bass (Baxter *et al.* 2008). Despite increases in largemouth bass populations and habitat, Nobriga and Feyrer (2007) did not find delta smelt as largemouth bass prey. Nor have more recent and extensive surveys of largemouth bass stomach contents. In captivity however, even young juvenile largemouth bass will attempt to consume delta smelt (Ferrari *et al.* 2014) so they presumably represent a predation threat when the species closely co-occur in the wild. In contrast to the situation for striped bass, several researchers have found inverse correlations between the relative abundance of largemouth bass or multi-species indices that included largemouth bass and the relative abundance of delta smelt (MacNally *et al.* 2010; Thomson *et al.* 2010; Maunder and Deriso 2011). At this time however, there is no way to determine whether these correlations are causative (predation by largemouth bass caused delta smelt to decline) or not (delta smelt simply use different habitats than largemouth bass and delta smelt habitat has decreased whil largemouth bass habitat has increased).

Other potential predators of eggs and larvae of smelt in littoral habitats are yelllowfin goby, entrarchids, and Chinook salmon. Potential native predators of juvenile and adult delta smelt would also have included numerous bird and fish species and this may be reflected in delta smelt's annual life-history. Annual fish species, also known as "opportunistic strategists", are adapted to high mortality rates in the adult stage (Winemiller and Rose 1992). This high mortality is usually due to predation or highly unpredictable environmental conditions, both of which could have characterized the ancestral niche of delta smelt.

Predation is a common source of density-dependent mortality in fish populations (Rose *et al.* 2001). Thus, it is possible that predation was a mechanism that historically generated the density-dependence observable in delta smelt population dynamics that has been noted by Bennett (2005) and Maunder and Deriso (2011). As is the case with other fishes, the vulnerability of delta smelt to predators may be influence primarily by habitat suitability. It is widely documented that pelagic fishes, including many smelt species, experience lower predation risks under turbid water conditions (Thetmeyer and Kils 1995; Utne-Palm 2002; Horpilla *et al.* 2004). Growth rates, a result of feeding success plus water temperature, are also well known to affect fishes' cumulative vulnerability to predation (Sogard 1997).

Competition: It has been hypothesized that delta smelt are adversely affected by competition from other introduced fish species that use overlapping habitats, including Mississippi silversides, (Bennett and Moyle 1995) striped bass, and wakasagi (Sweetnam 1999). Laboratory studies show that delta smelt growth is inhibited when reared with Mississippi silversides (Bennett 2005) but there is no empirical evidence to support the conclusion that competition between these species is a factor that influences the abundance of delta smelt in the wild. There is some speculation that the overbite clam competes with delta smelt for copepod nauplii (Nobriga and Herbold 2008). It is unknown how intensively overbite clam grazing and delta smelt directly compete for food, but overbite clam consumption of shared prey resources does have other ecosystem consequences that appear to have affected delta smelt indirectly.

Microcystis: Large blooms of toxic blue-green algae, *Microcystis aeruginosa*, were first detected in the Delta during the summer of 1999 (Lehman *et al.* 2005). Since then *M. aeruginosa* has bloomed each year, forming large colonies throughout most of the Delta and increasingly down into eastern Suisun Bay. Blooms typically occur between late spring and early fall (peak in the summer) when temperatures are above 20°C. *M. aeruginosa* can produce natural toxins that pose animal and human health risks if contacted or ingested directly. It is unclear whether microcystins and other toxins produced by local blooms are acutely toxic to fishes at current concentrations; however, the toxins accumulate in fish and their prey. During the summer of 2005, Age-0 striped bass and Mississippi silversides that were co-occurring with the *Microcystis* bloom showed various forms of liver damage (Lehman *et al.* 2010). When ingested with food, microcystins have been experimentally shown to cause substantial impairment of health in threadfin shad (Acuna *et al.* 2012). In addition, the copepods that delta smelt eat are particularly susceptible to these toxins (Ger 2008; Ger *et al.* 2010). An investigation of food web effects and fish toxicity concluded that even at low abundances, *M. aeruginosa* may impact estuarine fish productivity through both toxicity and food web impacts (Lehman *et al.* 2010). *M. aeruginosa* is most likely to affect juvenile delta smelt during summer blooms. Microcystis blooms may also decrease dissolved oxygen to lethal levels for fish (Saiki *et al.* 1998), although delta smelt do not strongly overlap the densest *Microcystis* concentrations, so dissolved oxygen is not likely a problem. *Microcystis* blooms are a symptom of eutrophication and high ammonia to nitrate ratios in the water.

Contaminants: Contaminants can change ecosystem functions and productivity through numerous pathways. However, contaminant loading and its ecosystem effects within the Delta are not well understood. Although a number of contaminant issues were first investigated during the Pelagic Organism Decline (POD) years, concern over contaminants in the Delta is not new. There are long-standing concerns related to mercury and selenium levels in the watershed, Delta, and San Francisco Bay (Linville *et al.* 2002; Davis *et al.* 2003). Phytoplankton growth rate may, at times, be inhibited by high concentrations of herbicides (Edmunds *et al.* 1999). New evidence indicates that phytoplankton growth rate is chronically inhibited by ammonium concentrations in and upstream of Suisun Bay (Wilkerson *et al.* 2006, Dugdale *et al.* 2007). Contaminant-related toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (e.g., Kuivila and Foe 1995, Giddings 2000, Werner *et al.* 2000, Weston *et al.* 2004). Undiluted drain water from agricultural drains in the San Joaquin River watershed can be acutely toxic (quickly lethal) to fish and have chronic effects on growth (Saiki *et al.* 1992).

Evidence for mortality of young striped bass due to discharge of agricultural drainage water containing rice herbicides into the Sacramento River (Bailey *et al.* 1994) led to new regulations for

water discharges. Bio assays using caged Sacramento sucker (Catostomus occidentalis) have revealed deoxyribonucleic acid strand breakage associated with runoff events in the watershed and Delta (Whitehead *et al.* 2004). Kuivila and Moon (2004) found that peak desities of larval and juvenile delta smelt sometimes coincided in time and space with elevated concentrations of dissolved pesticides in the spring. These periods of co-occurrence lasted for up to 2-3 weeks, but concentrations of individual pesticides were low and much less than would be expected to cause acute mortality. However, the effects of exposure to the complex mixtures of pesticides actually present are unknown.
Current science suggests the possible link between contaminants and the POD may be the effects of contaminant exposure on prey items, resulting in an indirect effect on the survival of POD species (Johnson *et al.* 2010). The POD investigators initiated several studies beginning in 2005 to address the possible role of contaminants and disease in the declines of Delta fish and other aquatic species. Their primary study consists of twice-monthly monitoring of ambient water toxicity at fifteen sites in the Delta and Suisun Bay. In 2005 and 2006, standard bioassays using the amphipod *Hyalella azteca* had low (<5 percent) frequency of occurrence of toxicity (Werner *et al.* 2008). The results indicated that 2007, a dry year, showed a higher incidence of toxic events than in the previous (wetter) year, 2006 (Werner *et al.* 2010). Parallel testing with the addition of piperonyl butoxide, an enzyme inhibitor, indicated that both organophosphate and pyrethroid pesticides may have contributed to the pulses of toxicity. Most of the tests that were positive for *H. azteca* toxicity have come from water samples from the lower Sacramento River.

Pyrethroids are of particular concern because of their widespread use, and their tendency to be genotoxic (DNA damaging) to fishes at low doses (in the range of micrograms per liter) (Campana *et al.* 1999). The pyrethroid esfenvalerate is associated with delayed spawning and reduced larval survival of bluegill sunfish (*Lepomis macrochirus*) (Tanner and Knuth 1996) and increased susceptibility of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) to disease (Clifford *et al.* 2005). In addition, synthetic pyrethroids may interfere with nerve cell function, which could eventually result in paralysis (Bradbury and Coats 1989; Shafer and Meyer 2004). Weston and Lydy (2010) found the largest source of pyrethroids flowing into the Delta to be coming from the Sacramento Regional Waste water Treatment Plant, where only secondary treatment occurs. Their data not only indicate the presence of these contaminants, but the concentrations found exceeded acute toxicity thresholds for the amphipod *Hyalella azteca.* This is of substantial concern because the use of insecticides flowing into the Delta. Furthermore, this was not the case for the Stockton Wastewater Treatment facility, where tertiary treatment occurs, suggesting that different treatment methods may remove or etain pyretroids differently (Baxter *et al.* 2010).

In conjunction with the POD investigation, larval delta smelt bioassays were conducted simultaneously with a subset of the invertebrate bioassays. The water samples for these tests were collected from six sites within the Delta during May-August of 2006 and 2007. Results from 2006 indicated that delta smelt are highly sensitive to high levels of ammonia, low turbidity, and low salinity. There is some preliminary indication that reduced survival may be due to disease organisms (Werner *et al.* 2008). No significant mortality of larval delta smelt was found in the 2006 bioassays, but there were two instances of significant mortality in June and July of 2007. In both cases, the water samples were collected from sites along the Sacramento River and had relatively low turbidity and salinity levels and moderate levels of ammonia. It is also important to note that no significant *H. azteca* mortality was detected in these water samples. While H. Azteca tests are very useful for detecting biologically relevant levels of water column toxicity for zooplankton, interpretation of the *H. azteca* test results with respect to fish should proceed with great caution. The relevance of the bioassay results to field conditions remains to be determined. Werner *et al.* (2010b) conducted *in situ* testing in the laboratory and compared contaminant sensitivity of delta smelt to common bioassay organisms, including *H. azteca*. The investigations included contaminants commonly observed in the

Delta, such as organophosphate and pyrethroid insecticides, copper, and total ammonia. In the laboratory, delta smelt were 1.8 to >11 times more sensitive thatn fathead minnow to ammonia, copper and all insecticides tested (except permethrin). The invertebrates tested were more sensitive to contaminants than delta smelt or fathead minnows. *Eurytemora affinis* and *Ceriodaphnia dubia* were the most sensitive to total ammonia. *C. dubia* was the most sensitive to copper and organophosphates pesticides. *H. azteca* was the most sensitive test organism to pyrethroids. Toxicity was not detected for the Sacramento River at Hood or the San Joaquin River at Rough and Ready Island during the 2009 in situ testing period. Delta smelt survival was low in treatment and control waters. Werner *et al.* (2010b) concluded that larval smelt may be too sensitive to salinity, temperature and transport stress for *in situ* exposures and recommended using surrogate species in future tests.

Persistent confinement of the spawning population of delta smelt to the Sacramento River increases the likelihood that a substantial portion of the spawners will be affected by a catastrophic event or localized chronic threat. For instance, large volumes of highly concentrated ammonia released into the Sacramento River from the Sacramento Regional County Sanitation District may affect embryo survival or inhibit prey production. Further, agricultural field in the Yolo Bypass and surrounding areas are regularly sprayed by pesticides, and water samples taken from Cache Slough sometimes exhibited toxicity to *H. azteca* (Werner *et al.* 2008; 2010). The thresholds of toxicity for delta smelt for most of the known contaminants have not been determined, but the exposure to a combination of different compounds increases the likelihood of adverse effects. The extent to which delta smelt larvae are exposed to contaminants varies with flow entering the Delta. Flow pulses during spawning increase exposure to many pesticides (Kuivila and Moon 2004) but decrease ammonia concentrations from wastewater treatment plants.

The POD investigations into potential contaminant effects also include the use of biomarkers that have been used previously to evaluate toxic effects on POD fishes (Bennett and Moyle 1996, Bennett 2005). The results to date have been mixed. A pathogen survey of 105 adult delta smelt, sampled from January through May, at several sites in the Delta, found that disease did not appear to overtly influence the health of the surveyed population for that year (Foott and Bigelow 2010). Histopathological and viral evaluation of young longfin smelt collected in 2006 indicated no histological abnormalities associated with exposure to toxics or disease (Foott *et al.* 2006). There was also no evidence of viral infection or high parasite loads. Similarly, young threadfin shad showed no histological evidence of contaminant effects or of viral infections (Foott *et al.* 2006). Parasites were noted in threadfin shad gills at a high frequency but the infections were not considered severe. Both longfin smelt and threadfin shad were considered healthy in 2006. Adult delta smelt collected from the Delta during the winter of 2005 also were considered healthy, showing little histopathological evidence for starvation or disease (Teh 2007). However, there was some evidence of low frequency endocrine disruption. In 2005, nine of 144 (six percent) of adult delta smelt males sampled were intersex, having immature oocytes in their testes (Teh 2007). Bennett (2005) reported that about 10 percent of the delta smelt analyzed for histopathological anomalies in 1999-2000 showed evidence of deleterious contaminant exposure. In contrast, 30-60 percent of these fish had liver glycogen depletion consistent with food limitation.

In contrast, preliminary histopathological analyses have found evidence of significant disease in other species and for POD species collected from other areas of the estuary. Massive intestinal infections with an unidentified myxosporean were found in yellowfin goby (*Acanthogobius flavimanus*) collected from Suisun Marsh. Severe viral infection was also found in Mississippi silverside and juvenile delta smelt collected from Suisun Bay during summer 2005. Lastly, preliminary evidence suggests that contaminants and disease may impair survival of age-0 striped bass. Baxter *et al.* 2008 found high occurrence and severity of parasitic infections, inflammatory conditions, and muscle degeneration in young striped bass collected in 2005; levels were lower in 2006. Several biomarkers of contaminant exposure including P450 activity (i.e., detoxification enzymes in liver), acetylcholinesterase activity (i.e., enzyme activity in brain), and vitellogenin induction (i.e., presence of egg yolk protein in blood of males) were also reported from striped bass collected in 2006 (Ostrach 2008).

Delta smelt can also be exposed to other toxic substances. Recent toxicological research has provided dose-response curves for several contaminants (Connon *et al.* 2009; 2011). This research has also shown that gene expression changes and impairment of delta smelt swimming performance occur at contaminant concentrations lower than levels that cause mortality.

Climate Change: Climate change is likely already impacting the delta smelt. Climate change may affect the delta smelt directly by creating physiological stress, the primary impacts of climate change on the species are expected to be through changes in the availability and distribution of delta smelt habitat.

The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). The term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years of being a typical period for such measurements (IPCC 2013a). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, whether the change is due to natural variability or human activity (IPCC 2013a). Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions.

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon *et al.* 2007;; IPCC 2013b;; IPCC 2014). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is "very likely" (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Solomon *et al.* 2007; IPCC 2013b). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), whom concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al.* 2007, entire; Ganguly *et al.* 2009; Prinn *et al.* 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increasing global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl *et al.* 2007; Ganguly *et al.* 2009; Prinn *et al.* 2011; IPCC 2013b). See IPCC 2013b (entire), for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation.

Current Drought Conditions and Relative Abundance: California is experiencing its fourth consecutive dry water-year due to low rainfall and low snowpack. On January 17, 2014, the Governor of California declared a State of Emergency due to the drought and directed state officials to take all necessary actions to make water immediately available (Office of the Governor 2014). As of June 2015, the Governor's drought declaration remains in place and the current drought conditions are comparable to the driest years on record in California. The severity of California's drought has been exacerbated by record warm temperatures and below-normal precipitation in 2015, resulting in a severely reduced snowpack. During the last two years, Federal and state governments (Bureau of Reclamation and California Department of Water Resources) have taken actions to ensure the reduced water quality and supply does not reach a level of concern for human health and safety, while complying with biological opinions. The actions taken include the 2015 placement of a salinity rock barrier on West False River and numerous Temporary Urgency Change Orders to modify requirements under Decision 1641 to meet certain water quality objectives, reduction of river flows caused by low reservoir storage, and river temperature requirements.

Drought conditions and some drought management actions have decreased suitable and available aquatic habitat in the Delta for delta smelt breeding and survival, thereby reducing the overall population in the Delta. Fish surveys indicate that the relative abundance of delta smelt is very low. In the last five years, the FMWT, TNS, and 20mm survey results have produced some of the lowest adult and larval delta smelt abundance indexes on record (CDFW 2013, 2014, 2015). The 2014 FMWT abundance index which determines the relative population status for the delta smelt was set at 9, which is the lowest index on record. The low index numbers and relatively few occurrences represent the additive impact of drought to the delta smelt and its habitat.

Status of the Delta Smelt Critical Habitat

The Service designated critical habitat for the delta smelt on December 19, 1994 (Service 1994). The geographic area encompassed by the designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (Service 1994).

Conservation Role of Delta Smelt Critical Habitat

The Service's primary objective in designating critical habitat was to identify the key components of delta smelt habitat that support successful spawning, larval and juvenile transport, rearing, and adult migration. Delta smelt are endemic to the Bay-Delta and the vast majority only live one year. Thus, regardless of annual hydrology, the Delta must provide suitable habitat all year, every year. Different regions of the Delta provide different habitat conditions for different life stages, but those habitat conditions must be present when needed, and have sufficient connectivity to provide migratory pathways and the flow of energy, materials and organisms among the habitat components. The entire Delta and Suisun Bay are designated as critical habitat; over the course of a year, the entire habitat is occupied.

Description of the Primary Constituent Elements

In designating critical habitat for the delta smelt, the Service identified the following primary constituent elements (PCEs) essential to the conservation of the species:

Primary Constituent Element 1: "Physical habitat" is defined as the structural components of habitat. Because delta smelt is a pelagic fish, spawning substrate is the only known important structural component of habitat. It is possible that depth variation is an important structural characteristic of pelagic habitat that helps fish maintain position within the estuary's low-salinity zone (LSZ) (Bennett *et al.* 2002, Hobbs *et al.* 2006).

Primary Constituent Element 2: "Water" is defined as water of suitable quality to support various delta smelt life stages with the abiotic elements that allow for survival and reproduction. Delta smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for delta smelt. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat.

Primary Constituent Element 3: "River flow" is defined as transport flow to facilitate spawning migrations and transport of offspring to LSZ rearing habitats. River flow includes both inflow to and outflow from the Delta, both of which influence the movement of migrating adult, larval, and juvenile delta smelt. Inflow, outflow, and Old and Middle Rivers flow influence the vulnerability of delta smelt larvae, juveniles, and adults to entrainment at Banks and Jones. River flow interacts with the fourth primary constituent element, salinity, by influencing the extent and location of the highly productive LSZ where delta smelt rear.

Primary Constituent Element 4: "Salinity" is defined as the LSZ nursery habitat. The LSZ is where freshwater transitions into brackish water; the LSZ is defined as 0.5-6.0 psu (parts per thousand salinity) (Kimmerer 2004). The 2 psu isohaline is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby *et al.* 1995). By local convention the location of the LSZ is described in terms of the distance from the 2 psu isohaline to the Golden Gate Bridge (X2); X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.* 1995, Kimmerer 2002a). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X2 has varied from San Pablo Bay (45 kilometers) to as far upstream as Rio Vista on the Sacramento River (95 kilometers). At all times of year, the location of X2 influences both the area and quality of habitat available for delta smelt to successfully complete their life cycle. In general, delta smelt habitat quality and surface area are greater when X2 is located in Suisun Bay. Both habitat quality and quantity diminish the more frequently and further the LSZ moves upstream, toward the confluence.

Overview of Delta Smelt Habitat Requirements and the Primary Constituent Elements

Delta smelt live their entire lives in the tidally-influenced fresh- and brackish waters of the San Francisco Estuary (Moyle 2002). Delta smelt are an open-water, or pelagic, species. They do not associate strongly with structure. They may use nearshore habitats for spawning (PCE #1), but free-swimming life stages mainly occupy offshore waters (PCE #2). Thus, the distribution of the population is strongly influenced by river flows through the estuary (PCE #3) because the quantity of fresh water flowing through the estuary changes the amount and location of suitable low-salinity, open-water habitat (PCE #4). This is true for all life stages. During periods of high river flow into the estuary, delta smelt distribution can transiently extend as far west as the Napa River and San Pablo Bay. Delta smelt distribution is highly constricted near the Sacramento-San Joaquin river confluence during periods of low river flow into the estuary (Feyrer *et al.* 2007). In the 1994 designation of critical habitat, the best available science held that the delta smelt population was responding to variation in spring X2.

Alterations to Estuarine Bathymetry (PCE # 1) (~ 1850-present)

The first major change in the LSZ was the conversion of the landscape over which tides oscillate and river flows vary (Nichols *et al.* 1986). The ancestral Delta was a large tidal marsh-floodplain habitat totaling approximately 300,000 acres. Most of the wetlands were diked and reclaimed for agriculture or other human use by the 1920s. The physical habitat modifications of the Delta and Suisun Bay were mostly due to land reclamation and urbanization. Water conveyance projects and river channelization have had some influence on the regional physical habitat by armoring levees with riprap, building conveyance channels like the Delta Cross Channel, storage reservoirs like Clifton Court Forebay, and by building and operating temporary barriers in the south Delta and permanent gates and water distribution systems in Suisun Marsh.

In the 1930s to 1960s, the shipping channels were dredged deeper (~12 m) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the Sacramento-San Joaquin river confluence region as the largest and most bathymetrically variable places in the LSZ. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995). However, the deeper landscape created to support shipping and flood control requires more freshwater outflow to maintain the LSZ in the large Suisun Bay/river confluence region than was once required (Gartrell 2010).

Seasonal salinity intrusion reduces the temporal overlap of the LSZ (indexed by X2) with the Suisun Bay region, especially in the fall (Feyrer *et al.* 2007, 2010). Thus, the second major change has been in the frequency with which the LSZ is maintained in Suisun Bay for any given amount of precipitation. This metric showed a step-decline in 1977 from which it has never recovered for more than a few years at a time. Based on model forecasts of climate change and water demand, this trend is expected to continue (Feyrer *et al.* 2011). As such this alteration of PCE # 1 also affects the other PCEs, particularly PCE # 4. The major landscape factor affecting this interaction was the dredging of shipping channels.

Spawning delta smelt require all four PCEs, but spawners and embryos are the life stage that is believed to most require a specific structural component of habitat. Spawning delta smelt require sandy or small gravel substrates for egg deposition (Bennett 2005). The major invasive species effect on physical habitat is the dense growth of submerged aquatic vegetation in the Delta. These plants carpet large areas in parts of the Delta such as Frank's Tract. The vegetation beds act as mechanical filters removing turbidity and possibly other water quality components as the tides and river flows move water over them (Hestir 2010). Thus, the proliferation of submerged aquatic plants has likely also reduced the area of nearshore habitat suitable for delta smelt spawning.

Alterations to Water (PCE # 2)

PCE # 2 is primarily referring to a few key water quality components (other than salinity) that influence spawning and rearing habitat suitability for delta smelt. Research to date indicates that water quality conditions are more important than physical habitat conditions for predicting where delta smelt occur (Feyrer *et al.* 2007; Nobriga *et al.* 2008) probably because delta smelt is a pelagic fish except during its egg/embryo stage. However, the interaction of water quality and bathymetry is thought to generally affect estuarine habitat suitability (Peterson 2003) and there is evidence that delta smelt habitat is optimized when appropriate water quality conditions overlap the Suisun Bay region (Moyle *et al.* 1992; Hobbs *et al.* 2006; Feyrer *et al.* 2011). This is discussed further in the section about PCE # 4 (salinity).

Changing predation pressure (1879 to present): Noting is known about the historical predators of delta smelt or their possible influence on delta smelt. Fish eggs and larvae can be opportunistically preyed upon by many invertebrate and vertebrate animals so there has always been a very long list of potential predators of delta smelt's eggs and larvae. Potential native predators of juvenile and adult delta smelt would also have included numerous bird and fish species and this may be reflected in delta smelt's annual life-history. Annual fish species, also known as "opportunistic strategists", are adapted to high mortality rates in the adult stage (Winemiller and Rose 1992). This high mortality is usually due to predation or highly unpredictable environmental conditions, both of which could have characterized the ancestral niche of delta smelt.

The introduction of striped bass into the San Francisco Estuary in 1879 added a permanently resident, large piscivorous fish to the low-salinity zone: a habitat that is not known to have had an equivalent predator prior to the establishment of striped bass (Moyle 2002). This likely changed predation rates on delta smelt, but there are no data available to confirm this hypothesis. For many decades the estuary supported higher striped bass and delta smelt numbers than it does currently. This is evidence that delta smelt is able to successfully coexist with striped bass.

The current influence of striped bass and other predators on delta smelt population dynamics is also not known mainly because quantitative descriptions of predator impacts on rare prey are extremely difficult to generate. Delta smelt were observed in the stomach contents of striped bass and other fishes in the 1960s (Stevens 1963; Turner and Kelley 1966), but have not been observed in more recent studies (Feyrer *et al.* 2003; Nobriga and Feyrer 2007). Predation is a common source of density-dependent mortality in fish populations (Rose *et al.* 2001). Thus, it is possible that predation was a mechanism that historically generated the density-dependence observed in delta smelt population dynamics (Bennett 2005; Maunder and Deriso 2011). Because it is generally true for fishes, the vulnerability of delta smelt to predators is influenced primarily by habitat conditions. Turbidity may be a key mediatory of delta smelt's vulnerability to predators (Nobriga *et al.* 2005; 2008). Growth rates, an interactive outcome of feeding success and water temperature, are also well known to affect fishes' cumulative vulnerability to predation (Sogard 1997). Thus, predation rate is best characterized as an aspect food web function linked to PCE # 2.

Food web alterations attributable to the overbite clam (1987-present): The next major change to PCE #2 occurred following the invasion of the estuary by overbite clam (*Corbula amurensis*). The overbite clam was first detected in 1986 and from 1987-1990 its influence on the ecosystem became evident. Since 1987, there has been a step-decline in phytoplankton biomass (Alpine and Cloern 1992; Jassby *et al.* 2002). Phytoplankton in the LSZ is an important component of the pelagic food web that delta smelt are a part of because a key part of the diet of delta smelt's prey is phytoplankton. Not only does the overbite clam reduce food for delta smelt's prey, it can also graze directly on the larval stages of the copepods eaten by delta smelt (e.g., Kimmerer *et al.* 1994). The grazing pressure applied by the overbite clam rippled through the historical zooplankton community that fueled fishery production in the LSZ (Kimmerer and Orsi 1996; Orsi and Mecum 1996; Kimmerer 2002b; Feyrer *et al.* 2003). This major change in the way energy moved through the ecosystem has likely facilitated the numerous invasions of the estuary by suppressing the production of historically dominant zooplankton, which increases the opportunity for invasion by other species that are less dependent on high densities of LSZ phytoplankton.

The distribution and abundance of several LSZ fishes have changed since 1987 (Kimmerer 2002b; Kimmereer 2006; Rosenfield and Baxter 2007; Mac Nally *et al.* 2010). Surprisingly, the changes in phytoplankton and zooplankton production have not been as evident for delta smelt as for other organisms (Kimmer 2002b; Kimmerer 2006; Sommer *et al.* 2007; Mac Nally *et al.* 2010). Nonetheless, delta smelt collected in the FMWT have been persistently smaller since the overbite clam invasion (Sweetnam 1999; Bennett 2005). This is evidence for reduced growth rates that could have been caused by food web changes stemming from overbite clam grazing. The Service considers the prey density aspect of the estuarine food web to be a component of PCE #3 ("Water"). The Central Valley Project and State Water Project entrain some food web production (about 4.5 percent on a daily average basis was attributed to all water diversions in the Delta; Jassby *et al.* 2002). However, prey densities have been most strongly affected by clam grazing (Kimmerer *et al.* 1994; Jassby *et al.* 2002). Urban wastewater input, *Microcystis* blooms, and pesticide loads may also impair the production of zooplankton eaten by delta smelt or eaten by delta smelt's prey (Wilkerson *et al.* 2006; Dugdale *et al.* 2007; Jassby 2008; Ger *et al.* 2009; Werner *et al.* 2010).

Proliferation of submerged aquatic vegetation (1980s to present): For many decades, the Delta's waterways were turbid and the growth of submerged plants was apparently unremarkable. That began to change in the mid-1980s, when the Delta was invaded by non-native plant *Egeria densa*, a fast-growing aquarium plant that has taken hold in many shallow habitats (Brown and Michnuik 2007; Hestir 2010). *Egeria densa* and other non-native species of submerged aquatic vegetation (SAV) grow most rapidly in the summer and late fall when water temperatures are warm (>20°C) and outflow is relatively low (Hestir 2010). The large canopies formed by these plants have physical and biological consequences for the ecosystem (Kimmerer *et al.* 2008). First, dense SAV promotes water transparency. Increased water transparency leads to a loss of habitat for delta smelt (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Second, dense SAV canopies provide habitat for a suite of non-native fishes, including largemouth bass, which now dominate many shallow habitats of the Delta and displace native fishes (Nobriga *et al.* 2005; Brown and Michniuk 2007). Finally, SAV colonization over the last three decades has led to a shift in the dominant freshwater food web pathways and that fuel fish production (Grimaldo *et al.* 2009b). It is noteworthy that SAV-dominated habitats are comparatively productive (Nobriga *et al.* 2005; Grimaldo *et al.* 2009b), but most of the productivity they generate remains in the nearshore environment and therefore does not contribute much to pelagic fish production (Grimaldo *et al.* 2009b).

Reduced turbidity (1999-present): The next major change was a change in estuarine turbidity that culminated in an estuary-wide step-decline in 1999 (Schoellhamer 2011). For decades, the turbidity of the modified estuary had been sustained by very large sediment deposits resulting mainly from gold mining in the latter 19th century. The sediments continued to accumulate into the mid-20th century, keeping the water relatively turbid even as sediment loads from the Sacramento River basin declined due to dam and levee construction (Wright and Schoellhamer 2004). The flushing of the sediment deposits may also have made the estuary deeper overall and thus a less suitable nursery from the 'static' bathymetric perspective (Schroeter 2008). Delta smelt larvae require turbidity to initiate feeding (Baskerville-Bridges *et al.* 2004), and as explained above, older fish are thought to use turbidity as cover from predators. Thus, turbidity is an aspect of PCE # 2 which is a necessary water quality aspect of delta smelt's critical habitat.

Dams and armored levees have contributed to the long-term decline in sediment load to the estuary (Wright and Schoellhamer 2004) and to the clearing of estuary water. This is a long-term effect that stemmed from building and maintaining infrastructure. Opportunities to substantively address this change are limited due to the extreme Central Valley flood and water supply risks that will result from decommissioning dams or removing levees.

Changing water temperature (present through long-term climate forecasts): Delta smelt is already subjected to thermally stressful temperatures every summer in the Delta. Water temperatures are presently above 20°C for most of the summer in core habitat areas, sometimes even exceeding the nominal lethal limit of 25°C for short periods. Coldwater fishes begin to have behavioral impairments (Marine and Cech 2004) and lose competitive abilities (Taniguchi *et al.* 1998) prior to reaching their thermal tolerance limits. Thus, the estuary can already be considered thermally stressful to delta smelt and can only become more so if temperatures warm in the coming decades.

All available regional climate change projections predict central California will be warmer still in the coming decades (Dettinger 2005). It is expected that warmer estuary temperatures will be yet another significant conservation challenge (Brown *et al.* 2013; Cloern *et al.* 2011). This is true because they will limit abiotic habitat suitability further than indicated by flow-based projection (e.g., Feyrer *et al.* 2011). In addition, warmer water temperatures mean that higher prey densities will be required just to maintain present-day growth rates, which are already lower than they once were (Sweetnam 1999; Bennett 2005). Water temperature is mainly affected by climate variation, both as air temperature and as flood and drought scale flow variation (Kimmer 2004; Wagner *et al.* 2011).

Sensitivities to contaminants (ongoing): Delta smelt's spawning migration coincides with early winter rains (Sommer *et al.* 2011). This 'first-flush' of inflow to the Delta brings sediment-bound pesticides with it (Bergamaschi *et al.* 2001), and peak densities of larvae and juveniles can co-occur with numerous pesticides (Kuivila and Moon 2004). Bennett (2005) reported that about 10 percent of the delta smelt analyzed for histopathological anomalies in 1999-2000 showed evidence of deleterious contaminant exposure, but this was low compared to the 30-60 percent of these fish that appeared to be food-limited.

Delta smelt can also be exposed to other toxic substances. Recent toxicological research has provided dose-response curves for several contaminants (Connon *et al.* 2009; 2011). This research has also shown the gene expression changes and impairment of delta smelt swimming performance occur at contaminant concentrations lower than levels that cause mortality. Climate scale flow variation (e.g., flood versus drought scale variation) affects the amount of methyl mercury (Darryl Slotton presentation) entering the ecosystem and may have some influence on the meaningful dilution of ammonium from urban wastewater inputs (Dick Dugdale presentation).

Invasive species may also affect PCE #2 by changing contaminant dynamics. For instance, *Microcystis* blooms generate toxic compounds that can kill delta smelt prey (Ger *et al.* 2009) and accumulate in the estuarine food web (Lehman *et al.* 2010). A second example is the biomagnification of selenium in the food web by *Corbula* (Stewart *et al.* 2004). This has been considered a potential issue for the clam's predators – namely sturgeon, splittail, and diving ducks (Richman and Lovvorn 2004; Stewart *et al.* 2004). However, it is not known whether this change in selenium dynamics negatively affects delta smelt and other fishes that do not directly prey on the clams.

Alterations of River Flows (PCE # 3)

This PCE refers to the transport flows that help guide young delta smelt from spawning habitats to rearing habitats, and to flows that guide adult delta smelt from rearing habitats to spawning habitats. Delta outflow also has some influence on delta smelt's supporting food web (Jassby *et al.* 2002; Kimmerer 2002a) and it affects abiotic habitat suitability as well (Feyrer *et al.* 2007; 2011). The latter is expanded upon in the discussion of PCE # 4. The environmental driver with the strongest influence on PCE # 3 is highly dependent on the time-scale being considered. The tide has the largest influence on flow velocities and directions in delta smelt's critical habitat at very short timescales (minutes to days), whereas interannual variation in precipitation and runoff has the largest influence on flows into and through the Delta at very long timescales (years to decades), and sometimes at shorter time scales (days to weeks) during major storm events. Changes to flow regimes can have the largest influence on PCE #3 at timescales of weeks to seasons. This is particularly true during periods of low natural inflow, for instance during the fall and during droughts, and in the south Delta where Old and Middle River flows are often managed using changes in export flow rates.

Entrainment into water export diversions (1951 to present): The amount of water diverted from the estuary has generally increased over time, and most of the increase during the 1950s and 1960s was due to CVP exports and since the latter 1960s, SWP exports. There are two basic potential fishery impacts that result from water diversion from the Delta: ecosystemic impacts and direct entrainment. From the ecosystemic perspective, water diversions are unnatural 'predators' because they 'consume' organisms at every trophic level in the ecosystem from phytoplankton (Jassby *et al.* 2002) to fish (Kimmerer 2008). Unlike natural predators which typically shift their prey use over time in association with changes in prey fish density (Nobriga and Feyrer 2008), fractional entrainment losses of fishes to diversions are functions of water and demand (e.g., Grimaldo *et al.* 2009). Thus, water diversions not only elevate 'predation' mortality in an aquatic system, but they can do so in an atypical, density-independent manner. Diversions and fish collection facilities in the south Delta are very large structures which attract large aggregations of actual predatory fish and prey on smaller species like delta smelt before they reach the fish salvage facilities and within these facilities (Gingras 1997).

Estimated entrainment losses of delta smelt to SWP and CVP diversions can be substantial in some years (Kimmerer 2008). Given the delta smelt's current density-independent population dynamics, even a statistically indiscernible entrainment effect on the population is likely to cause the species to continue to decline (Kimmerer 2011). The entrainment losses of delta smelt are not generally observed until they reach the early juvenile stage (~20-30 mm in length), but combinations of 20-mm Survey distribution data and hydrodynamic modeling provide evidence that their risk of entrainment into the CVP and SWP diversions can be described by any of several indices that integrate Delta inflow and export flow (Kimmerer and Nobriga 2008; Kimmerer 2008; Service 2008; Grimaldo *et al.* 2009).

Delta smelt entrainment losses estimated from survey data and hydrodynamics can also be substantial in some years (Kimmerer 2008), though it is possible that Kimmerer may have overestimated them (Miller 2011). Nonetheless, increasing higher outflow (or lower X2) moves the bulk of the larval population increasingly west, which results in fewer larvae distributed in the south Delta where they are at highest risk of entrainment. At the same time, indices like the export to inflow ratio or Old and Middle river flow are useful metrics for gauging the effect of exports on the south Delta.

The risk of delta smelt entrainment into smaller agricultural irrigation diversions used mainly to irrigate crops within the Delta is also related to flow conditions. These in-Delta irrigation diversions generally have mean flow rates less than 1 cubic meter per second (Nobriga *et al.* 2004). The lower the Delta outflow, the higher the proportion of the young delta smelt population that overlaps the array of irrigation diversions in the Delta (Kimmerer and Nobriga 2008). However, the irrigation diversions are not currently considered to represent a substantial source of mortality because they individually draw small quantities of water relative to channel volumes (Nobriga *et al.* 2004).

In Suisun Marsh, water diversions are largely made to support waterfowl production. Some Suisun Marsh diversions are larger for the size of channels they are in than most of the agricultural irrigation diversions in the Delta. Based on hydrodynamic simulations, proximity to water diversions in the marsh is expected to correlate strongly with entrainment (Culberson *et al.* 2004), and substantial delta smelt losses have been reported when these diversions are not screened (Pickard *et al.* 1982). Entrainment risk for delta smelt in western Suisun Marsh is considered low because the habitat surrounding the diversions is often too saline (Enos *et al.* 2007).
Salinity PCE # 4

The core delta smelt habitat, is the LSZ (Moyle *et al.* 1992; Bennett 2005). The LSZ is where freshwater transitions into brackish water; the LSZ is defined as the area of the estuary where salinity ranges from 0.5-6.0 psu (Kimmerer 2004). This area is always moving due to tidal and river flow variation. The 2 psu isohaline is a specific location within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby *et al.* 1995). By local convention, changes in the location of the LSZ are described in terms of the distance from the Golden Gate Bridge to the 2 psu isohaline (X2); X2 is an indicator of habitat suitability for many of the estuary's organisms and it is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.* 1995; Kimmerer 2002b; Kimmerer *et al.* 2009). The LSZ expands and moves downstream when river flows into the estuary are high (Kimmerer *et al.* 2009). Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X2 has varied from as far downstream of San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km).

Larval delta smelt tend to reside somewhat landward (upstream) of X2 (Dege and Brown 2004), but the center of juvenile distribution tends to be very near X2 until the fish start making spawning migrations in the winter (Feyrer *et al.* 2011; Sommer *et al.* 2011). Because of this association between the distribution of salinity in the estuary and the distribution of the delta smelt population, the tidal and river flows that comprise PCE # 3 affect PCE # 4.

The expansion and contraction of the LSZ affects the areal extent of abiotic habitat for delta smelt, both during spring (Kimmerer *et al.* 2009) and fall (Feyrer *et al.* 2007; 2011). In the spring, most delta smelt are larvae or young juveniles and the LSZ is typically maintained over the expansive Suisun Bay region. Thus, abiotic habitat "limitation" is unlikely and no consistent influence of spring X2 variation on later stage abundance estimates has been reported to date (Jassby *et al.* 1995; Bennett 2005; Kimmerer *et al.* 2009). In fact, historical maxima in juvenile abundance according to CDFW's TNS occurred in low outflow years when abiotic habitat area was comparatively low (Kimmerer 2002a; Kimmerer *et al.* 2009).

In contrast, during fall delta smelt are late stage juveniles and for the past decade or more, the LSZ has been persistently constricted by low Delta outflow. Fall habitat conditions affect delta smelt distribution and the concurrent FMWT abundance index (Feyrer *et al.* 2007; 2011). However, the quantitative life cycle models developed to date have not found evidence for a year over year effect of fall LSZ location on delta smelt population dynamics (Mac Nally *et al.* 2010; Thompson *et al.* 2010; Maunder and Deriso 2011).

It is now recognized that some delta smelt occur year-round in the Cache Slough region including the Sacramento Deep Water Shipping Channel and Liberty Island (Kimmerer 2011; Miller 2011; Sommer *et al.* 2011). The latter has been a consistently available habitat only since 1997. This region is often lower in salinity than 0.6 psu, the lower formal limit of the LSZ as defined by Kimmerer (2004). Delta smelt likely use it because it is one of the most turbid habitats remaining in the Delta (Nobriga *et al.* 2005). A recent population genetic study found no evidence that delta smelt inhabiting this region are unique compared to delta smelt using the LSZ-proper (Fisch *et al.*

2011), therefore it is likely that individual delta smelt migrate between the LSZ and the Cache Slough region. This is consistent with the high summer water temperatures observed there, which might compel individual delta smelt to seek out cooler habitats within and outside the Cache Slough region.

Delta Smelt Environmental Baseline

The portions of the Action Area that fall within the range of delta smelt include the Sacramento River east levee, south of Sacramento and the Sacramento Weir. Delta smelt typically migrate up into this area as early as December and move out in the spring and summer. The proposed project contains habitat components that can be used for feeding, spawning, rearing, and movement. Some amount of erosion protection has already occurred within the action area. Additionally, the Corps has a project which will place rock along 31,000 linear feet of the right bank of the Sacramento River immediately across the river and extending upstream from the proposed project footprint. Compensation for the placement of this rock will be through the development of a setback levee that will provide 118 acres of newly created shallow water habitat.

Giant Garter Snake Status of the Species

For the most recent assessment of the species' range-wide status please refer to the *Giant Garter Snake (Thamnophis gigas) 5-year Review: Summary and Evaluation* (Service 2012) for the current status of the species. Ongoing threats to giant garter snake include habitat loss from water transfers, rice fallowing due to drought conditions, habitat disturbance and loss from irrigation and drainage ditch maintenance, climate change, and invasive species. While these threats continue to effect the giant garter snake throughout its range, to date no project has proposed a level of effect for which the Service has issued a biological opinion of jeopardy for the giant garter snake.

Giant Garter Snake Environmental Baseline

The *Draft Recovery Plan for the Giant Garter Snake* (Service 1999b) subdivides the range of the species into four recovery units. Each recovery unit includes populations. The action area for the proposed project is located within the Yolo Basin-Willow Slough unit and the American Basin unit. According to the 2012, 5-year review (Service 2012) the abundance and distribution of giant garter snakes has not changed significantly. Within the Action Area habitat loss and fragmentation is the most significant threat to the giant garter snake. Urbanizing areas within the Action Area include Sacramento and West Sacramento. Habitat loss through water transfers and rice fallowing also negatively affects giant garter snakes. In the Sacramento Valley, rice has served as a substitute for the large amounts of historical wetlands that used to exist in the Central Valley. Loss of this habitat has been shown to reduce or exclude giant garter snakes compared to areas which are actively irrigated in rice (Wylie *et al.* 2002a, b, 2004).

Flood control maintenance and agricultural activities can reduce and prevent the establishment of vegetation and burrows needed by the giant garter snake for cover and shelter on canals, levees, and agricultural ditches. This can also reduce the prey base for giant garter snake, affecting their feeding. Additionally, clearing, scraping and/or re-contouring canals, ditches, and levees, destroys burrows and crevices that are used as over-wintering habitat and during the summer for thermoregulation, shedding, and giving birth. These activities are being conducted by local maintaining agencies throughout the Action Area.

Other factors which effect the giant garter snake population in the Action Area include vehicular mortality particularly where canals or aquatic habitat are bordered by roads such as the crown of the levees. Non-native predators such as game fish, bull frogs (*Rana catesbiana*), and domestic cats can affect giant garter snake populations (Service 1999b). This can be particularly detrimental to young and juvenile giant garter snakes. All of the Action Area has non-native predators occurring in it.

Snakes have been located within the Yolo Bypass within 2 miles of the Sacramento Bypass. Numerous irrigation and drainage canals exist which provide connectivity from the Sacramento Bypass and areas that are known to support snakes in the Yolo Bypass. A snake observed 0.5 mile to the west of the NEMDC along Elkhorn Boulevard in 1996 (CNDDB 2015). Borrow site 2's northern boundary is Elkhorn Boulevard on the east side of the NEMDC. Giant garter snakes could be using the NEMDC for aquatic habitat and the surrounding grasslands for uplands.

Western Yellow-Billed Cuckoo Status of the Species

For the most recent assessment of the species range-wide status please refer to the October 3, 2014, *Determination of Threatened Status for the Western Distinct Population Segment of the Yellow-billed Cuckoo (Coccyzus americanus occidentalis)* (79 FR 59991). Ongoing threats to the yellow-billed cuckoo include habitat loss from flood control projects and maintenance, alterations to hydrology, climate change, and invasive species. While these threats continue to affect the yellow-billed cuckoo throughout its range, no project, to date, has proposed a level of effect for which the Service has issued a biological opinion of jeopardy for the yellow-billed cuckoo.

Western Yellow-Billed Cuckoo Baseline

Yellow-billed cuckoo detections have occurred most frequently in the upper Sacramento River where levees are setback from the river or do not exist. Additionally, the last 20 years has seen a large amount of riparian restoration occur in the upper Sacramento River. Habitat in the action area tends to be more narrow and linear than in the upper Sacramento River. Levees were constructed close to the bank of the Sacramento River leaving narrow bands of small patch sizes. Construction of the setback levee along the right bank of the Sacramento River as part of the West Sacramento Flood Control Project will provide some wider patches of riparian habitat that will benefit the yellow-billed cuckoo. The American River has a wider floodplain due to levees being setback from the channel. There are some patches large enough to support nesting yellow-billed cuckoos, though cuckoos have not been observed nesting along the American River.

Effects of the Proposed Action

Valley Elderberry Longhorn Beetle

Vegetation removal, including elderberries could cause mortality of any beetle larvae within the elderberry shrub. Transplanting the shrubs between November 1 and February 15, when the shrubs are dormant, will minimize the likelihood of killing larvae within the shrub. Transplanting the shrub could still result in mortality to larvae within the shrub, particularly if the shrub does not survive transplantation. Proper care of the transplants through watering in the initial years can minimize this loss and increase the likelihood that the shrub will survive and provide continued habitat for the valley elderberry longhorn beetle.

Construction that occurs near elderberry shrubs that will be protected in place can kill adult beetles if construction equipment is operating between the months of March and June when valley elderberry longhorn beetles have emerged from the elderberry shrubs and are locating mates for reproduction. Fencing the area which contains riparian habitat, specifically elderberry shrubs, and keeping a minimum of a 20 foot buffer from the dripline of the elderberry shrub will keep construction equipment from driving too close to the shrubs and minimize the number of beetles that might be struck or run over by equipment.

Transplanting elderberry shrubs out of the construction footprint has the potential to affect valley elderberry longhorn beetle dispersal if there is potential to remove large areas of elderberry shrubs. The Corps has provided maps of where existing valley elderberry longhorn beetle habitat exists and where shrubs will be removed due to the project. Along the Sacramento River, 13 elderberry shrubs distributed within 70 acres of riparian habitat will be transplanted as part of the project, however during surveys the Corps has documented an additional 60 elderberry shrubs that will be protected in place along the Sacramento River. The Corps has also proposed to include elderberry shrub plantings along the bank repair footprint where the elevation is suitable so the shrubs are not inundated too frequently. Along the American River, 250 elderberry shrubs distributed within 65 acres of riparian habitat will be transplanted as part of the project. The American River has many conservation sites and the Corps has proposed to offset the removal of elderberry shrubs through development of additional sites and enlargement of existing sites in the lower American River Parkway. The Corps is proposing to create an additional 69.91 acres of habitat for the valley elderberry longhorn beetle in the lower American River Parkway.

Trimming of elderberry shrubs can result in the loss of some habitat for the valley elderberry longhorn beetle. Unlike transplantation however, the shrub remains within the riparian corridor and can provide habitat for the beetle during dispersal. There is potential for one of the pruned stems to contain the larvae of the valley elderberry longhorn beetle. While elderberry shrubs do resprout readily, there is a temporal loss of habitat for the beetle and as part of the maintenance any resprouted stems will be removed in order to provide maintenance equipment access. To offset these effects the local maintaining agencies have proposed to create a 40-acre conservation area for the valley elderberry longhorn beetle. This area will be selected as described in the preceding paragraph. This will ensure habitat connectivity and help with long-term maintenance and monitoring of these lands.

Delta Smelt

Construction along the Sacramento River will place bank protection along a 50,300 linear foot section of the left bank of the Sacramento River. Delta smelt are a pelagic species that is typically found in the center of the channel. However, as described in the status of the species they do spawn on sandy beaches in shallow water habitat (0 to 3 meters) and in this portion of the Sacramento River are found close to the banks. The rock footprint will change the substrate along the 50,300 linear feet of 33 acres of shallow water habitat. Additionally 13 acres are being converted from riverine bank edge to a rock wedge. Construction related effects to individual delta smelt will be avoided because construction is occurring between August 1 and November 30, a time when delta smelt are located further downstream in the Delta and Suisun Bay. Effects due to increasing sediment downstream of the work area will be minimized through the conservation measures involving monitoring water quality during construction to ensure that effects do not extend into the portion of the Delta that delta smelt occupies during the late summer/fall period. Construction to widen the Sacramento Weir will occur on the landside of the existing Sacramento River right bank levee. Upon completion of the weir extension the levee removed between August 1 and November 30 avoiding effects to delta smelt habitat.

The primary negative effect of the project on potential spawning habitat is the change of substrate from sand to riprap. Rock used for bank protection is large enough to retard erosional forces of the river and therefore has interstitial spaces. Should delta smelt spawn over this riprap substrate, it is very likely that any eggs will fall into these interstitial spaces resulting in the loss of eggs and potentially causing fertilization to not occur if the eggs fall into the interstitial spaces. The Corps has proposed to offset this loss of spawning potential in these areas through the purchase of 33 acres of credits at a Service-approved delta smelt conservation bank. The placement of rock will permanently narrow the channel by 13 acres through the change of riverine edge to rock wedge. Rock slope protection limits the lateral mobility of a river channel, increases flow velocities (Sedell *et al.* 1990), limit sediment transport, and eliminates bankside refugia areas (Gregory *et al.* 1991). Rock placement can also affect primary productivity through the loss of vegetation. The Corps will protect large trees in place and plant riparian benches at the conclusion of the rock placement to replace the loss of vegetation. Planting benches and vegetation planting will also help to offset the increased velocities that the bank protection sites will experience due to the smoother rock surface. To offset the complete loss of riverine edge habitat the Corps has proposed to purchase 39 acres of credits at a Service-approved delta smelt conservation bank for a total of 72 acres of credits.

The Corps has proposed to evaluate effects to listed species including delta smelt when long-term maintenance activities for the Sacramento River can be described. If maintenance activities will affect delta smelt the Corps will reinitiate consultation with the Service. Therefore, this biological opinion does not address effects to the delta smelt from any long-term levee maintenance activities.

Delta Smelt Critical Habitat

This opinion on the critical habitat for the delta smelt does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR § 402.02. Instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in *Gifford Pinchot Task Force v. U. S. Fish and Wildlife Service* (No. 03-35279) to complete the following analysis with respect to the proposed critical habitat.

Implementation of the proposed project will affect PCE #1 Physical Habitat as described under the environmental baseline section above. The placement of rock will change the substrate of shallow water habitat for 46 acres. Any loss of shallow water habitat will be compensated through the purchase of credits at a delta smelt conservation bank. It is expected that planting the sites post-construction will replace any loss of primary productivity within the Sacramento River water column.

Giant Garter Snake

Borrow Site 2 – Upland habitat will be disturbed at borrow site 2 (5.5 acres) when heavy equipment is brought in to remove soil for the Arcade Creek levee repair. Removal of soil from the site will result in the crushing of burrows that snakes use for aestivating and thermoregulation. Fencing the borrow site prior to borrow excavation will minimize the likelihood that snakes will be in the borrow site when construction equipment begins to mobilize. Fencing the site will temporarily (one active season) exclude the use of the area for giant garter snake. This could result in snakes having to move further distances to find upland refugia in the summer months and expose them to predation or other sources of mortality such as being run over by a vehicle on the levee road on the opposite side of the NEMDC. Because the aquatic habitat will not be disturbed by the project, there will not be any effects on the snake's ability to forage.

Upon completion of the project, the site will restored and re-graded to create three habitat types. The creation of additional tule marsh along the edge of the canal will benefit giant garter snakes that may be using the NEMDC as it will provide cover, an area for prey production, and refugia from predators. Additionally, the seasonal wetland bench will only provide aquatic habitat in the winter months when the snake is typically in burrows. The wetland bench will provide some upland habitat for the giant garter snake during the summer when the snake is active in the form of basking habitat and if dried wetland vegetation remains some refugia from predators; however, because the site will be flooded in the winter it will not serve as overwintering habitat for the snake. The remaining 3.5 acres of the borrow site will be restored to native grassland and will function as summer upland refugia and basking and in the winter serve as overwintering habitat for the snake.

Sacramento Bypass – Enlarging the Sacramento Bypass and Weir will result in both permanent and temporary effects to giant garter snake habitat. Construction of the widened bypass will have similar effects to giant garter snake as the work along borrow site 2. Snakes could be crushed by heavy equipment, entombed in refugia when burrows collapse, and exposed to increased predation because they may have to travel further to find habitat that is unavailable to them due to the project. The 25 acres of aquatic habitat and 50 acres of upland habitat that will be temporarily affected because of the relocation of a levee toe drain will be replaced within one year of construction. The Corps has committed to creating a toe drain that closely mimics the existing aquatic and upland habitat along the northern levee of the Sacramento Bypass. The effects of crushing snakes and exposing them to increased predation will be minimized through the use of the conservation measures described in the project description above.

Permanently, 15 acres of aquatic and 30 acres of upland habitat will be lost through the removal of drainage ditches and farm canals in the area that is currently outside of the bypass footprint. The Corps has committed to offsetting the loss of this habitat through the purchase of 135 acres of giant garter snake credits at a Service-approved conservation bank. Conservation banks provide protection, conservation easement, and funding, endowment, in perpetuity for the giant garter snake. These long-term protections and location of the conservation banks all contribute to the long-term recovery of the giant garter snake.

Operation of the expanded Sacramento Weir and Bypass will result in an increase of water surface elevation of approximately 0.5-foot on the levee slopes on either side of the Yolo Bypass. However, when this increase occurs, during a 200-year flood event, the Yolo Bypass levees already contain water up to 21 feet deep. As a result, giant garter snake burrows would likely already be saturated before the additional water associated with the widened Sacramento Bypass is a factor. The additional 0.5-foot resulting from this action would not significantly change the timing or duration of this flooding and would not result in further impacts to giant garter snake habitat.

The Corps has proposed to evaluate effects to listed species including giant garter snake when long-term maintenance activities for the Sacramento Bypass can be described. If maintenance activities will affect giant garter snakes the Corps will reinitiate consultation with the Service. Therefore, this biological opinion does not address effects to the giant garter snake from any long-term levee maintenance activities.

Yellow-Billed Cuckoo

Sacramento River – The Corps is planning on removing 70 acres of riparian habitat along the Sacramento River. The riparian corridor in this section of the Sacramento River is narrow (about 100 feet wide) because the levees were constructed so close to the edge of the channel bank. This is too narrow for the yellow-billed cuckoo to nest, however it is possible for the yellow-billed cuckoo to use this as a stopover when migrating to the Central Valley to breed. Vegetation removal will reduce the width of the riparian corridor from 100 feet to 40 feet on average. The Corps proposal to plant the bank protection sites will create a 25-foot wide planting berm leaving a loss of about 35 feet of riparian corridor. The Corps proposes to offset the loss of the 70 acres of riparian through the creation of 140 acres of riparian habitat along the lower American River.

American River – The construction of launchable rock trench will remove 65 acres of riparian habitat along the lower American River. The lower American River does have habitat patches large enough to support nesting yellow-billed cuckoos. Large patches of habitat will not be removed; rather a strip will be removed adjacent to the levee which could reduce the size of some of the potential nesting areas. To compensate for this the Corps is proposing to plant 130 acres along the lower American River. As described in the conservation measures, the Corps will develop a Riparian Conservation Plan that will determine the best locations to develop additional riparian habitat. The conservation areas will provide both habitat for yellow-billed cuckoo and valley elderberry longhorn. The areas will also ensure that there is a net increase of potential yellow-billed cuckoo nesting habitat along the lower American River Parkway. There will be a temporal loss of habitat because riparian habitat can take up to 20 years to develop.

In addition to the habitat loss for both the Sacramento and American Rivers, construction itself has the potential to adversely affect yellow-billed cuckoos. Construction that occurs when the cuckoo is in the Sacramento Valley has the potential to harass the bird due to noise. To minimize effects to the cuckoo due to construction noise the Corps conservation measure to do protocol level surveys prior to beginning construction will enable the Corps to determine if yellow-billed cuckoos are nesting near the construction footprint. The Corps has committed to avoid construction near an active yellow-billed cuckoo nest. However, cuckoos that could be foraging in the area could be harassed due to construction activities and noise and move to other locations in the lower American River parkway which could expose individual cuckoos to increased predation.

The Corps has proposed to evaluate effects to listed species including yellow-billed cuckoo when long-term maintenance activities for the Sacramento River and American River can be described. If maintenance activities will affect yellow-billed cuckoos the Corps will reinitiate consultation with the Service. Therefore, this biological opinion does not address effects to the yellow-billed cuckoo from any long-term levee maintenance activities.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area 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 Act.

Valley Elderberry Longhorn Beetle

Non-Federal adverse effects to the valley elderberry longhorn beetle include effects from nearby pesticide spraying drifting into valley elderberry longhorn beetle habitat and levee and channel maintenance. In the areas of the urbanized areas of the American and Sacramento Rivers human started fires is by far the largest effect to valley elderberry longhorn beetles. Over the last several years numerous fires have burned portions of the American River Parkway.

Delta Smelt

Adverse effects to delta smelt may result from point and non-point source chemical contaminant discharges within the action area. These contaminants include but are not limited to ammonia and free ammonium ion, numerous pesticides and herbicides from agricultural activities, and oil and gasoline product discharges. Oil and gasoline product discharges may be introduced into the Sacramento River from shipping and boating activities and from urban activities and runoff. Other future, non-Federal actions within the action area that are likely to occur and may adversely affect delta smelt include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; agricultural activities, including burning or removal of vegetation on levees that reduce riparian and wetland habitats that contribute to the quality of habitat used by delta smelt; and livestock grazing activities that may degrade or reduce riparian and wetland habitats that contribute to the quantity and quality of habitat used by delta smelt.

San Francisco Bay-Delta Climate Change

The effects of climate change do not act in isolation; they are anticipated to exacerbate existing threats to delta smelt. We considered the potential effects of climate change on the delta smelt based on projections derived from various modeling scenarios. A series of publications (Feyrer *et al.* 2011; Cloern *et al.* 2011; Brown *et al.* 2013) have modeled future impacts of climate change in the Delta and projected how this will affect delta smelt. These models used the B1 and A2 scenarios from the 2007 IPCC report. Each scenario included both a warmer-wetter and warmer-dryer sub scenario. Modeled predictions presented in these publications are based on current baseline conditions (no increased outflow, no breeching of levees) which may or may not change in the future. Temperature increases are likely to lead to a continued rise in sea level, further increasing salinity which will increasingly restrict delta smelt's already limited geographic range (Feyrer *et al.* 2011; Cloern *et al.* 2011; Brown *et al.* 2013). Higher air temperatures will reduce snowpacks, melt snow earlier in the winter or spring, and increase water temperatures. These changes will likely alter freshwater flows, possibly shifting and condensing the timing and location of delta smelt reproduction (Brown *et al.* 2013).

Projections indicate that temperature and precipitation changes will diminish snowpack, changing the availability of natural water supplies (Reclamation 2011). Warming may result in more precipitation falling as rain and less storage as snow. This would result in increased rain on snow events and increase winter runoff with an associated decrease in runoff for the remainder of the year (Reclamation 2011). Sacramento Valley Ecoregion projections include a 27 percent decrease in annual freshwater flows and earlier snowmelts, with increased freshwater flows in January and February but reduced throughout the rest of the year (PRBO Conservation Science 2011). Earlier seasonal warming increases the likelihood of rain-on-snow events, which are associated with mid-winter floods. Smaller snowpacks that melt earlier in the year may result in increased drought frequency and severity (Rieman and Isaak 2010). Thus overall, these changes may lead to increased frequency of flood and drought cycles during the 21st century (Reclamation 2011).

Sea level rise is likely to increase the frequency and range of saltwater intrusion. Salinity within the northern San Francisco Bay is projected to rise by 4.5 by the end of the century (Cloern *et al.* 2011). Elevated salinity levels could push the position of X2 farther up the estuary if outflows were not increased to compensate for it. Fall X2 mean values are projected to increase by a mean of about 7 km to the area of Antioch for a distance of about 90 km from the Golden Gate Bridge by 2100 (Brown *et al.* 2013). This increase in the position of X2 in the fall is expected to result in a decrease in suitable physical habitat (Brown *et al.* 2013) if current levees and channel structures are maintained. A decrease in spring habitat due to the movement of X2 upstream due to sea level rise is also expected to result from climate change.

We expect warmer estuary temperatures to be yet another significant conservation challenge based on climate change models. Mean annual water temperatures within the upper Sacramento River portion of the Bay-Delta estuary are expected to approach or exceed 14 °C during the second half of this century (Cloern *et al.* 2011). Warmer water temperatures could reduce delta smelt growth, increase delta smelt mortality and constrict suitable habitat within the estuary during the summer months. Due to warming temperatures, delta smelt are projected to spawn an average of 10 to 25 days earlier in the season depending on the location (Brown *et al.* 2013). Also due to expected temperature increases, total number of high mortality days is expected to increase for all IPCC climate change scenarios (Brown *et al.* 2013). The number of stress days is expected to be stable or decrease partly because many stress days will become high mortality days. This could lead to delta smelt being forced to grow under highly stressful conditions during summer and fall with less time to mature because of advanced spawning (Brown *et al.* 2013). Growth rates have been shown to slow as water temperatures increase therefore requiring delta smelt to consume more food to reach growth rates that are normal at lower water temperatures (Rose *et al.* 2013a). Delta smelt are already often smaller than they used to be (Sweetnam 1999; Bennett 2005) and expected temperature increases due to climate change will likely further slow growth rates.

At the same time, warmer water will tend to move the spawning season earlier in the year (Brown *et al.* 2013). That means the fish will have to grow faster still to compensate for that shorter growing season to produce even as many eggs as they do now – and that may already be a serious limitation on their population fecundity (Rose *et al.* 2013b). Higher temperatures may restrict delta smelt distribution into the fall, limiting their presence in Suisun Bay for more than just salinity reasons and force greater inhabitation of cooler high salinity waters (Brown *et al.* 2013). Water temperatures are already presently above 20°C for most of the summer in core habitat areas, sometimes even exceeding 25 °C for short periods.

The delta smelt is currently at the southern limit of the inland distribution of the family Osmeridae along the eastern Pacific coast. That indicates that this region was already about as warm as that fish family can handle. Increased temperatures associated with climate change may result in a habitat in the Bay-Delta that is outside of the species ecological tolerance limits.

Giant Garter Snake

The Service is aware of other projects currently under review by the State, county, and local authorities where biological surveys have documented the occurrence of federally-listed species. These projects include such actions as urban expansion, water transfer projects that may not have a Federal nexus, and continued agricultural development. The cumulative effects of these known actions pose a significant threat to the eventual recovery of the species. Additionally, an undetermined number of future land use conversions and routine agricultural practices are not subject to Federal permitting processes and may alter the habitat or increase incidental take of snakes, and are, therefore, cumulative to the proposed project. For example other cumulative effects include: (1) unpredictable fluctuations in aquatic habitat due to water management and diversions; (2) dredging and clearing of vegetation from irrigation canals; (3) discing or mowing upland habitat; (4) increased vehicular traffic on access roads adjacent to aquatic habitat; (5) use of burrow fumigants on levees and other potential upland refugia; (6) human intrusion into habitat; (7) use of inappropriate plastic erosion control netting (Stuart *et al.* 2001); (8) riprapping or lining of canals and stream banks; (9) fluctuations in acreages of rice production due to market conditions or water availability; (10) ornamental cultivation; (11) routine grounds maintenance of upland habitat; (12) contaminated runoff from agriculture and urbanization; (13) maintenance of non-Federal flood control structures; and (14) predation by feral animals and pets. Specific cumulative effects related to the proposed project include maintenance activities and/or an increased potential for vandalism, which may degrade or destroy habitat or cause unpredictable fluctuations in habitat.

Yellow-Billed Cuckoo

Habitat that is currently occupied by the yellow-billed cuckoo occurs on public and privately owned lands. Activities on non-Federal lands that may affect the yellow-billed cuckoo include the construction and maintenance of recreational hiking and bicycle trails; restoration of native riparian habitat; transportation related projects like construction and maintenance of State, county, and private roads and bridges; flood channel maintenance by the State water resources agencies, and conversion of riparian habitat to agriculture on private lands.

Conclusion

After reviewing the current status of the valley elderberry longhorn beetle, delta smelt, giant garter snake and yellow-billed cuckoo, the environmental baseline for the action area, the effects of the proposed ARFC project, and the cumulative effects on these species, it is the Service's biological opinion that the proposed AFRC project, is not likely to jeopardize the continued existence of these species. The Service reached this conclusion because the project-related effects to the species, when added to the environmental baseline and analyzed in consideration of all potential cumulative effects, will not rise to the level of precluding recovery or reducing the likelihood of survival of the species based on the conservation measures proposed by the Corps including: creating additional riparian habitat for the valley elderberry longhorn beetle and the yellow-billed cuckoo; purchasing credits at conservation banks for giant garter snake and delta smelt; and restoring any temporarily affected habitat to pre-project conditions.

After reviewing the current status of designated critical habitat for delta smelt, the environmental baseline of critical habitat in the action area, the effects of the proposed ARFC project, and the cumulative effects, it is the Service's biological opinion that the proposed ARFC project, as proposed, is not likely to destroy or adversely modify designated critical habitat. The Service reached this conclusion because the project-related effects to the designated critical habitat, when added to the environmental baseline and analyzed in consideration of all potential cumulative effects, will not rise to the level of precluding the function of the delta smelt critical habitat, to serve its intended conservation role for the species based on the Corps proposal to purchase credits at a conservation bank for permanent effects to the substrate of the Sacramento River. The effects to delta smelt critical habitat are small and discrete, relative to the entire area designated, and are not expected to appreciably diminish the value of the critical habitat or prevent it from sustaining its role in the conservation of the delta smelt.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by Service regulations at 50 CFR 17.3 as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Harm is defined by the same regulations as an act which actually kills or injures wildlife. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavior patterns, including breeding, 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 intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary, and must be undertaken by the Corps and SAFCA so that become binding conditions of any contract issued for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity that is covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions, or (2) fails to require their contractor or SAFCA or to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the contract, 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 the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

Amount or Extent of Take

Valley Elderberry Longhorn Beetle

The Service anticipates that incidental take of valley elderberry longhorn beetle will be difficult to detect due to its life history and ecology. Specifically, valley elderberry longhorn beetles can be difficult to locate due to the fact that a majority of their life cycle is spent in the elderberry shrub and finding a dead or injured individual is unlikely due to their relatively small size. There is a risk of harm, harassment, injury and mortality as a result of the proposed construction activities; therefore, the Service is authorizing take incidental to the proposed action as harm, harassment, injury, and mortality of all valley elderberry longhorn beetles within 263 shrubs that will be transplanted as a result of construction and 40 acres of elderberry shrubs that will be trimmed for maintenance purposes over the project's 50 year life.

Delta Smelt

The Service expects that incidental take of delta smelt will be difficult to detect or quantify for the following reasons: the small size of adults, their occurrence in turbid aquatic habitat makes them difficult to detect, and the low likelihood of finding dead or impaired specimens. The Service anticipates that the extent of incidental take will be minimized due to the proposed conservation measures and low relative abundance. Due to the difficulty in quantifying the number of delta smelt that will be taken as a result of the proposed action, the number of acres of affected habitat becomes a surrogate for the species that will be taken. The Service anticipates that all individual adult delta smelt in the 46 acres of the action area may be subject to incidental take in the form of harm as described in this biological opinion. Incidental take of delta smelt for maintenance activities is not covered in this biological opinion.

Giant Garter Snake

The Service anticipates that incidental take of the snake will be difficult to detect or quantify for the following reasons: snakes are cryptically colored, secretive, and known to be sensitive to human activities. Snakes may avoid detection by retreating to burrows, soil crevices, vegetation, and other cover. Individual snakes are difficult to detect unless they are observed, undisturbed, at a distance. Most close-range observations represent chance encounters that are difficult to predict. It is not possible to make an accurate estimate of the number of snakes that will be harassed during construction activities, including in staging areas and roads carrying vehicular traffic. In instances when take is difficult to detect, the Service may estimate take in numbers of species per acre of habitat lost or degraded as a result of the action as a surrogate measure for quantifying individuals.

Therefore, the Service anticipates the number of giant garter snakes that may be found in 125.5 acres of aquatic and upland habitat will be harmed or killed as a result of habitat modification due to the proposed project. Incidental take of giant garter snake for maintenance activities is not covered in this biological opinion.

Yellow-Billed Cuckoo

The Service anticipates that incidental take of yellow-billed cuckoo will be difficult to detect due to its life history and ecology. Specifically, yellow-billed cuckoos can be difficult to locate due to their cryptic appearance and behavior and finding a dead or injured individual is unlikely. There is a risk of harm and harassment as a result of proposed construction activities and operations and maintenance of the restoration plantings; therefore, the Service is authorizing take incidental to the proposed action as harm of all yellow-billed cuckoos within 135 acres. Incidental take of yellow-billed cuckoo for maintenance activities is not covered in this biological opinion.

Effect of the Take

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

Reasonable and Prudent Measures

All necessary and appropriate measure to avoid or minimize effects on the species resulting from implementation of this project have been incorporated into the project's proposed conservation measures. Therefore, the Service believes the following reasonable and prudent measure is necessary and appropriate to minimize incidental take of the species.

1. All conservation measures, as described in the biological assessment and restated here in the Project Description section of this biological opinion, shall be fully implemented and adhered to. Further, this reasonable and prudent measure shall be supplemented by the terms and conditions below.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measure described above. These terms and conditions are nondiscretionary.

1. The Corps shall include full implementation and adherence to the conservation measures as a condition of any permit or contract issued for the project.

2. The Corps will develop a Riparian Planting Plan. The plan will evaluate locations for riparian vegetation planting based on land use in the lower American River Parkway, effects from future projects, such as the reoperation of Folsom Dam, where existing riparian and valley elderberry longhorn beetle habitat exists, creating and maintaining connectivity between large riparian patches, and coordination with Sacramento County Parks. The plan will maximize habitat quality for both the valley elderberry longhorn beetle and the yellow-billed cuckoo.

3. In order to monitor whether the amount or extent of incidental take anticipated from implementation of the project is approached or exceeded, the Corps shall adhere to the following reporting requirements. Should this anticipated amount or extent of incidental take be exceeded, the Corps must immediately reinitiate formal consultation as per 50 CFR 402.16.

   (a) For those components of the action that will result in habitat degradation or modification whereby incidental take in the form of harm is anticipated, the Corps will provide monthly updates to the Service with a precise accounting of the total acreage of habitat impacted. Updates shall also include any information about changes in project implementation that result in habitat disturbance not described in the Project Description and not analyzed in this biological opinion.
   (b) For those components of the action that may result in direct encounters between listed species and project workers and their equipment whereby incidental take in the form of harassment, harm, injury, or death is anticipated, the Corps shall immediately contact the Service's Sacramento Fish and Wildlife Office (SFWO) at (916) 414-6600 to report the encounter. If the encounter occurs after normal working hours, the Corps shall contact the SFWO at the earliest possible opportunity the next working day. When injured or killed individuals of the listed species are found, the Corps shall follow the steps outlined in the Salvage and Disposition of Individuals section below.
   (c) Injured listed species must be cared for by a licensed veterinarian or other qualified person(s), such as a Service-approved biologist. Dead individuals must be sealed in a resealable plastic bag containing a paper with the date and time when the animal was found, the location where it was found, and the name of the person who found it. The bag containing the specimen must be frozen in a freezer located in a secure site, until instructions are received from the Service regarding the disposition of the dead specimen. The Service contact persons are the Habitat Conservation Division Chief at the Sacramento Fish and Wildlife Office at (916) 414-6600; the Assistant Field Supervisor of ESA/Regulatory Division at the Bay Delta Fish and Wildlife Office at (916) 930-5603; and the Resident Agent-in-Charge of the Service's Office of Law Enforcement at (916) 569-8444.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The Service recommends the following actions:

1. The Service recommends the Corps develop and implement restoration measures in areas designated in the Delta Fishes Recovery Plan (Service 1996) the Giant Garter Snake Recovery Plan (1999) and the Valley Elderberry Longhorn Beetle Recovery Plan (1984).

2. The Corps and SAFCA should develop and implement projects that support DWR's Central Valley Flood System Conservation Strategy. This document provides goals and measurable objectives and potential projects which could be implemented in a manner that while improving the riverine ecosystem also will improve the flood system.

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

REINITIATION - CLOSING STATEMENT

This concludes formal consultation with the Corps on the American River Common Features GRR Project. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and:

(a) If the amount or extent of taking specified in the incidental take statement is exceeded;

(b) If 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;

(c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

(d) If a new species is listed or critical habitat designated that may be affected by the identified action.

If you have any questions regarding this biological opinion, please contact Jennifer Hobbs (jennifer_hobbs@fws.gov or (916) 414-6541) or Doug Weinrich, Assistant Field Supervisor at the letterhead address, (916) 414-6600.

Sincerely,

Jennifer M. Norris
Field Supervisor

cc:
Elif Fehm-Sullivan, National Marine Fisheries Service, Sacramento, CA
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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

SEP 9 2015

Refer to NMFS No: WCR-2014-1377

Ms. Alicia Kirchner
Department of the Army
United States Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814-2922

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response, for the American River Common Features General Reevaluation Report (Common Features GRR)

Dear Ms. Kirchner:

Thank you for your letter of April 3, 2015, providing an updated biological assessment and requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 *et seq.*) for the Common Features GRR.

This letter also transmits NMFS's essential fish habitat (EFH) conservation recommendations for Pacific salmon as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*).

Based on the best available scientific and commercial information, the Biological Opinion (BO) concludes that the Common Features GRR is not likely to jeopardize the continued existence of the federally listed threatened Central Valley (CV) spring-run Chinook salmon evolutionarily significant unit (ESU) (*Oncorhynchus tshawytscha*), endangered Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha*), threatened California CV steelhead distinct population segment (DPS) (*O. mykiss*), or the threatened Southern DPS (sDPS) of North American green sturgeon (*Acipenser medirostris*) and is not likely to destroy or adversely modify their designated critical habitats. For the above species, NMFS has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take of listed species associated with the project.

The EFH consultation concludes that the proposed action would adversely affect the EFH of Pacific salmon in the action area. The EFH consultation adopts the ESA reasonable and prudent measures and associated terms and conditions from the BO and includes additional conservation recommendations specific to the adverse effects to fall- and late fall-run Chinook salmon (*O. tshawytscha*) EFH.

The U.S. Army Corps of Engineers (Corps) has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed written response to NMFS within 30 days of receipt of these conservation recommendations, and 10 days in advance of any action, that includes 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)). If unable to complete a final response within 30 days, the Corps should provide an interim written response within 30 days before submitting its final response. 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 Common Features GRR and the measures needed to avoid, minimize, or mitigate (also referred to as compensate by NMFS) such effects.

Please contact Howard Brown at the NMFS California Central Valley Office, 916-930-3608, or at Howard.Brown@noaa.gov, if you have any questions concerning this section 7 consultation, or if you require additional information.

Sincerely,

for Maria Rea
William W. Stelle, Jr.
Regional Administrator

Enclosure

CC: CHRON File: 151422WCR2014SA00215

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation.

Common Features GRR
NMFS Consultation Number: 151422WCR2015SA00215

Action Agency: U.S. Army Corps of Engineers (Corps)

Affected Species and NMFS' Determinations:

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

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

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

Issued By:

for William W. Stelle, Jr.
Regional Administrator

Date:

List of Acronyms

BA	Biological Assessment
BCSSRP	Battle Creek Salmon and Steelhead Restoration Program
BMP	Best Management Practices
BO	Biological Opinion
BSSCP	Bentonite Slurry Spill Contingency Plan
CCV	California Central Valley
CDFG	California Department of Fish and Game
CDFW	California Department of Fish Wildlife
CEQA	California Environmental Quality Act
cfs	Cubic Feet per Second
CNFH	Coleman National Fish Hatchery
Corps	US Army Corps of Engineers
CRR	Cohort Replacement Rate
CV	Central Valley
CVP	Central Valley Project
CVFPB	Central Valley Flood Protection Board
CWA	Clean Water Act
CWT	Coded Wire Tag
dbh	Diameter at Breast Height
DCC	Delta Cross Channel
Delta	Sacramento-San Joaquin Delta
DO	Dissolved Oxygen
DPS	distinct population segment
DWR	California Department of Water Resources
DWSC	Deep Water Ship Channel
EFH	Essential Fish Habitat
EIP	Early Implementation Project
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
ETL	Engineering Technical Letter
FRFH	Feather River Fish Hatchery
GCID	Glenn-Colusa Irrigation District
GRS	General Reevaluation Study
HU	Hydrologic Unit
ITS	Incidental Take Statement
IWM	Instream Woody Material
JPE	Juvenile Production Estimate
Kelts	Post-Spawning Steelhead
lf	Linear Feet
LSNFH	Livingston Stone National Fish Hatchery
LWM	Large Woody Material
mm	millimeter

MMP	Mitigation and Monitoring Plan
MSA	Magnuson-Stevens Fishery Conservation and Management Act
nDPS	Northern Distinct Population Segment
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTUs	Nephelometric Turbidity Units
O&M	Operation and Maintenance
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCE	primary constituent elements
PL	Public Law
PVA	Population Viability Analysis
RBDD	Red Bluff Diversion Dam
RD	Reclamation District
Reclamation	United States Department of the Interior, Bureau of Reclamation
RM	River Mile
RWQB	Regional Water Quality Control Board
SAM	Standard Assessment Methodology
SDFPF	Skinner Delta Fish Protection Facility
sDPS	Southern Distinct Population Segment
SJRRP	San Joaquin River Restoration Program
SPCCP	Spill Prevention, Control, and Counter-Measure Plan
SRA	Shaded Riverine Aquatic
SRBPP	Sacramento River Bank Protection Project
SRFCP	Sacramento River Flood Control Project
SWP	State Water Project
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TCP	Temperature Compliance Point
TFCF	Tracy Fish Collection Facility
TRT	Technical Review Team
USACE	United State Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
VSP	Viable Salmonid Populations
VVR	Vegetation Variance Request
WRDA	Water Resources Development Act
WRI	Weighted Species Response Index
WRO	Water Rights Order
WSAFCA	West Sacramento Area Flood Control Agency

Note: Throughout this document there are references cited as CDFG. This refers to the California Department of Fish and Game. This name was changed to California Department of Fish and Wildlife on January 1, 2013. However, for consistency on publications, references prior to January 1, 2013, will remain CDFG.

INTRODUCTION

The U.S. Army Corps of Engineers (Corps) proposes to implement flood risk management improvements under the American River Common Features General Reevaluation Report (Common Features GRR). The purpose of this Biological Opinion (BO) is to analyze the potential effects of repairing the levees in the Sacramento Metropolitan area (including both the Sacramento and American Rivers), widening the Sacramento Weir and Bypass, and diverting more flows into the Yolo Bypass on listed threatened or endangered species and on designated critical habitat, within the project's area of effect (action area).

1.1 Common Features GRR Project Study Area

The Common Features GRR project study area is located within the Sacramento and American River Watersheds. The Sacramento River watershed covers approximately 26,000 square miles in central and northern California. Major tributaries of the Sacramento River include the Feather, Yuba, and American Rivers. The American River Watershed covers about 2,100 square miles northeast of the city of Sacramento and includes portions of Placer, El Dorado, Alpine, and Sacramento counties. The American River watershed includes Folsom Dam and Reservoir; inflowing rivers and streams, including the North, South, and Middle forks of the American River; and the lower American River downstream of Folsom Dam to its confluence with the Sacramento River in the city of Sacramento. The Sacramento and American Rivers, in the Sacramento area, form a flood plain covering roughly 110,000 acres at their confluence. The flood plain includes most of the developed portions of the city of Sacramento. Figure 1 shows the study area.

The Common Features GRR study area includes:

1. Approximately 12 miles of the north and south banks of the American River immediately upstream from the confluence with the Sacramento River.
2. The east bank of the Dry, and Robla Creeks and the Magpie Creek Diversion Channel (collectively referred to as the East Side Tributaries).
3. The east bank of the Sacramento River downstream from the American River to Freeport, where the levee ties into Beach Lake Levee.
4. The Sacramento Weir and Bypass, located along the north edge of the city of West Sacramento (Figure 1).

The action area for the ARCF GRR project includes the American River from below Folsom Dam to the confluence with the Sacramento River and the Sacramento River from the Sacramento Bypass down to below Freeport. In addition the action area includes the East Side Tributaries: Dry and Robla Creeks, and the Magpie Creek Diversion Channel.

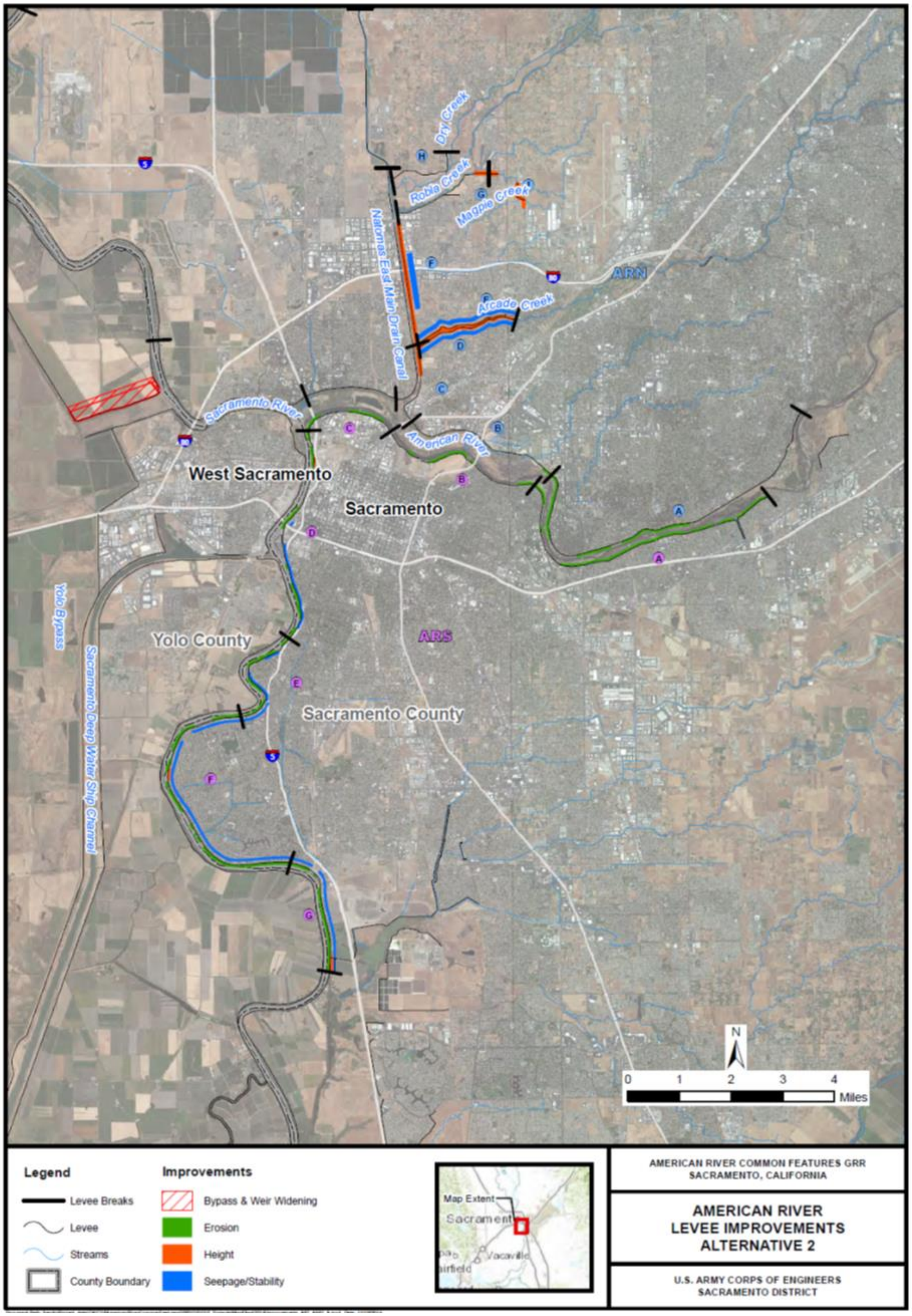

Figure 1. Common Features GRR Study Area (Corps 2014).

1.2 Background, Authority and Policy

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

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

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

1.2.1 Background

After the flood of 1986, Congress directed the Corps to investigate the feasibility of reducing flood risk to the city of Sacramento. The Corps completed feasibility studies in 1991 and 1996, recommending a concrete gravity flood detention dam on the north fork of the American River at the Auburn site along with levee improvements downstream of Folsom Dam. Other plans evaluated in the report were Folsom Dam improvements and a stepped release plan for Folsom Dam releases. These additional plans also included levee improvements downstream of Folsom Dam. Congress recognized that levee improvements were "common" to all candidate plans in the report and that there was a Federal interest in participating in these "common features." Thus, the ARCF Project was authorized in WRDA 1996 and a decision on Auburn Dam was deferred to a later date. Major construction components for ARCF in the WRDA 1996 authorization include construction of seepage remediation along approximately 22 miles of American River levees and construction of levee strengthening and raising of 12 miles of Sacramento River levee in Natomas.

Following the flood of 1986, significant seepage was experienced on the Sacramento River from Verona (upstream end of Natomas) at River Mile (RM) 79 to Freeport at RM 45.5. In addition, both the north and south bank of the American River from RM 0 to approximately RM 11.4 experienced seepage. Seepage on the Sacramento River was so extensive that Congress, soon after the 1986 flood event, funded remediation in the Sacramento Urban Levee Improvement Project (Sac Urban). The Sac Urban Project constructed shallow seepage cutoff walls from Powerline Road in Natomas at approximately RM 64 down to Freeport.

In 1999, Congress decided not to authorize Auburn Dam but instead to authorize improvements for Folsom Dam. By doing this, improvements to levees downstream of Folsom Dam could be fine-tuned to work closely with the Folsom Dam improvements being discussed by Congress. Therefore, the Common Features project was modified by WRDA 1999 to include additional necessary features for the American River so that it could safely convey the proposed emergency release of 160,000 cfs from Folsom Dam. Major construction components for the Common Features project in the WRDA 1999 authorization include construction of seepage remediation and levee raises along four stretches of the American River, and construction of levee strengthening and raising of 5.5 miles of Natomas Cross Canal levee in Natomas. All American River features authorized in WRDA 1996 and 1999 have been constructed or are in design analysis for construction within a year or two.

Because of the considerable cost increase of seepage remediation on the American River, all funds appropriated by Congress throughout the late 1990s and the early part of the 2000s were used for construction activities on the American River instead of for design efforts in the Natomas Basin. Combining this with the recognition that all work in the Natomas Basin would also require significantly more effort than was anticipated at the time of authorization, it was decided in 2002 that a general reevaluation study would be required for at least the Natomas Basin portion of the ARCF project. This general reevaluation started in 2006.

At approximately the same time that the reevaluation study was beginning, the Folsom Dam Post Authorization Change report (PAC) was being completed by the Sacramento District. Results of this study showed that additional levee improvements were needed on the American River and on the Sacramento River below the American River in order to truly capture the benefits of the Folsom Dam projects. These levee improvements consisted primarily of addressing erosion concerns on the American River and seepage, stability, erosion, and height concerns on the Sacramento River below the American River.

There are three additional flood management Corps projects related to the Common Features GRR that provide additional context. The Corps initiated consultation for the West Sacramento GRS project in early 2015. Many of the proposed elements associated with the West Sacramento GRS are anticipated to be similar in nature to proposed elements with the Common Features GRR. The project area will include the opposite bank (west bank) of the Sacramento River from the West Sacramento GRS. Potential impacts associated with vegetation removal and bank armoring associated with the West Sacramento GRS could further degrade this area of the Sacramento River watershed. These potential impacts in combination with potential impacts associated with the West Sacramento GRR could degrade the overall health of the lower Sacramento River watershed.

The Corps has initiated consultation for the Sacramento Bank Protection Project Phase II project. Sacramento Bank Protection Project Phase II will cover up to 80,000 lf of bank protection as part of the SRFCP. A number of the potential bank protection sites are located in the general vicinity of the Common Features GRR.

Under the Water Resources Development Act of 1999, Pub. L. No. 106-53, § 366, 113 Stat. 269, 319-320 (1999) (WRDA 1999), Congress authorized improvements to Folsom Dam to control a 200-year flood event with a peak release of 160,000 cfs. WRDA 1999 also authorized the Folsom Dam Modification Project to modify the existing outlets to allow for higher releases earlier in flood events. At the same time, Congress also directed the Corps to review additional modifications to the flood storage of Folsom Dam, indicating that Congress was looking at maximizing the use of Folsom Dam to reduce flood risk prior to consideration of any additional upstream storage on the American River. The Folsom Dam Raise Project was subsequently authorized by Congress in 2004. The project is designed to allow for the release of 160,000 cubic feet per second (cfs) from Folsom Dam. The levees along the American River are unable to withstand these maximum flows for extended periods of time without increased risk of erosion and potential failure. Erosion within the American River Parkway is being addressed as part of the Folsom Reoperation project currently under evaluation and a biological assessment is being prepared to initiate Section 7 consultation with both USFWS and NMFS. These projects have the potential to increase the bank armoring and could exacerbate any impacts associated with the Common Features GRR.

1.2.2 Authority and Policy

According to the Corps' BA, they have no discretion in regards to the continuing existence and operation of the flood control structures of the SRFCP. They assert to have responsibility to maintain Civil Works structures so that they continue to serve their congressionally authorized purposes is inherent in the authority to construct them and is, according to the Corps, non-discretionary. The Corps also asserts that only Congressional actions to de-authorize the structures can alter or terminate this responsibility and thereby allow the maintenance of the structures to cease.

The Corps BA also claims that it has a non-discretionary duty to maintain the SRFCP and the fact the Corps perpetuates the projects existence is not an action subject to consultation. The Federal government maintains oversight but has no ownership of or direct responsibilities for performing maintenance of the Federal levee system, except for few select features that continue to be owned and operated by the Corps. However, the Corps asserts they do have discretion in regard to how and where maintenance actions are performed. The discretion lies within the authorities of the SRBPP and section 408 of the Rivers and Harbors Act. The Corps is seeking additional authorities that will include discretion over future flood risk reduction projects associated with the West Sacramento GRS and the Common Features GRR.

Considering these exceptions, the Corps maintains that the majority of levees, channels, and related flood risk management structures are owned, operated, and maintained by the State of California and local levee and reclamation districts as governed by Corps Operations and Maintenance (O&M) manuals. The Corps points to the May 1955 Standard O&M manual for the SRFCP as the primary O&M manual for the area. The levees of the West Sacramento and Common Features Projects are part of the SRFCP and therefore covered in the 1955 O&M manual.

The BA states that following completion of construction, the Corps will prepare a supplement to the 1955 O&M manual which will specify maintenance requirements for these projects. Because the Corps does have discretion in how and when levee maintenance activities are performed (as opposed to the results of maintenance), maintenance is a discretionary activity that is part of the proposed action subject to consultation.

Typical maintenance activities would include vegetation control through mowing, herbicide application, and/or slope dragging; rodent control; patrol road maintenance; and erosion control and repair. Vegetation control typically would be performed twice a year. Herbicide and bait station application would be conducted under county permit by experts licensed by the state for pest control. Erosion control and slope repair activities would include re-sloping and compacting; fill and repair of damage from rodent burrows would be treated similarly.

To meet Federal Flood Control Regulations (33 CFR 208.10) and state requirements (California Water Code Section 8370), the Federal Flood Risk Management facilities are inspected four times annually, at intervals not exceeding 90 days. The California Department of Water Resources (DWR) would inspect the system twice a year, and the local maintaining authorities would inspect it twice a year and immediately following major high water events. The findings of these inspections would be reported to the Central Valley Flood Protection Board's (CVFPB) Chief Engineer through DWR's Flood Project Integrity and Inspection Branch.

Each federal agency has an obligation to insure that any discretionary action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify its critical habitat. Furthermore, under Section 2 of the ESA, it is declared that all Federal agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of the ESA. In regards to species and critical habitat compensation, the Corps has the authority to compensate prior to or concurrent with project construction impacts. This authority is given under WRDA 1986 (33 USC §§ 2201–2330).

The Common Features Project is being proposed in accordance with the principles that have been outlined in the Corps' SMART Planning Guide (Corps 2013). SMART Planning requires that all feasibility studies should be completed within a target of 18 months (to no more than three years at the greatest), at a cost of no more than $3 million, utilizing 3 levels of vertical team coordination, and of a "reasonable" report size. All designs associated with the Common Features GRR use the largest footprint to evaluate affects to listed species. The larger footprint will look at the maximum extent the project could affect species in the action area.

The Corps proposes to construct the Common Features Project levee improvement measures to comply with the Engineering Technical Letter (ETL) 1110-2-571 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures. The vegetation requirements include a vegetation-free zone on the levee slopes and crown, 15 feet from both landside and waterside levee toes, and 8 feet vertically.

The levees within the study area require seepage, slope stability, height, and erosion improvements in order to meet Corps levee safety criteria. In order to protect existing vegetation and allow for revegetation to occur, the Corps must apply for and issue itself with a vegetation variance. The vegetation variance will be sought during the preconstruction engineering and design phase to allow vegetation to remain on the lower 2/3 of the waterside slope and out 15 feet from the waterside toe. If the Corps grants itself a variance, the variance would allow for vegetation to remain in these areas. No vegetation would be permitted on the landside slope or within 15 feet of the landside toe. To show that the safety, structural integrity, and functionality of the levee would be retained with a variance, an evaluation of underseepage and waterside embankment slope stability was completed by Corps engineers.

The Corps' preliminary analysis for the vegetation variance was conducted by analyzing two index points. These two index points were chosen for the vegetation variance analyses because they were considered to be representative of the most critical channel and levee geometry, underseepage, slope stability conditions, and vegetation conditions of the respective basins. The analysis incorporated tree fall and scour on the cross-section geometry of the index points by using a maximum depth of scour for cottonwoods as approximately 11.0 feet; the associated soil removed was projected at a 2:1 slope from the base of the scour toward both the landside, and waterside slopes. The base scour width was equal to the maximum potential diameter at breast height (dbh) of cottonwoods (12.0 feet) projected horizontally at a depth of 11.0 feet below the existing ground profile. The results show that the tree fall and scour did not significantly affect levee performance and that the levee would meet Corps seepage and slope stability criteria when the seepage and slope stability improvement measures are in place ("with-project" conditions). Therefore, it is a reasonable conclusion that allowing vegetation to remain on the lower waterside levee slope would not affect the safety, structural integrity, and functionality of the Sacramento River levee.

As a result of the geotechnical analysis, the Corps would request a vegetation variance of themselves for the Sacramento River, Dry/Robala Creeks, Arcade Creek, and Magpie Creek portions of the project. In many cases along the American River levees, the levee is far enough back from the water's edge to allow vegetation providing shaded riverine aquatic cover to remain on the bank with no vegetation variance necessary. However, the Sacramento Weir and Bypass levees would be constructed in compliance with the Corps ETL as these would be new levees. No vegetation removal would be required within the existing or expanded Sacramento Bypass. There will be no Vegetation Variance requested for the American River sites and will require removal of vegetation and will therefore comply with the ETL. Refer to Table 1 for reach specific information regarding presence or absence of a vegetation variance.

Table 1: Summary of ETL compliance Method by Waterway.

	Vegetation Variance	**SWIF**
Sacramento River (lower ½ of levee slope which is outside construction footprint)		
Waterside	X	
Landside		X
American River		
Trench Landside[1]		X
Bank Protection		X
North Area Tributaries[2]		
NEMDC	X	X
Dry/Robla Creeks	X	X
Arcade Creek	X	X
Magpie Creek[3]	X	X

1 The waterside footprint for the trench construction would require removal of vegetation and therefore compliance with the ETL.
2 A variance is included for these tributaries waterside slopes outside of the construction footprint, and a SWIF would be prepared by the non-Federal partners for the landside slopes and access.
3 The new levee constructed along Raley Boulevard would be constructed in compliance with the ETL.

In addition to the Vegetation variance, this project will implement the System Wide Improvement Framework (SWIF). The SWIF is an agreement between the Corps and the non-Federal sponsor that allows the local maintain agency (LMA) to defer compliance with ETL 1110-2-583. In an effort to modernize the levee system to meet current engineering standards, vegetation and encroachment issues (including landside levee access) in the study area will be resolved through a combination of construction actions associated with implementation of the recommended plan and formal agreements. The formal agreements involve the integrated use of a SWIF agreement with the LMA and a variance from vegetation standards in ETL 1110-2-583, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures.

Under the SWIF agreement, the LMA would address landside vegetation and encroachment issues (including landside levee access) through the implementation of their standard operation and maintenance (O&M) actions over time. Therefore, vegetation not impacted by project construction would be addressed by the LMA in accordance with the State's Levee Vegetation Management Strategy in the Central Valley Flood Protection Plan (CVFPP) over the next 20 to 40 years. The SWIF will be planned and implemented by the non-Federal sponsor and includes the following criteria:

- An engineering inspection and evaluation shall be conducted to identify trees and other woody vegetation (alive or dead) on the levee and within 15 feet of the levee toe that pose an unacceptable threat to the integrity of the levee. Identified trees shall be removed and associated root balls and roots shall be appropriately remediated. Based on the engineering inspection and evaluation, trees and other woody vegetation that do not pose an unacceptable threat need not be removed.

- In cases of levee repair or improvement projects, vegetation within the project footprint shall be removed as part of construction activities.

- Trees and other woody vegetation that are not removed must be monitored as part of routine levee maintenance to identify changed conditions that cause any of these remaining trees and other woody vegetation to pose an unacceptable threat to levee integrity. Otherwise, such trees and woody vegetation are to be maintained according to the levee vegetation management criteria included in the CVFPP which establish a vegetation management zone (including the landside levee slope, crown and upper 1/3 of the waterside slope) in which trees are trimmed up to 5 feet above the ground (12-foot clearance above the crown road) and thinned for visibility and access while brush, trees and other woody vegetation less than four inches in diameter at breast height, weeds or other such vegetation over 12 inches high are to be removed in an authorized manner.

The standard O&M activities will be adjusted to reflect any vegetation variance. Under the adjusted O&M manual, large trees that were protected in place under the variance will be allowed to remain on the waterside slopes, but smaller shrubs will be removed and grasses will be regularly mowed to allow for inspection and access.

The ARCF project was authorized by Section 106(a)(1) of the Water Resources Development Act (WRDA) of 1996, (Public Law [PL] 104-303) (110 Stat. 3658, 3662-3663), as amended by Section 130 of the Energy and Water Development and Related Agencies Appropriations Act of 2008, (PL 110-161) (121 Stat. 1844, 1947). Additional authority was provided in Sections 366 and 566 of WRDA 1999, (PL 106-53), (113 Stat. 269, 319-20. The current estimated cost of the authorized project is $274,100,000. In accordance with Section 902 of WRDA 1986 (Pub. L. 99-662, § 902, Nov. 17, 1986, 100 Stat. 4183), the allowable cost limit is $284,000,000.

1.3 Consultation History

NMFS received a request for initiation of consultation on July 1, 2014. However, the initial request did not contain an appropriate effects determination. The Biological Assessment (BA) was missing necessary information to perform a species impact analysis. NMFS reviewed the biological assessment provided with the initiation letter and concluded it lacked sufficient detail to determine the extent to which the proposed project may affect federally listed species and their designated critical habitats. In addition, NMFS found that the information provided with the letter was incomplete and lacked all the information necessary to initiate section 7 consultation on the proposed project, as outlined in the regulations governing interagency consultation (50 CFR §402.12). On September 9th, 2014 NMFS sent an insufficiency letter outlining the information needs to initiate consultation.

On April 3, 2015 NMFS received a new request for initiation of consultation. The request included the North Sacramento Streams projects that were to be conducted by SAFCA. In the April 3, 2015 letter the Corps requested concurrence from NMFS that the Common Features GRR will adversely affect threatened Central Valley (CV) spring-run Chinook salmon evolutionarily significant unit (ESU) (*Oncorhynchus tshawytscha*), endangered Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha*), threatened California CV (CCV) steelhead distinct population segment (DPS) (*O. mykiss*), and threatened Southern DPS (sDPS) of North American green sturgeon (*Acipenser medirostris*), and their designated critical habitats. Additionally, the Corps has determined that the Common Features Project may adversely affect Essential Fish Habitat (EFH) pursuant to the Magnuson-Stevens Fishery Management Act. The Corps also states that there is an expectation that the Common Features GRR may benefit long-term EFH quality in the action area.

After phone conversations, emails, and an inter-agency meeting on April 21, 2015 the Corps agreed to send a letter advising that the North Sacramento Streams projects would be separated from the Common Features GRR for a separate consultation, and that new SAM analysis models needed to be run. NMFS informed the Corps that consultation could not begin until the letter was received and SAM analysis completed.

May 14, 2015 another interagency meeting that included the Corps and NMFS occurred for the revised SAM analysis. NMFS again informed the Corps that consultation could not begin until the letter was received and SAM analysis completed. NMFS and the Corps agreed that the following information should be included in the letter transmitting the new Standard Assessment Methodology (SAM) analysis Memo:

1. Establish that for all of the three reaches what Sac Bank approximation was used for all SAM runs. Meaning the sites constructed near to the sites to be constructed, those specifications were used for the with-construction conditions, remember to add to the SAM analysis memo we are working on.

2. Add all green sturgeon life stages to the SAM analysis for site C since it is in Green Sturgeon Critical habitat.

3. Add green sturgeon juvenile rearing habitat SAM analysis for all America River sites.

4. Add justification for not including certain life history stages to the SAM analysis.

5. Addition of a discussion for the purchase of mitigation credits appropriate for each site.

6. Addition of numbers for fall-run juvenile migration all water levels for EFH.

7. Incorporate 60% IWM into the SAM analysis.

8. Incorporate a discussion of possibly incorporating 80% IWM.

9. Incorporation of plantings (*i.e.* button bush) at the lowest/Fall water line to increase the value.

June 11, 2015 NMFS received email with Draft memo of new Sam analysis information which included a new reach of the Sacramento bypass and weir and NMFS initiated consultation.

August 24, 2015 NMFS met with the Corps and received new conservation measures to add to the project description.

August 28, 2015. NMFS received a letter from the Corps officially providing the revised project description and new Green Sturgeon conservation measures.

1.4 Proposed Action

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

The Corps has identified a number of problems associated with the flood risk management system protecting the city of West Sacramento and surrounding areas. There is a high probability that flows in the American and Sacramento Rivers will stress the network of levees protecting Sacramento to the point that levees could fail. Such a levee failure would flood a highly urbanized area.

Levees in the Common Features GRR action area require improvements to address seepage, stability, erosion, and height concerns identified for the American River levees, Dry/Robla, and Magpie Creeks. The levees along the Sacramento River would be improved to address identified seepage, stability, erosion, and a minimal amount of height concerns. Most height concerns along the Sacramento River would be addressed by a widening of the Sacramento Weir and Bypass to divert more flows into the Yolo Bypass. The measures proposed to improve the levees consist of: (1) bank protection or launchable rock trenches, (2) install cutoff walls, (3) levee raise, (4) construct floodwalls, (5) raise floodwalls, (6) construct new levee, (7) acquire property to create a flood detention basin, (8) widen and raise a bridge crossing, (9) remove a culvert, (10) widen the Sacramento Weir and Bypass, (11) construction of a new weir, and 12) removal of existing levee. The above measures will be implemented by fixing levees in place or constructing adjacent levees. It is possible that sheet pile walls, jet grouting, and relief wells will be used at various locations so they are also described below. Once a levee is modified, regardless of the measure implemented for the alternative, the levee will be brought into compliance with Corps levee design criteria.

For more details on the potential levee repairs listed above and in Table 2, refer to the American River Common Features General Reevaluation Report North Sacramento Streams Levee Improvement Project, specifically Chapter 2 (Corps 2015a).

In addition to the proposed levee improvements measures, the following measures and policies will apply to all of the levee repair alternatives, and will be addressed during construction:

1. Utility encroachments such as structures, certain vegetation, power poles, pump stations, and levee penetrations (*e.g*., pipes, conduits, cables) will be brought into compliance with applicable Corps policy or removed depending on type and location. This measure will include the demolition of such features and relocation or reconstruction as appropriate on a case-by-case basis (or retrofit to comply with standards). Utilities replacements will occur via one of two methods: (1) a surface line over the levee prism, or (2) a through-levee line equipped with positive closure devices.

2. Private encroachments shall be removed by the non-federal sponsor prior or property owner prior to construction.

The O&M of the levees in the Sacramento area are the responsibility of the local maintaining agencies, including the American River Flood Control District, Maintenance Area 9, The California Department of Water Resources (DWR), and the City of Sacramento. The applicable O&M Manual for the Sacramento levees is the Standard O&M Manual for the Sacramento River Flood Control Project. Typical levee O&M in the Sacramento area includes the following actions:

1. Vegetation maintenance up to four times a year by mowing or applying herbicide.

2. Control of burrowing rodent activity monthly by baiting with pesticide.

3. Slope repair, site-specific and as needed, by re-sloping and compacting.

4. Patrol road reconditioning up to once a year by placing, spreading, grading, and compacting aggregate base or substrate.

5. Visual inspection at least monthly, by driving on the patrol road on the crown and maintenance roads at the base of the levee.

6. Post-construction, groundwater levels would be monitored using the piezometers.

Flood risk reduction construction activities will primarily occur during the April 15 to October 31 time frame, although extension of the CVFPB encroachment permit may be sought if weather conditions permit. However, construction activities, including, but not limited to, structure and vegetation removal, roadway removal and replacement, revegetation, and utility removal and replacement, regardless of the construction season will be subject to the conditions of environmental and encroachment permits and authorizations to be issued by the California Department of Fish and Wildlife (CDFW), CV Regional Water Quality Control Board (RWQCB), CVFPB, the Corps, US Fish and Wildlife Service (USFWS), NMFS, Yolo County, City of West Sacramento, and others.

Construction of the Common Features Project is proposed to take approximately 13 years if each reach is constructed sequentially. The construction reaches have been prioritized based on a variety of factors, including the condition of the levee, the potential damages that will occur due to levee failure, and construction feasibility considerations, such as the availability of equipment at any given time. A summary of the flood risk reduction measures proposed as part of this study are included in Table 2.

Table 2. Proposed Measures for the Common Features GRR Project.

Waterway/Location	Extent of Action	Proposed Measure
American River	North and south levees from the confluence with the Sacramento River upstream for approximately 12 miles.	• Construct bank protection or launchable rock trenches
Sacramento River	East levee from the American River to Morrison Creek.	• Install cutoff walls • Construct bank protection • Construct levee raise
Dry/Robla Creek		• Raise floodwalls
Magpie Creek Diversion Canal	Upstream of Raley Boulevard	• Construct floodwalls
Magpie Creek area	South of Raley Boulevard	• Construct new levee
Magpie Creek area	East of Raley Boulevard	• Acquire property to create a flood detention basin • Widen the Raley Boulevard/Magpie Creek bridge and raise the elevation of the roadway • Remove the Don Julio Creek culvert
Sacramento Weir and Bypass	North bypass levee to 1,500 feet north.	• Widen the Sacramento Weir and Bypass by approximately 1,500 feet • Construct a new section of weir and levee • Remove the existing Sacramento Bypass north levee

The tentative schedule of construction is shown in Table 3. The durations are for construction activities only, and do not include the time needed for design, right-of-way, utility relocation, *etc*.

Table 3. Common Features GRR Project Construction Schedule.

PRIORITY	WATERWAY	REACH	YEAR OF PROJECT CONSTRUCTION												
			1	2	3	4	5	6	7	8	9	10	11	12	13
1	Sacramento River	ARS F													
2	Sacramento River	ARS E													
3	American River	ARS A													
4	Sacramento River	ARS G													
5	Sacramento River	ARS D													
6	American River	ARS B													
7	American River	ARN A													
8	American River	ARS C													
9	American River	ARN B													
10	Sacramento Weir & Bypass	--													
11	Dry/Robla Creek	ARN G													
12	Magpie Creek	ARN I													

Analysis of total linear feet (lf) of shaded riverine aquatic (SRA) habitat was conducted using Google Earth Pro for the reaches only associated with bank protection on the American and Sacramento Rivers in the Common Features GRR action area (Table 4). However, site specific conditions at proposed bank protection sites will evaluate SRA habitat values using the SAM method of analysis to determine impacts and onsite compensation value based on actual designs. The East Side Tributaries were not evaluated because no bank erosion protection is planned. It should be noted however that there is minimal, if any, SRA associated with the tributaries in the reaches where construction is proposed, except Arcade Creek. It is not anticipated that trees would need to be removed within the Sacramento Bypass as a result of the levee relocation effort, since the footprint of the expanded Bypass area is open farmland with no trees present. However, trees along the Sacramento River would be removed to construct the new 1,500 foot Sacramento Weir.

Identification of individual reaches in the Common Features GRR action area can be seen in Figure 1. American River North (ARN) reaches A through I includes the north side of the American River and the East Side Tributaries. American River South (ARS) reaches A through G includes the south side of the American River and the east side of the Sacramento River.

Table 4. SRA Reach Specific Summary

AMERICAN RIVER		SACRAMENTO RIVER	
REACH	**LINEAR FEET (lf) of SRA**	**REACH**	**LINEAR FEET (lf) of SRA**
A	31,174	D	9,643
B	7,259	E	7,709
C	6,934	F	21,263
		G	11,689
		Sac Weir	1,500
Total	**45,367**	**Total**	**51,804**

1.11 Vegetation Policy Compliance

Vegetation removal under the Common Features GRR project would be limited to no more than the upper one-half of the waterside of the levees therefore leaving the lower one-half or more of the trees in place on the Sacramento River within the study area. SRA would not be compromised, thus maximizing existing SRA values in the study area. No vegetation removal would be required within the existing or expanded Sacramento Bypass. New levees (such as setback levees) would be designed to be compliant with Corps levee vegetation policy. Consistent with the Central Valley Flood Protection Plan (CVFPP) guidance. Any vegetation removed as part of direct construction activities would not be replaced onsite if possible.

1.12 Interrelated and Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). In this case, there are no interrelated or interdependent actions.

The Folsom Dam Raise Project and subsequent Folsom Reoperation Project have the potential to increase the bank armoring and could exacerbate any impacts associated with the common Features GRR, but are not interrelated or interdependent actions because neither project depends on the other for their justification and they both have independent utility. The erosion issues within the American River Parkway is being addressed as part of the Folsom Reoperation Project currently under evaluation and a biological assessment is being prepared to initiate Section 7 consultation with both USFWS and NMFS.

1.13 Conservation Actions

The Corps will seek to avoid and minimize construction effects on listed species and their critical habitat to the extent feasible, and will implement on-site, and off-site compensation actions as necessary. Compensation time is the time required for on-site plantings to provide significant amounts of shade or structural complexity. Depending on project impacts, a project may incorporate various habitat and species benefits to compensate for short-term losses in habitat for listed species. Long-term compensation to offset short-term losses is generally not an option for the loss of critical habitats under the ESA (USFWS 1998a). The Corps uses the following compensation time periods (based loosely on life expectancy) as guidelines for compensation:

- Green sturgeon, 15 years;
- Chinook salmon, 5 years; and
- Central Valley steelhead, 4 years (Corps 2012).

1. Obtain an ETL approved vegetation variance exempting sites from vegetation removal prior to final design and construction phase for the Sacramento River.
2. Minimize the removal of existing vegetation in the proposed project area. Any disturbance or removal of vegetation will be replaced with native riparian vegetation, outside of the vegetation-free zone, as established in the ETL.
3. Implement best management practices (BMPs) to prevent slurry seeping out to river and require piping system on land side only.
4. The Corps will incorporate compensation for SRA habitat losses either by project constructed compensation sites or in combination with purchase of credits at a NMFS approved conservation bank where appropriate.
5. The Corps will seek an ETL-approved vegetation variance exempting the Sacramento River sites from vegetation removal in the lower one-third of the waterside of the levee prior to final construction and design phase. Construction may require removal of vegetation on the upper two-thirds of the waterside and landside slope. Full ETL compliance will occur on some of the American River reaches.
6. The Corps will use a rock soil mixture to facilitate re-vegetation of the project sites that require bank protection work. A (70:30) rock to soil ratio will be implemented. The soil-rock mixture will be placed on top of the of the rock revetment along the Sacramento River levees to allow native riparian vegetation to be planted to insure that SRA habitat lost is replaced or enhanced.
7. In addition to an approved vegetation variance, the Corps will minimize the removal of existing vegetation in the proposed project area. Disturbance or removal of trees or larger woody vegetation will be replaced with native riparian species, outside of the vegetation-free zone, as established in the ETL.
8. Levee repair designs will be analogous to those developed for an SRBPP repair site. These levee repair designs include installation of IWM, native vegetation planting, incorporation of soil with the rock, *etc*.
9. Construction will be scheduled when listed terrestrial and aquatic species will be least likely to occur in the project area. If construction needs to extend into the timeframe that species are present coordination with the resource agencies will occur.

10. Stockpile construction materials such as portable equipment, vehicles, and supplies, at designated construction staging areas and barges, exclusive of any riparian and wetlands areas.
11. Stockpile all liquid chemicals and supplies at a designated impermeable membrane fuel and refueling station with a containment system.
12. Erosion control measures including Storm Water Pollution Prevention Program (SWPPP) and Water Pollution Control Program that minimize soil or sediment from entering the river. BMPs shall be installed, monitored for effectiveness, and maintained throughout construction operations to minimize effects to Federally listed fish and their designated critical habitat.
13. Site access will be limited to the smallest area possible in order to minimize disturbance.
14. Litter, debris, unused materials, equipment, and supplies will be removed from the project area daily. Such materials or waste will be deposited at an appropriate disposal or storage site.
15. Immediately (within 24 hours) cleanup and report 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.
16. 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.
17. Vegetation removed as a part of ETL compliance will be compensated on site, outside of the vegetation-free zone, to the extent feasible. When on-site compensation is not feasible, compensation is proposed at local conservation banks with available credits. If credits are not available locally, then compensation is proposed to occur within the West Sacramento city limits.
18. The Corps will compensate for any short and longer term impacts through additional onsite compensation, purchase of compensatory conservation credits, or development of suitable created aquatic habitat.
19. Screen any water pump intakes.
20. The Corps will work with local cost share sponsors to ensure GRR-related future flood risk reduction actions related to widening the Sacramento Weir shall fully mitigate upstream and downstream fish passage effects at the weir and within the spillway basin.
21. The goal is to ensure that adult CV spring-run and Sacramento River inter-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are able to migrate upstream while the weir is spilling into the bypass and that juvenile stranding in the spillway basin is minimized to the maximum extent possible.
22. The Corps shall ensure the widening of the Sacramento Bypass is designed and constructed to minimize stranding of fish in the depressions wound within the bypass though grading or construction of drainage channels.
23. The goal is to ensure that the bypass is designed and constructed in a manner that reduces adult and juvenile stranding to the maximum extent possible.

A number of measures will be applied to the entire Common Features Project or specific actions, and other measures may be appropriate at specific locations within the Common Features Project study area. Avoidance activities to be implemented during final design and construction may include, but are not limited to, the following:

1. Identifying all habitats utilized by listed terrestrial, wetland, and plant species in the potentially affected project areas. To the extent practicable efforts will be made to minimize effects by modifying engineering design to avoid potential direct and indirect effects.
2. Incorporating sensitive habitat information into project bid specifications.
3. Incorporating requirements for contractors to avoid identified sensitive habitats into project bid specifications.
4. Minimizing vegetation removal to the extent feasible.
5. Minimizing, to the extent possible, grubbing and contouring activities.
6. Where feasible compensating for impacts close to where impacts have occurred.

1.14 Additional Conservation Measures for sDPS Green Sturgeon

Through collaboration with NMFS, the Corps has updated the project description in the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) and will implement the following additional measures that have been coordinated with NMFS to reduce impacts to green sturgeon habitat.

1. The Corp's final Environmental Impact Statement/Environmental Impact Report for the American River Common Features GRR shall include a proposal to develop a green sturgeon habitat, mitigation, and monitoring plan (HMMP) with the specific elements that are described below.

   The goal of the developing the HMMP is to ensure that adverse impacts of future American River Common Features GRR projects on sDPS green sturgeon are fully mitigated in order to maintain the growth, survival and recovery of the species in the study area.

2. The green sturgeon HMMP shall be developed in coordination with the IEP green sturgeon project work team and consulted on with NMFS prior to the construction of any work within the designated critical habitat of sDPS green sturgeon related to the American River Common Features GRR. The HMMP should focus on filling important data gaps on green sturgeon life history and micro and macro habitat ecology in both the Sacramento River and the north Delta within the project impact area, in regard to how bank stabilization measures proposed in the American River Common Features GRR affect sturgeon ecology and survival, particularly in regard to juvenile rearing and survival.

   The goal of this conservation measure is to leverage the resources of the IEP to develop an HMMP that utilizes and applies the best available scientific expertise and information available.

3. The Corps shall either refine the SAM or develop an alternative green sturgeon survival and growth response model based on using and updating the existing Hydrologic Engineering Center Ecosystem Function Model (HEC-EFM) that reflects green sturgeon's preference for benthic habitat and that accounts for the physical loss of habitat from revetment footprints instead of the convention used by the SAM where the fish response is evaluated at the intersect of seasonal water surface elevations. The new modeling may include hydraulic modeling, but must be capable of evaluating green sturgeon survival in response to levee repair projects in the project impact area and their effects on all habitat conditions, not exclusively flow changes. Development of the model shall be initiated at the start of the preconstruction engineering and design (PED) phase of the American River Common Features GRS and shall be peer reviewed by sturgeon experts on the IEP, other academia with sturgeon expertise and be consulted on with NMFS.

   The goal of this measure is to develop a functional assessment methodology using the best available scientific expertise and information available to model the effects of future American River Common Features GRR actions and evaluate the performance of mitigation actions relative to the survival and growth of sDPS green sturgeon that are exposed to such actions.

4. The HMMP shall also, restore or compensate for the number of acres and ecological function of soft bottom benthic substrate for sDPS green sturgeon permanently lost to project construction. This mitigation shall be coordinated with the Interagency Working Group (IWG) or a Bank Protection Working Group (BPWG) and must be carried out within the lower Sacramento River/North Delta in order to offset the adverse modification to designated critical habitat. The restored habitat must be capable of providing abundant benthic prey freshwater or estuarine areas; with adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth and viability of all life stages; and provide safe and unobstructed migratory pathways are necessary for timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats. The restoration/mitigation shall be initiated prior to commencement of construction within the designated critical habitat of sDPS green sturgeon for the American River Common Features GRR and the updated model should be used to validate performance. The restoration site and plan shall be developed in coordination with the IEP and be consulted on with NMFS.

   The goal is to ensure the spatial and temporal ecological impacts from project-related permanent loss of critical habitat for green sturgeon critical for juvenile green sturgeon are fully compensated.

5. The green sturgeon HMMP shall also be developed with measurable objectives for completely offsetting all adverse impacts to all life stages of sDPS green sturgeon (as modeled using refined approaches described in RPA action 3, above, and considering design refinements that occur in the PED phase of project implementation).

The goal of this measure is to develop "SMART" objectives for mitigation. "SMART" objectives are specific (target a specific area for improvement), measurable (quantify or suggest an indicator of progress), attainable (specify who will do the work and if possible how), realistic (state what results can realistically be achieved, given available resources) and timely (specify when the results can be achieved) habitat performance objectives for green sturgeon mitigation.

6. Mitigation actions shall be initiated prior to the construction activities affecting sDPS green sturgeon and their critical habitat. Specific mitigation plans may be developed during project design engineering to reduce the specific impacts of levee construction actions.

   The goal of this measure is to ensure that mitigation coincides with project implementation and to minimize, to the maximum extent possible, extended temporal effects.

7. The sDPS green sturgeon HMMP will include measurable performance standards at agreed upon intervals and will be monitored for a period of at least ten years following construction. If additional monitoring is necessary, the monitoring shall be included in the project O&M plan and carried out by the local sponsor. The HMMP will include adaptive management strategies for correcting any mitigation measures that do not meet performance standards.

   The goal of this measure it to provide a reasonable amount of time to measure performance standards after mitigation occurs to ensure that it meets the objectives of the HMMP.

1.5 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area for the Common Features GRR includes: (1) approximately 12 miles of the north and south banks of the American River immediately upstream from the confluence with the Sacramento River; (2) the east bank of the Natomas East Main Drainage Canal (NEMDC), Dry, Robla, and Arcade Creeks and the Magpie Creek Diversion Channel (collectively referred to as the East Side Tributaries); (3) the east bank of the Sacramento River downstream from the American River to Freeport, where the levee ties into Beach Lake Levee, the southern defense for Sacramento; and (4) the Sacramento Weir and Bypass, located along the north edge of the city of West Sacramento (Figure 1).

The action area includes perennial waters of the Sacramento River extending 200 feet perpendicular from the average summer-fall shoreline and 1,000 feet downstream from proposed in-water construction areas. This represents the potential area of turbidity and sedimentation effects based on the reported limits of visible turbidity plumes in the Sacramento River during similar construction activities (NMFS 2008).

ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

2.1 Analytical Approach

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

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This BO does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[1]

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

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

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

2.1.1 Use of Analytical Surrogates

The effects of the Common Features GRR are primarily analyzed using Standard Assessment Methodology (SAM). The Corps provided the background data, assumptions, analyses, and assessment of habitat compensation requirements for the federally protected fish species relevant to this consultation.

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.

It is a computational modeling and tracking tool that evaluates bank protection alternatives by taking into account several key factors affecting threatened and endangered fish species. By identifying and then quantifying the response of focal species to changing habitat conditions over time, project managers, biologists and design engineers can make changes to project design to avoid, minimize, or compensate for impacts to habitat parameters that influence the growth and survival of target fish species by life stage and season. The model is used to assess species responses as a result of changes to habitat conditions, either by direct quantification of bank stabilization design parameters (*e.g.,* bank slope, substrate).

In 2003, the Corps established a program to carry out "a process to review, improve, and validate analytical tools and models for USACE Civil Works business programs". Reviews are conducted to ensure that planning models used by the Corps are technically and theoretically sound, computationally accurate, and in compliance with the Corps planning policy. As such, all existing and new planning models developed by the Corps are required to be certified through the appropriate Planning Center of Expertise and Headquarters in accordance with Corps rules and procedures.

The assumptions, model variables, and modeling approaches used in the SAM have been developed to be adapted and validated through knowledge gained from monitoring and experimentation within the SRBPP while retaining the original overall assessment method and framework. The first update to the SAM included the addition of sDPS green sturgeon as well as a number of modifications to modeled-species responses based upon updated literature reviews and recent monitoring efforts at completed bank protection sites (Stillwater Sciences 2009, USACE 2009).

In late 2010, the certification process for the SAM was initiated by the Corps, Sacramento District in coordination with the Ecosystem Planning Center of Expertise. The process entailed charging a panel of six experts to review the SAM, along with the SAM (version 3.0). The Review Panel was composed of a plan formulation expert, fisheries biologist, aquatic ecologist, geomorphologist/geologist, population biologist/modeling expert, and software programmer.
A major advantage of the SAM is that it integrates species life history and seasonal flow-related variability in habitat quality and availability to generate species responses to project actions over time. The SAM systematically evaluates the response of each life stage to habitat features affected by bank protection projects.

The SAM quantifies habitat values in terms of a 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 attributes (described below) and the species and life stage responses. Species response indices vary from 0 to 1, with 0 representing unsuitable conditions and 1 representing optimal conditions for survival, growth, and/or reproduction. 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 habitat attribute 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 linear feet or area of shoreline to which it applies to generate a weighted species response index expressed in feet or square feet. The species WRI provides a common metric that can be used to quantify habitat values over time, compare project conditions to existing conditions, and evaluate the effectiveness of on-site and off-site compensation actions.

The WRI represent an index of a species growth and survival based on a 30-day exposure to post project conditions over the life of the project. As such, negative SAM values can be used as a surrogate to quantify harm to a target fish species by life stage and season. Also, although SAM values represent and index of harm to a species, since the values are expressed as "weighted bankline feet" or "weighted area", these values can be used to help quantify compensatory conservation actions such as habitat restoration, and are used for that purpose in this BO.

During the process of this consultation, the Corps and NMFS identified several short comings with the SAM as a tool for reliably forecasting the growth and survival of green sturgeon. The primary short coming is that the SAM evaluates habitat conditions at the seasonal water surface intersect with the river bank. While this is considered an effective point for measuring salmon and steelhead habitat, green sturgeon have a greater affinity for benthic habitat than shoreline habitat. Further, during discussions between the Corps and NMFS, it was widely agreed upon that levee repair actions in the West Sacramento Study Area are likely to only affect the juvenile rearing life stage and probably have little to no adverse impacts on the adult life stages of green sturgeon because spawning habitat is not present and adults that are migrating upstream are probably more influenced by impacts that affect swimming speed and upstream passage than shoreline habitat manipulations. Because of this, NMFS has decided to use the SAM as a proxy for quantifying habitat disturbance and harm and use as an ecological surrogate for quantifying the amount and extent of take for juvenile rearing and migrating green sturgeon, but the precision is not as sharp as for salmon and steelhead. Therefore, a new model will be developed to determine compensatory mitigation actions and tracking performance.

2.1.2 Compensation Timing

As described in the proposed action, projects such as this often propose compensation for unavoidable short-term effects to species and impacts to habitat. These compensation timeframes are generally based on anticipated SAM response time. Under the Corps BA, compensation timing is defined and in practice adopts an approach that the SAM modeled impact at the proposed timing (Green sturgeon: 15 years: Chinook salmon, 5 years: Central Valley steelhead, 4 years) is sufficient to compensate for project effects. NMFS adopts a slightly different approach to the analysis of the BO in that the compensation time should be a target for avoiding exposure of more than one generation of a population with a multiple age class structure. Negative SAM-modeled values beyond those years, especially at winter and spring water surface elevations, may have significant effects to the species and impacts to critical habitat that would reduce the species survival and recovery in the wild or substantially reduce the conservation value of the species because the adverse effects (reduced growth and survival of individuals) would begin to reduce the number of reproducing individuals across multiple generations. In some cases, negative SAM values extend beyond these compensation periods, in which case offsite compensatory mitigation can reduce the long-term effects to a species survival and recovery by creating high quality habitat conditions in areas that provide high ecological value for the species. Because we have determined the SAM model is not a strong representation of green sturgeon growth and survival response, we are applying the implementation of the USACE Green Sturgeon Conservation Measures As key actions necessary to both avoid reducing the survival and recovery of the species in the wild and reducing the conservation value of critical habitat, instead of applying a specific compensation time period for green sturgeon. As such, this BO applies the following compensation timing as general targets for avoiding such long-term effects to salmon and steelhead:

1. Chinook salmon, 5 years;
2. Central Valley steelhead, 4 years

2.2 Rangewide Status of the Species and Critical Habitat

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

One factor affecting the rangewide status of the CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon, and aquatic habitat at large is climate change.

The following federally listed species and designated critical habitats occur in the action area and may be affected by the proposed action:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchu tshawytscha*) Listed as endangered (70 FR 37160, June 28, 2005)

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

CV spring-run Chinook salmon ESU (*O. tshawytscha*)
Listed as threatened (70 FR 37160, June 28, 2005)

CV spring-run Chinook salmon designated critical habitat (70 FR 52488, September 2, 2005)

CCV steelhead DPS (*O. mykiss*)
Listed as threatened (71 FR 834, January 5, 2006)

CCV steelhead designated critical habitat
(70 FR 52488, September 2, 2005)

Southern DPS of North American green sturgeon (*Acipenser medirostris*)
Listed as threatened (71 FR 17757, April 7, 2006)

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

Critical habitat designations identify those physical and biological features of the habitat that are essential to the conservation of the species and that may require special management consideration or protection. Within the Common Features GRR this includes the river water, river bottom, 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 is defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of one to two years on the annual flood series) used by listed salmonids and sturgeon.

NMFS has recently completed an updated status review of five Pacific salmon ESUs and one steelhead DPS, including Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead, and concluded that the species' status should remain as previously listed (76 FR 50447; August 15, 2011). The 2011 status reviews (NMFS 2011a, 2011b, 2011c) additionally stated that, although the listings should remain unchanged, the status of these populations have worsened over the past five years since the 2005/2006 reviews and recommended that status be reassessed in two to three years as opposed to waiting another five years.

2.2.1 Sacramento River Winter-run Chinook salmon

The Sacramento River winter-run Chinook salmon (winter-run *Oncorhynchus tshawytscha*) ESU, currently listed as endangered, was listed as a threatened species under emergency provisions of the ESA on August 4, 1989 (54 FR 32085) and formally listed as a threatened species in November 1990 (55 FR 46515). On January 4, 1994 (59 FR 440), NMFS re-classified winter-run as an endangered species. NMFS concluded that winter-run in the Sacramento River warranted listing as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its first listing as a threatened species in 1989;

(2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the "take" of winter-run (August 15, 2011, 76 FR 50447).

On June 28, 2005, NMFS concluded that the winter-run ESU was "in danger of extinction" due to risks to the ESU's diversity and spatial structure and, therefore, continues to warrant listing as an endangered species under the ESA (70 FR 37160). In August 2011, NMFS completed a 5-year status review of five Pacific salmon ESUs, including the winter-run ESU, and again determined that the species' status should remain as "endangered" (August 15, 2011, 76 FR 50447). The 2011 review concluded that although the listing remained unchanged since the 2005 review, the status of the population had declined over the past five years (2005–2010).

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

Life History

1. <u>Adult Migration and Spawning</u>

Winter-run exhibit a unique life history pattern (Healey 1994) compared to other salmon populations in the CV (*i.e.*, spring-run, fall-run, and late-fall run), in that they spawn in the summer, and the juveniles are the first to enter the ocean the following winter and spring. Adults first enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate up the Sacramento River, past the RBDD from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type (Table 5; Yoshiyama *et al.* 1998, Moyle 2002).

Winter-run tend to enter freshwater while still immature and travel far upriver and delay spawning for weeks or months upon arrival at their spawning grounds (Healey 1991). Spawning occurs primarily from mid-May to mid-August, with the peak activity occurring in June and July in the upper Sacramento River reach (50 miles) between Keswick Dam and RBDD (Vogel and Marine 1991). Winter-run deposit and fertilize eggs in gravel beds known as redds excavated by the female that then dies following spawning. Average fecundity was 5,192 eggs/female for the 2006–2013 returns to LSNFH, which is similar to other Chinook salmon runs [*e.g.*, 5,401 average for Pacific Northwest (Quinn 2005)]. Chinook salmon spawning requirements for depth and velocities are broad, and the upper preferred water temperature is between 55–57°F (13–14°C) degrees (Snider *et al.* 2001). The majority of winter-run adults return after three years.

Table 5. The temporal occurrence of adult (a) and juvenile (b) winter-run in the Sacramento River. Darker shades indicate months of greatest relative abundance.

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

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

2. <u>Eggs/Fry Emergence</u>

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

3. <u>Juvenile/Outmigration</u>

Juvenile winter-run have been found to exhibit variability in their life history dependent on emergence timing and growth rates (Beckman *et al.* 2007). Following spawning, egg incubation, and fry emergence from the gravel, juveniles begin to emigrate in the fall. Some juvenile winter-run migrate to sea after only 4 to 7 months of river life, while others hold and rear upstream and spend 9 to 10 months in freshwater. Emigration of juvenile winter-run fry and pre-smolts past RBDD (RM 242) may begin as early as mid-July, but typically peaks at the end of September (Table 5), and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997).

4. Estuarine/Delta Rearing

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

5. Ocean Rearing

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

Description of Viable Salmonid Population (VSP) Parameters

1. Abundance

Historically, winter-run population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (NMFS 2011). In recent years, since carcass surveys began in 2001 (Figure 3), the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. However, from 2007 to 2012, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011 (Figure 3). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley *et al.* 2009), drought conditions from 2007-2009, and low in-river survival (NMFS 2011a). In 2013, the population increased to 6,075 adults, well above the 2007–2012 average, but below the high for the last ten years.

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

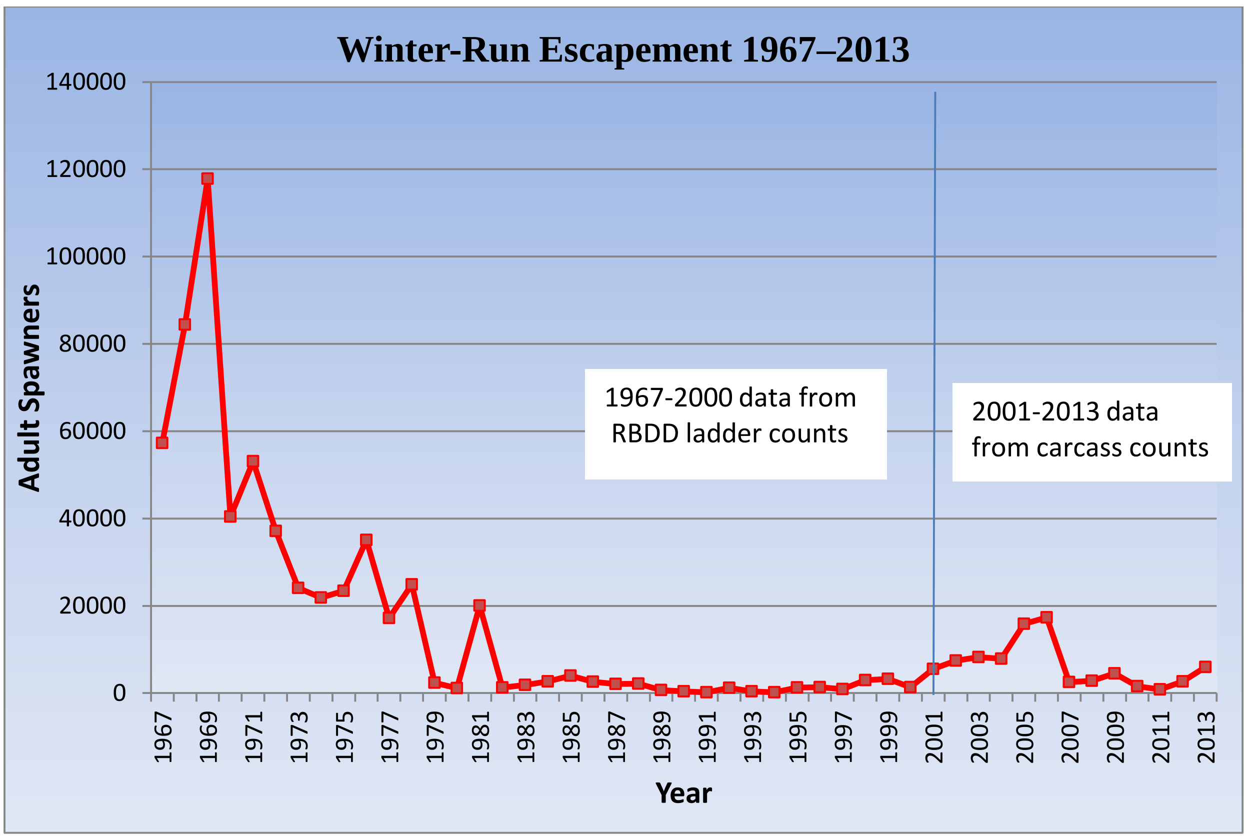

Figure 2. Winter-run Chinook salmon escapement numbers 1970-2013, includes hatchery broodstock and tributaries, but excludes sport catch. RBDD later counts used pre-2000, carcass surverys post 2001(3).

2. Productivity

ESU productivity was positive over the period 1998–2006, and adult escapement and juvenile production had been increasing annually until 2007, when productivity became negative (Figure 4) with declining escapement estimates. The long-term trend for the ESU, therefore, remains negative, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on cohort replacement rate (CRR) for the period 2007–2012 suggests a reduction in productivity (Figure 4), and indicates that the winter-run population is not replacing itself. In 2013, winter-run experienced a positive CRR, possibly due to favorable in-river conditions in 2011 (a wet year), which increased juvenile survival to the ocean.

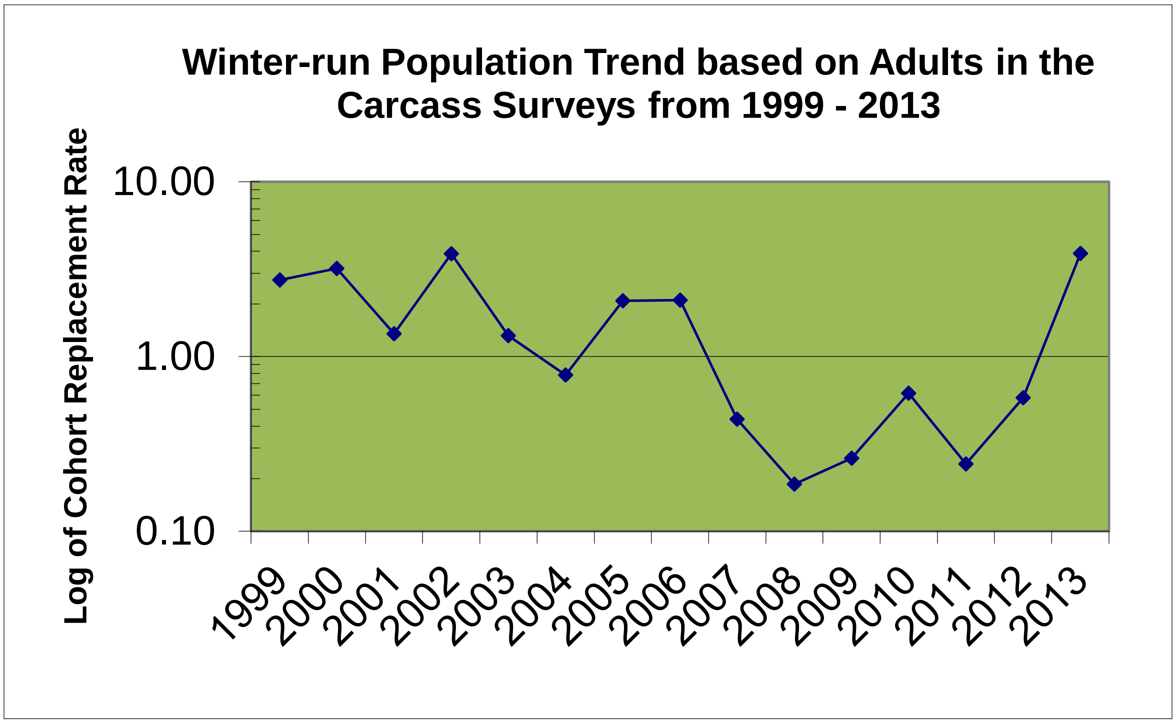

Figure 3. Winter-run population trend using cohort replacement rate derived from adult escapement, including hatchery fish, 1986–2013.

An age-structured density-independent model of spawning escapement by Botsford and Brittnacher (1998) assessing the viability of winter-run found the species was certain to fall below the quasi-extinction threshold of three consecutive spawning runs with fewer than 50 females (Good *et al.* 2005). Lindley and Mohr (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the growth rate for the winter-run population improved up until 2006, it exhibits the typical variability found in most endangered species populations. The fact that there is only one population, dependent upon cold-water releases from Shasta Dam, makes it vulnerable to periods of prolonged drought (NMFS 2011). Productivity, as measured by the number of juveniles entering the Delta, or juvenile production estimate (JPE), has declined in recent years from a high of 3.8 million in 2007 to 1.1 million in 2013 (Table 6). Due to uncertainties in the various factors, the JPE was updated in

2010 with the addition of confidence intervals (Cramer Fish Sciences model), and again in 2013 with a change in survival based on acoustic tag data (NMFS 2014). However, juvenile winter-run productivity is still much lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

Table 6. Winter-run adult and juvenile population estimates based on RBDD counts (1986–2001) and carcass counts (2001–2013), with corresponding 3-year-cohort replacement rates

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

[a] Population estimates include adults taken into the hatchery and were based on ladder counts at RBDD until 2001, after which the methodology changed to carcass surveys (CDFG 2012).

[b] Assumes all adults return after three years. NMFS calculated a CRR using the adult spawning population, divided by the spawning population three years prior. Two year old returns were not used.

[c] JPE estimates include survival estimates from the spawning gravel to the point where they enter the Delta (Sacramento I St Bridge), but does not include through-Delta survival.

3. Spatial Structure

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

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

4. Diversity

The current winter-run population is the result of the introgression of several stocks (*e.g.*, spring-run and fall-run Chinook) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam which blocked access and did not allow spatial separation of the different runs (Good *et al.* 2005). Lindley *et al.* (2007) recommended reclassifying the winter-run population extinction risk from low to moderate, if the proportion of hatchery origin fish from the LSNFH exceeded 15 percent due to the impacts of hatchery fish over multiple generations of spawners. Since 2005, the percentage of hatchery winter-run recovered in the Sacramento River has only been above 15 percent in two years, 2005 and 2012 (Figure 5).

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

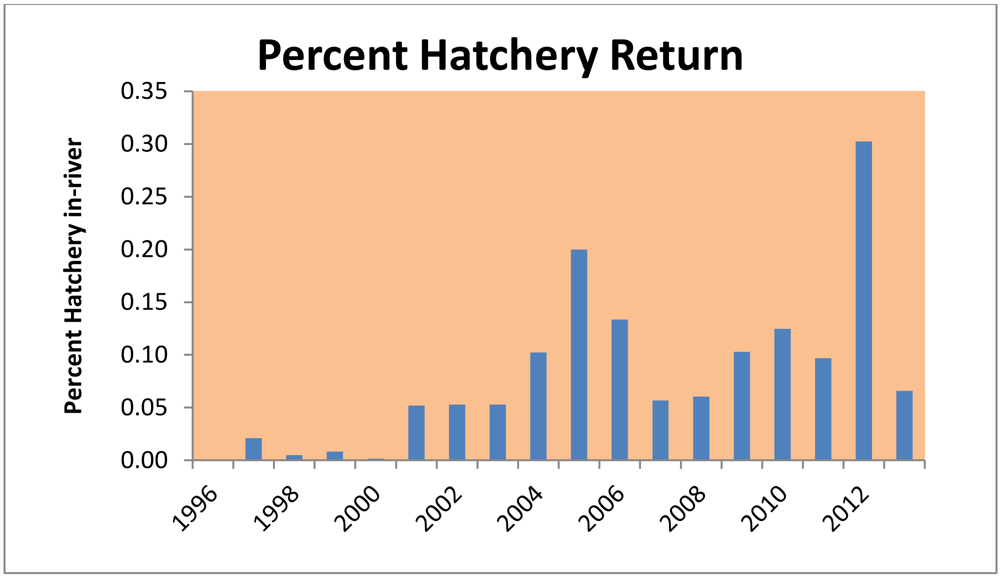

Figure 4. Percentage of hatchery-origin winter-run Chinook salmon naturally spawning in the Sacramento River (1996–2013). Source: CDFW carcass surveys, 2013.

Summary of Sacramento River Winter-run Chinook Salomon ESU Viability

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

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

NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). Critical habitat was delineated as the Sacramento River from Keswick Dam at river mile (RM) 302 to Chipps Island, RM 0, at the westward margin of the Sacramento-San Joaquin Delta (Delta), including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge. In the Sacramento River, critical habitat includes the river water, river bottom, and the adjacent riparian zone.

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

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

1. <u>Access from the Pacific Ocean to Appropriate Spawning Areas</u>

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

2. <u>The Availability of Clean Gravel for Spawning Substrate</u>

Suitable spawning habitat for winter-run exists in the upper 60 miles of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD). However, the majority of spawning habitat currently being used occurs in the first 10 miles downstream of Keswick Dam.

The available spawning habit is completely outside the historical range utilized by winter-run upstream of Keswick Dam. Because Shasta and Keswick dams block gravel recruitment, the U.S. Bureau of Reclamation (Reclamation) annually injects spawning gravel into various areas of the upper Sacramento River. With the supplemented gravel injections, the upper Sacramento River reach continues to support a small naturally-spawning winter-run Chinook salmon population. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

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

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

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

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

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

5. Habitat and Adequate Prey Free of Contaminants

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

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

6. Riparian and Floodplain Habitat that Provides for Successful Juvenile Development and Survival

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

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

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

Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. Unscreened diversions that entrain juvenile salmonids are prevalent throughout the mainstem Sacramento River and in the Delta. Predators such as striped bass (*Morone saxatilis*) and Sacramento pikeminnow (*Ptychocheilus grandis*) tend to concentrate immediately downstream of diversions, resulting in increased mortality of juvenile Chinook salmon.

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

2.2.2 Central Valley Spring-run Chinook salmon

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

CV spring-run Chinook salmon were listed as threatened on September 16, 1999, (64 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent modification of the CV spring-run Chinook salmon listing status (70 FR 37160). Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005, (70 FR 52488), and includes the action area for the Proposed Action. It includes stream reaches of the Feather and Yuba rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the main stem of the Sacramento River from Keswick Dam through the Delta; and portions of the network of channels in the northern Delta.

Historically spring-run Chinook salmon were the second most abundant salmon run in the CV and one of the largest on the west coast (CDFG 1990, 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 feet elevation) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The CV Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions (diversity groups) (Lindley *et al.* 2004). Of these 18 populations, only 3 extant populations currently exist (Mill, Deer, and Butte creeks on the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. All populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated. The northwestern California diversity group did not historically contain independent populations, and currently contains two or three populations that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

Construction of low elevation dams in the foothills of the Sierras on the Mokelumne, Stanislaus, Tuolumne, and Merced rivers, was thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American and Yuba rivers of the Sacramento River basin. However, observations in the last decade suggest that perhaps a naturally occurring population may still persist in the Stanislaus and Tuolumne rivers (Franks, personal communication, 2012), as well as in the Yuba River. Documented naturally-spawning populations of CV spring-run Chinook salmon are currently restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and the Yuba River (CDFG 1998).

Life History

Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River beginning in March (Yoshiyama 1998). Spring-run Chinook salmon move into tributaries of the Sacramento River (*e.g.* Butte, Mill, Deer creeks) beginning as early as February in Butte Creek and typically mid-March in Mill and Deer creeks (Lindley *et al.* 2004). Adult migration peaks around mid-April in Butte Creek, and mid-to end of May in Mill and Deer creeks, and is complete by the end of July in all three tributaries (Lindley *et al.* 2004) (Table 7). Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al.* 1998).

Spring-run Chinook salmon spawning occurs between September and October (Moyle 2002). Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year or as juveniles or yearlings. The model size of fry migrants at approximately 40 millimeters (mm) between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2004). Studies in Butte Creek, (Ward *et al.* 2003, McReynolds *et al.* 2007) found the majority of CV spring-run Chinook salmon migrants to be fry, which occurred primarily during December, January, and February; and that these movements appeared to be influenced by increased flow. Small numbers of CV spring-run Chinook salmon were observed to remain in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al.* 2004). CDFW (CDFG 1998) observed the emigration period for spring-run Chinook salmon extending from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period. Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also would disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow larger. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002).

Table 7. 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.

Table 7

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

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

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

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

Description of VSP Parameters

Like the winter-run Chinook salmon population, the CV spring-run Chinook salmon population fails to meet the "representation and redundancy rule" since there are only one demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them. Over the long term, these remaining populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount

Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other.

1. Abundance

The CV drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported large runs of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam began in 1939 and was completed in 1942, which blocked access to upstream habitat.

The FRFH spring-run Chinook salmon population has been included in the ESU based on its genetic linkage to the natural population and the potential development of a conservation strategy for the hatchery program. On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRFH. Since 1954, spawning escapement has been estimated using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 2 fish in 1978 (DWR 2001). Spring-run estimates after 1981 have been based solely on salmon entering the hatchery during the month of September. The 5-year moving averages from 1997 to 2006 had been more than 4,000 fish, but from 2007 to 2011, the 5-year moving averages have declined each year to a low of 1,783 fish in 2011 (CDFG 2012). However, coded wire tag (CWT) information from these hatchery returns has indicated that fall-run and spring-run Chinook salmon have overlap (DWR 2001). In addition, genetic testing has indicated substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (DWR 2001). Because Chinook salmon have not always been spatially separated in the FRFH, spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock (Good *et al.* 2005; DWR draft Hatchery Genetic Management Plan 2010). For the reasons discussed above, the Feather River spring-run Chinook salmon population numbers are not included in the following discussion of ESU abundance.

In addition, monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem very difficult to determine, but counts of early spawning Chinook salmon redds are typically used as an indicator of abundance. Less than 15 redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (USFWS 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 salmon redds from Keswick Dam downstream to the RBDD, ranging from three to 105 redds (CDFG, unpublished data, 2011). Therefore, even though physical habitat conditions can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely to have caused extensive introgression between the populations (CDFG 1998). For these reasons, Sacramento River mainstem spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the primary independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998. Tributary numbers during 2005 to 2011 showed a downturn; however, 2012 and 2013 showed an increase to 10,810 and 18,499 fish, respectively. Escapement numbers for 2013 increased in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1960. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish from 1995 to 2005. During this same period, adult returns on Mill and Deer creeks have averaged 780 fish, and 1,464 fish respectively. From 2001 to 2005, the CV spring-run Chinook salmon ESU has experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remains well below estimates of historic abundance.

In 2002 and 2003, mean water temperatures in Butte Creek exceeded 21°C for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris Disease (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to the pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek due to the disease. Since 2005, abundance numbers in most of the tributaries have declined. From 2006 to 2009, adult returns indicate that population abundance is declining from the peaks seen in the 5 years prior for the entire Sacramento River basin.

For Mill Creek the 2009, return of 220 spring-run Chinook salmon was the lowest return since 1997. Assuming the 2012, spring-run Chinook salmon return was primarily of three year old fish, then those 768 Chinook salmon represent a significant increase over the 2009, parent year. The 2013 estimate was 644, which was an increase from 2010 estimate of 482. The Mill Creek population of spring-run Chinook salmon is currently at a moderate risk of extinction, due to the significant decline in abundance from prior to 2008 through 2011. However, with the increase in abundance in 2012 and 2013, this trend may be improving. The Deer Creek abundance of spring-run Chinook salmon experienced a significant decline starting in 2008, with an increase in 2012 and 2013.

The abundance of spring-run Chinook salmon in Clear Creek was lower in 2010, 2011, and from 2005 through 2011, abundance numbers in most of the tributaries declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin was declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011). Butte Creek had sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer and Mill creeks (NMFS 2011). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. Year 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 adult escapement numbers combined for Butte, Mill and Deer creeks increased (over 17,000), which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. 2014 adult escapement was lower than 2013 to be lower, with an adult escapement of just over 5,000 fish, which indicates a highly fluctuating and unstable ESU.

1. Productivity

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

2. Spatial Structure

With only one of four diversity groups currently containing viable populations, the spatial structure of CV spring-run Chinook salmon is severely reduced. Butte Creek spring-run Chinook salmon cohorts have recently utilized all currently available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The persistent populations in Clear Creek and Battle Creek, with habitat restoration completed and underway are anticipated to add to the spatial structure of the CV spring-run Chinook salmon ESU if they can reach viable status in the basalt and porous lava and northwestern California diversity group areas. The spatial structure of the spring-run Chinook salmon ESU would still be lacking with the extirpation of all San Joaquin River basin spring-run Chinook salmon populations. Plans are underway to re-establish a spring-run Chinook salmon experimental population downstream of Friant Dam in the San Joaquin River, as part of the San Joaquin River Settlement Agreement. This would be done with Feather River Hatchery stock. Interim flows for this began in 2009. Its long-term contribution to the CV spring-run Chinook salmon ESU is uncertain. It is clear that further efforts would need to involve more than restoration of currently accessible watersheds to make the ESU viable. The draft CV Recovery Plan calls for reestablishing populations into historical habitats currently blocked by large dams, such as a population upstream of Shasta Dam. It also calls to facilitate passage of fish upstream and downstream of Englebright Dam on the Yuba River (NMFS 2009b).

3. Diversity

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

Summary of CV Spring-run Chinook salmon DPS Viability

Lindley et al. (2007) indicated that the spring-run Chinook salmon populations in the CV had a low risk of extinction in Butte and Deer creeks, according to their population viability analysis (PVA) model and other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence, which correlate with VSP parameters abundance, productivity, spatial structure, and diversity). The Mill Creek population of spring-run Chinook salmon was at moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the CV spring-run Chinook salmon population failed to meet the "representation and redundancy rule" since there are only demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them. Over the long term, these remaining populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

In the 2011 California CV status review for spring-run Chinook salmon, NMFS identified the status of CV spring-run Chinook salmon ESU as having probably deteriorated since the 2005 status review and Lindley et al.'s (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Since the abundance of some populations is improving, though this is based on only two years (2012 and 2013), the extinction risk of Sacramento tributary populations generally has improved from high to moderate.

Critical Habitat and Primary Constituent Elements for CV Spring-Run Chinook Salmon

Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005, (70 FR 52488). Critical habitat for CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of one to two years on the annual flood series) (Bain and Stevenson 1999; 70 FR 52488). Critical habitat for CV spring-run Chinook salmon is defined as specific areas that contain the primary constituent elements (PCEs) essential to the conservation of the species. Following are the inland habitat types used as PCEs for CV spring-run Chinook salmon.

1. Spawning Habitat

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

2. Freshwater Rearing Habitat

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

Freshwater rearing habitat also has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment.

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For adults, upstream passage through the Delta and much of the Sacramento River is not a problem, yet a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PCE. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

4. Estuarine Areas

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

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

2.2.3 California Central Valley steelhead

CCV steelhead were listed as threatened on March 19, 1998, (63 FR 13347). Following a new status review (Good *et al.* 2005) and after application of the agency's hatchery listing policy, the NMFS reaffirmed its status as threatened and also listed several hatchery stocks as part of the DPS in 2006 (71 FR 834). In June 2004, after a complete status review of 27 west coast salmonid ESUs, the NMFS proposed that CCV steelhead remain listed as threatened (69 FR 33102). On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the

DPS policy to the listed steelhead ESUs because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS (71 FR 834). On August 15, 2011, the NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2011a).

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

Life History

1. Migratory Forms Present in CV

Steelhead in the CV historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning. Between 1944 and 1947, annual counts of summer-run steelhead passing through the Old Folsom Dam fish ladder during May, June, and July ranged from 400 to 1,246 fish (Gerstung 1971). After 1950, when the fish ladder at Old Folsom Dam was destroyed by flood flows, summer-run steelhead were no longer able to access their historic spawning areas, and either perished in the warm water downstream of Old Folsom Dam or hybridized with winter-run steelhead. Only winter-run (ocean maturing) steelhead currently are found in California CV rivers and streams (Moyle 2002; McEwan and Jackson 1996). Summer-run steelhead have been extirpated due to a lack of access to suitable holding and staging habitat, such as coldwater pools in the headwaters of CV streams, presently located upstream of impassible dams (Lindley *et al.* 2006).

2. Age Structure

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

3. Egg to Parr Stages

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

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

4. Preferred Juvenile Habitat

Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or bolders. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Optimal water temperatures for growth range from 15°C to 20°C (McCullough *et al.* 2001, Spina 2006).

5. Smolt Migration

Juvenile steelhead will often migrate downstream as parr in the summer or fall of their first year of life (USFWS 2002), but this is not a true smolt migration (Loch *et al.* 1988). Smolt migrations occur in the late winter through spring, when juveniles have undergone a physiological transformation to survive in the ocean, and become slender in shape, bright silvery in coloration, with no visible parr marks. Emigrating steelhead smolts use the lower reaches of the Sacramento River and the Delta primarily as a migration corridor to the ocean. There is little evidence that they rear in the Delta or on floodplains, though there are few behavioral studies of this life-stage in the CV.

6. Ocean Behavior

Unlike Pacific salmon, steelhead do not appear to form schools in the ocean (Behnke 1992). Steelhead in the southern part of their range appear to migrate close to the continental shelf, while more northern populations may migrate throughout the northern Pacific Ocean (Barnhart 1986).

7. Adult Run-Timing and Spawning Habitat

CCV steelhead generally leave the ocean from August through April (Busby *et al.* 1996), enter freshwater from August to November with a peak in September (Hallock 1961), and spawn from

December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Table 8; Williams 2006; Hallock *et al.* 1961; McEwan and Jackson 1996). Timing of upstream migration is correlated with higher flow events, such as freshets, and the associated change in water temperatures (Workman *et al.* 2002). Adults typically spend a few months in freshwater before spawning (Williams 2006). Female steelhead construct redds in suitable gravel and cobble substrate, primarily in pool tailouts and heads of riffles.

8. <u>Fecundity</u>

The number of eggs laid per female is highly correlated with adult size, though the strain of the fish can also play a role. Adult steelhead size depends on the duration of and growth rate during their ocean residency (Meehan and Bjornn 1991). CCV steelhead generally return to freshwater after one to two years at sea (Hallock *et al.* 1961), and adults typically range in size from two to twelve pounds (Reynolds *et al.* 1993). Steelhead about 55 cm long may have fewer than 2,000 eggs, whereas steelhead 85 cm long can have 5,000 to 10,000 eggs, depending on the stock (Meehan and Bjornn 1991). The average for Coleman National Fish Hatchery (CNFH) since 1999 is about 3,900 eggs per female (USFWS 2011).

9. <u>Iteroparity</u>

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

10. <u>Kelts</u>

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

11. <u>Population Dynamics</u>

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period from 1967 to 1977, to an average of approximately 2,000 through the early 1990's, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

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

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

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

Existing naturally produced steelhead stocks in the CV 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). Clear Creek steelhead spawner abundance has not been estimated.

Until recently, CCV steelhead were thought to be extirpated from the San Joaquin River system. Monitoring has detected small numbers of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995. A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon, and have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FishBio 2012a,b). In addition, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FishBio 2012b).

Rotary screw traps are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in the rotary screw traps on the Merced River until 2012, when a total of 381 were caught (FishBio 2013). The unusually high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24 hour period. Zimmerman *et al.* (2009) has documented CCV steelhead in the Stanislaus, Tuolumne, and Merced rivers based on otolith microchemistry.

CDFW conducts annual Kodiak trawl sampling on the San Joaquin River near Mossdale. Based on these catches, as well as rotary screw trap efforts in all three tributaries, Marston (2004) stated that it is "clear from this data that *O. mykiss* do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River." Mossdale Kodiak trawl catches continue to occur and are still being conducted by CDFW. The low adult returns to these tributaries and the low numbers of juvenile emigrants captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

In the Mokelumne River, East Bay Municipal Utilities District has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (NMFS 2011a). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000-2010). However, according to Satterthwaite *et al.* (2010), it is likely that most of the *O. mykiss* spawning in the Mokelumne River are non-anadromous (or resident) fish rather than steelhead. The Mokelumne River steelhead population is supplemented by Mokelumne River Hatchery production. In the past, this hatchery received fish imported from the Feather River and Nimbus hatcheries (Merz 2002). However, this practice was discontinued 11 years ago for Nimbus stock, and 3 years ago for Feather River stock. Recent results show that the Mokelumne River Hatchery steelhead are closely related to Feather River fish, suggesting that there has been little carry-over of genes from the Nimbus stock.

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

The most recent status review of the CCV steelhead DPS (NMFS 2011a) found that the status of the population appears to have worsened since the 2005 status review (Good *et al.* 2005), when it was considered to be in danger of extinction. Analysis of data from the Chipps Island monitoring program indicates that natural steelhead production has continued to decline and that hatchery origin fish represent an increasing fraction of the juvenile production in the CV. Since 1998, all hatchery produced steelhead in the CV have been adipose fin clipped (ad-clipped). Since that time, the trawl data indicates that the proportion of ad-clip steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. In recent years, the proportion of hatchery produced juvenile steelhead in the catch has exceeded 90 percent and in 2010 was 95 percent of the catch. Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the CV.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities has also shown a shift towards reduced natural production. In the past decade, there has been a decline in the percentage of salvaged juvenile steelhead that are naturally produced from 55 percent in 1998 down to 22 percent in 2010 (NMFS 2011a).

In contrast to the data from Chipps Island and the CVP and SWP fish collection facilities, some populations of wild CCV steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the CV compared to hatchery produced fish (NMFS 2011a). Since 2003, fish returning to the CNFH have been identified as wild (adipose fin intact) or hatchery produced (Ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely; ranging from 624 to 2,968 fish per year. The returns of wild fish remained steady, even during the recent poor ocean conditions and the 3-year drought in the CV, while hatchery produced fish showed a decline in the numbers returning to the hatchery (NMFS 2011a). Furthermore, the continuing widespread distribution of wild steelhead in the CV provides the spatial distribution necessary for the DPS to survive and avoid localized catastrophes. However, these populations are frequently very small, and lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011a).

Table 8. The temporal occurrence of (a) adult and (b) juvenile CCV steelhead at locations in the CV. Darker shades indicate months of greatest relative abundance

(a) Adult migration and holding

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

(b) Juvenile migration

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

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

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

Description of VSP Parameters

1. <u>Abundance</u>

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005; NMFS 2011a); the long-term trend remains negative. Comprehensive steelhead population monitoring has not taken place in the CV, despite 100 percent marking of hatchery steelhead since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being considered (Eilers *et al.* 2010). Hatchery production and returns are dominant over natural fish and include significant numbers of non-DPS-origin Eel/Mad River steelhead stock. Continued decline in the ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

2. <u>Productivity</u>

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

3. <u>Spatial Structure</u>

Steelhead appear to be well-distributed throughout the CV (Good *et al.* 2005; NMFS 2011a). In the San Joaquin River Basin, steelhead have been confirmed in all of the tributaries: Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers. Zimmerman *et al.* (2009) used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries. The efforts to provide passage of salmonids over impassable dams may increase the spatial diversity of CCV steelhead populations if the passage programs are implemented for steelhead. In addition, the San Joaquin River Restoration Program (SJRRP) calls for a combination of channel and structural modifications along the San Joaquin River downstream of Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2011a).

4. <u>Diversity</u>

CCV steelhead abundance and growth rate continue to decline, largely the result of a significant reduction in the diversity of habitats available to CCV steelhead (Lindley *et al.* 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen *et al.* 2003). Garza and Pearse (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish downstream of barriers in the CV were more closely related to downstream of barrier fish from other watersheds than to *O. mykiss* upstream of barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact upstream of barriers, but may have been altered below barriers by stock transfers. The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the spawning run, placing the natural population at a high risk of extinction (Lindley *et al.* 2007). There are four hatcheries (CNFH, FRFH, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the CV which combined release approximately 600,000 yearling steelhead smolts each year. These programs are intended to compensate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (from the Eel and Mad rivers) and are not presently considered part of the DPS.

Summary of CCV Steelhead DPS Viability

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

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

The widespread distribution of wild steelhead in the CV provides the spatial distribution necessary for the DPS to survive and avoid localized catastrophes. However, these populations are frequently very small, and lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011a). The most recent status review of the CCV steelhead DPS (NMFS 2011a) found that the status of the population appears to have worsened since the 2005 status review (Good et al. 2005), when it was considered to be in danger of extinction.

Critical Habitat and Primary Constituent Elements for CCV Steelhead

Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488). Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries, and the waterways of the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (Bain and Stevenson 1999; 70 FR

52488). Critical habitat for CCV steelhead is defined as specific areas that contain the PCE and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CCV steelhead. PCEs for CCV steelhead include:

1. Freshwater Spawning Habitat

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most of the available spawning habitat for steelhead in the CV is located in areas directly downstream of dams due to inaccessibility to historical spawning areas upstream and the fact that dams are typically built at high gradient locations. These reaches are often impacted by the upstream impoundments, particularly over the summer months, when high temperatures can have adverse effects upon salmonids spawning and rearing downstream of the dams. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

2. Freshwater Rearing Habitat

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

3. Freshwater Migration Corridors

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

4. Estuarine Areas

Estuarine areas free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging LWM, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas are considered to have a high conservation value as they provide factors which function to provide predator avoidance and as a transitional zone to the ocean environment.

2.2.4 Southern DPS of North American Green Sturgeon

The following section entails the status of the species for the Southern distinct population segment of SDPS green sturgeon (sDPS green sturgeon). This section establishes the life history and viability for sDPS green sturgeon, and discusses their critical habitat. The critical habitat analysis is approached by examining the PCEs of that critical habitat, and this analysis considers separately freshwater and estuarine environments. Throughout this analysis of life history, viability, and critical habitat, the focus is upon the CV of California. Therefore, not all aspects of sDPS green sturgeon are presented; for example, the PCEs for the critical habitat in the marine environment are not included.

1. Listed as threatened on June 6, 2006 (71 FR 17757)
2. Critical habitat designated October 9, 2009 (74 FR 52300)

Life History

Our understanding of the biology of the sDPS of green sturgeon is evolving. In areas where information is lacking, inferences are sometimes made from what is known about the Northern distinct population segment (nDPS) green sturgeon and, to a lesser extent, from other sturgeon species, especially the sympatric white sturgeon (*Acipenser transmontanus*). Green sturgeon are long lived, iteroperous, anadromous fish. They may live up to 60-70 years; green sturgeon captured in Oregon have been age-estimated using a fin-spine analysis up to 52 years (Farr and Kern 2005). The green sturgeon sDPS includes those that spawn south of the Eel River. Until recently, it was believed that the green sturgeon sDPS was composed of a single spawning population on the Sacramento River. However, recent research conducted by DWR has revealed spawning activity in the Feather River (Seesholtz, A. M., M. J. Manuel, and J. P. Van Eenennaam). 2015. First documented spawning and associated habitat conditions for green sturgeon in the Feather River, California. Environmental Biology of Fishes 98:905-912. Additionally, there is some evidence of spawning in the Yuba River downstream of Daguerre Point Dam (Cramer Fish Sciences 2013).

Laboratory studies have provided some important information about about larval sturgeon diet and habitat use. Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 15^{o} C (59^{o} F) (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Studies conducted at the University of California, Davis by Van Eenennaam *et al.* (2005) using nDPS juveniles indicated that an optimum range of water temperature for egg development ranged between 14^{o} C (57.2^{o}F) and 17^{o} C (62.6^{o}F). Temperatures over 23 ^{o}C (73.4^{o}F) resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5^{o} C (63.5^{o}F) and 22^{o} C (71.6^{o}F) resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14^{o} C (57.2^{o}F), hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so (Van Eenennaam *et al.* 2005).

Young green sturgeon appear to rear for the first one to two 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, indicating they are approximately two weeks old (CDFG 2002, USFWS 2002). Growth is rapid as juveniles reach up to 300 mm the first year and over 600 mm in the first 2 to 3 years (Nakamoto *et al.* 1995). Juvenile green sturgeon have been salvaged at the Federal and State pumping facilities (which are located in the southern region of the Delta), and sampled in trawling studies by the CDFW during all months of the year (CDFG 2002). The majority of these fish that were captured in the Delta 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 sDPS green sturgeon likely hold in the mainstem Sacramento River for up to 10 months, as suggested by Kynard *et al.* (2005). Both nDPS and sDPS green sturgeon juveniles tested under laboratory conditions, with either full or reduced rations, had optimal bioenergetic performance (*i.e.*, growth, food conversion, swimming ability) between 15^{o}C (59^{o} F) and 19^{o} C (66.2^{o} F), thus providing a temperature related habitat target for conservation of this rare species (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed.

Radtke (1966) inspected the stomach contents of juvenile green sturgeon in the Delta and found food items to include a mysid shrimp (*Neomysis awatschensis)*, amphipods (*Corophium* spp.*)*, and other unidentified shrimp. No additional information is available regarding the diet of sDPS green sturgeon in the wild, but they are presumed to be generalist, opportunistic benthic feeders.

There is a fair amount of variability (1.5 – 4 years) in the estimates of the time spent by juvenile green sturgeon in freshwater before making their first migration to sea. Nakamoto *et al.* (1995) found that nDPS green sturgeon on the Klamath River migrated to sea, on average by age three and no later than by age four. Moyle (2002) suggests juveniles migrate out to sea before the end of their second year, and perhaps as yearlings. Laboratory experiments indicate that both nDPS and sDPS green sturgeon juveniles may occupy fresh to brackish water at any age, but they are physiologically able to completely transition to saltwater at around 1.5 years in age (Allen and Cech 2007). In studying nDPS green sturgeon on the Klamath River, Allen *et al.* (2009) devised a technique to estimate the timing of transition from fresh water to brackish water to seawater by taking a bone sample from the leading edge of the pectoral fin and anlyzing the ratios of stontium and barium to calcium. The results of this study indicate that green sturgeon move from freshwater to brackish water (such as the estuary) at ages 0.5−1.5 years and then move into seawater at ages 2.5-3.5 years. Table 9 shows the migration timing of various life stages throughout the CV, Delta, San Francisco Bay, and into the Pacific Ocean.

In the summer months, multiple rivers and estuaries throughout the sDPS range are visited by dense aggregations of green sturgeon (Moser and Lindley 2007, Lindley *et al.* 2011). Capture of green sturgeon as well as tag detections in tagging studies have shown that green sturgeon are present in San Pablo Bay and San Francisco Bay at all months of the year (Kelly *et al.* 2007, Heublein *et al.* 2009, Lindley *et al.* 2011). An increasing amount of information is becoming available regarding green sturgeon habitat use in estuaries and coastal ocean, and why they aggregate episodically (Lindley *et al.* 2008, Lindley *et al.* 2011). Genetic studies on green sturgeon stocks indicate that almost all of the green sturgeon in the San Francisco Bay ecosystem belong to the sDPS (Israel and Klimley 2008).

Green sturgeon do not mature until they are at least 15−17 years of age (Beamesderfer *et al.* 2007). Therefore, it would not be expected that a green sturgeon returning to freshwater would be younger than this. However, once mature, green sturgeon appear to make spawning runs once every few years. Erickson and Hightower (2007) found that nDPS green sturgeon returned to the Rogue River 2–4 years after leaving; it is presumed that sDPS green sturgeon display similar behavior and return to the Sacramento River or Feather River system to spawn every 2–5 years. Adult sDPS green sturgeon begin their upstream spawning migrations into freshwater as early as late February with spawning occuring between March and July (CDFG 2002, Heublein 2006, Heublein *et al.* 2009, Vogel 2008). Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates featuring crevices and interstices (Van Eenennaam *et al.* 2001). Poytress *et al.* (2012) conducted spawning site and larval sampling in the upper Sacramento River from 2008–2012 and has identified a number of confirmed spawning locations (Figure 6). Green sturgeon fecundity is approximately 50,000 to 80,000 eggs per adult female (Van Eenennaam *et al.* 2001). They have the largest egg size of any sturgeon. The outside of the eggs are mildly adhesive, and are more dense than than those of white sturgeon (Kynard *et al.* 2005, Van Eenennaam *et al.* 2009).

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

Table 9. The temporal occurrence of (a) adult, (b) larval (c) juvenile and (d) subadult coastal migrant sDPS of green sturgeon. Locations emphasize the CV of California. Darker shades indicate months of greatest relative abundance.

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

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

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

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

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

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

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

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

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

* Fish Facility salvage operations

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

Threats and Stressors

Green sturgeon are long lived, and thus face environmental and anthropocentric stressors that may affect the probability that they reach reproductive maturity. Males are observed to reproduce as early as 14 years old, while females grow older prior to maturing as early as 16 years old (Van Eenennaam et al. 2005). Both males and females occupy all types of aquatic environments- freshwater, estuarine, and marine. Numerous environmental factors potentially limit green sturgeon survival during the earliest stages of their life cycle while in freshwater. This period is called the "critical age" in fishes due to its relevance in survival and recruitment of individuals into the adult population (Hardy and Litvak 2004). Recruitment failure of the earliest life history stages may be a significant bottleneck for other North American acipenserids such as Pallid sturgeon and the white sturgeon in Upper Columbia and Kootenai rivers, the populations of which have numerous reproductive adults, but few recently surviving wild juveniles (Duke et al. 1999, Hildebrand et al. 1999, Korman and Walters 2001) .

There are many potential limiting factors during this early life period. They are the following: 1) warm water temperatures, 2) insufficient flows, 3) decreased dissolved oxygen, 4) lack of rearing habitat, and 5) increased predation. Water is released from Shasta Dam to maintain daily temperatures below 18º C downstream to a temperature compliance point, which in 2007 was maintained at Jellys Ferry and Balls Ferry to facilitate the incubation of eggs of spawning winter-run Chinook. This maintenance of cool water temperatures benefits green sturgeon spawning upstream of Red Bluff Diversion Dam. Temperature records from acoustic telemetry receivers along the mainstem have not been analyzed, but may provide data for assessing whether temperatures are limiting survival of embryos, larvae or juveniles downstream of RBDD. Once larvae grow into juveniles, their survival may be limited by lack of habitat, insufficient food, and possibly contaminants. Juveniles are fairly tolerant of variable temperature and dissolved oxygen, and are likely mobile enough to select favorable habitats (see Ecology sections). It is possible that juveniles can also be entrained in water diversions for farmland irrigation, although their benthic behavior likely limits this impact, and this is not well understood.

The members of the older age classes principally face anthropocentric threats to their survival in estuarine and marine environments. Once within the estuary, juveniles might accumulate pollutants such as methyl-mercury and pyrethroids, whose uptake is enhanced by the benthic feeding orientation of green sturgeon. Pyrethroids also may limit the availability of prey for young green sturgeon due to their effect of very low dosages on zooplankton and bottom-dwelling organisms. The size of the populations of subadults and adults have been potentially limited by human fisheries and barriers to spawning areas which may prevent them from racing the most optimal spawning habitats. Harvest can cause abrupt declines in green sturgeon adult abundance. Even an amount as small as 10% additional mortality over the green sturgeon's life-span can reduce population abundance by 50% and adult abundance by 90% (Beamesderfer et al. 2007). An additional simulated increase in mortality of 20% over natural mortality resulted in no green sturgeon surviving to adulthood. These forms of mortality could include human and nonhuman sources of direct mortality, and are not well quantified for the Southern DPS. Of greater concern, might be even much smaller additional mortality rates' influence on green sturgeon's reproductive potential. Additional rates of only 2-3% annual mortality over green sturgeon's life cycle reduced egg production to levels making sturgeon stocks extremely susceptible to overfishing (Beamesderfer et al. 2007).

Modification of the riverscape has resulted in loss of spawning habitat, rearing habitat, and increased barriers to migration. Larvae, juveniles, and adults life history stages are all benthic in orientation and all require deep habitats for dispersal, holding, and spawning. Successful fertilization and survival of embryos seems to require spawning habitats reflecting specific water quality and quantity parameters, which have been negatively impacted by construction of dams and channelization of the river. Riparian habitats provide allochthonous contributions to the river food web that indirectly support juvenile prey items. It is possible that modifications in temperature regime controlled by the Shasta Dam temperature control device may benefit green sturgeon spawning above Red Bluff Diversion Dam, but more research is necessary to understand the impacts of temperature on the distribution and success of green sturgeon spawning.

Channelization of the estuary has likely negative impacted the amount of subtidal and intertidal habitat available for green sturgeon foraging. These habitats have been lost along San Pablo and Suisun bays, where subadult and adult green sturgeon are commonly found. These estuarine habitats are likely important for growth during the juvenile, coastal migrant, and adults life stages. Invasive plant species in the estuary have likely impacted the quantity of shallow habitat available to coastal migrant and adult green sturgeon, and alterations of the food web due to invasive species have also likely shifted green sturgeon estuarine diet.

Future Research

One conclusion of the NMFS BRT assessing the status of green sturgeon was that “it is essential that immediate efforts be undertaken to implement population monitoring for the DPS using methods that directly assess population status” (NMFS 2005). Although laboratory studies have yielded much information on the physiological needs of the species, field studies have yet to be completed applying this information to identifying adult spawning, larval survival, juvenile rearing, and juvenile smoltification. Information is necessary about the life history diversity, abundance, population growth rate, foraging behavior and temporal presence of Sacramento River green sturgeon.

Managers should develop research and monitoring to estimate the riverine larval and juvenile populations for a period of time reflecting the potential variation in physical and biological processes influencing recruitment. These results will give managers an idea for the effect of management on critical habitats, influence of adult demography on recruitment dynamics, and the actual production of green sturgeon in younger cohorts. Estimates derived from these types of studies may be a good indication for spawning and abundance, which are not negatively influenced by the impact of entrainment, operations, and harvest. If estimates of young riverine fish are known, then adaptive research evaluating the impacts of anthropocentric stressors on older life history stages will allow managers to assess the actual effects of these anthropocentric stressors. Currently, abundance derived from harvest or operational entrainment data does not allow managers to determine if these impacts are causing declines in abundance or just reflect the natural production of spawning adults.

The distribution of spawning adults as well as a characterization of their spawning habitat within the Sacramento River should be completed. This will provide insight into the density of spawning adults and influence spawning aggregation have to the juvenile population, the rates of egg and larval mortality, and the potential loss of this spawning habitat by flow and temperature modification in the system. In 2008, UCD, BOR, and FWS initiated tracking green sturgeon as they move within the upper mainstem and collected eggs at spawning sites. Additional funding is necessary to adequately monitor spawning movements and increased egg and larval collection sites along the Sacramento riverscape to evaluate green sturgeon habitat relationships.

Little is known about green sturgeon food selection and foraging behavior making the predictability of where preferred food is available low. As green sturgeon move into lower riverine reaches, the estuary and marine environments, food resources are not well understood (Israel and Klimley 2008). If native food sources have declined due to invasive species occupying their habitat or pollutants reducing available food, finding sufficient food may be problematic for juvenile green sturgeon. There is a need to investigate further the effects of selenium and other contaminants on green sturgeon and to find ways to reduce sources. Recent evidence indicates adult white sturgeon may be accumulating selenium in concentrations detrimental to reproduction, presumably by consuming the introduced overbite clam (Linville 2006).

Support should be provided for priority research guided by the Interagency Ecological Program Sturgeon Work Team. This conceptual model should indicate that much is already known about the basic biology of green sturgeon from laboratory studies and can serve as the basis for developing hypotheses for testing in field studies. The next research step should be to discern the importance of this biology on population viability within the watershed. A systematically applied research program attempting to study the critical periods and habitats of green sturgeon in riverine and estuarine environments will provide managers with information on the actual utilization, status, and abundance of different life history stages of green sturgeon in the Sacramento River. Once these field observations are completed, our larger and more comprehensive understanding for the basic ecology of the species will permit the development of a population viability model, which could prioritize the above-mentioned risks to the population and guide management decisions (Israel and Klimley 2008).

Description of Viability Parameters for sDPS Green Sturgeon

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

1. <u>Abundance</u>

Abundance is one of the most basic principles of conservation biology, and from this measurement other parameters can be related. In applying the VSP concept, abundance is examined at the population level, and therefore population size is perhaps a more appropriate term. Population estimates of the green sturgeon sDPS are in development. A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities; the Skinner Delta Fish Protection Facility (SDFPF) and the Tracy Fish Collection Facility (TFCF) (Figure 7). There are, however, uncertainties with the data in figure 7. Adams et al. (2007) describe that while the numbers of green sturgeon still were higher in the pre 1986 period, it appears that the expansion procedure exaggerated that difference. These entrainment estimates suffer from problems of species identification (green sturgeon were not identified until 1981 at the federal facility), and the estimates are expanded catches from brief sampling periods.

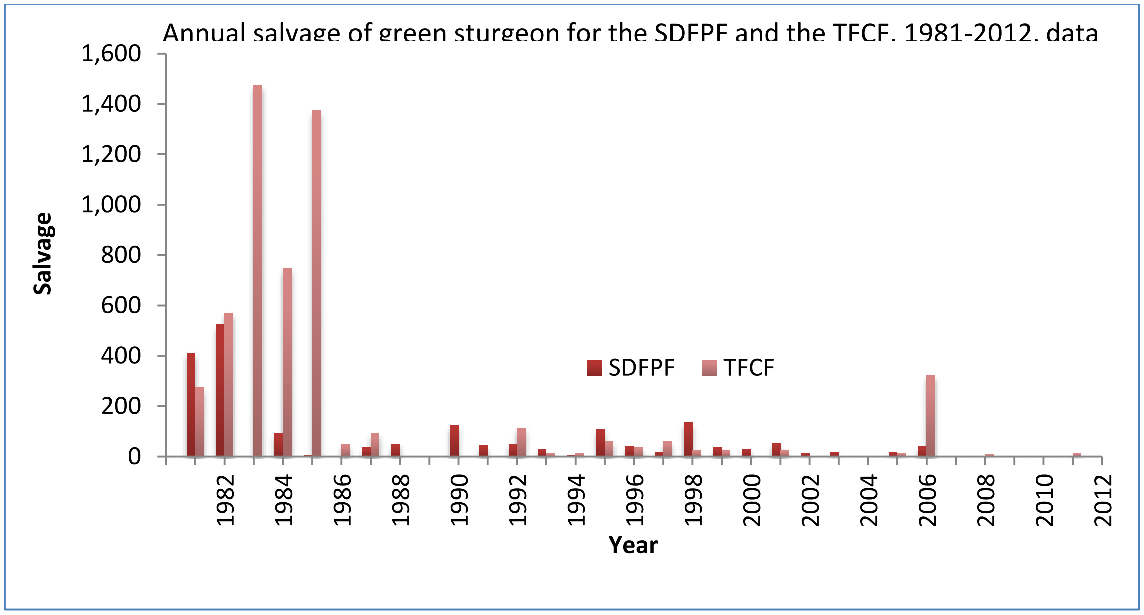

Figure 7. Annual salvage of green sturgeon for the SDFPF and the TFCF from 1981 to 2012. Data source: ftp://ftp.delta.dfg.ca.gov/salvage

Adult spawning population estimates in the upper Sacramento River (above RBDD*)*, using sibling based genetics, indicates 10-28 spawners contributed to juvenile production per year between 2002-2006 (Israel and May 2010). This is a minimum estimate of the effective adult spawning population because sampling was limited, may have preferentially selected for larvae spawning immediately above RBDD, and did not include animals spawning downstream of the RBDD. Fish monitoring efforts at RBDD and Glen Colusa Irrigation District (GCID) on the upper Sacramento River have captured anywhere between 0 and 2,068 juvenile green sturgeon per year, between 1986 and 2000 (Adams *et al.* 2002).

In determining the conservation status of sDPS green sturgeon, a few notes with regards to population size are crucial. Population(s) should be large enough to survive environmental variations, catastrophes, and anthropogenic perturbations. Also, the population(s) should be sufficiently large to maintain long term genetic diversity (McElhany *et al.* 2000). Our understanding of the status of sDPS green sturgeon towards these concerns is developing.

Because of their long life span, green sturgeon abundance is particularly sensitive to increased mortality. Even relatively small increases in annual mortality can substantially reduce adult abundance due to cumulative effects accruing over a number of years. Because of their delayed age of maturation, cumulative impacts may severely reduce the population's reproduction potential.

Beamesderfer *et al*. (2007) used the life table model to evaluate the sensitivity of the population to additional mortality rates when applied to different life stages. The analyses showed that low rates of additional mortality (2% to 5%), when applied across multiple life stages, can result in abrupt declines in green sturgeon population numbers and reproductive potential.

2. <u>Productivity</u>

For long-lived species such as sturgeon, abundance, age structure, and sex ratios are particularly powerful indicators of long-term productivity patterns. Viable sturgeon populations are characterized by a broad distribution of size classes and ages. In order for sDPS green sturgeon to rebound from being threatened to a viable status, its population growth rate will need to be positive until some equilibrium population size is reached, at which point the growth rate should stabilize.

Productivity and recruitment information for sDPS green sturgeon is an area that requires additional research; existing data is too limited to be presented as robust estimates. Incidental catches of larval green sturgeon in the mainstem Sacramento River and of juvenile green sturgeon at the south Delta pumping facilities suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer *et al.* 2007, Lindley *et al.* 2007). In general, sturgeon year class strength appears to be episodic with overall abundance dependent upon a few successful spawning events (NMFS 2010). It is unclear if the population is able to consistently replace itself. This is significant because the VSP concept requires that a population meeting or exceeding the abundance criteria for viability should, on average, be able to replace itself (McElhany *et al*. 2000). More research is needed to establish green sturgeon sDPS productivity.

3. <u>Spatial Structure</u>

Green sturgeon, as a species, are known to range from Baja California to the Bering Sea along the North American continental shelf. During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett 1991, Moser and Lindley 2007). Based on genetic analyses and spawning site fidelity (Adams *et al.* 2002, Israel *et al.* 2004), green sturgeon are comprised of at least two DPSs.

1. A nDPS consisting of populations originating from coastal watersheds northward of and including the Eel River (*i.e.* Klamath, Rogue, and Umpqua rivers), and
2. A sDPS consisting of populations originating from coastal watersheds south of the Eel River.

Throughout much of their range, sDPS and nDPS green sturgeon are known to co-occur, especially in northern estuaries and over-wintering grounds. However, those green sturgeon that are found within the inland waters of the Central Valley, California are almost entirely sDPS green sturgeon (Israel and Klimley 2008).

Adams *et al.* (2007) summarizes information that suggests green sturgeon may have been distributed upstream of the locations of present-day dams on the Sacramento and Feather rivers. In the California CV, sDPS green sturgeon are known to range from the Delta to the Sacramento River up to Keswick Dam, the Feather River up to the fish barrier structure downstream of Oroville Dam, and the Yuba River up to Daguerre Point Dam. Additional habitat may have historically existed in the San Joaquin River basin. Anecdotal evidence from anglers suggest sDPS green sturgeon presence in the San Joaquin River. Since implementation of the Sturgeon Report Card in 2007, anglers have reported catching 177 white sturgeon and 7 green sturgeon on the San Joaquin River upstream from Stockton (Dubois, J., M. D. Harris, and J. Mauldin. 2014. 2013 Sturgeon Fishing Report Card: Preliminary Data Report. CDFW Bay Delta Region, Stockton, CA, May 8, 2014).

In applying the VSP concept to sDPS green sturgeon, it is important to look at the within-population spatial diversity. Ongoing research is being conducted to determine if the green sturgeon sDPS is composed of a single population, or perhaps several populations. It is known that sDPS green sturgeon spawn in the mainstem Sacramento River, the Feather River, and the Yuba River; but it is not yet known if these spawning areas represent individual populations, sub-populations, or if they are all part of one single population. However, it is encouraging to note that at least this level of spatial diversity exists; when sDPS green sturgeon were originally listed as threatened under the ESA, the only known spawning locations at the time were those on the mainstem Sacramento River.

4. Diversity

The VSP concept identifies a variety of traits that exhibit diversity within and among populations, and this variation has important effects on population viability (McElhany *et al.* 2000). For sDPS green sturgeon, such traits include, but are not limited to fecundity, age at maturity, physiology, and genetic characteristics. On a species-wide scale, studies have examined the genetic differentiation between sDPS and nDPS green sturgeon (Israel *et al.* 2004).

Although the population structure of sDPS green sturgeon is still being refined, it may be the case that only a single population exists. This may have the effect of providing for lower diversity than if two or more populations existed. Lindley *et al.* (2007), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population.

Summary of sDPS Green Sturgeon Viability

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

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

There is a strong need for additional information about sDPS green sturgeon, especially with regards to a robust abundance estimate, a greater understanding of their biology, and further information about their habitat needs.

Southern DPS of North American Green Sturgeon Critical Habitat

Critical habitat was designated for the sDPS green sturgeon on October 9, 2009 (74 FR 52300). A full and exact description of all sDPS green sturgeon critical habitat, including excluded areas, can be found at 50 CFR 226.219. Critical habitat includes the stream channels and waterways in the Delta to the ordinary high water line. Critical habitat also includes the main stem Sacramento River upstream from the I Street Bridge to Keswick Dam, the Feather River upstream to the fish barrier dam adjacent to the Feather River Fish Hatchery, and the Yuba River upstream to Daguerre Dam. Coastal marine areas include waters out to a depth of 60 fathoms, from Monterey Bay in California, to the Strait of Juan de Fuca in Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are also included as critical habitat for sDPS green sturgeon.

Critical habitat for sDPS green sturgeon includes principal biological or physical constituent elements within the defined area that are essential to the conservation of the species. PCEs for sDPS green sturgeon have been designated for freshwater riverine systems, estuarine habitats, and nearshore coastal areas. In keeping with the focus on the California CV, we will limit our discussion to freshwater riverine systems and estuarine habitats.

Freshwater Riverine Systems

1. <u>Food Resources</u>

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

2. <u>Substrate Type or Size</u>

Critical habitat in the freshwater riverine system should include substrate suitable for egg deposition and development, larval development, subadults, and adult life stages. For example, spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Emmett *et al.* 1991, Moyle *et al.* 1995). Eggs are likely to adhere to substrates, or settle into crevices between substrates (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Larvae exhibited a preference for benthic structure during laboratory studies (Van Eenennaam *et al.* 2001, Deng *et al.* 2002, Kynard *et al.* 2005), and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker 2006).

3. <u>Water Flow</u>

An adequate flow regime is necessary for normal behavior, growth, and survival of all life stages in the upper Sacramento River. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11°C - 19°C) (Mayfield and Cech 2004, Van Eenennaam *et al.* 2005, Allen *et al.* 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cfs [average daily water flow during spawning months: 6,900 – 10,800 cfs; Brown (2007)]. In Oregon's Rogue River, nDPS green sturgeon have been shown to emigrate to sea during the autumn and winter when water temperatures dropped below 10° C and flows increased (Erickson *et al.* 2002). On the Klamath

River, the fall outmigration of nDPS green sturgeon has been shown to coincide with a significant increase in discharge resulting from the onset of the rainy season (Benson *et al* 2007). On the Sacramento River, flow regimes are largely dependent on releases from Shasta Dam, thus the operation of this dam could have profound effects upon sDPS green sturgeon habitat.

4. Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics are necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures would include: stable water temperatures within spawning reaches; temperatures within 11°C - 17°C (optimal range = 14°C - 16°C) in spawning reaches for egg incubation (March-August) (Van Eenennaam *et al.* 2005); temperatures below 20°C for larval development (Werner *et al.* 2007); and temperatures below 24°C for juveniles (Mayfield and Cech 2004, Allen *et al.* 2006). Suitable salinity levels range from fresh water (< 3 ppt) for larvae and early juveniles to brackish water (10 ppt) for juveniles prior to their transition to salt water. Prolonged exposure to higher salinities may result in decreased growth and activity levels and even mortality (Allen and Cech 2007). Adequate levels of dissolved oxygen (DO) are needed to support oxygen consumption by early life stages (ranging from 61.78 to 76.06 mg O_2 hr^{-1} kg^{-1} for juveniles, Allen and Cech (2007). Suitable water quality would also include water with acceptably low levels of contaminants (*i.e*., pesticides, organochlorines, selenium, elevated levels of heavy metals, *etc*.) that may disrupt normal development of embryonic, larval, and juvenile stages of green sturgeon. Poor water quality can have adverse effects on growth, reproductive development, and reproductive success. Studies on effect of water contaminants upon green sturgeon are needed; studies performed upon white sturgeon have clearly demonstrated the negative impacts contaminants can have upon white sturgeon biology (Foster *et al.* 2001a, 2001b, Feist *et al.* 2005, Fairey *et al.* 1997, Kruse and Scarnecchia 2002). Legacy contaminants such as mercury still persist in the watershed and pulses of pesticides have been identified in winter storm discharges throughout the Sacramento River basin, and the CV and Delta.

5. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning and rearing habitats within freshwater rivers to rearing habitats within the estuaries. Unobstructed passage throughout the Sacramento River up to Keswick Dam (RM 302) is important, because optimal spawning habitats for green sturgeon are believed to be located upstream of the RBDD (RM 242).

6. Depth

Deep pools of ≥ 5 m depth are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon are observed in these pools in the upper Sacramento River upstream of GCID. The significance and purpose of these aggregations are unknown at the present time, but may be a behavioral characteristic of green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson *et al.* 2002, Benson *et al.* 2007). As described above approximately 54 pools with adequate depth have been identified in the Sacramento River upstream of the GCID location.

7. Sediment Quality

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

For Estuarine Habitats

1. Food Resources

Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages are required for the proper functioning of this PCE for green sturgeon. Green sturgeon feed primarily on worms, mollusks, and crustaceans (Moyle 2002). Radtke (1966) studied the diet of juvenile sDPS green sturgeon and found their stomach contents to include a mysid shrimp, amphipods, and other unidentified shrimp. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within the bays and estuaries. Currently, the estuary provides these food resources, although annual fluctuations in the population levels of these food resources may diminish the contribution of one group to the diet of green sturgeon relative to another food source.

Invasive species are a concern because they may replace the natural food items consumed by green sturgeon. The Asian overbite clam (*Corbula amurensis*) is one example of a prolific invasive clam species in the Delta. It has been observed to pass through white sturgeon undigested (Kogut 2008).

2. Water Flow

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

3. Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 24°C (75ºF). At temperatures above 24°C, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen *et al.* 2006). Suitable salinities in the estuary range from brackish water (10 ppt) to salt water (33 ppt). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech 2007), whereas subadults and adults tolerate a wide range of salinities (Kelly *et al.* 2007). Subadult and adult green sturgeon occupy a wide range of DO levels, but may need a minimum DO level of at least 6.54 mg O_2/l (Kelly *et al.* 2007, Moser and Lindley 2007).

Suitable water quality also includes water free of contaminants (*e.g*., pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages. In general, water quality in the Delta and estuary meets these criteria, but local areas of the Delta and downstream bays have been identified as having deficiencies. Discharges of agricultural drain water have also been implicated in local elevations of pesticides and other related agricultural compounds within the Delta and the tributaries and sloughs feeding into the Delta. Discharges from petroleum refineries in Suisun and San Pablo bay have been identified as sources of selenium to the local aquatic ecosystem (Linville *et al.* 2002).

4. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats. Within the waterways comprising the Delta, and bays downstream of the Sacramento River, safe and unobstructed passage is needed for juvenile green sturgeon during the rearing phase of their life cycle. Passage within the bays and the Delta is also critical for adults and subadults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. Within bays and estuaries outside of the Delta and the areas comprised by Suisun, San Pablo, and San Francisco bays, safe and unobstructed passage is necessary for adult and subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean. Currently, safe and unobstructed passage has been diminished by human actions in the Delta and bays. The CVP and SWP, responsible for large volumes of water diversions, alter flow patterns in the Delta due to export pumping and create entrainment issues in the Delta at the pumping and Fish Facilities. Power generation facilities in Suisun Bay create risks of entrainment and thermal barriers through their operations of cooling water diversions and discharges. Installation of seasonal barriers in the South Delta and operations of the radial gates in the Delta Cross Channel (DCC) facilities alter migration corridors available to green sturgeon. Actions such as the hydraulic dredging of ship channels and operations of large ocean going vessels create additional sources of risk to green sturgeon within the estuary. Commercial shipping traffic can result in the loss of fish, particularly adult fish, through ship and propeller strikes.

5. Water Depth

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

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

6. Sediment Quality

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

Summary of the Conservation Value of Green Sturgeon Critical Habitat

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

2.3 Environmental Baseline

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

The environmental baseline describes the status of listed species and critical habitat in the action area, to which we add the effects of the Common Features GRR, to consider the effects of the proposed Federal actions within the context of other factors that impact the listed species. The effects of the proposed Federal action are evaluated in the context of the aggregate effects of all factors that have contributed to the status of listed species and, for non-Federal activities in the action area, those actions that are likely to affect listed species in the future, to determine if implementation of the Common Features GRR is likely to cause an appreciable reduction in the likelihood of both survival and recovery or result in destruction or adverse modification of critical habitat.

Reaches throughout the Common Features GRR planning area historically provided both shallow and deeper water habitat. Channel confining levees and upstream reservoirs that maintain year-round outflow have eliminated much of the adjacent shallow water floodplain habitat. Many native fish species are adapted to rear in flooded, shallow water areas that provide abundant cover and prey. As a consequence of habitat alterations, and the introduction of non-native species and pollutants, some native fish species are now extinct while most others are reduced in numbers (Moyle 2002).

The Sacramento River watershed receives winter/early spring precipitation in the form of rain and snow (at higher elevations). Prior to the construction and operation of any reservoirs, winter rainfall events caused extensive flooding and spring snowmelt resulted in high flows during spring and early summer. Summer and fall flows were historically low. Currently, much of the total runoff is captured and stored in reservoirs for gradual release during the summer and fall months. High river flows occur during the winter and spring, but these are usually lower than during pre-European settlement times; summer and fall low flows are sustained by releases from upstream reservoirs.

The flood risk management system protecting the City of Sacramento has been identified as insufficient by the Corps. According to the Corps, there is a high probability that flows in the American and Sacramento Rivers will stress the network of levees protecting Sacramento to the point that levees could fail. Failure of these levees could inundate highly urbanized areas up to 20 feet deep.

Sixteen land cover types were identified in the Common Features GRR project area. Nine of the land cover types are considered natural communities: all four riparian habitats, emergent marsh, valley oak woodland, walnut woodland, nonnative annual grassland, pond, and perennial drainage. The other cover types are associated with human activities: all three agricultural field types, walnut orchard, agricultural ditch, and developed/landscaped.

Despite the impaired status of the Sacramento and American Rivers in the proposed project action area, the value of the lower Sacramento River as a migratory corridor for CV spring-run Chinook salmon, CCV steelhead, Sacramento River winter-run Chinook salmon, and sDPS green sturgeon is high primarily because it contains habitat elements that support the rearing and growth of juveniles and the successful upstream migration of adults. The same high value can be attributed to the American River for both CV spring-run and sDPS green sturgeon. The Common Features GRR will occur downstream of the confluence of major watersheds, including the American, Yuba, and Feather river and watersheds further upstream such as Butte Creek and Battle Creek. Thus, the action area is also within the migratory corridor for the fish that utilize all the aforementioned watersheds.

Anticipated climate change may affect spatial and temporal precipitation patterns along with the intensity and duration of precipitation within the Sacramento and American River watersheds. The effect of climate change is anticipated to be more winter and less spring and summer run-off within the watershed. In addition, expected run-off is anticipated to be warmer, possibly affecting the ability to meet downstream water temperature objectives to protect salmon, steelhead, and green sturgeon. This combined with more precipitation as rain will affect future operations of all reservoirs within the California CV. A change in the run-off pattern within the Sacramento and American River watersheds will likely affect reservoir storage and downstream river flows due to more frequent spillway releases.

This same flood management system impacts the natural meander and ecosystem of the Sacramento and American Rivers. The Common Features Project study area includes the mainstem The Common Features GRR action area includes the mainstem Sacramento River from Freeport (RM 46) in the Delta upstream to the American River confluence (RM 60). The region also includes the lower American River from the confluence with the Sacramento River upstream to RM 11, NEMDC, Arcade Creek, Dry/Robla Creeks and Magpie Creek.

Downstream from the American River confluence, the Sacramento River is moderately sinuous, with the channel confined on both sides by man-made levees enhanced by decades of man-made additions. The channel in this reach is of uniform width, is not able to migrate, and is typically narrower and deeper relative to the upstream reach 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 because of man-made levees and regulated flows from Folsom and Nimbus Dams.

The natural banks and adjacent floodplains of both rivers are composed of silt- to gravel-sized particles with poor to high permeability. Historically, the 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 to 20 feet above the floodplain for as far as 10 miles from the channel (Thompson 1961). The present day channels consist of fine-grained cohesive banks that erode due to natural processes as well as high flow events (Corps 2012).

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.

NEMDC is an approximately 13.3-mile, human-made, partially leveed drainage channel that provides drainage from Sankey Road and connects streams of the American Basin (Dry, Robla, and Arcade Creeks) to the American River. South of the confluence with Arcade Creek, the east and west levees of NEMDC are dominated by wild oats grasslands, while the channel is characterized by Fremont cottonwood forest, with smaller amounts of valley oak woodland, smart-weed cocklebur patches, and perennial rye grass fields.

The approximately 16.2-mile-long channel of Arcade Creek extends east-to-west from Orangevale to the American River, via NEMDC. The north and south levees are dominated by wild oats grasslands. Valley oak woodland is the main riparian vegetation type along Arcade Creek, but Fremont cottonwood forest occurs in small patches along the easternmost reach of Arcade Creek near NEMDC. Hardstem bulrush marsh is found within Arcade Creek near Norwood Avenue while water primrose wetlands are predominant within the channel of Arcade Creek from approximately the confluence with NEMDC to Norwood Avenue. East of Norwood Avenue, the creek channel becomes narrower, and dominated by a shaded canopy of valley oak woodland.

The environmental baseline in the Common Features GRR action area also includes the sites completed under the WRDA 1996 and WRDA 1999 authorizations for the project. The WRDA 1996 construction included installing slurry walls in the American River levees to address seepage and slope stability concerns. The WRDA 1999 construction included shape and slope improvements to specific reaches of the American River levee system, and some segments of the Sacramento River levees.

The Common Features Project study area consists of primarily riparian forest, valley oak woodland, riparian scrub-shrub habitat, and typically non-native annual grassland. Early riparian habitat may be called scrub-shrub. Scrub-shrub generally refers to areas where the woody riparian canopy is composed of trees or shrubs approximately 20 feet high. Species that are typically found in these habitats include young cottonwood (*Populus trichocarpa*), willow (*Salix spp.*), elderberry (*Sambucus spp.*), buttonbush (*Cephalanthus occidentalis*), Himalaya blackberry (*Rubus armeniacus*), wild grape (*Vitis vinifera*), and poison oak (*Toxicodendron spp.*).

Riparian forest typically has a dominant overstory of cottonwood, California sycamore (*Platanus racemosa*), or valley oak (*Quercus lobata*). Species found in the scrub-shrub will make up the sub canopy and could also include white alder and box elder. Layers of climbing vegetation make up part of the subcanopy, with wild grape being a major component, but wild cucumber and clematis are also found in riparian communities.

The herbaceous ruderal habitat is found on most levees along the Sacramento River. It occurs on the levees and also within gaps in the riparian habitats. Plant species include wild oats (*Avena spp.*), soft chess (*Bromus hordeaceus*), ripgut brome (*Bromus hordeaceus*), red brome (*Bromus madritensis*), wild barley (*Bromus hordeaceus)*, and foxtail fescue (*Festuca megalura*). Common forbs include broadleaf filaree (*Erodium spp.*), red stem filaree (*Erodium spp.*), turkey mullein (*Eremocarpus setigerus*), clovers (*Trifolium spp.*), and many others. The majority of these plants are not native to the project area.

Riparian recruitment and establishment models (Mahoney and Rood 1998; Bradley and Smith 1986) and empirical field studies (Scott et al. 1997, 1999) emphasize that hydrologic and fluvial processes play a central role in controlling the elevational and lateral extent of riparian plant species. These processes are especially important for pioneer species that establish in elevations close to the active channel, such as cottonwood and willows (*Salix* spp.). Failure of cottonwood recruitment and establishment is attributed to flow alterations by upstream dams (Roberts et al. 2001) and to isolation of the historic floodplain from the river channel. In addition, many of these formerly wide riparian corridors are now narrow and interrupted by levees and weirs. Finally, draining of wetlands, conversion of floodplains to agricultural fields, and intentional and unplanned introduction of exotic plant species have altered the composition and associated habitat functions of many of the riparian communities that are able to survive under current conditions.

2.3.1 Status of the Species in the Action Area

The action area, which encompasses portions of the lower Sacramento River and lower American River, and associated floodplains and riparian areas at and adjacent to the proposed construction sites functions as a migratory corridor for CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. The action area is also used for rearing and adult feeding.

1. Presence of CCV Steelhead in the Action Area

The CCV steelhead DPS final listing determination was published on January 5, 2006 (71 FR 834) and included all naturally spawned populations of steelhead (and their progeny) downstream of natural and manmade barriers in the Sacramento and San Joaquin rivers and their tributaries. FRFH steelhead are also included in this designation. All adult CCV steelhead originating in the Sacramento River watershed will have to migrate through the action area in order to reach their spawning grounds and to return to the ocean following spawning. Likewise, all CCV steelhead smolts originating in the Sacramento River watershed will also have to pass through the action area during their emigration to the ocean. The waterways in the action area also are expected to provide some rearing benefit to emigrating steelhead smolts. The CCV steelhead DPS occurs in both the Sacramento River and the San Joaquin River watersheds. However the spawning population of fish is much greater in the Sacramento River watershed and accounts for nearly all of the DPS' population.

CCV steelhead smolts will first start to appear in the action area in November. This is based on the records from the CVP and SWP fish salvage facilities, as well as the fish monitoring program in the northern and central Delta. Their presence increases through December and January, peaks in February and March, and declines in April. By June, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP. Adult steelhead are expected to move through the action area throughout the year with the peak of upriver immigration expected to occur August through November. There is potential exposure to adult steelhead moving back downstream in a post-spawn condition (kelts) through the action area during the February to May period. It is expected that more kelts will be observed earlier in the period (February) due to the timing of spawning in the Sacramento River basin.

Based on the temporal presence of adult and juvenile steelhead in the lower Sacramento and American Rivers, the timing of the proposed project, and the location of the action area, it is likely that adult steelhead will be using the action area as a migration corridor during construction. Additionally, it is likely that juvenile steelhead may be emigrating through the action area during construction. Depending on the water year type and the timing of high flows in the Sacramento River basin, adult and/or juvenile CCV steelhead may be present in the Yolo Bypass and the Sacramento Bypass.

2. Presence of CV spring-run Chinook salmon in the Action Area

A similar application of the CVP and SWP salvage records and the northern and Central Delta fish monitoring data to the presence of CV spring-run Chinook salmon indicates that juvenile spring-run Chinook salmon first begin to appear in the action area in December and January, but that a significant presence does not occur until March and peaks in April. By May, the salvage of juvenile CV spring-run Chinook salmon declines sharply and essentially ends by the end of June. The data from the northern and central Delta fish monitoring programs indicate that a small proportion of the annual juvenile spring-run emigration occurs in January and is considered to be mainly composed of older yearling spring-run juveniles based on their size at date. Adult spring-run Chinook salmon are expected to start entering the action area in approximately January. Low levels of adult migration are expected through early March. The peak of adult spring-run Chinook salmon movement through the action area is expected to occur between April and June with adults continuing to enter the system through the summer. Currently, all known populations of CV spring-run Chinook salmon inhabit the Sacramento River watershed.

Based on the temporal presence of CV spring-run Chinook salmon in the lower Sacramento and American River, the timing of the proposed project, and the location of the action area, it is likely that adult and juvenile CV spring-run Chinook salmon will be using the action area. Depending on the water year type and the timing of high flows in the Sacramento River basin, adult and/or juvenile CV spring-run Chinook salmon may be present in the Yolo Bypass and the Sacramento Bypass. It is possible that any CV spring-run Chinook salmon (particularly adults) that arein the lower Sacramento River may enter into the American River.

3. Presence of Sacramento River winter-run Chinook salmon in the Action Area

The temporal occurrence of Sacramento River winter-run Chinook salmon smolts and juveniles within the action area are best described by a combination of the salvage records of the CVP and SWP fish collection facilities and the fish monitoring programs conducted in the northern and central Delta. Based on salvage records at the CVP and SWP fish collection facilities, juvenile Sacramento River winter-run Chinook salmon are expected in the actions area starting in December. Their presence peaks in March and then rapidly declines from April through June. The majority of winter-run juveniles will enter the action area during February through June. Presence of adult Chinook salmon is interpolated from historical data. Adult winter-run Chinook salmon are expected to enter the action area starting in January, with the majority of adults passing through the action area between February and April.

Based on the temporal presence of Sacramento River winter-run Chinook salmon in the lower Sacramento River, the timing of the proposed project, and the location of the action area, it is likely that adult and juvenile Sacramento River winter-run Chinook salmon will be using the action area. Depending on the water year type and the timing of high flows in the Sacramento River basin, adult and/or juvenile Sacramento River winter-run Chinook salmon may be present in the Yolo Bypass and the Sacramento Bypass. It is possible that any Sacramento River winter-run Chinook salmon (particularly adults) that are in lower Sacramento River may enter into the American River.

4. Presence of sDPS green sturgeon in the Action Area

The Sacramento River and a portion of the American River serve as an important migratory corridor for larval and juvenile sturgeon during their downstream migration to the San Francisco Bay Delta and Estuary. The San Francisco Bay Delta and Estuary provides year-round rearing habitat for juveniles, as well as foraging habitat for non-spawning adults and subadults in the summer months (NMFS 2008).

Detailed information regarding historic and current abundance, distribution and seasonal occurrence of SDPS green sturgeon in the action area is limited due to a general dearth of green sturgeon monitoring. The action area is located on the main migratory route for adults moving upstream to spawn, post spawn adults migrating back to the ocean, juvenile outmigrants, and rearing subadults. Juvenile green sturgeon from the sDPS are routinely collected at the SWP and CVP salvage facilities throughout the year. Based on the salvage records, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August. Adult green sturgeon begin to enter the Delta in late February and early March during the initiation of their upstream spawning run. The peak of adult entrance into the Delta appears to occur in late February through early April with fish arriving upstream in April and May. Adults continue to enter the Delta until early summer (June-July) as they move upriver to spawn. It is also possible that some adult green sturgeon will be moving back downstream in April and May through the action area, either as early post spawners or as unsuccessful spawners. Some adult green sturgeon have been observed to rapidly move back downstream following spawning, while others linger in the upper river until the following fall. It is possible that any of the adult or sub-adult sturgeon that inhabit the lower Sacramento River may swim into the American River. Similar to the salmonid species, depending on the water year type, it is possible that sturgeon will enter the Sacramento and Yolo bypass.

2.3.2 Status of Critical Habitat within the Action Area

The action area occurs within the USGC Hydrologic Unit Code (HUC) Lake Greenhaven-Sacramento River subbasin designated HUC 180201630701. Designated critical habitat for Sacramento River winter-run Chinook salmon (June 16, 1993, 58 FR 33212), CV spring-run Chinook salmon (September 2, 2005, 70 FR 52488), CCV steelhead (September 2, 2005, 70 FR 52488) and the sDPS of green sturgeon (October 9, 2009, 74 FR 52300) occur in this hydrologic unit. The HUC includes portions of the Sacramento and American Rivers. The critical habitat analytical review team (CHART) concluded that it contained one or more PCEs for both the CCV steelhead DPS and CV spring-run Chinook salmon ESU (NMFS 2005). The PCEs for steelhead and spring-run Chinook salmon habitat within the action area include freshwater rearing habitat and freshwater migration corridors. The features of the PCEs included essential to the conservation of the CCV steelhead DPS and CV spring-run Chinook salmon include the following: sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions necessary for salmonid development and mobility, sufficient water quality, food and nutrients sources, natural cover and shelter, migration routes free from obstructions, no excessive predation, holding areas for juveniles and adults, and shallow water areas and wetlands. Habitat within the action area is primarily utilized for freshwater rearing and migration by CCV steelhead and CV spring-run Chinook salmon juveniles and smolts and for adult freshwater migration. CCV steelhead also utilize the American River for spawning habitat.

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

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

The general condition and function of the aquatic habitat has already been described in the *Status of the Species and Critical Habitat* section of this BO. The substantial degradation over time of several of the essential critical elements has diminished the function and condition of the freshwater rearing and migration habitats in the action area. It has only rudimentary functions compared to its historical status. The channels of the lower Sacramento and American Rivers have been riprapped with coarse stone slope protection on artificial levee banks and these channels have been straightened to enhance water conveyance through the system. The extensive riprapping and levee construction has precluded natural river channel migrations. The natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been "reclaimed" and subsequently drained and cleared for farming.

Even though the habitat has been substantially altered and its quality diminished through years of human actions, its conservation value remains high for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. CCV steelhead adults migrate into the lower American River to spawn, which is within the Lake Greenhaven-Sacramento River HUC, and the resulting fry rear and hold over within the American river until they are ready to migrate out to the ocean. All juvenile winter-run and spring-run Chinook salmon, sDPS green sturgeon, as well as those CCV steelhead smolts originating in the Sacramento River basin must pass into and through the Lake Greenhaven-Sacramento River HUC to reach the lower Delta and the ocean. A large fraction of these fish will likely pass downstream through the action area within the Sacramento River channel. Likewise, adults migrating upstream to spawn must pass through Lake Greenhaven-Sacramento River HUC to reach their upstream spawning areas on the tributary watersheds or main stem Sacramento River. A large proportion of the population is expected to move through the action area within the main channel of the Sacramento River. Therefore, it is of critical importance to the long-term viability of the Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon ESUs, the sDPS of green sturgeon, and the Sacramento River basin portion of the CCV steelhead DPS to maintain a functional migratory corridor and freshwater rearing habitat through the action area and the Lake Greenhaven-Sacramento River HUC in general.

2.3.4 Factors Affecting the Species and Habitat in the Action Area

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

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

High water temperatures also limit habitat availability for listed salmonids in the lower Sacramento River. High summer water temperatures in the lower Sacramento River can exceed 72ºF (22.2ºC), and create a thermal barrier to the migration of adult and juvenile salmonids (Kjelson *et al*. 1982). In addition, water diversions at the dams (*i.e.* Friant, Goodwin, La Grange, Folsom, Nimbus, and other dams) for agricultural and municipal purposes have reduced in-river flows below the dams. These reduced flows frequently result in increased temperatures during the critical summer months which potentially limit the survival of juvenile salmonids in these tailwater sections (Reynolds *et al*. 1993). The elevated water temperatures compel many salmon juveniles to migrate out of the valley floor systems before summer heat makes the tailwaters unsuitable for salmonids. Those fish that remain either succumb to the elevated water temperatures or are crowded into river reaches with suitable environmental conditions.

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

The use of rock armoring limits recruitment of LWD (*i.e.*, from non-riprapped areas), and greatly reduces, if not eliminates, the retention of LWD once it enters the river channel. Riprapping creates a relatively clean, smooth surface which diminishes the ability of LWD to become securely snagged and anchored by sediment. LWD 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. Recruitment of LWD is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows. Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectedness of remaining near shore refuge areas.

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

As previously stated in the *Rangewide Status of the Species and Critical Habitat* section, the transformation of the Sacramento River from a meandering waterway lined with a dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the rivers sinuosity. These impacts likely included the removal of valuable pools and holding habitat for SDPS green sturgeon. In addition, the change in the ecosystem as a result of the removal of riparian vegetation and LWD likely reduce access to floodplain and offchannel rearing habitat, reduced the quantity and quality of benthic habitat and reduced the abundance prey items rearing, foraging and holding habitat. A major factor in the decline of sDPS green sturgeon, and the primary reason for listing this species, was the alteration of its adult spawning and larval rearing habitat in California's Sacramento River Basin (71 FR 17757, April 7, 2006).

2.4 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (in this case there are no interrelated or interdependent actions), that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

To evaluate the effects of the Common Features GRR, NMFS examined the potential proposed actions in the designated action areas. We analyzed construction-related impacts and the expected short- and long-term fish response to habitat modifications using the SAM. We also reviewed and considered the Corps proposed conservation measures. This assessment relied heavily on the information from the Corps BA developed for the Common Features GRR, and available monitoring data from other CV fish studies.

In general, the footprint for the Common Features Project consists of the flood risk management system protecting the city of Sacramento and surrounding areas. This will include structure upgrades, levee deconstruction, and adjacent staging areas. The continued existence of any new or improved flood management structures, associated critical habitat disturbance, vegetation removal, and operational aspects may adversely affect several life stages of CV spring-run Chinook salmon, CCV steelhead, Sacramento River winter-run Chinook salmon, and the sDPS of SDPS green sturgeon in the action area.

The assessment will consider the nature, duration, and extent of the potential actions relative to the migration timing, behavior, and habitat requirements of federally listed CV spring-run Chinook salmon, CCV steelhead, Sacramento River winter-run Chinook salmon, and sDPS of SDPS green sturgeon. Specifically, this assessment will consider the potential impacts resulting from the construction and subsequent O&M activites. Effects of the Common Features Project on aquatic resources include both short- and long-term impacts. Short-term effects, which are related primarily to construction activities (*i.e.*, increased suspended sediment and turbidity), may last several hours to several weeks. Long-term impacts may last months or years and generally involve physical alteration of the river bank and riparian vegetation adjacent to the water's edge.

The Common Features Project construction activities may increase noise, turbidity, suspended sediment, and sediment deposition that may disrupt feeding or temporarily displace fish from preferred habitat or impair normal behavior. Construction activities will also introduce rip rap material into the water column that may injure, harm, or kill listed fish. Some of these effects may occur downstream of the construction activities because noise and sediment may be propagated downstream. Substantial increases in suspended sediment could temporarily bury substrates and submerged aquatic vegetation that supports invertebrates for feeding juvenile fish.

The bank armoring and some of the levee repairs will also contribute to the continued confinement of the riverine system that in turn negatively impacts listed fish species and their designated critical habitat. Even with an ETL variance in place, adopting the ETL as part of the proposed project may have long-term impacts to critical habitat and listed species. Additionally, despite the assumption of a variance, there are uncertainties as to the subsequent O&M activities and their impacts.

Since specific project designs were not available at the time of this analysis, impacts are characterized using "worst case scenario" assumptions. With-project conditions were assumed to be analogous a typical SRBPP repair site (bank armoring paired with onsite restoration features including a planted riparian bench and installed IWM). A Vegetation Variance Request (VVR) was assumed to be in place. Project actions along the Sacramento Bypass and weir reaches, including slurry wall construction, slope stabilization, and levee raises, weir repair, and levee construction were assumed to result in removal of all woody and herbaceous vegetation and armoring of both summer-fall and winter-spring shorelines.

The Common Features project reach will be implemented in increments. The timing of each project sub-reach (Table 4) is based on the proposed schedule provided in the BA (USACE 2015). Some of the project increments will be of varying length, thereby impacting the subsequent analysis.

2.4.1 Construction Related Effects

NMFS expects that adult and juvenile CCV steelhead, adult winter-run Chinook salmon, adult spring-run Chinook salmon, and adult and juvenile green sturgeon may be present in the action area (although in low numbers because the construction window avoids periods of peak abundance) during construction activities. Only those fish that are holding adjacent to or migrating past the project sites will be directly exposed or affected by construction activities. Those fish that are exposed to the effects of construction activities will encounter short-term (*i.e.*, minutes to hours) construction-related noise, physical disturbance, and water quality changes that may cause injury or harm by increasing the susceptibility of some individuals to predation by temporarily disrupting normal behaviors, and affecting sheltering abilities. If an adult salmonid were to enter the action area, they will likely exhibit avoidance behavior in response to construction and associated activities.

Larger fish will likely respond to construction activities by quickly swimming away from the construction sites, and will escape injury. Toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products could enter the waterway as a result of spills or leakage from machinery and injure listed salmonids, and green sturgeon. Petroleum products also tend to form oily films on the water surface that can reduce DO 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.

Green sturgeon move to estuaries and the lower reaches of rivers between late winter and early summer, and ascend rivers to spawn in the spring and early summer. Adult green sturgeon may leave the rivers soon after spawning or hold in the river through the fall or winter (Heublein et al. 2009). Movement and foraging during downstream migration occurs at night for both larvae (approximately 10 days post-hatch) and juveniles (73 FR 52084; Cech *et al*. 2000, as cited in Reclamation 2008). Juvenile emigration reportedly occurs from May through September. Juveniles will experience the greatest exposure to construction activities.

Direct effects are defined as “the direct or immediate effects of the Proposed Action on the species or its habitat” (USFWS and NMFS, March 1998). Direct effects associated with in-river construction work will involve equipment and activities that will produce pressure waves, and create underwater noise and vibration, thereby temporarily altering in-river conditions.

Any increases in turbidity will most likely disrupt feeding and migratory behavior activities of juvenile salmonids (which CCV juvenile Steelhead have a high likely hood of being present).though their abundance is expected to be low). 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). Green sturgeon, which can occupy waters containing variable levels of suspended sediment and thus turbidity, are not expected to be impacted by the slight increase in the turbidity levels anticipated from the pile driving action as explained above. The construction activities are unlikely to impact any deepwater areas where the species spawn and hold.

NMFS expects that actual physical damage or harassment to listed fish species will be low during the months of construction. Adults will not sustain any physical damage due to construction because their size, preference for deep water, and their crepuscular migratory behavior will enable them to avoid most temporary, nearshore disturbance that occurs during typical daylight construction hours.

2.4.2 Standard Assessment Methodology Analysis

Common Features Project impacts were analyzed using SAM. The Corps provided the background data, assumptions, analyses, and assessment of habitat compensation requirements for the federally protected fish species relevant to this consultation. The Corps also included analysis for fall-run and late-fall run Chinook salmon.

The Sacramento River SAM analysis reach includes the entire left bank (east side) of the Sacramento River from the American River confluence to approximately 4,020 linear feet (lf) below the Freeport Bridge. The American River SAM analysis (ARN A-B and ARS A-C) reaches include portions of the right and left bank of the American River from Goethe Park to the confluence of the Sacramento. It also includes portions of NEMDC, Arcade Creek, Magpie Creek, and Dry/Robla Creek.

As described in the *Analytical* Approach section of the BO, during the process of this consultation, the Corps and NMFS identified several short comings with the SAM as a tool for reliably forecasting the growth and survival of green sturgeon. The primary short coming is that the SAM evaluates habitat conditions at the seasonal water surface intersect with the river bank. While this is considered an effective point for measuring salmon and steelhead habitat, green sturgeon have a greater affinity for benthic habitat than shoreline habitat. Further, during discussions between the Corps and NMFS, it was widely agreed upon that levee repair actions in the West Sacramento Study Area are likely to only affect the juvenile rearing life stage and probably have little to no adverse impacts on the adult life stages of green sturgeon because spawning habitat is not present and adults that are migrating upstream are probably more influenced by impacts that affect swimming speed and upstream passage than shoreline habitat manipulations. Because of this, NMFS has decided to use the SAM as a temporary proxy for quantifying habitat disturbance and harm that will ultimately be replaced by a more precise model as proposed by the Corps in the *Proposed Action* section of this BO.

The following data sources were used to characterize SAM habitat conditions (as defined by bank slope, floodplain availability, substrate size, instream structure, aquatic vegetation, and overhanging shade) within the Common Features Project area under baseline conditions:

1. The Corps' Sacramento River revetment database.
2. Aerial images of the Common Features Project reach (Google™ Earth).

The SAM employs six habitat variables to characterize near-shore and floodplain habitats of listed fish species:

1. Bank slope;
2. Floodplain availability;
3. Bank substrate size;
4. Instream structure;
5. Aquatic vegetation; and
6. Overhanging shade.

The following describes how input values for each of these attributes were derived for existing conditions in the SAM assessment.

1. **Bank Slope:** Existing bank slopes (rise-over-run ratio) were extrapolated from cross sections along the Sacramento River and existing SAM analyses performed on regionally analogous sites. Bank slope along all sub-reaches was assumed to be 2.5 for existing conditions.

2. **Floodplain Availability:** The SAM attribute of floodplain inundation ratio, which represents floodplain availability, was assumed to have a value of 1, reflecting the absence of significant floodplain habitat above the winter-spring shoreline under existing conditions.

3. **Bank Substrate Size:** The median substrate size along the summer-fall and winter-spring shorelines of the project reach was determined by referencing the Revetment Database (USACE 2004) and current and historical aerial images.

4. **Instream Structure:** The shoreline coverage of IWM along the average summer-fall and winter-spring shorelines of the Common Features project reach were determined by referencing the revetment database (USACE 2004). The revetment database uses four classes of instream structure, based on ranges of percent shoreline having IWM.

5. **Overhanging Shade:** The extent of overhanging shade along the summer-fall and winter-spring shorelines was determined through analysis of current and historic aerial images. Summer-fall conditions were analyzed using imagery from late summer and early fall months, typically representative of low water conditions. Winter-spring conditions were analyzes using imagery from late winter and early spring months, typically representative of high water conditions.

The following describes how input values for each of the SAM habitat attributes were derived for with-project conditions:

1. **Bank Slope:** With-project bank slopes (rise-over-run ratio) were based on the description of project actions for each sub-reach. Bank slopes for the SAC sub-reach were assumed to be analogous to SRBPP repair sites.

2. **Floodplain Availability:** Levee repair and bank stabilization actions typically do not increase floodplain availability (with exception of constructing setback levees). The Common Features project reaches being analyzed under this SAM do not include construction of any setback levees; therefore, the SAM attribute of floodplain inundation ratio, which represents floodplain availability, was assumed to lack significant floodplain habitat above the winter-spring shoreline under existing conditions.

3. **Bank Substrate Size:** The median substrate size along the summer-fall and winter-spring shorelines of the project reach were based on the description of project actions

for each reach. Bank substrate size along the Sacramento River reach was assumed to be analogous to SRBPP repair sites. Project actions at all other sub-reaches were expected to result in placement of 10 inch rock revetment along both summer-fall and winter-spring shorelines.

4. **Instream Structure:** The shoreline coverage of IWM along the average summer-fall and winter-spring shorelines was based on the description of project actions for each sub-reach. IWM coverage along the SAC sub-reach was assumed to be analogous to SRBPP repair sites (installation of 40 percent shoreline coverage at summer-fall shoreline). Project actions at all other sub-reaches were not expected to result in a change in available IWM along both summer-fall and winter-spring shorelines; IWM values for these sub-reaches will mirror existing condition values.

5. **Aquatic Vegetation:** The shoreline coverage of aquatic vegetation along the average summer-fall and winter-spring shorelines was based on the description of project actions for each sub-reach. Aquatic vegetation along the Sacramento River was assumed to be analogous to SRBPP repair sites. The vegetation growth model below that was applied to the Sacramento River was taken from a previous SAM analysis conducted for Sacramento RM 62.5R (USACE 2008).

6. **Overhanging Shade:** The shoreline coverage of overhanging shade along the average summer-fall and winter-spring shorelines was based on the description of project actions for each sub-reach. Overhanging shade along the Sacramento River was assumed to be analogous to SRBPP repair sites. It was assumed that a variance will be in place allowing for retention of woody vegetation along the lower 2/3 of the levee slope (applies to Sacramento River only). As the result of constructing a planted bench, it was assumed that the with-project seasonal shoreline will be shifted away from the existing shade providing canopy. Under this assumption, existing summer-fall values for overhanging shade were taken as the starting point for with-project winter-spring conditions. The with-project winter-spring values were further reduced by 75 percent (winter) and 25 percent (spring) to account for defoliation. As a final step, these winter-spring values were reduced by 20 percent to account for trees removed for construction equipment access. With-project overhanging shade values were expected to start at 0 percent as the result of a constructed bench shifting the shoreline away from the existing canopy. The shade growth model used was taken from a previous SAM analysis conducted for Sacramento RM 62.5R (USACE 2008).

Project actions at all other sub-reaches were expected to result in a complete removal of woody vegetation without revegetation efforts. For these sub-reaches, a value of 0 percent shoreline coverage of overhanging shade was applied throughout the life of the project along both summer-fall and winter-spring shorelines.

For more information on the SAM analysis and inputs, refer to the Appendix A.

2.4.3 SAM Results

The SAM results presented below and in Table 10, 11, and 12 are based on a "worst case scenario" analysis, as developed by the Corps. Table 10 and 11 show negative WRI values, but there are several areas where the action will result in improved conditions for salmon and steelhead. These are discussed below, and are summarized in Appendix A table 26, 27, and 28. The with-project conditions for the focus fish species and life stages were evaluated over a 50-year assessment timeline with baseline habitat values for each species and life stage described by pre-project conditions. Biological responses of each focus fish species life stage and average seasonal water surface elevation were predicted within each habitat unit and for each time step, based on habitat variable values and fish residency determined from region-specific timing tables (USACE 2012b). This analysis automatically includes or excludes particular life stages of the focus fish by assessing the river mile locations of each bank repair site, with the encoded timing tables. In general, as calculated, positive differences between the existing and with-project responses are considered to result in improved growth and survival for the focus fish species (*i.e.*, the bank repair action produced superior conditions than pre-project conditions). Negative values indicate the bank repair actions produced inferior conditions when compared with pre-project conditions and reduced growth and survival over a 30 day exposure period. In almost all cases, regardless of the integrated conservation and compensation measures (*i.e.*, installation of IWM, planting riparian habitat, and construction of engineered floodplain) there is a short-term temporal negative habitat impact associated with many of the bank repair activities, mainly because new levee configurations move the river bank away from existing, protected riparian vegetation and because it takes several years for newly planted riparian vegetation to growth out over the river channel and create overhanging shade and other benefits to aquatic habitat such as a source of macroinvertebrate production.

American River

NMFS reviewed the SAM results provided by the Corps. Details of the SAM results can be found Appendix A of this document. This includes tables and graphs of the SAM results from year 0 (beginning of construction) to year 50. Tables 10, 11, and 12 summarize all negative Common Features Project SAM WRI values for Chinook salmon, steelhead, and green sturgeon. It is important to note that when interpreting SAM results, year 0 refers to the year of construction.

Summary of CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, CCV steelhead and sDPS green sturgeon effects by water surface elevation per location:

Common Features American River North Reaches A and B:

At fall water surface elevations:

Reduced growth and survival of fry and juvenile rearing CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The adverse effects are greatest in the first 3 to 5 years for each species at -366 WRI, -712, and -5577, respectively.

Reduced growth and survival of juvenile migrating (smolts) CV spring-run Chinook salmon is expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this adverse effect is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The adverse effect is greatest at -2303 WRI.

The SAM displays reduced survival of adult migrating CCV steelhead is expected for up to 48 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this potential effect is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The adverse effect is greatest at -1554 WRI and exceeds baseline following year 48 to a maximum increase benefit of 8 WRI.

At winter surface elevations:

Increased growth and survival of fry and juvenile rearing CV spring-run Chinook salmon is expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size reaching a maximum of 1,102 WRI. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO.

Reduced growth and survival of fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The adverse effects are greatest at -36 WRI for steelhead in the first year and the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected. After year one, survival and growth values improve to 1507 for CCV steelhead. The adverse effects to sDPS green sturgeon are greatest at -5020 and are expected to extend past 50 years.

Reduced growth and survival of migrating (smolts) CV spring-run Chinook salmon is expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The adverse effects are greatest at -3,002 WRI. At year 2, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 1,699 WRI.

The SAM displays reduced survival of adult migrating CCV steelhead for up to 5 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this potential effect is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The adverse effect is greatest at -1554 WRI. At year 5, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 460 WRI.

Reduced survival of adult residence CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The adverse effect is greatest at -1,558 and -3,621 WRI, respectively. At year 5 for CCV steelhead, the SAM modeled habitat conditions exceed baseline conditions and improves growth and survival conditions are expected, reaching 460 WRI.

At spring water surface elevations:

Increased growth and survival of fry and juvenile rearing CV spring-run Chinook salmon occurs after any construction activities by the first year and reaching a maximum of 1354 WRI. Increased growth and survival of fry and juvenile are expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO.

Reduced growth and survival of fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction due to impacts to riparian habitat IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The adverse effects are greatest at -2681 and -5020, respectively. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1418 WRI. The adverse effects to sDPS green sturgeon are greatest at -5020 WRI and are expected to extend past 50 years.

Reduced growth and survival of juvenile migrating (smolts) CV spring-run Chinook salmon and CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The adverse effects are greatest at -3129 and -2096 WRI, respectively. At year 4, for CV spring-run Chinook salmon, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 1,699 WRI. At year 2, for CCV steelhead, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 1173 WRI.

The SAM displays reduced survival of adult migrating CCV steelhead after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this potential effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The adverse effect is greatest at -1635 WRI. At year 6, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 407 WRI.

Reduced survival of adult resident CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO.

The adverse effects are greatest at -1635 WRI for CCV steelhead in the first six years and the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected. After six years, survival and growth values improve to 407 for CCV steelhead.

At summer surface elevations:

Reduced growth and survival of fry and juvenile rearing CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The adverse effects are greatest for each species at -421 WRI, -833, and -7118, respectively.

Reduced growth and survival of juvenile migrating (smolts) of CV spring-run Chinook salmon and CCV steelhead are expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these adverse effects are quantified in the SAM in table 26 in Appendix A and summarized in table 10 of this BO. The adverse effects are greatest at -3,129 and -3013 WRI, respectively.

Reduced survival of adult resident CV steelhead is expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM and, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The adverse effects on the species are greatest at -3061 WRI, and -942, respectively.

American River South Bank sites A, B, and C

At fall surface elevations:

Reduced growth and survival of fry and juvenile rearing CV spring run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected after any construction activities due to impacts riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The adverse effects are greatest for each species at -229 WRI, -489, and -2154, respectively. At year 26 for CV spring run Chinook salmon and year 36 for CCV steelhead, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 112 WRI and 88, respectively. The adverse effects to sDPS green sturgeon are greatest at -2154 and are expected to extend past 50 years.

Reduced growth and survival of juvenile migrating (smolts) CV spring run Chinook salmon is expected after any construction due to impacts riparian habitat, IWM, and bank substrate size. The amount and extent of this adverse effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The adverse effect is greatest at -620 WRI. After year 21, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected reaching a maximum of 526 WRI.

The SAM displays increased survival of adult migrating CV steelhead after construction activities due to impacts), IWM, and bank substrate size. The amount and extent of this potential effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The increased benefit maximizes at 3696 of WRI.

Increased survival of adult resident CCV steelhead is expected after construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The maximum increase benefit is for the species is 3696 and WRI and 1548, respectively.

At winter water surface elevations:

Increased growth and survival of fry and juvenile rearing CV spring run Chinook salmon occurs after any construction activities by the first year and reaching a maximum of 1578 WRI. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO.

Reduced growth and survival of fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction due to impacts to riparian habitat IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The adverse effects are greatest at – 489 WRI and – 876, respectively. At year 36, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 88 WRI. At year one, the SAM modeled habitat conditions for sDPS green sturgeon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 2941 WRI.

Increased growth and survival of juvenile migrating (smolts) CV spring run Chinook salmon is expected to occur after construction activities due to impacts on riparian habitat, IWM and, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The maximum increase benefit for this species is 5377 WRI.

The SAM displays increased survival of adult migrating CCV steelhead after construction activities due to impacts on riparian habitat, IWM and, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The increased benefit maximizes at 4015.

Increased survival of adult resident CV steelhead is expected to occur after construction activities, the maximum increase benefit for this species is 4015 WRI.

At spring water surface elevations:

Increased growth and survival of fry and juvenile rearing CV spring run Chinook salmon and CCV steelhead occurs starting at year 0 and increased to the maximum above baseline scores of 2,100 and 2,601 WRI, respectively. Reduced growth and survival of fry and juvenile rearing sDPS green sturgeon is expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these effects are quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The greatest adverse effect is at -876 WRI. At year 1, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 2,941 WRI.

Increased growth and survival of juvenile migrating (smolts) CV spring run Chinook salmon and CV steelhead is expected due to impacts on riparian habitat, IWM, and bank substrate size. The greatest effects for each species is 5123 WRI and 4061 WRI respectively. The amount and extent of this potential effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO.

The SAM displays increased survival of adult migrating CCV steelhead after the first year of construction due to impacts on riparian habitat, IWM, and bank substrate size the amount and extent of this potential effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The maximum benefit is 4164 WRI.

Increased survival of resident CCV steelhead occurs starting at year 0 and increased to above baseline 4164 WRI due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these effects are quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO.

Increased survival of adult resident CV steelhead is expected to occur after construction activities, the maximum increase benefit for this species is 4015 WRI.

At summer water surface elevations:

Reduced growth and survival of fry and juvenile rearing CV spring run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The adverse effects are greatest at – 239, -512, and – 2496 WRI, respectively. At year 26, the SAM modeled habitat conditions for CV spring run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 111 WRI. At approximately year 6, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 64 WRI. The adverse effects to sDPS green sturgeon are expected to extend past 50 years.

Reduced growth and survival of juvenile migrating (smolts) CV spring run Chinook salmon and CCV steelhead are expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these effects are quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The adverse effects are greatest at -967 and -722 WRI, respectively. At year 22, the SAM modeled habitat conditions for CV spring run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 510 WRI. At year 25, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 583 WRI.

Increased survival of adult resident CCV steelhead is expected after construction activities due to impacts on riparian habitat, IWM, and bank substrate size, with maximum benefits of 3616 and 1537 WRI, respectively. The amount and extent of this effect is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO.

Project actions along portions of the American River reach will likely not include bank armoring in their final design, which will significantly reduce estimated impacts to fish species. Additional compensatory mitigation design features or improved erosion repair designs may result in reduced impact compared to the legacy designs used for the basis of this analysis. Site specific designs will be implemented on a site by site basis in consultation with resource agencies and project partners to minimize impacts as well as maximize opportunities for implementing onsite compensatory mitigation features.

The Corps has proposed to offset the effects with onsite and offsite compensation. During project implementation, site specific SAM analyses will be run on final designs to better evaluate these effects. These offsets are likely to improve growth and survival of Chinook salmon and steelhead at higher value habitats in the Delta and along their primary migration corridor of the Sacramento and American Rivers, and spawning and rearing areas along the American River.

Sacramento River Sites D,E,F, and G

At fall water surface elevations:

Reduced growth and survival of fry and juvenile rearing CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. Reduced growth and survival of fry and juvenile rearing sDPS green sturgeon is expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these effects are quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The greatest adverse effects for the salmonids are -558 WRI, -1156, and -558 WRI respectively. The SAM modeled habitat conditions exceed baseline conditions and improve growth and survival is expected in year 35, 44, and 35, respectively with maximum values reaching 116, 99, and 116 WRI, respectively. The adverse effects to sDPS green sturgeon are greatest at -4674 WRI and are expected to extend past 50 years.

Reduced growth and survival of juvenile migrating (smolts) CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon is expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these adverse effects are quantified in the SAM analysis table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest at -3845 WRI, -3985, and -3845, respectively.

The SAM displays reduced survival of adult migrating CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and the extent of these potential effects is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The greatest adverse effects for the salmonids are -1394 WRI, -2053, and 1394, respectively. The SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected at years 35, 29, and 35 respectively. After these years, survival and growth values improve to 362, WRI, 832, and 362 WRI, respectively.

Reduced survival of adult resident CCV steelhead after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this potential effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effect is greatest at -2053 WRI and exceeds baseline following year 29, where adult resident survival increases to a maximum value of 832 WRI.

At winter surface elevations:

Increased growth and survival of fry and juvenile rearing CV spring run Chinook salmon and Sacramento River winter-run Chinook salmon occurs after any construction activities by the first year and reaching a maximum of 2390 WRI for both species. The amount and extent of this effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO.

Reduced growth and survival of fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction due to impacts on riparian habitat, IWM and, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest at -77 and -4397, respectively. At year 1, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 3234 WRI. The adverse effects to sDPS green sturgeon are expected to extend past 50 years.

Reduced growth and survival of juvenile migrating (smolts) CCV spring run Chinook salmon, CCV steelhead, and CV winter run is expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this adverse effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the species at -3451 WRI, -3044, and -3451, respectively. At year two, the SAM modeled habitat conditions for CV spring run Chinook salmon and Sacramento River winter-run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 4794 WRI for both species. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 3355 WRI.

The SAM displays reduced survival of adult migrating CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon are expected to occur after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this potential effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the species at -892 WRI, -1747, and -892 WRI, respectively. At year 4, the SAM modeled habitat conditions for CV spring run Chinook salmon and CV winter run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 643 WRI. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1455 WRI.

Reduced survival of adult residence CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the species at -1801 WRI, and -3068, respectively. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

At spring water surface elevations:

Increased growth and survival of fry and juvenile rearing CV spring run and winter-run Chinook salmon occurs after any construction activities by the first year and reaching a maximum of 3445 WRI. The amount and extent of this effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO.

Reduced growth and survival of fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest at -36 WRI and -4397, respectively. At year 1, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 4317 WRI. The adverse effects to sDPS green sturgeon are expected to extend past 50 years.

Reduced growth and survival of juvenile migrating (smolts) CCV spring run Chinook salmon, CCV steelhead, and CV winter run is expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this adverse effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the species at -3484 WRI, -3082, and -3484, respectively. At year 2, the SAM modeled habitat conditions for CV spring run Chinook salmon and Sacramento River winter-run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 4862 WRI for both species. At year three, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 3474 WRI.

The SAM displays reduced survival of adult migrating CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon are expected to occur after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this potential effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the species at -946 WRI, -1801, and -

946 WRI, respectively. At year 4, the SAM modeled habitat conditions for CV spring run Chinook salmon and CV winter run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 931 WRI. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

Reduced survival of adult residence CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the species at -1801 WRI, and -3068, respectively. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

At summer water surface elevations:

Reduced growth and survival of fry and juvenile rearing CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. Reduced growth and survival of fry and juvenile rearing sDPS green sturgeon is expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these effects are quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the salmonids are -578 WRI, -1206, and -578 WRI respectively. The SAM modeled habitat conditions exceed baseline conditions and improve growth and survival is expected in years 36, 45, and 36, respectively, with maximum increased WRI values of 113, 92, and 113. The adverse effects to sDPS green sturgeon are greatest at -5009 WRI and are expected to extend past 50 years.

Reduced growth and survival of juvenile migrating (smolts) CCV spring run Chinook is expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this adverse of these adverse effects are quantified in the SAM analysis table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest at -4258 WRI.

The SAM displays reduced survival of adult migrating CV spring run Chinook salmon, CV steelhead, and Sacramento River winter-run Chinook salmon after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and the extent of these potential effects is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The greatest adverse effects for these species are -2136 WRI, -3793, and -2136 WRI, respectively. The SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected at years 37, 32, and 37 respectively. After these years, survival and growth values improve to 319 WRI, 748, and 319 WRI, respectively.

Reduced survival of adult residence CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this effect is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The adverse effects are greatest for the species at -3793 WRI, and -1298, respectively. At year

32, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 748 WRI.

Effects at the Sacramento Weir and Bypass

Bypass flooding may affect juvenile fish in two different manners: (1) stranding (and killing) of juvenile fish in the widened bypass is possible on the declining limb of flood flows when weir operations cease after a flood event, and (2) increasing floodplain inundation area and increasing juvenile growth and survival. Sommer *et. al.* (2001), have demonstrated that the Yolo Bypass, the primary floodplain of the lower Sacramento River, provides better rearing and migration habitat for juvenile chinook salmon (*Oncorhynchus tshawytscha*) than adjacent river channels. We expect that due to the proximity of the Sacramento Bypass to the Yolo Bypass, the fact that the Sacramento Bypass flows into the Yolo Bypass and similar floodplain conditions in both bypasses, that similar growth and survival conditions would be expected. Both effects are expected to occur approximately once every ten years when the river reaches an elevation of 27.5 feet at the I Street gage with a forecast to continue rising. The duration of bypass inundation is highly variable depending of the magnitude and duration of flood events. After a flood event, weir gates are typically closed as rapidly as practicable once the stage at the weir drops below 25 feet. This provides "flushing" flows to re-suspend sediment deposited in the Sacramento River between the Sacramento Weir and the American River during the low flow periods when the weir is open during the peak of the flood event Baseline stranding and growth levels are not known and it is difficult to predict specific stranding rates with a widened bypass, however, the Corps proposes to grade new and existing bypass features to drain in a manner that reduce juvenile stranding.

Interruption of upstream passage of adult salmonids and sturgeon along the Sacramento weir and stranding within the bypass may occur due to the declining hydrograph as a result of the widening of the bypass. This is also expected to occur once every ten years following the spilling of river water and as the flood flows recede. Stranding in the Sacramento Bypass and blocked upstream passage may not occur however, with the implemented conservation measures as outlined in the project description and may in fact improve passage conditions currently found at the Sacramento weir and bypass and reduce current stranding rates.

Migrating green sturgeon in the lower portion of the Sacramento River become stranded during high flow events in flood control weirs and bypasses. In April 2011, 24 threatened green sturgeon were stranded in two flood diversions along the Sacramento River. Modeling and research suggests that recurrent stranding of a similar magnitude without rescue could affect the long-term viability of Green Sturgeon (Thomas et. al., 2013). With the widening of the Sacramento Weir for increased flow capacity during high flow events, there is a potential to maintain or increase stranding of adults behind the weir individuals if no passage criteria are included within the weir design. However, as stated in the conservation measures as outlines in the Proposed Action section of this BO, the Corps also will work with local cost share sponsors to ensure GRR-related future flood risk reduction actions related to widening the Sacramento Weir shall fully mitigate upstream and downstream fish passage effects at the weir and within the spillway basin. The goal is to ensure that adult CV spring-run and Sacramento River inter-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are able to migrate upstream while the weir is spilling into the bypass and that juvenile stranding in the spillway basin is minimized to the maximum extent possible. These measures are expected to reduce juvenile and adult stranding in the bypass and provide long-term benefits through improved growth and survival of juveniles and improved survival of adults.

Implementation of the Corps proposed Green Sturgeon Conservation Measures

The implementation of the Corp's Green Sturgeon Conservation Measures will serve several purposes to address scientific uncertainty about the species in the study area and to provide compensatory mitigation for the adverse effects related to shoreline and benthic habitat impacts. The HMMP with ensure that adverse impacts of future West Sacramento projects are sufficiently compensated in order to allow for the growth, survival and recovery of the species in the study area. Coordination of the HMMP with the IEP will leverage green sturgeon scientific expertise to ensure selected mitigation actions fully address the micro- and macro-ecological and survival needs of the species in the study area. Refinement of the SAM or development of alternative green sturgeon survival and response model using the Corps' Hydrologic Ecosystem Function Model, in consultation with NMFS and the IEP, will result in new modeling capacity that more accurately evaluates adverse project actions and the beneficial effects of mitigation actions relative to the growth and survival of green sturgeon in the study area. Restoring and compensating for the number of acres and ecological function of impacted benthic habitat and the initiation of this compensatory mitigation in the study area prior to the commencement of levee construction will reduce the impact of levee construction actions. The development of SMART compensatory mitigation objectives will ensure that all of the ecological impacts of levee construction actions are fully addressed.

2.4.4 Project Effects on Critical Habitat

For CV spring-run Chinook salmon and steelhead, the project generally will have short term impacts on the freshwater rearing and freshwater rearing PCEs of critical habitat. For winter-run Chinook salmon, and for winter-run Chinook salmon impacted essential features of critical habitat that will be affect include the river water, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. The SAM model, which models fish response, also serves as a good proxy for measuring impact to these species critical habitat because it the model evaluates changes to important attributes of PCEs and essential features including overhanging shade, substrate size, instream woody material, bank slope and instream aquatic vegetation. The changes to these features are recognized in Table 10, 11 and 12 below. In general, impacts to critical habitat will generally last between 1 and 10 years, and in almost all cases they improve each year and eventually exceed baseline conditions over the life of the project. For these reasons, we do not expect the proposed action to reduce the conservation value of the critical habitat.

Because the proposed action occurs along the lower Sacramento River at the convergence of the north Delta, the action area includes both freshwater and estuarine habitat types. For green sturgeon, this means there are freshwater and estuarine including:

Freshwater

a) Food resources. Abundant prey items for larval, juvenile, subadult, and adult life stages.
b) Substrate type or size (*i.e*., structural features of substrates). Substrates suitable for egg deposition and development (*e.g.*, bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (*e.g.*, substrates with interstices or voids providing refuge from predators and from high flow conditions), and feeding of juveniles, subadults, and adults (*e.g.*, sand/mud substrates).

Estuarine

a) Food resources. Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages.

NMFS estimates that approximately 20 acres of soft substrate habitat below the ordinary high water mark will be permanently lost to rock revetment. This number was calculated by using the provided linear feet in reaches C, D, E, F, and G in Table 4 and multiplying it by 15 feet which is the length of the distance revetment is placed from the bank into the river. This is a conceptual estimate that will be further refined during the preliminary engineering design (PED) phase before construction begins. This loss of habitat is expected to adversely affect benthic substrate and impair food resources for all life stages; and the quantity of sediment to allow for normal physiological and behavioral responses to the environment. Similar to salmon and steelhead, the SAM serves as a reasonable proxy for measuring impacts to critical habitat. For most life stages and season water surface elevations, the SAM show immediate adverse effects that continue to decline for the life of the project. However, the Corps' Green Sturgeon Conservation Measures will reduce the impact on critical habitat by providing compensatory mitigation within the action area. Specifically, the HMMP shall also restore or compensate for the number of acres and ecological function of soft bottom benthic substrate for sDPS green sturgeon permanently lost to project construction. This compensation will be carried out within the lower Sacramento River/North Delta in order to offset the adverse modification to designated critical habitat. The restored habitat will be capable of providing abundant benthic prey, freshwater or estuarine areas with adequate water quality, temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth and viability of all life stages. It will also provide safe and unobstructed migratory pathways necessary for timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats.

Table 10. American River North Portion (ARN_AB) of the Common Feathers GRR Project Maximum SAM Modelled WRI Deficits and Duration of Deficits by Species, Life-Stage, and Season.

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Spring-Run Chinook Salmon				
Fall	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-366	50	0
	Juvenile Migration	-2,303	50	0
Winter	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	1,102
	Juvenile Migration	-3,002	2	1,699
Spring	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	1,354
	Juvenile Migration	-2,681	4	1,699
Summer	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-421	50	0
	Juvenile Migration	-3,129	50	0
Fall-Run Chinook Salmon				
Fall	Adult Migration	-877	39	59
	Fry and Juvenile Rearing	-366	50	0
	Juvenile Migration	-2,303	50	0
Winter	Adult Migration	-759	5	245
	Fry and Juvenile Rearing	0	0	1,102
	Juvenile Migration	-3,002	4	1,699
Spring	Adult Migration	**	**	**
	Fry and Juvenile Rearing	0	0	1,354
	Juvenile Migration	-2,681	3	1,418
Summer	Adult Migration	**	**	**
	Fry and Juvenile Rearing	-421	50	0
	Juvenile Migration	-3,129	50	0
Steelhead				
Fall	Adult Migration	-1,554	48	8
	Fry and Juvenile Rearing	-712	50	0
	Juvenile Migration	***	***	***
	Adult Residence	-1,554	48	8
Winter	Adult Migration	-1,558	5	460
	Fry and Juvenile Rearing	-36	1	1,507

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
	Juvenile Migration	***	***	***
	Adult Residence	-1,558	5	460
Spring	Adult Migration	-1,635	6	407
	Fry and Juvenile Rearing	-1	1	1,731
	Juvenile Migration	-2,096	2	1,173
	Adult Residence	-1,635	6	407
Summer	Fry and Juvenile Rearing	-833	50	0
	Juvenile Migration	-3,013	50	0
	Adult Residence	-3,061	50	0
Green Sturgeon				
Fall	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-5,677	50	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA
Winter	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-5,020	50	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA
Spring	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-5,020	50	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA
Summer	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-7,118	0	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA

* Not applicable, adult spring-run Chinook salmon are not present on the American River

** Not applicable, adult migration of fall-run Chinook begins in early fall.
*** Not applicable, historically juvenile steelhead migration occurs in spring and summer.

Table 11. American River South Portion (ARS_ABC) of the Common Features GRR Project Maximum SAM modelled WRI Deficits and Duration of Deficits by Species, Life-Stage, and Season.

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Spring-Run Chinook Salmon				
Fall	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-229	26	112
	Juvenile Migration	-620	21	526
Winter	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	1,578
	Juvenile Migration	-333	1	5,377
Spring	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	2,001
	Juvenile Migration	0	0	5,123
Summer	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-239	26	111
	Juvenile Migration	-967	22	510
Fall-Run Chinook Salmon				
Fall	Adult Migration	0	0	1,860
	Fry and Juvenile Rearing	-229	26	112
	Juvenile Migration	-620	21	526
Winter	Adult Migration	0	0	1,937
	Fry and Juvenile Rearing	0	0	1,578
	Juvenile Migration	-333	1	5,377
Spring	Adult Migration	**	**	**
	Fry and Juvenile Rearing	0	0	965
	Juvenile Migration	0	0	5,123
Summer	Adult Migration	**	**	**
	Fry and Juvenile Rearing	-239	26	111
	Juvenile Migration	-967	22	510
Steelhead				
Fall	Adult Migration	0	0	3,696
	Fry and Juvenile Rearing	-489	36	88
	Juvenile Migration	***	***	***
	Adult Residence	0	0	3,696
Winter	Adult Migration	0	0	4,015
	Fry and Juvenile Rearing	0	0	2,194

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
	Juvenile Migration	***	***	***
	Adult Residence	0	0	4,015
Spring	Adult Migration	0	0	4,164
	Fry and Juvenile Rearing	0	0	2,601
	Juvenile Migration	0	0	4,061
	Adult Residence	0	0	4,164
Green Sturgeon				
Fall	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-2,154	50	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA
Winter	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-876	1	2,941
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA
Spring	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-876	1	2,941
	Juvenile Migration	0	0	0
	Adult Residence	-2,917	50	0
Summer	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-2,496	50	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA

* Not applicable, adult spring-run Chinook salmon are not present on the American River

** Not applicable, adult migration of fall-run Chinook begins in early fall.

*** Not applicable, historically juvenile steelhead migration occurs in spring and summer.

Table 12. Sacramento River Portion (ARS_DEFG) portion of the Common Feathers GRR Project Maximum SAM Modelled WRI Deficits and Duration of Deficits by Species, Life-Stage, and Season.

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Spring-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	-946	4	931
	Fry and Juvenile Rearing	0	0	3,445
	Juvenile Migration	-3,484	2	4,862
Summer	Adult Migration	-2,136	37	319
	Fry and Juvenile Rearing	-578	36	113
	Juvenile Migration	-4,258	50	0
Fall-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	3,445
	Juvenile Migration	-3,484	2	4,862
Summer	Fry and Juvenile Rearing	-578	36	113
	Juvenile Migration	-4,258	50	0
Late-Fall-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	-946	4	931
	Fry and Juvenile Rearing	0	0	3,445
Summer	Fry and Juvenile Rearing	-578	36	113
Winter-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	-946	4	931
	Fry and Juvenile Rearing	0	0	3,445
	Juvenile Migration	-3,484	2	4,862
Summer	Adult Migration	-2,136	37	319
	Fry and Juvenile Rearing	-578	36	113
Steelhead				
Fall	Adult Migration	-2,053	29	832
	Fry and Juvenile Rearing	-1,156	44	99
	Juvenile Migration	-3,985	50	0
	Adult Residence	-2,053	29	832
Winter	Adult Migration	-1,747	3	1,455
	Fry and Juvenile Rearing	-77	1	3,234
	Juvenile Migration	-3,044	3	3,355
	Adult Residence	-1,747	3	1,455
Spring	Adult Migration	-1,801	3	1,757
	Fry and Juvenile Rearing	-36	1	4,317
	Juvenile Migration	-3,082	3	3,474
	Adult Residence	-1,801	3	1,757
Summer	Adult Migration	-3,793	32	748
	Fry and Juvenile Rearing	-1,206	45	92
	Adult Residence	-3,793	32	748

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
sDPS Green Sturgeon				
Fall	Fry and Juvenile Rearing	-4,674	50	0
	Juvenile Migration	0	0	0
Winter	Adult Migration	NA	NA	NA
	Fry and Juvenile Rearing	-4,397	50	0
	Adult Residence	NA	NA	NA
Spring	Fry and Juvenile Rearing	-4,397	50	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA
	Adult Migration	NA	NA	NA
Summer	Fry and Juvenile Rearing	-5,009	50	0
	Juvenile Migration	0	0	0
	Adult Residence	NA	NA	NA

* Not applicable because adult fall-run Chinook salmon migrate in early fall.

2.5 Cumulative Effects

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

2.5.1 Water Diversions and Agricultural Practices

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found along the Common Features GRR action area. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile listed anadromous species. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a CV database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001).

Agricultural practices in the action area may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow. Grazing activities from cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the associated watersheds. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect listed salmonid and sDPS green sturgeon reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003).

2.5.2 Aquaculture and Fish Hatcheries

More than 32-million fall-run Chinook salmon, 2-million spring-run Chinook salmon, 1-million late fall-run Chinook salmon, 0.25-million winter-run Chinook salmon, and 2-million steelhead are released annually from six hatcheries producing anadromous salmonids in the CV. All of these facilities are currently operated to mitigate for natural habits that have already been permanently lost as a result of dam construction. The loss of this available habitat results in dramatic reductions in natural population abundance which is mitigated for through the operation of hatcheries. Salmonid hatcheries can, however, have additional negative effects on ESA-listed salmonid populations. The high level of hatchery production in the CV can result in high harvest-to-escapements ratios for natural stocks. California salmon fishing regulations are set according to the combined abundance of hatchery and natural stocks, which can lead to over-exploitation and reduction in the abundance of wild populations that are indistinguishable and exist in the same system as hatchery populations. Releasing large numbers of hatchery fish can also pose a threat to wild Chinook salmon and steelhead stocks through the spread of disease, genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production. Impacts of hatchery fish can occur in both freshwater and the marine ecosystems. Limited marine carrying capacity has implications for naturally produced fish experiencing competition with hatchery production. Increased salmonid abundance in the marine environment may also decrease growth and size at maturity, and reduce fecundity, egg size, age at maturity, and survival (Bigler *et al.* 1996). Ocean events cannot be predicted with a high degree of certainty at this time. Until good predictive models are developed, there will be years when hatchery production may be in excess of the marine carrying capacity, placing depressed natural fish at a disadvantage by directly inhibiting their opportunity to recover (NPCC 2003).

2.5.3 Increased Urbanization

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, will not require Federal permits, and thus will not undergo review through the ESA section 7 consultation process with NMFS.

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

2.5.4 Global Climate Change

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

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

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

In light of the predicted impacts of global warming, the CV has been modeled to have an increase of between +2°C and +7°C by 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Stewart 2005), with a drier hydrology predominated by rainfall rather than snowfall. This will alter river runoff patterns and transform the tributaries that feed the CV from a spring and summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This will truncate the period of time that suitable cold-water conditions exist downstream of 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 downstream of reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Sacramento River winter-run Chinook salmon and CCV steelhead) that must hold and/or rear downstream of the dam over the summer and fall periods.

2.5.5 Rock Revetment and Levee Repair Projects

Cumulative effects include non-Federal riprap projects. 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 riprap occur within the Sacramento River watershed. For example, most of the levees have roads on top of the levees which are either maintained by the county, reclamation district, owner, or by the state. Landowners may utilize roads at the top of the levees to access part of their agricultural land. 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 Common Features Project.

2.6 Integration and Synthesis

The *Integration and Synthesis* section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of the proposed action. In this section, NMFS performs two evaluations: whether, given the environmental baseline and status of the species and critical habitat, as well as future cumulative effects, it is reasonable to expect the proposed action is not likely to: (1) reduce the likelihood of both survival and recovery of the species in the wild; and (2) result in the destruction or adverse modification of designated critical habitat (as determined by whether the critical habitat will remain functional to serve the intended conservation role for the listed anadromous species or retain its current ability to establish those features and functions essential to the conservation of the species).

The *Analytical Approach* described the analyses and tools we have used to complete this analysis. This section is based on analyses provided in the *Status of the Species*, the *Environmental Baseline*, and the *Effects of the Proposed Action*.

In our *Status of the Species* section, NMFS summarized the current likelihood of extinction of each of the listed species. We described the factors that have led to the current listing of each species under the ESA across their ranges. These factors include past and present human activities and climatological trends and ocean conditions that have been identified as influential to the survival and recovery of the listed species. Beyond the continuation of the human activities affecting the species, we also expect that ocean condition cycles and climatic shifts will continue to have both positive and negative effects on the species' ability to survive and recover. The *Environmental Baseline* reviewed the status of the species and the factors that are affecting their survival and recovery in the action area. The *Effects of the Proposed Action* reviewed the exposure of the species and critical habitat to the proposed action and cumulative effects. NMFS then evaluated the likely responses of individuals, populations, and critical habitat. The

Integration and Synthesis will consider all of these factors to determine the proposed action's influence on the likelihood of both the survival and recovery of the species, and on the conservation value of designated critical habitat.

The criteria recommended for low risk of extinction for Pacific salmonids are intended to represent a species and populations that are able to respond to environmental changes and withstand adverse environmental conditions. Thus, when our assessments indicate that a species or population has a moderate or high likelihood of extinction, we also understand that future adverse environmental changes could have significant consequences on the ability of the species to survive and recover. Also, it is important to note that an assessment of a species having a moderate or high likelihood of extinction does not mean that the species has little or no chance to survive and recover, but that the species faces moderate to high risks from various processes that can drive a species to extinction. With this understanding of both the current likelihood of extinction of the species and the potential future consequences for species survival and recovery, NMFS will analyze whether the effects of the proposed action are likely to in some way increase the extinction risk each of the species faces.

In order to estimate the risk to CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, CCV steelhead, and green sturgeon as a result of the proposed action, NMFS uses a hierarchical approach. The condition of the ESU or DPS is reiterated from the *Status of the Species* section of this BO. We then consider how the status of populations in the action area, as described in the *Environmental Baseline*, is affected by the proposed action. Effects to individuals is summarized, and to the consequence of those effects is applied to establish risk to the diversity group, ESU, or DPS.

In designating critical habitat, NMFS considers the physical and biological features (essential features) within the designated areas that are essential to the conservation of the species and that may require special management considerations or protection. Such requirements of the species include, but are not limited to: (1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing offspring, and generally; and (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of this species [see 50 CFR § 424.12(b)]. In addition to these factors, NMFS also focuses on the principal biological or physical constituent elements within the defined area that are essential to the conservation of the species. Primary constituent elements may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

The basis of the "destruction or adverse modification" analysis is to evaluate whether the proposed action results in negative changes in the function and role of the critical habitat in the conservation of the species. As a result, NMFS bases the critical habitat analysis on the affected areas and functions of critical habitat essential to the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality.

2.6.1 Status of the CV Spring-Run Chinook Salmon ESU

The CV spring-run Chinook salmon ESU is at moderate risk of extinction (Lindley *et al.* 2007). The most recent viability assessment of CV spring-run Chinook salmon was conducted during NMFS' 2011 status review (NMFS 2011b). This review found that the biological status of the ESU has worsened since the last status review. In the 2011, the ESU as a whole could not be considered viable because there were no extant viable populations in the three other diversity groups. In addition, Mill, Deer, and Butte creeks are close together geographically, decreasing the independence of their extinction risks due to catastrophic disturbance. These and other conditions covered in the 2011 status review have not changed since 2011. While the abundance for some populations appears to be slightly improving, the ESU is still demonstrating a high variability in adult abundance (especially in Butte Creek), we cannot say based on the trend over the past three years that the risk of extinction for the ESU has improved.

2.6.2 Summary of the Status of the CCV Steelhead DPS

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

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

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

The CCV steelhead DPS is at high risk of extinction (NMFS 2011c), and the extinction risk is increasing. The most recent viability assessment of CCV steelhead was conducted during NMFS' 2011 status review (NMFS 2011c). This review found that the biological status of the ESU has worsened since the last status review recommend that its status be reassessed in two to three years as opposed to waiting another five years, if it does not respond positively to improvements in environmental conditions and management actions.

2.6.3 Summary of the Status of the Green Sturgeon southern DPS

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (NMFS 2010a).

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

Adult green sturgeon migrate through the action area to reach upstream spawning habitat. Early larval drift and rearing is also likely to occur upstream from the action area near spawning sites. As juveniles migrate downstream toward the ocean, they become more oriented to benthic environments. Juvenile green sturgeon migrate toward seawater portions of natal estuaries as early as one and a half years old (75cm TL, Allen and Cech 2007). Juvenile and subadult green sturgeon may rear in freshwater and brackish water for up to three years. During laboratory experiments, juvenile green sturgeon select low light habitats and are primarily inactive during daylight hours, while they seemed to forage actively during night (Kynard et al. 2005). Juvenile green sturgeon were captured during the summer in shallow shoals (1-3 m deep) in the lower San Joaquin River (Radtke 1966), and are assumed to occupy similar habitats along the lower Sacramento River.

There is a strong need for additional information about sDPS green sturgeon, especially with regards to a robust abundance estimate, a greater understanding of their biology, and further information about their micro- and macro-habitat ecology.

2.6.4 Summary of Status of the Environmental Baseline and Cumulative Effects in the Action Area

The action area is used by most diversity groups and populations of the salmon, steelhead and green sturgeon ESUs and DPSs that are the subject of this BO. Salmon, steelhead and green sturgeon use the action area as an upstream and downstream migration corridor and for rearing.

Within the action area, the essential features of freshwater rearing and migration habitats for salmon, steelhead and green sturgeon 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. Levees have been constructed near the edge of the river and most floodplains have been completely separated and isolated from the Sacramento and American Rivers (USFWS 2000). Severe long-term riparian vegetation losses have occurred in this part of the Sacramento and American Rivers, and there are large open gaps without the presence of these essential features due to the high amount of riprap (USFWS 2000). The change in the ecosystem as a result of halting the lateral migration of the river channel, the loss of floodplains, the removal of riparian vegetation and IWM have likely affected the functional ecological processes that are essential for growth and survival of salmon, steelhead and green sturgeon in the action area.

The *Cumulative Effects* section of this BO describe how continuing or future effects such as non-Federal water diversions, the discharge of point and non-point source chemical contaminant discharges, and climate change affect the species in the action area. These actions typically result in habitat fragmentation, and conversion of complex nearshore aquatic habitat to simplified habitats that reduce the carrying capacity of the rearing and migratory corridors.

2.6.5 Summary of Project Effects on Sacramento River Winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS Green Sturgeon Individuals

1. <u>Construction and O&M-related Effects</u>

During construction and O&M, some injury or death to individual fish could result from rock placement (crushing), or predation related to displacement of individuals away from the shoreline or at the margins or turbidity plumes. These construction type actions will occur during summer and early fall months, when the abundance of individual salmon and steelhead is low and should result in correspondingly low levels of injury or death.

Green sturgeon adults may be migrating downstream through the area during construction (Heublein et al. 2009) and juveniles may be in the area May through September (noted in section 2.4.1, pg. 83). Adults and subadults would likely respond to construction activities by quickly swimming away, escaping injury, but juveniles are not strong swimmers and will experience the greatest exposure and may encounter short-term construction-related noise, physical disturbance, and water quality changes that may cause injury or harm by increasing the susceptibility of some individuals to predation by temporarily disrupting normal behaviors and affecting sheltering abilities.

2. <u>Long-term Effects Related to the Presence of Project Features</u>

For juvenile and outmigrating salmon and steelhead, the proposed action will result in short- and long-term adverse effects to individual salmon and steelhead that are exposed to the project features along the Sacramento and American Rivers. These adverse effects are indexed by SAM model results and expressed as WRI deficits. The long term WRI deficits are highest at fall and summer water surface elevations. We interpret those flow conditions to be consistent with summer and fall months, which are seasons during which individual Sacramento River winter-run, CV spring-run and CCV steelhead is low (fall), or they are absent. For other seasonal water surface elevations, there will be short term reductions in survival and growth as indicated by WRI values, but these values will increase above baseline and result in beneficial conditions that exceed baseline values.

NMFS expects that the most significant habitat deficits will occur at summer and fall flows due to the inherent difficulty of successfully establishing riparian vegetation in a zone that is 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 these periods. 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. Long-term effects at the winter and spring WSELs will be substantially positive, with conditions improving beyond existing conditions through year 50.

SAM modeled WRI values for adult salmon and steelhead migration and steelhead residence (outmigrating post spawning adults) are deficits at winter, spring and summer water surface elevations. These effects are considered to be *de minimus* because, although modeled as a result of a reduction in IWM and riparian habitat, the actual survival of adults is unlikely to be affected because there will be no increase in predation, and the upstream migration will not be impeded by any structural features that influence upstream migration.

Project actions along portions of the American River reach will likely not include bank armoring in their final design, which will significantly reduce estimated impacts to fish species. Additional compensatory mitigation design features or improved erosion repair designs may result in reduced impact compared to the legacy designs used for the basis of this analysis. Site specific designs will be implemented on a site by site basis in consultation with resource agencies and project partners to minimize impacts as well as maximize opportunities for implementing onsite compensatory mitigation features.

During project implementation, site specific SAM analyses will be run on final designs to better evaluate impact. SAM results will be used by the Corps and NMFS in the negotiation of appropriate mitigation for project actions. Although short term impacts are expected to be self-mitigating through the development of onsite compensatory mitigation features, the Corps will compensate for the temporal impacts to habitat through the purchase of offsite compensatory mitigation credits. Typically appropriate mitigation will be based on the identification of maximum negative WRI values. Offsite mitigation is expected to provide compensatory mitigation value at all seasonal habitat conditions. Longer term impacts to habitat may not recover to baseline conditions over the life of the project due to design restrictions. These impacts to habitat will be compensated through the purchase of offsite compensatory mitigation credits as well as the incorporation of additional onsite compensatory mitigation features (*i.e.* low water plantings, additional IWM, additional revegetation).

Details regarding the extent of juvenile green sturgeon rear in this reach of the river is not clear, but all juvenile sDPS must pass through the area on their migration to the estuary and ocean. Levee repair actions in the Common Features Study Area are likely to only affect the juvenile rearing life stage and probably have little to no adverse impacts on the adult life stages of green sturgeon because spawning habitat is not present in the action area and upstream migrating adults are probably more influenced by impacts that affect swimming speed and upstream passage than shoreline habitat manipulations. The levee repair actions will cause long-term reductions in shoreline habitat features for juvenile rearing and migrating green sturgeon and a loss of several acres of benthic habitat that is most likely used for foraging.

The implementation of the Corp's Green Sturgeon Conservation Measures will serve several purposes to address scientific uncertainty about the species in the study area and to provide compensatory mitigation for the adverse effects related to shoreline and benthic habitat impacts. The HMMP with ensure that adverse impacts of future Common Features GRR projects are sufficiently compensated in order to allow for the growth, survival and recovery of the species in the study area. Coordination of the HMMP with the IEP will leverage green sturgeon scientific expertise to ensure selected mitigation actions fully address the micro- and macro-ecological and survival needs of the species in the study area. Refinement of the SAM or development of alternative green sturgeon survival and response model using the Corps' Hydrologic Ecosystem Function Model, in consultation with NMFS and the IEP, will result in new modeling capacity that more accurately evaluates adverse project actions and the beneficial effects of mitigation actions relative to the growth and survival of green sturgeon in the study area. Restoring and compensating for the number of acres and ecological function of impacted benthic habitat and the initiation of this compensatory mitigation in the study area prior to the commencement of levee construction will reduce the impact of levee construction actions. The development of SMART compensatory mitigation objectives will ensure that all of the ecological impacts of levee construction actions are fully addressed.

The Corps also will work with local cost share sponsors to ensure GRR-related future flood risk reduction actions related to widening the Sacramento Weir shall fully mitigate upstream and downstream fish passage effects at the weir and within the spillway basin. The goal is to ensure that adult CV spring-run and Sacramento River inter-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are able to migrate upstream while the weir is spilling into the bypass and that juvenile stranding in the spillway basin is minimized to the maximum extent possible. Long-term, and once implemented, this measure would be expected to improve the growth and survival of all affected salmon, steelhead and green sturgeon.

2.6.6 Summary of Project Effects on Sacramento River Winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS Green Sturgeon Critical Habitat

Within the action area, the relevant PCEs of the designated critical habitat for listed salmonids are migratory corridors and rearing habitat, and for green sturgeon the six PCEs include food resources, water flow, water quality, migratory corridors, water depth, and sediment quality.

Based on SAM modeled WRIs, we expect small reductions in the value of PCEs for salmon and steelhead freshwater rearing due to the temporary loss of riparian habitat, the conversion of natural substrate river banks with revetment and the short term loss of IWM, but these reductions are at fall and summer water surface elevations and not at water surface elevations when the habitat use is the highest and most significant. Additionally, as planted vegetation begins to grow, the quality of rearing habitat will improve over baseline. There will also be SAM modeled WRI deficits for adult migration-related PCEs for all species. These deficits are temporary and eventually increase over baseline, so over time we do not expect these effects to reduce the conservation value of critical habitat.

The current condition of critical habitat for the green sturgeon sDPS in the action area is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the survival and recovery of the species. In particular, passage and water flow PCEs have been impacted by human actions, substantially altering the historical river characteristics in which the green sturgeon sDPS evolved.

The Corps estimates that approximately 20 acres of soft substrate habitat below the ordinary high water mark will be permanently lost to rock revetment. This is a conceptual estimate that will be further refined during the PED phase before construction begins. This loss of habitat is expected to adversely affect benthic substrate and impair food resources for all life stages; and the quantity of sediment to allow for normal physiological and behavioral responses to the environment. Similar to salmon and steelhead, the SAM serves as a reasonable proxy for measuring impacts to critical habitat. For most life stages and season water surface elevations, the SAM show immediate adverse effects that continue to decline for the life of the project. However, the Corps' Green Sturgeon Conservation Measures will reduce the impact on critical habitat by providing compensatory mitigation within the action area. Specifically, the HMMP shall also restore or compensate for the number of acres and ecological function of soft bottom benthic substrate for sDPS green sturgeon permanently lost to project construction. This compensation will be carried out within the lower Sacramento River/North Delta in order to offset the adverse modification to designated critical habitat. The restored habitat will be capable of providing abundant benthic prey, freshwater or estuarine areas with adequate water quality, temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth and viability of all life stages. It will also provide safe and unobstructed migratory pathways necessary for timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats.

The proposed action will permanently destroy up to 20 acres of critical habitat but also includes implementation of a comprehensive suite of conservation measures that will fill important data gaps, address existing modeling insufficiencies and implement compensatory measures with the goal of maintaining green sturgeon growth, survival and recovery in the action area through measures that will be developed in coordination with the IEP's green sturgeon project work team and in consultation with NMFS. The measures will be undertaken prior to or concurrent with project implementation. For these reasons, we expect the proposed action will not reduce the conservation value of critical habitat for sDPS green sturgeon.

2.6.7 Summary

Although there are some short-term and SAM modeled WRI deficits for salmon and steelhead, the effects of these deficits, when added to the environmental baseline and cumulative effects in the action area are small, occur during seasons when fish abundance is low or they are not present at all, and is of short duration. In the case of fry and juvenile rearing and migration for all species, the SAM modeled WRI values show significant increases in the growth and survival of individuals over baseline conditions between years 0 and 13, especially at winter spring water surface elevations, which represent a shoreline area where most emigrating salmon and steelhead would be exposed. Because the WRI measure growth and survival values recover rather quickly and generally exceed baseline conditions, the incremental effects of the action are not expected to increase the extinction risk of the Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon and ESU CCV steelhead and or reduce the conservation value of their designated critical habitat.

Furthermore, the anticipated growth and survival of salmon, steelhead rearing and juvenile migration are substantially positive and demonstrate how integrating NMFS high priority recovery actions, such as setback levee construction and restoration of floodplain habitat can contribute to an increase in the production and abundance of the Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon and ESU CCV steelhead.

The project will result in unavoidable impacts to the shoreline and benthic habitat of green sturgeon. However, the Corps' proposed Green Sturgeon Conservation Measures are expected to make significant contributions to monitor the species, address important data gaps in the action area, improve species growth and survival modeling and use the modeling to develop and track the performance of compensatory mitigation with the goal of fully addressing the loss of micro and macro-ecological impacts of the levee construction work in a manner that maintains the growth, survival and recovery of the species. The measures also address critical habitat PCEs and will ensure the conservation value of critical habitat is not reduced.

2.7 Conclusion

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

2.8 Incidental Take Statement

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

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 permittee, contractor, or grantee 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)).

2.8.1 Amount or Extent of Take

NMFS anticipates incidental take of adult and juvenile listed CV spring-run Chinook salmon, CCV steelhead, and juvenile sDPS green sturgeon and juvenile Sacramento River winter-run Chinook salmon in the action area through the implementation of the proposed action.

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, CCV steelhead, and the sDPS 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. However, it is possible to describe the general programmatic conditions and ecological surrogates using negative SAM WRI values.

Accordingly, NMFS is quantifying take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon incidental to the action resulting from short-term construction impacts, as well as long-term impacts as indexed by the SAM model.

The amount and extent of take described below is in the form of harm due to habitat impacts that will reduce the growth and survival of individuals from predation, or by causing fish to relocate and rear in other locations and reduce the carrying capacity of the existing habitat. This SAM values represent the extent of habitat impacts that will harm fish. As described in the *Analytical Approach* and the *Effects Analysis Sections* of this BO, the SAM values represent an index of fish response to habitat variables to which fish respond including bank slope, bank substrate size, instream structure, overhanging shade, aquatic vegetation and floodplain availability. Positive SAM values represent a positive growth and survival response and negative values index negative growth and survival. There is not a stronger ecological surrogate based on the information available. Due to a lack of site-specific fish data, the exact number of fish that will be affected is not known. The following level of incidental take from program activities is anticipated:

Incidental Take Associated with Construction:

1. Take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS 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 levee construction activities.

2. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS 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). Approximately 60 percent of the 600 cubic yards will be at or below the ordinary high water mark, or approximately 360 cubic yards. Take will be in the form of harm to the species through modification or degradation of the PCEs for rearing and migration that reduces the carrying capacity of habitat.

Incidental Take Associated with Exposure to Project Facilities along the Sacramento and American Rivers

Common Features American River North Reaches A and B:

At fall water surface elevations:

1. Take in the form of harm to fry and juvenile rearing CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The amount and extent of harm is greatest in the first 3 to 5 years for each species at -366 WRI, -712, and -5577, respectively.

2. Take in the form of harm to juvenile migrating (smolts) CV spring-run Chinook salmon is expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The amount and extent of harm is greatest at -2303 WRI.

3. Take in the form of harm to adult migrating CCV steelhead for up to 48 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The amount and extent of harm is greatest at -1554 WRI and exceeds baseline following year 48 to a maximum increase benefit of 8 WRI.

At winter surface elevations:

1. Take in the form of harm to fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction activities due to impacts on riparian habitat,

IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The amount and extent of harm is greatest at -36 WRI for steelhead in the first year and the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected. After year one, survival and growth values improve to 1507 for CCV steelhead. The amount and extent of harm to sDPS green sturgeon are greatest at -5020 and are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CV spring-run Chinook salmon are expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO, harm is greatest in approximately year 3 at -2303 WRI.

3. Take in the form of harm to adult migrating CCV steelhead for up to 48 after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in Table 10 of this BO. The amount and extent of harm is greatest at -1554 WRI. At year 48, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 8 WRI.

At spring water surface elevations:

1. Take in the form of harm to fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction due to impacts to riparian habitat IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The amount and extent of harm is greatest at -2681 and -5020, respectively. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1418 WRI. The extent and amount of harm to sDPS green sturgeon are greatest at -5020 WRI and are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CV spring-run Chinook salmon and CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The amount and extent of harm is greatest at -3129 for CV spring-run Chinook salmon and is expected to extend past 50 years. The greatest amount and extent of harm for CCV steelhead is greatest at -2096 WRI. At year 2, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 1173 WRI.

3. Take in the form of harm to adult migrating CCV steelhead after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this harm is quantified in the SAM table 26 in Appendix A and summarized

in table 10 of this BO. The amount and extent of harm is greatest at -1635 WRI. At year 6, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching 407 WRI.

4. Take in the form of harm to adult resident CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The amount and extent of harm is greatest at -1635 WRI for CCV steelhead in the first six years and the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected. After six years, survival and growth values improve to 407 for CCV steelhead.

At summer surface elevations:

1. Take in the form of harm to fry and juvenile rearing CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The amount and extent of harm is greatest for each species at -421 WRI, -833, and -7118, respectively.

2. Take in the form of harm to juvenile migrating (smolts) of CCV steelhead is expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM in table 26 in Appendix A and summarized in table 10 of this BO. The amount and extent of harm is greatest at -3013 WRI.

3. Take in the form of harm to adult resident CV steelhead is expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM and, and bank substrate size. The amount and extent of harm is quantified in the SAM table 26 in Appendix A and summarized in table 10 of this BO. The amount and extent of harm on the species is greatest at -3061 WRI.

American River North, South Bank sites A, B, and C

***At fall surface elevations*:**

1. Take in the form of harm to fry and juvenile rearing CV spring run Chinook salmon, CCV steelhead, and S DPS green sturgeon are expected after any construction activities due to impacts riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The amount and extent of harm is greatest for each species at -229 WRI, -489, and -2154, respectively. At year 26 for CV spring run Chinook salmon and year 36 for CCV steelhead, the SAM modeled habitat conditions exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 112 WRI and 88,

respectively. The amount and extent of harm to sDPS green sturgeon are greatest at -2154 and are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CV spring run Chinook salmon is expected after any construction due to impacts riparian habitat, IWM, and bank substrate size. The amount and extent of this amount and extent of harm is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The amount and extent of harm is greater greatest at -620 WRI and exceed baseline conditions and improved growth and survival conditions are expected following year 2 with the maximum increase benefit of 526 WRI.

3. The SAM displays increased survival of adult migrating CV steelhead after construction activities due to impacts), IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 27and summarized in table 11 of this BO. The increased benefit maximizes at 3696 of WRI.

At winter water surface elevations:

1. Take in the form of harm to fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction due to impacts to riparian habitat IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The amount and extent of harm is greatest at – 489 WRI and – 876, respectively. At year 36, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 88 WRI. At year one, the SAM modeled habitat conditions for sDPS green sturgeon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 2941 WRI.

At summer water surface elevations:

1. Take in the form of harm to fry and juvenile rearing CV spring run Chinook salmon and sDPS green sturgeon are expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The amount and extent of harm is greatest at – 239 WRI and – 2496, respectively. At year 26, the SAM modeled habitat conditions for CV spring run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 111 WRI. The amount and extent of harm to sDPS green sturgeon are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CV spring run Chinook salmon is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 27 in Appendix A and summarized in table 11 of this BO. The amount and extent of harm is greatest at -967 WRI. At year 22, the SAM modeled habitat conditions for CV spring run

Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 510 WRI.

Sacramento River Sites D, E, F, and G

At fall water surface elevations:

1. Take in the form of harm to fry and juvenile rearing CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. Take in the form of harm to fry and juvenile rearing sDPS green sturgeon is expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The greatest amount and extent of harm for the salmonids is -558 WRI, -1156, and -558 WRI respectively. The SAM modeled habitat conditions exceed baseline conditions and improve growth and survival is expected in year 35, 44, and 35, respectively. The amount and extent of harm to sDPS green sturgeon is greatest at -4674 WRI and are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon is expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM analysis table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest at -3845 WRI, -3985, and -3845, respectively.

3. Take in the form of harm to adult migrating CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and the extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The greatest amount and extent of harm for the salmonids are -1394 WRI, -2053, and 1394, respectively. The SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected at years 35, 29, and 35 respectively. After these years, survival and growth values improve to 362, WRI, 832, and 362 WRI, respectively.

4. Take in the form of harm to adult resident CCV steelhead after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest at -2053 WRI and exceeds baseline following year 29, where adult resident survival increases to a maximum value of 837 WRI.

At winter surface elevations:

1. Take in the form of harm to fry and juvenile rearing CCV steelhead, CV winter run Chinook salmon, and sDPS green sturgeon are expected after any construction due to impacts on riparian habitat, IWM and, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest at -77 WRI, -4397, and -558, respectively. At year 1, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 3234 WRI. At year 35, the SAM modeled habitat conditions for CV winter run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 116 WRI. The amount and extent of harm to sDPS green sturgeon are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CCV spring run Chinook salmon, CCV steelhead, and CV winter run is expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the species at -3451 WRI, -3044, and -3085, respectively. At year two, the SAM modeled habitat conditions for CV spring run Chinook salmon and Sacramento River winter-run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 4794 WRI for both species. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 3355 WRI.

3. Take in the form of harm to adult migrating CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon are expected to occur after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the species at -892 WRI, -1801, and -892 WRI, respectively. At year 4, the SAM modeled habitat conditions for CV spring run Chinook salmon and CV winter run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 643 WRI. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

4. Take in the form of harm to adult residence CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the species at -1801 WRI. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

At spring water surface elevations:

1. Take in the form of harm to fry and juvenile rearing CCV steelhead and sDPS green sturgeon are expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest at -36 WRI and -4397, respectively. At year 1, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 4317 WRI. The amount and extent of harm to sDPS green sturgeon are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CCV spring run Chinook salmon, CCV steelhead, and CV winter run is expected after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the species at -3484 WRI, -3082, and -3484, respectively. At year 2, the SAM modeled habitat conditions for CV spring run Chinook salmon and Sacramento River winter-run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 4862 WRI for both species. At year three, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

3. Take in the form of harm to adult migrating CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon are expected to occur after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the species at -946 WRI, -1801, and -946 WRI, respectively. At year 4, the SAM modeled habitat conditions for CV spring run Chinook salmon and CV winter run Chinook salmon exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 931 WRI. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

4. Take in the form of harm to adult residence CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the species at -1801 WRI. At year 3, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 1757 WRI.

At summer water surface elevations:

1. Take in the form of harm to fry and juvenile rearing CV spring run Chinook salmon, CCV steelhead, and CV winter run Chinook salmon after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. Take in the form of harm to fry and juvenile rearing sDPS green sturgeon is expected to extend past 50 years after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of these effects are quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the salmonids are -578 WRI, -1206, and -578 WRI respectively. The SAM modeled habitat conditions exceed baseline conditions and improve growth and survival is expected in years 36, 45, and 36, respectively, with maximum increased WRI values of 113, 92, and 113. The amount and extent of harm to sDPS green sturgeon are greatest at -5009 WRI and are expected to extend past 50 years.

2. Take in the form of harm to juvenile migrating (smolts) CCV spring run Chinook is expected to extend past 50 years after any construction due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of this adverse of these amount and extent of harm is quantified in the SAM analysis table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest at -4258 WRI.

3. Take in the form of harm to adult migrating CV spring run Chinook salmon, CV steelhead, and Sacramento River winter-run Chinook salmon after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and the extent of these potential effects is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The greatest amount and extent of harm for these species are -2136 WRI, -3793, and -2136 WRI, respectively. The SAM modeled habitat conditions exceed baseline conditions and improved growth and survival is expected at years 37, 32, and 37 respectively. After these years, survival and growth values improve to 319 WRI, 748, and 319 WRI, respectively.

4. Take in the form of harm to adult residence CCV steelhead is expected after any construction activities due to impacts on riparian habitat, IWM, and bank substrate size. The amount and extent of harm is quantified in the SAM table 28 in Appendix A and summarized in table 12 of this BO. The amount and extent of harm is greatest for the species at -3793 WRI. At year 32, the SAM modeled habitat conditions for CCV steelhead exceed baseline conditions and improved growth and survival conditions are expected, reaching a maximum of 748 WRI.

Take along and within the Sacramento Bypass and Weir

1. Take in the form of injury or death to adult and juvenile CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, CCV steelhead, and sDPS green sturgeon as a result of stranding in the spillway basin along 3425 linear feet of the expanded Sacramento Weir as a result of impaired upstream or downstream migrations. This take

is expected to occur once every 10 years following the spilling of river water and as the flood flows recede standing these species in the spillway basin.

2. Take in the form of injury or death to adults and juvenile CV spring-run, Sacramento River winter-run Chinook salmon, CCV steelhead, and sDPS green sturgeon due to stranding on the declining hydrograph within 660 acres (Personal Communication, Anne Baker, Army Corps of Engineers) as a result of the widening of the bypass. This take is expected to occur once every ten years following the spilling of river water and as the flood flows recede stranding these species in the Sacramento Bypass.

2.9.2 Effect of the Take

In the BO, NMFS determined that the amount or extent of anticipated take is not likely to result in jeopardy to the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon or destruction or adverse modification of their critical habitat.

2.8.3 Reasonable and Prudent Measures

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

1. Measures shall be taken to ensure that future flood risk reduction projects related to the American River Common Features GRR minimize, to the maximum extent practicable, any adverse effects on federally listed salmon, steelhead and green sturgeon that are subject to this consultation.

2. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures through the HMMP to ensure their effectiveness.

3. Measures shall be taken to minimize the impacts of bank protection and setback levee construction by implementing integrated conservation measures that provide beneficial growth and survival conditions for salmonids, and the sDPS of North American green sturgeon.

4. 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 BO.

5. Measures shall be taken to ensure that riparian habitat within the study area is preserved and protected to the maximum extent feasible for protection of fish habitat features that are the subject of this BO.

2.9.4 Terms and Conditions

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

1. The following terms and conditions implement reasonable and prudent measure 1: "*Measures shall be taken to ensure that future flood risk reduction projects related to the American River Common Features GRR minimize, to the maximum extent practicable, any adverse effects on federally listed salmon, steelhead and green sturgeon that are subject to this consultation.*"

    a. The Corps shall participate in an existing IWG or work with other agencies to participate in a new BPWG to coordinate stakeholder input into future flood risk reduction actions associated with the American River Common Features GRR. The BPWG will hold technical deliberations over proposed bank protection, including the need (basis of/for design), purpose and proposed designs (emphasis on avoidance and fish-friendly designs). Membership in the BPWG will be subject to agency decisions to participate, but should at a minimum include participation from resource agency staff (USFWS, NMFS, CDFW), CVFPB and SAFCA (local sponsors).
    b. The Corps shall coordinate with NMFS during PED as future flood risk reduction actions are designed to ensure conservation measures are incorporated to the extent practicable and feasible and projects are designed to maximize ecological benefits.
    c. The Corps shall include as part of the HMMP, a Riparian Corridor Improvement Plan with the overall goal of mitigating for the impacts to the ecological function and value of the existing levee system within the GRR study area. The Corps shall coordinate this plan with NMFS prior to the construction of any projects related to the GRS.
    d. The Corps shall ensure the widening of the Sacramento Bypass is designed and constructed to minimize stranding of fish at facilities of the weir and in the depressions of the bypass though grading or construction of drainage channels or other mechanisms as applicable.
    e. During Preconstruction Engineering and Design, the Corps, in coordination with the local sponsor, shall coordinate with NMFS to provide an operation of the Sacramento Weir to allow, without detrimental effects to flood management operations, for controlled ramp down rates of water into the Sacramento Bypass following peak flows.
    f. The Corps, in coordination with the local sponsors, shall compensate for fish passage impacts that result from the widening of the Sacramento Weir by including an adult fish passage facility associated with flood operations at the new weir. The fish passage facility would be designed with NMFS technical experts as part of the design team. Measures also shall be taken to modify the downstream side of the Weir to prevent adult and juvenile green sturgeon from stranding in the spillway basin.

g. The Corps shall update the O&M manual to incorporate, without detrimental effects to flood operations, the following measures: (1) an adaptive management plan for operations of the Sacramento Weir that allows for ramp down flows in a manner that minimize juvenile fish stranding in the Sacramento Bypass, (2) integration of Sacramento Weir operations with the Yolo Bypass.

2. The following terms and conditions implement reasonable and prudent measure 2: "*Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures through the HMMP to ensure their effectiveness*."

   a. The Corps shall develop a HMMP with an overall goal of ensuring the conservation measures achieve a high level of ecological function and value. The HMMP shall include specific goals and objectives and a clear strategy for maintaining all of the project conservation elements for the life of the project. The HMMP shall be consulted on with NMFS prior to the onset of any riverside construction, including the placement of in-water revetment or removal of riparian vegetation.
   b. The HMMP measures shall be monitored by the Corps for 10 years following construction and shall update their O&M manual to ensure the HMMP is adopted by the local sponsor to ensure the goals and objectives of the conservation measures are met for the life of the project.
   c. The HMMP shall include specific goals and objectives and a clear strategy for achieving full compensation for all project-related impacts on the affected species described above.
   d. The HMMP shall include a compensatory mitigation accounting plan to ensure the tracking of compensatory measures associated with future American River Common Features GRR projects as described in the proposed action.
   e. The Corps shall continue to coordinate with NMFS during all phases of construction, implementation, and monitoring by hosting annual meetings and issuing annual reports throughout the construction period as described in the HMMP.
   f. The Corps shall host an annual meeting and issue annual reports for five years following completion of project construction. The purpose is to ensure that conservation features of the project are developing consistent with the MMP.
   g. The Corps shall update their O&M Manual to ensure that the self-mitigating elements are meeting the criteria established in the HMMP with the goal of meeting SAM values.
   h. The Corps, in coordination with the local sponsor, shall ensure that the mitigation and monitoring plan for the Sacramento Bypass includes baseline post-project monitoring of fish stranding. The monitoring plan shall be developed in coordination with NMFS.

3. The following terms and conditions implement reasonable and prudent measure 3: "*Measures shall be taken to minimize the impacts of bank protection and setback levee construction by implementing integrated conservation measures that provide beneficial growth and survival conditions for salmonids, and the sDPS of North American green sturgeon*."

a. The Corps shall ensure that, for salmon and steelhead, the maximum SAM WRI deficits for each seasonal water surface elevation as determined appropriate with input from the IWG or the BPWG are fully offset through habitat improvements along the future American River Common Features GRR project or through the purchase of credits at a NMFS approved conservation bank (as described in the BA).
b. 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 or if not feasible, new IWM will be anchored in place.
c. The Corps shall ensure that the planting of native vegetation will occur as described in the Corps 2014 BA and within this BO. All plantings must be provided with the appropriate amount of water to ensure successful establishment.
d. The Corps shall compensate for lost habitat using NMFS approved mitigation actions at a 1:1 ratio prior to construction, 2:1 ratio during construction, or a 3:1 ratio if mitigation actions occur after construction. This includes habitat improvements adjacent to the project area, or through conservation bank credit purchase as described in the Corps revised, American River Common Features GRR SAM Analysis as received by email on June 18, 2015 and included in this document in Appendix A.

4. The following terms and conditions implement reasonable and prudent measure 4: "*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 BO*."

   a. The Corps shall provide a copy of this BO, or similar documentation, to the prime contractor, making the prime contractor responsible for implementing all requirements and obligations included in these documents and to educate and inform all other contractors involved in the project as to the requirements of this BO. A notification that contractors have been supplied with this information will be provided to the reporting address below.
   b. 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, their critical habitat, 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 BO. Written documentation of the training must be submitted to NMFS within 30 days of the completion of training.
   c. The Corps shall consider installing IWM along future flood risk reduction projects associated with the American River Common Features GRR at 40 to 80 percent shoreline coverage at all seasonal water surface elevations in coordination with the IWG or the BPWG. The purpose is to maximize the refugia and rearing habitats for juvenile fish.

5. The following terms and conditions implement reasonable and prudent measure 5: "*Measures shall be taken to ensure that riparian habitat within the study area is preserved and protected to the maximum extent feasible for protection of fish habitat features that are the subject of this BO*."

    a. The Corps shall develop a vegetation variance in consultation with NMFS to allow for the protection of existing vegetation in place and the planting of new low-risk vegetation on the lower 1/3 slope of the levee system.

2.10 Conservation Recommendations

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

1. The Corps should integrate the 2017 California Central Valley Flood Protection Plan's Conservation Strategy into all flood risk reduction projects they authorize, fund, or carry out.
2. The Corps should prioritize and continue to support flood management actions that set levees back from rivers and in places where this is not technically feasible, repair in place actions should pursue land-side levee repairs instead of waterside repairs.
3. The Corps should consult with NMFS in the review of ETL variances for future projects that require ETL compliance.
4. The Corps should develop ETL vegetation variances for all flood management actions that are adjacent to any anadromous fish habitat.
5. The Corps should use all of their authorities, to the maximum extent feasible to implement high priority actions in the NMFS Central Valley Salmon and Steelhead Recovery Plan. High priority actions related to flood management include setting levees back from river banks, increasing the amount and extent of riparian vegetation along reaches of the Sacramento River Flood Control Project.
6. The Corps should encourage cost share sponsors and applicants to develop floodplain and riparian corridor enhancement plans as part of their projects.
7. The Corps should seek out opportunities for setback levee and other flood management activities that promote overall riverine system restoration.
8. The Corps should support and promote aquatic and riparian habitat restoration within the Sacramento River and other watersheds, especially those with listed aquatic species. Practices that avoid or minimize negative impacts to listed species should be encouraged.
9. The Corps should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid habitat restoration projects.

10. The Corps should continue to work with NMFS and other agencies and interests to restore fish passage to support the improved growth, survival and recovery of native fish species in the Yolo Bypass and other bypasses within the Sacramento River Flood Control Project.

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

2.10 Reinitiation of Consultation

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

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

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

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

The proposed action is described in detail in Section 1.4 of the Common Features GRR BO.

3.1 Essential Fish Habitat Affected by the Project

The action area for the Common Features GRR has been identified as EFH for Pacific coast salmon. Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), CV spring-run Chinook salmon (*O. tshawytscha*), and CV fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Pacific coast salmon fishery management plan that occur within the proposed action area.
This BO addresses Sacramento River winter-run and CV spring-run Chinook salmon (*O. tshawytscha*). The Sacramento River winter-run and CV spring-run Chinook salmon are listed under both ESA and the MSA and potentially will be affected by the Common Features GRR. This EFH consultation will concentrate on CV fall-/late fall-run Chinook salmon (*O. tshawytscha*) because their habitat is covered under the MSA but not covered in subject BO.

The Habitat Areas of Particular Concern (HAPCs) in the action area include complex channels, floodplain habitats and constrained channels with large woody debris.

3.2 Adverse Effects on Essential Fish Habitat

The effects of the proposed action on Pacific Coast salmon EFH will be similar to those discussed in the *Effects of the Action* section (2.4) for Sacramento River winter-run and CV spring-run Chinook salmon. Based on the information provided, NMFS concludes that the proposed action would adversely affect EFH for federally managed Pacific salmon. A summary of the effects of the proposed action on EFH for Chinook salmon are discussed below.

Adverse effects to the HAPCs of Pacific salmon EFH resulting from the proposed action construction activities may contribute sediment, increase turbidity, and increase localized sound levels, including areas downstream and upstream of the construction site. These impacts will occur only during the time when construction is occurring in or adjacent to the water column. There is potential for toxic compounds to be introduced into EFH during construction. This could occur at any time during the construction, both during in-water and out-of-water phases. All of the above impacts will be short-term. Construction activities may also eliminate or alter habitat that is essential to the life-cycle of Pacific salmon. For example, the addition of rock revetment to a previously vegetated bank may eliminate juvenile rearing habitat. These habitat impacts are better illustrated in Tables 10, 11, and 12 of the BO associated with this EFH consultation and Tables 26, 27 and 28 in Appendix A that summarizes SAM deficits for the Common Features GRR.

3.3 Essential Fish Habitat Conservation Recommendations

Fully implementing these EFH conservation recommendations will protect, by avoiding or minimizing the adverse short-term habitat effects described in section 3.2. The Corps should mitigate for WRI deficits by offsetting the maximum deficits. Below is a summary of WRI that should be mitigated to minimize the adverse effects of the Common Features GRR to Pacific coast salmon species. The Corps should offset deficits either onsite or at a NMFS approved conservation bank. The mitigation should be at a 1:1 ratio if conducted prior to the compensation timing schedule described in the *Analytical Approach* section of the BO, or at a 3:1 ratio if carried out any later.

Common Features American River North Reaches A and B:

At fall water surface elevations:

1. The maximum impact from the Common Features GRR to adult fall-run Chinook salmon migrating habitat is -877 WRI for 39 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon rearing habitat is -366 WRI for 50 years.

3. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is -2,303 WRI for 50 years.

At winter surface elevations:

1. The maximum impact from the Common Features GRR to adult fall-run Chinook salmon migrating habitat is -759 WRI for 5 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is –3,002 WRI for 4 years.

At spring water surface elevations:

1. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is -2,681 WRI for 3 years.

2. The maximum impact from the Common Features GRR to adult fall-run Chinook salmon habitat is -773 WRI for 4 years.

At summer surface elevations:

1. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon rearing habitat is -421 WRI for 50 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is -3,129 WRI for 50 years.

American River North, South Bank sites A, B, and C

At fall water surface elevations:

1. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon rearing habitat is -229 WRI for 26 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is -620 WRI for 21 years.

At winter surface elevations:

1. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is -333 WRI for 1 years.

At summer surface elevations:

1. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon rearing habitat is -239 WRI for 26 years.

2. The maximum impact from the Common Features GRR to juvenile fall- run Chinook salmon migration habitat is -697 WRI for 22 years.

Sacramento River Sites D, E, F, and G

At fall water surface elevations:

1. The maximum impact from the Common Features GRR to adult fall-run and late-fall run Chinook salmon migration habitat is -1,394 WRI for 35 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run and late-fall run Chinook salmon rearing habitat is -558 WRI for 35 years.

3. The maximum impact from the Common Features GRR to juvenile fall-run and late-fall run Chinook salmon migration habitat is -3,845 WRI for 50 years.

At winter surface elevations:

1. The maximum impact from the Common Features GRR to adult fall-run and late-fall run Chinook salmon migration habitat is -892 WRI for 4 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run and late-fall run Chinook salmon migration habitat is -3,451 WRI for 2 years.

At spring water surface elevations:

1. The maximum impact from the Common Features GRR to adult late-fall run Chinook salmon migration habitat is -946 WRI for 4 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is -3,484 WRI for 2 years.

At summer surface elevations:

1. The maximum impact from the Common Features GRR to juvenile fall-run and late-fall run Chinook salmon rearing habitat is -578 WRI for 36 years.

2. The maximum impact from the Common Features GRR to juvenile fall-run Chinook salmon migration habitat is -4,258 WRI for 50 years.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

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

DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the Corps. Other interested users could include SAFCA, USFWS, CDFW, or DWR. Individual copies of this opinion were provided to the Corps. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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APPENDIX A.

Appendix A comprises the updated SAM analysis report emailed to NMFS from the USACE on JUNE 11, 2015. This represents the final SAM run agreed upon jointly.

Appendix A
American River Common Features GRR SAM Analysis

ARCF GRR Project Reach SAM Analysis

1.0 Introduction

This document provides the background data and assumptions for the Standard Assessment Methodology (SAM) effects analysis of the American River Common Features General Reevaluation Report (ARCF GRR) project on the following focus fish species (Table 1).

Table 1. ARCF GRR Project Focus Fish Species

Species/ESUs	Federal Status
Chinook salmon (*Oncorhynchus tshawytscha*)	
Central Valley spring-run ESU	Threatened
Central Valley fall-run ESU	Species of concern
Central Valley late fall-run ESU	Species of concern
Sacramento River winter-run ESU	Endangered
Central Valley steelhead DPS (*Oncorhynchus mykiss*)	Threatened
green sturgeon (*Acipenser medirostris*)	Threatened

1.1 Background

The US Army Corps of Engineers (Corps) initiated formal Section 7 consultation with the National Marine Fisheries Service (NMFS) for the ARCF GRR on June 27, 2014. The original SAM analysis included in the Section 7 consultation for the ARCF GRR was determined to be insufficient in detail. Through internal discussions and interagency coordination with the NMFS, a revised set of parameters was developed to better assess the project's impact on focus fish species and their habitat. This report documents and provides justification for the revised SAM analysis and should replace the analysis included in the original Biological Assessment (BA) Appendix B.

1.2 SAM Modeling Approach

Long-term effects of the ARCF GRR project on focus fish species and their habitat were estimated using the SAM. The SAM computations were performed using the SAM Electronic Calculation Template (ECT) Version 4.0 (April 2012) developed by the Corps and Stillwater Sciences, in consultation with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife Service (CDFW), and California Department of Water Resources (DWR), academic contributions from the University of California at Davis and Humboldt State University, and peer reviewed by sixteen professionals in fish biology, river geomorphology, environmental sciences, and engineering (USACE 2012). The SAM allows agencies to quantitatively assess the potential effects of bank protection and stream restoration projects to ensure that these activities do not jeopardize Chinook salmon, steelhead, and green sturgeon, or destroy or adversely modify their critical habitat. The SAM can also determine suitable compensation for habitat loss, by evaluating the benefits of certain design features (*e.g*., planted emergent vegetation) to target fish species.

The SAM employs six habitat variables to characterize near-shore and floodplain habitats of listed fish species:

- *bank slope*—average bank slope of each average seasonal water surface elevation;
- *floodplain availability*—ratio of wetted channel and floodplain area during the 2-year flood, to the wetted channel area during average winter and spring flows;
- *bank substrate size*—the median particle diameter of the bank (*i.e.*, D50) along each average seasonal water surface elevation;
- *instream structure*—percent of shoreline coverage of instream woody material along each average seasonal water surface elevation;
- *aquatic vegetation*—percent of shoreline coverage of aquatic or riparian vegetation along each average seasonal water surface elevation; and
- *overhanging shade*—percent of the shoreline coverage of shade along each average seasonal water surface elevation.

The SAM does not directly model changes in the above variables. Instead, habitat changes are estimated separately by the user and entered into an input data file to an electronic calculation template (ECT) developed within an MS Access database to track species responses to project actions over time. Changes in habitat variables may be fixed in time, such as installation of revetment at a particular slope and substrate size. In other circumstances, habitat evolution over time may be represented by more gradual changes in variables such as changes in floodplain inundation due to meander migration or changes in shade due to growth of planted vegetation. Typically, habitat evolution modeling is restricted to shade estimates from riparian growth models, but the SAM accommodates any number of other habitat modeling approaches such as meander migration modeling or large woody debris recruitment modeling.

Once a particular time series of habitat variable estimates is developed and entered into an ECT input file fish responses are calculated using previously developed relationships between habitat variables and species/life stage responses (USACE 2012). The response indices vary from 0 to 1, with 0 representing unsuitable conditions and 1 representing optimal conditions for survival, growth, and/or reproduction. For a given site and scenario (*e.g*., with- or without-project), the ECT uses these relationships to determine the responses of individual species and life stages to the measured or predicted values of each variable, for each season and target year; the ECT then multiplies these values together to generate an overall species response index. This index is then multiplied by the linear distance or area of bank to which it applies; the product is then integrated through time, generating a weighted species response index (WRI expressed as ft or ft^2) in each year of the analysis. The WRI provides a common metric that can be used to quantify habitat values over time, compare project designs to existing conditions, and evaluate the effectiveness of on-site and off-site habitat compensation actions.

2.0 Habitat Analysis

Following procedures described in the SAM (USACE 2012), construction activities at each site were translated into habitat variables for pre-project and with project conditions in each of four seasons using available data sources. The relevant habitat conditions to encode the conceptual response models for the focus fish species from the present to the future (t = 0, 1, 5, 15, 25, and 50 yrs), and under pre-project and with-project conditions are described below. Revisions to the original SAM analysis are summarized in the discussion.

2.1 Project Description

The ARCF GRR project tentatively selected plan – Alternative 2 – Sacramento Bypass and Improve Levees, involves the construction of fix-in-place levee remediation measures along the Sacramento River, American River, and north side tributaries as well as widening of the Sacramento Weir and Bypass. Proposed repair actions for each waterway are presented below (Table 2). This SDAM analysis groups project actions into 4 SAM reaches based on hydrologic connectivity: American River North (ARN_AB), American River South (ARS_ABC), Sacramento River South (ARS_DEFG), and the Sacramento Bypass (SBP).

2.1.1 Sacramento River

The levees along the Sacramento River under Alternative 2 would be improved to address identified seepage, stability, erosion, and a minimal amount of height concerns. Most height concerns along the Sacramento River would be addressed by a widening of the Sacramento Weir and Bypass to divert more flows into the Yolo Bypass.

2.1.2 American River

Levees along the American River under Alternative 2 require improvements to address erosion. The proposed measures for these levees consist of waterside armoring to prevent erosion to the river bank and levee, which could potentially undermine the levee foundation. There are two measures proposed for the American River levees: (1) bank protection, and (2) launchable rock trench. Both of these measures are described in detail in the BA.

2.1.3 East Side Tributaries

Natomas East Main Drain Canal (NEMDC) requires improvements to address seepage and stability at locations where historic creeks had intersected the current levee alignment. A conventional open trench cutoff wall would be constructed at these locations to address the seepage and stability problems. The NEMDC east levee also has height issues which will be addressed with construction of a new floodwall. The floodwall would be placed at the waterside hinge point of the levee and would be designed to disturb a minimal amount of waterside slope and levee crown for construction.

We will be doing no in-water work on NEMDC under the Alternative 2 scenario and after consultation with NMFS, NEMDC was left out of the SAM analyses.

2.1.4 Sacramento Weir and Bypass

Under Alternative 2, the width of the Sacramento Weir and Bypass would be roughly doubled to accommodate increased bypass flows. The expanded Sacramento Weir and Bypass would generally result in an additional 25,000 cfs flow during high water conditions. The frequency of water diversion is expected to be the same, which is to to use the current Sacramento Weir operation based on a stream gage at the I Street Bridge (Schlunegger 2014). Under normal flow conditions the Sacramento Weir and Bypass would be operating at pre-existing conditions described in detail in the ARCF GRR biological assessment (USACE 2014). Implementation of this action would result in the degradation of the existing north levee of the Sacramento Bypass and construction of a new levee approximately 1,500 feet to the north. The existing Sacramento Weir would be expanded to match the wider bypass. At this time, it is not known whether the new segment of weir would be constructed consistent with the 1916 design described above, or whether it would be designed to be a gravity-type weir. The new north levee of the bypass would be designed to be consistent with the existing Sacramento Bypass north levee, however, it would also include a 300-foot-wide seepage berm on the landside with a system of relief wells.

Table 2. ARCF GRR Project Alternative 2 – Proposed Remediation Measures by Waterway.

Waterway	Seepage Measures	Stability Measures	Erosion Protection Measures	Overtopping Measures
American River[1]	---	---	Bank Protection, Launchable Rock Trench	---
Sacramento River	Cutoff Wall	Cutoff Wall	Bank Protection	Sacramento Bypass and Weir Widening, Levee Raise
NEMDC	Cutoff Wall	Cutoff Wall	---	Floodwall
Arcade Creek	Cutoff Wall	Cutoff Wall	---	Floodwall
Dry/Robla Creeks	---	---	---	Floodwall
Magpie Creek[2]	---	---	---	Floodwall, Levee Raise

[1]American River seepage, stability, and overtopping measures were addressed in the American River Common Features, WRDA 1996 and 1999 construction projects.
[2]In addition to the Floodwall, Magpie Creek will include construction of a new levee along Raley Boulevard south of the creek, and construction of a detention basin on both sides of Raley Boulevard. In addition, some improvements would need to occur on Raley Boulevard, including widening of the Magpie Creek Bridge, raising the elevation of the roadway, and removing the Don Julio Creek culvert.

2.1.5 Construction Schedule

The ARCF GRR project reach will be implemented in increments. The timing of each project reach (Table 3) is based on the proposed schedule provided in the Biological Assessment: American River Common Features General Reevaluation Report (USACE 2014).

Table 3. ARCF GRR Project Alternative 2 – Construction Sequence and Duration

Priority	Construction Sequence	Reach	Construction Duration
1	Sacramento River	ARS F	5 years
2	Sacramento River	ARS E	3 years
3	American River	ARS A	4 years
4	Sacramento River	ARS G	3 years
5	Sacramento River	ARS D	3 years
6	American River	ARS B	2 years
7	American River	ARN A	4 years
8	American River	ARS C	3 years
9	American River	ARN B	2 years
10	Sacramento Weir & Bypass		4 years
11	Arcade Creek	ARN D	2 years
12	NEMDC	ARN F	2 years
13	Arcade Creek	ARN E	2 years
14	NEMDC	ARN C	2 years
15	Dry/Robla Creek	ARN G	3 years
16	Magpie Creek	ARN I	3 years

2.1.6 Vegetation on Levees

Compliance with Engineering Technical Letter 1110-2-571 (ETL) vegetation requires implementation of a vegetation-free zone within 15 ft of the waterside and landside toes of a levee. The levees along the Sacramento and American rivers were often set close to the river which has resulted in limited riparian vegetation in the project reach. The Corps is seeking a variance from the ETL vegetation requirements along the Sacramento River and American River portions of this project. This SAM analysis assumes that a Vegetation Variance Request (VVR) was assumed to be in place for the Sacramento and American River reaches. The Corps will obtain an ETL-approved vegetation variance exempting the Sacramento River sites from vegetation removal in the lower third of the waterside of the levee prior to final construction and design phase. The Corps will be complying with the ETL on the American River via a System Wide Implementation Framework (SWIF). The VVR is not assumed to apply to the SBP.

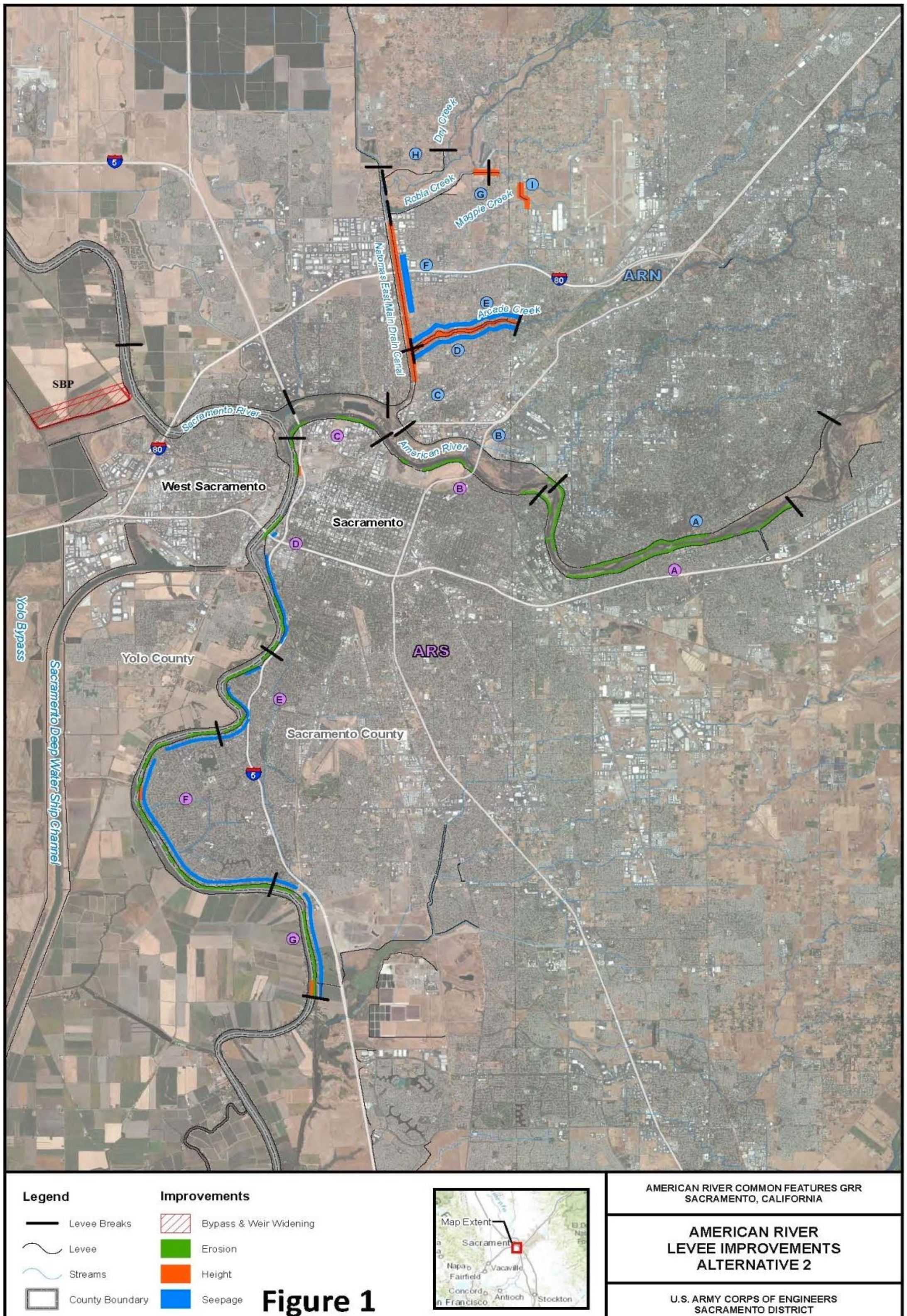
Dry Creek
Robla Creek
Magpie Creek
Natomas East Main Drain Canal
Arcade Creek
ARN
SBP
Sacramento River
American River
West Sacramento
Sacramento
ARS
Yolo Bypass
Yolo County
Sacramento County
Sacramento Deep Water Ship Channel
Legend
Levee Breaks
Levee
Streams
County Boundary
Improvements
Bypass & Weir Widening
Erosion
Height
Seepage
Map Extent
AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA
AMERICAN RIVER
LEVEE IMPROVEMENTS
ALTERNATIVE 2
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Figure 1

2.2 Characterization of Existing Conditions

The following data sources were used to characterize SAM habitat conditions (as defined by bank slope, floodplain availability, substrate size, instream structure, aquatic vegetation, and overhanging shade) within the ARCF GRR project area under existing or pre-project conditions.

Sacramento River Revetment Database – This database was used to stratify the project reach into subreaches that encompass relatively uniform bank conditions based on their general physical characteristics (USACE 2007). This database was used to characterize existing habitat conditions within individual reaches where more recent data were unavailable.

Aerial images of the ARCF GRR project reach (Google™ Earth Pro), provided current and historical images of bank conditions that were used to address gaps or uncertainties related to existing cover characteristics within individual subreaches.

The following describes how input values for each of these attributes were derived for existing conditions in the SAM assessment. Specific input values for each site can be seen below at the end of report in (Tables 6-25).

2.2.1 Bank Slope

In the SAM, bank slope serves as an indicator of the availability of shallow-water habitat and is obtained from point estimates of bank slope (horizontal change to vertical change, dW:dH) along each seasonal shoreline (*i.e.*, the line where the water surface intersects the bank on average fall, winter, spring, and summer) (USACE 2012). Existing bank slopes were extrapolated from cross sections along the Sacramento River, American River, and existing SAM analyses performed on regionally analogous sites. Bank slope along all reaches was assumed to be 2 for existing conditions.

2.2.2 Floodplain Availability

In the SAM, floodplain habitat availability is considered important for juvenile life stages and is defined by areas that are flooded by the 2-year flood event (Q2) and measured by calculating a Floodplain Inundation Ratio (USACE 2012). This ratio is calculated by dividing the wetted channel and inundated floodplain areas during the 2-year flood event (AQ2) by the wetted channel area (AQavg) during average winter and spring flows. The amount of available floodplain habitat is consequently proportional to the ratio's positive deviation from unity (*i.e.*, values greater than 1) (USACE 2012).

In this SAM analysis, it was assumed that the with-project floodplain inundation ratios would be the same as pre-project values, which is consistent with assumptions made during the pre-construction SAM analyses. As a result, no impacts to habitat quality at the ARCF GRR reaches are expected with respect to this habitat variable.

2.2.3 Bank Substrate Size

The median substrate size (D_{50}) along the summer-fall and winter-spring shorelines of the project reach was determined through by referencing the Revetment Database (USACE 2007) and current and historical aerial images. Based on previous analysis of Sacramento River Bank Protection Project (SRBPP) sites (USACE 2008, USACE 2013) sections of shoreline with natural substrate were assigned a D_{50} of 0.25 inches. Sections of shoreline with rock revetment were assigned a D_{50} of 10 inches.

2.2.4 Instream Structure

The shoreline coverage of Instream Woody Material (IWM) along the average summer-fall and winter-spring shorelines of the ARCF GRR project reach were determined by referencing the revetment database (USACE 2007). The revetment database uses four classes of instream structure, based on ranges of percent shoreline having IWM. Table 4 indicates how these revetment database attribute values were converted to a single value for input to SAM. These values were assumed to be appropriate for both the summer-fall and winter-spring seasons. For sub-reaches without available data, an estimate was based on shoreline conditions assessed from aerial images. Shorelines with dense riparian canopy were assigned 5% shoreline coverage of IWM. Shorelines without dense riparian canopy were assigned 0% shoreline coverage of IWM.

Table 4. Conversion of Revetment Database Instream Woody Material Classes to SAM Attribute Value for Instream Structure

Revetment Database IWM Class	SAM Input Value
None	0%
1 - 10%	5%
11 - 50%	30%
> 50%	75%

2.2.5 Aquatic Vegetation

The revetment database attribute for Emergent Vegetation was used for summer-fall aquatic vegetation characterization, and the Ground Cover attribute was used for winter-spring characterization. Within the ARCF GRR project reaches, this approach generally gave a vegetation value of zero for summer-fall conditions, which is appropriate given the scarcity of emergent aquatic vegetation. Table 5 summarizes the conversion of revetment database attribute values for input to the SAM analysis.

Table 5. Conversion of Revetment Database Emergent Vegetation and Ground Cover Classes to SAM Attribute Values for Vegetation.

	Revetment Database IWM Class	SAM Input Value
Summer and Fall Revetment Database: “Emergent Vegetation” Attribute	False	0%
	PEM 1 - 5%	3%
	PEM 6 - 25%	15%
	PEM 26 – 75%	50%
	PEM >75%	85%
Winter and Spring Revetment Database: “Ground Cover” Attribute	<25%	13%
	26-50%	38%
	51-75%	63%
	>75%	88%

2.2.6 Overhanging Shade

The extent of overhanging shade along the summer-fall and winter-spring shorelines was determined through analysis of current and historic aerial images. Summer-fall conditions were analyzed using imagery from late summer and early fall months, typically representative of low water conditions. Winter-spring conditions were analyzed using imagery from late winter and early spring months, typically representative of high water conditions. Values for overhanging shade at winter and spring habitat conditions were modified by factors of 0.25 and 0.75 respectively to account for seasonal defoliation.

2.3 Characterization of With-Project Conditions

The with-project conditions were characterized using the project description outlined for Alternative 2 in the ARCF GRR BA. This analysis was conducted at a feasibility level of design; specific project designs will be developed under a Planning and Engineering Design phase. In the absence of more specific designs, this SAM analysis was developed using a set of “reasonable worst-case” parameters. The parameters were developed by evaluating the applicability of past levee repair designs to the project reach. Past levee repairs were conducted under the Sacramento River Bank Protection Project (SRBPP) within each of the sub-reaches (USACE 2008, USACE 2013). Applicability of design features was evaluated using the professional judgment and experience of the project team. In cases where the applicability of a particular design feature for a particular reach was in question, the analysis erred on the side of caution and applied reduced values or omitted the feature from final analysis. The set of reasonable worst-case parameters is designed to provide a maximum estimation of impact for the purpose of consultation at feasibility planning level. A Vegetation Variance Request (VVR) was assumed to be in place for the Sacramento and American River reaches. The Corps will obtain an ETL-approved vegetation variance exempting the Sacramento River sites from vegetation removal in the lower third of the waterside of the levee prior to final construction and design phase. The

Corps will be complying with the ETL on the American River via a SWIF. The VVR is not assumed to apply to the SBP. Specific habitat attributes are provided by site in (Tables 6-25) and specific justifications for each variable is also provided in those tables.

The following describes how input values for each of the SAM habitat attributes were derived for with-project conditions:

2.3.1 Bank Slope

In the SAM, bank slope serves as an indicator of the availability of shallow-water habitat and is obtained from point estimates of bank slope (horizontal change to vertical change, dW:dH) along each seasonal shoreline (*i.e.*, the line where the water surface intersects the bank on average fall, winter, spring, and summer) (USACE 2004). With-project bank slopes were based on the description of project actions for each reach. Bank slopes for the Sacramento and American River reaches were assumed to be analogous to associated SRBPP repair sites that were in close proximity to the reach being analyzed. Consequently, bank slopes with a summer-fall slope of 3 and winter-spring slope of 10 were used.

2.3.2 Floodplain Availability

The with-project floodplain inundation ratios used in this SAM analysis remained unchanged from existing conditions. Levee repair and bank stabilization actions typically do not increase floodplain availability (with exception of constructing setback levees). In the absence of levee setback actions, the amount of available floodplain areas and channel cross sections would not be greatly altered during levee repair activities.

In this SAM analysis, it was assumed that the with-project floodplain inundation ratios would be the same as pre-project values. As a result, no impacts to habitat quality at the ARCF GRR reaches are expected with respect to this habitat variable.

2.3.3 Bank Substrate Size

The median substrate size (D_{50}) along the summer-fall and winter-spring shorelines of the project reach were based on the description of project actions for each sub-reach. Bank substrate size along the American River sub-reaches were assumed to be 18 inch rock revetment at summer-fall shoreline and 0.25 inch natural substrate at winter-spring shoreline. Bank substrate size along the Sacramento River sub-reaches were assumed to be 12 inch rock revetment at summer-fall shoreline and 0.25 inch natural substrate at winter-spring shoreline.

2.3.4 Instream Structure

The shoreline coverage of IWM along the average summer-fall and winter-spring shorelines was based on the description of project actions for each reach. In the SAM analysis, IWM coverage along the Sacramento and American River reaches were assumed to include installation of 40% shoreline coverage at summer-fall and winter-spring shoreline conditions.

2.3.5 Aquatic Vegetation

The shoreline coverage of aquatic vegetation along the average summer-fall and winter-spring shorelines was based on the description of project actions for each sub-reach. Aquatic vegetation along the Sacramento and American River sub-reaches were assumed to be analogous to SRBPP repair sites. The vegetation growth models below applied to the Sacramento and American River sub-reaches were taken from previous SAM analysis'. For the American River (ARN_AB, ARS_ABC) four previously constructed SRBPP sites within the ARCF GRR project area were used for analysis (LAR 0.3L, LAR 2.8L, LAR 10.0L, and LAR 10.6L)(USACE, 2013). For the Sacramento River 15 previously constructed SRBPP sites within the ARCF GRR project area were used for analysis (SAC 49.7L, SAC 52.3L, and SAC 53.5R)(USACE 2013) and (RM 47.0L, RM 47.9R, RM 48.2R, RM 49.6R, RM 49.9L, RM 50.2L, RM 50.4L, RM 50.8L, RM 51.5 L, RM 52.4L, RM 53.1L, and RM 56.7L)(USACE 2008). Relevant O&M activities were considered but excluded from this analysis. The assumed vegetation variance would apply to woody vegetation only and O&M activities would be expected to result in the removal of shrubs on the slope of the levee; however, it was assumed that typical SRBPP repair designs would locate the planted riparian bench at appropriate elevations and distance from the levee to allow for revegetation efforts. Any removal of shrubby vegetation as the result of O&M activities would take place on the upper slope of the levee and would not impact the habitat considered in a typical SAM analysis.

2.3.6 Overhanging Shade

The shoreline coverage of overhanging shade along the average summer-fall and winter-spring shorelines was based on the description of project actions for each sub-reach. Overhanging shade along the Sacramento and American River sub-reaches were assumed to be analogous to SRBPP repair sites. It was assumed that a variance would be in place allowing for retention of woody vegetation along the lower 2/3 of the levee slope. As the result of constructing a planted bench, it was assumed that the with-project seasonal shoreline would be shifted away from the existing shade providing canopy. Under this assumption, existing summer-fall values for overhanging shade were taken as the starting point for with-project winter-spring conditions. The with-project winter-spring values were further reduced by 75% (winter) and 25% (spring) to account for defoliation. As a final step, these winter-spring values were reduced by 20% to account for trees removed for construction equipment access. With-project overhanging shade values were expected to start at 0% as the result of a constructed bench shifting the shoreline away from the existing canopy. The shade growth models below were applied to the starting seasonal values for overhanging shade described above along the Sacramento and American River sub-reaches. These shade growth models were taken from previous SRBPP SAM analysis' conducted within the ARCF GRR project area.

3.0 Results

The SAM results are presented as weighted response indices (WRI), that give a relative indication of fish response to a project action over time. A negative WRI can be interpreted as a reduction in habitat value and a positive WRI can be interpreted as a increase in habitat value Although the WRI values are not directly representative of actual lengths or areas, the resource agencies have used those values as proxies in determining determine mitigative requirements. Appropriate mitigation is typically determined by identifying the maximum negative WRI for critical life stages (spawning and egg incubation, fry and juvenile rearing, and juvenile migration) on a site-by-site basis. Therefore this section will present results with a focus on the identification of maximum negative WRIs.

As described above, the ARCF GRR project reaches were grouped into four SAM analysis reaches based on hydrologic connectivity. Results are presented below by reach and species and are summarized in tables 30-32 and figures 2-22 at the end of the document.

3.1 Sacramento River SAM Analysis (ARS_DEFG)

The Sacramento River SAM analysis reach includes the entire left bank (east side) of the Sacramento River from the American River confluence to approximately 4,020 linear feet (lf) below the Freeport Bridge. The response of all runs of Chinook salmon, steelhead, and green sturgeon to project actions were included in the analysis of this reach. The green sturgeon spawning and egg incubation life stage was excluded from the analysis because spawning does not occur in the project area.

3.1.1 Spring/ Fall/ Late-Fall/ Winter Run Chinook Salmon

Chinook salmon are expected to show a long term positive response to project actions in the Sacramento River SAM analysis reach over the lifetime of the project. Chinook salmon should exhibit a positive response by year 5 in the winter-spring when most juvenile Chinook salmon are expected in the ARCF GRR project area. Short term negative WRI are expected within the recommended recovery period for Chinook salmon. The maximum negative WRI identified is -4,258 ft for the juvenile migration life stage of Chinook salmon in the summer of year 9. Short term negative WRI values will result from the initial loss of aquatic vegetation and over hanging shade at fall/summer habitat conditions. The SAM data iterations for the various life stages for Chinook salmon can be seen in (Table 28). The WRI response curves for juvenile migration and rearing can be located in (Figures 4 and 7). The NMFS SAM effects analysis summary tables can be seen in (Table 32).

3.1.2 Steelhead

Steelhead are expected to show a long term positive response to project actions in the Sacramento River SAM analysis reach over the lifetime of the project. Steelhead should exhibit a positive response by year 4 in the winter-spring when most juvenile steelhead will be migrating and rearing through the project area. The maximum negative WRI identified is -3,985 ft for the juvenile migration life stage of steelhead in the fall of year 10. Short term negative WRI values will result from the initial loss of aquatic vegetation and over hanging shade at fall/summer habitat conditions. The WRI response curves for juvenile migration and rearing can be located in (Figures 10 and 13).

3.1.3 Green Sturgeon

SRBPP onsite mitigative features were designed to maximize habitat response for salmonid species. SAM WRI's for green sturgeon generally indicate a negative response or no response to typical onsite mitigative features. Green sturgeon are expected to show long term negative response to project actions in the Sacramento River SAM analysis reach for several life stages at all seasonal habitat conditions over the lifetime of the project. The maximum negative WRI identified is -5,009 for fry and juvenile rearing in the summer of year 1. Negative WRI displayed a general trend toward decreasing beyond the lifetime of the project for fry and juvenile rearing life stages. Negative WRI values for adult life stages will result from the creation of a 10:1 planted bench at winter/spring habitat conditions. The WRI response curves for juvenile rearing can be located in (Figure 16).

3.2 American River SAM Analysis (ARN_AB and ARS_ABC)

The American River SAM analysis reaches include portions of the right and left bank of the American River from Goethe Park to the confluence of the Sacramento. The response of spring and fall runs of Chinook salmon, steelhead, and green sturgeon were included in the analysis of these reaches. Additional seasonal fall run juvenile migration life stage analysis was conducted after consultation with NMFS. Green sturgeon analysis was also included because of critical habitat in the lowest sub-reach (ARS_C) of the American River project area.

3.2.1 Spring/ Fall Chinook Salmon

Chinook salmon are expected to show a long term positive response to project actions in the American River SAM analysis reaches over the lifetime of the project when both IWM and planted benches are incorporated into the with-project conditions. Chinook salmon should exhibit a positive response by year 5. Short term habitat deficits are expected within the recommended recovery period for Chinook salmon. The maximum negative WRI value identified for the American River SAM ARN_AB and ARS_ABC is -3,129 ft for the juvenile migration life stage of fall-run Chinook salmon in the summer of year 1. Short term negative WRI values will result from the initial loss of aquatic vegetation and over hanging shade at fall/summer/winter/spring habitat conditions. The SAM data iterations for the various life stages for Chinook salmon can be seen in (Tables 26-27). The WRI response curves for juvenile migration and rearing can be located in (Figures 2,3,5,and 6). Additional fall-run Chinook salmon juvenile migration life stages not normally set as default in SAM were included on the American River reaches per NMFS request.

3.2.2 Steelhead

Steelhead are expected to show a long term positive response to project actions in the American River SAM analysis reach over the lifetime of the project. Steelhead should exhibit a positive response by year 4. Short term habitat deficits are expected within the recommended recovery period for steelhead. The maximum negative WRI value identified for the American River SAM analysis is -3,061 ft for the adult residence life stage in the summer of year 1 (Figures 20 and 21). Short term negative WRI values will result from the initial loss of aquatic vegetation and over hanging shade at fall/summer/winter/spring habitat conditions. The WRI response curves for juvenile migration and rearing can be located in (Figures 8,9,11, and 12).

3.2.3 Green Sturgeon

Project actions in the American River SAM analysis reach will mimic SRBPP repair site onsite mitigative features. SRBPP onsite mitigative features were designed to maximize habitat response for salmonid species; green sturgeon will exhibit a negative response for juvenile rearing in the summer/fall to these onsite mitigative features. However, during the winter/spring green sturgeon juvenile rearing life stages will exhibit a positive response to these onsite mitigative features. The maximum negative WRI value identified is -7,118 ft for the fry and juvenile rearing life stage in the summer of year 1. The WRI response curves for juvenile rearing can be located in (Figures 14 and 15).

3.3 Sacramento Bypass and Weir SAM Analysis

The Sacramento Bypass SAM analysis reach includes the right bank (north side) of the Sacramento Bypass levee in its entirety from the confluence of the Sacramento River to its termination at the Yolo Bypass. The response of all runs of Chinook salmon, steelhead, and green sturgeon were included in the analysis of this reach.

3.3.1 Spring/ Fall/ Late-Fall/ Winter Run Chinook Salmon

Chinook salmon are expected to show a small long term negative response to project actions in the Sacramento Bypass SAM analysis reach over the lifetime of the project. Chinook salmon should exhibit a negative response by year 1. The maximum negative WRI value identified is -188 ft for the juvenile migration life stage of Spring and Winter-run Chinook salmon in the spring of year 2. Short term and long term negative WRI values will result from the loss of aquatic vegetation and over hanging shade at fall/summer/winter/spring habitat conditions during and after the construction of the extension to the Sacramento Bypass Weir. The SAM data iterations for the various life stages for Chinook salmon can be seen in (Table 29). The NMFS SAM effects analysis summary tables can be seen in (Table 33).

3.3.2 Steelhead

Steelhead are also expected to show a small long term negative response to project actions in the Sacramento Bypass SAM analysis reach over the lifetime of the project. Steelhead should exhibit a negative response by year 1. The maximum negative WRI value identified is -174 ft for the juvenile migration life stage in the spring of year 2. Short term and long term negative WRI values will result from the loss of aquatic vegetation and over hanging shade at fall/summer/winter/spring habitat conditions during and after the construction of the extension to the Sacramento Bypass Weir. The NMFS SAM effects analysis summary tables can be seen in (Table 33).

3.3.3 Green Sturgeon

Green Sturgeon are expected to show a long term positive response to project actions in the Sacramento Bypass SAM analysis reach over the lifetime of the project for the fry and juvenile rearing life stages in the winter/spring/summer/fall of year 1. The maximum negative WRI value identified is -8 ft for the adult residence life stage of green sturgeon in the winter/spring/summer of year 1 which carries over through the life of the project into year 50. The SAM data iterations for the various life stages for green sturgeon can be seen in (Table 29). The NMFS SAM effects analysis summary tables can be seen in (Table 33).

4.0 Discussion

The SAM analysis indicates that the project actions in the Sacramento River SAM analysis reach, American River SAM analysis reach, and the Sacramento Bypass SAM analysis reach would result in short and longer-term impacts for focus fish species. Impacts to Chinook salmon, Central Valley steelhead, and green sturgeon are generally the result of reduction in the available natural substrate, shade and the alteration of near-shore slope resulting from bank armoring. Long term recovery of onsite vegetation, addition of IWM, and retention of existing vegetation are all expected to minimize impact as well as contribute to long term gains in habitat value.

This SAM analysis employed a set of worst case scenario parameters developed to capture the maximum potential impacts of the project for the Section 7 consultation process. Future implementation of the project is expected to result in significantly lower impacts. Project actions along portions of the American River reach will likely not include bank armoring in their final design, which will significantly reduce estimated impacts to fish species. Additional mitigative design features or improved erosion repair designs may result in reduced impact compared to the legacy designs used for the basis of this analysis. Site specific designs will be implemented on a site by site basis in consultation with resource agencies and project partners to minimize impacts as well as maximize opportunities for implementing onsite mitigative features.

During project implementation, site specific SAM analyses will be run on final designs to better evaluate impact. SAM results will be used by the Corps and NMFS in the negotiation of appropriate mitigation for project actions. Although short term impacts are generally self mitigating through the development of onsite mitigative features, the Corps will compensate for the temporal impacts to habitat through the purchase of offsite mitigative credits. Typically appropriate mitigation will be based on the identification of maximum negative WRI values. By mitigating for the maximum negative WRI, lesser impacts are expected to be appropriately mitigated. As a general rule, the SAM applies any habitat characteristics at summer/fall conditions to winter/spring conditions with the assumption that those characteristics would provide similar value during inundation. Onsite mitigation at summer/fall conditions is expected to provide similar habitat benefit for winter/spring conditions. Offsite mitigation is expected to provide mitigative value at all seasonal habitat conditions. Longer term impacts to habitat may not recover to baseline conditions over the life of the project due to design restrictions. These impacts to habitat will be compensated through the purchase of offsite mitigative credits as well as the incorporation of additional onsite mitigative features (ie. low water plantings, additional IWM, additional revegetation).

Additional mitigative concerns, not considered in a SAM analysis, will be addressed along the Sacramento Bypass reach, including potential adult and juvenile passage issues, loss of shoreline riparian vs. gain in floodplain, and contradicting ESA species habitat requirements. These issues will be considered and appropriate actions will be taken where possible in coordination with other agencies.

4.1 Chinook Salmon

Impacts to Chinook salmon were analyzed for the Sacramento River SAM analysis reach (ARS_DEFG), American River SAM analysis reach (ARN_AB, ARS_ABC) and the Sacramento Bypass SAM analysis reach. In the Sacramento River SAM analysis reach, negative WRI values are due to short term removal of aquatic vegetation and overhanging shade caused by the repair action. The SAM analysis indicates that repair actions would result in a maximum negative WRI value of -4,258 ft. This value is based on the maximum negative WRI value observed for juvenile migration life stage of Chinook salmon in the summer of year 9. USACE will mitigate for -4,258 ft of equivalent habitat as described above in Section 4.0.

In the American River SAM analysis reaches ARN_AB and ARS_ABC negative WRI values are due to short term removal of aquatic vegetation and overhanging shade caused by the repair action. The SAM analysis incorporating planted benches and IWM indicates that repair actions would result in a maximum habitat deficit of -3,129 ft. This value is based on the maximum negative WRI value observed for the juvenile migration life stage of spring and fall-run Chinook salmon in the summer and fall of year 1. USACE will mitigate for -3,129 ft of equivalent habitat as described above in Section 4.0.

There were no initial construction impact negative WRI values for the juvenile rearing life stage of Chinook salmon in the winter and spring water levels on the American and Sacramento River reaches. A possible explanation is that the SAM ECT does not produce an output at Year-0. It does not calculate the difference from the baseline to with-Project results. SAM at Year-0 is zero. The relative response for Year-1 is actually the Year-0 results+Year-1 results divided by 2, see pages 5-29 to 5-31 in the SAM Certification Update for SAM formula detailed explanation. In Year-0 revetment will be added, vegetation will be removed and slope will have a positive change. In Year-1 IWM will be added, soil and planting on the bench will occur, and the VVR will kick in. Year-0 habitat deficits would be more than the Year-1 deficits where the positive and negative deficits are equal.

In the Sacramento Bypass SAM analysis reach negative WRI values are due to short and long term removal of aquatic vegetation and overhanging shade for the upstream extension of the Sacramento Bypass Weir. The SAM analysis indicates that repair and removal actions would result in a maximum negative WRI value of -146 ft. This value is based on the maximum negative WRI value observed for juvenile migration of Chinook salmon in the winter of year 1. USACE will mitigate for -146 ft of equivalent habitat as described above in Section 4.0.

4.2 Steelhead

Impacts to steelhead were analyzed for the Sacramento River SAM analysis reach, American River SAM analysis reach, and the Sacramento Bypass SAM analysis reach. The Sacramento River SAM analysis indicates that repair actions would result in maximum negative WRI values of -3,985 ft. This value is based on the maximum negative WRI value observed for the juvenile migration life stage of steelhead in the fall of year 10.

The American River SAM analysis ARN_AB and ARS_ABC indicates that repair actions would result in negative WRI values of -3,061 ft. This negative WRI is expected to be adequately compensated through mitigation of a greater negative WRI for Chinook salmon.

There were no initial construction impact negative WRI values for the juvenile rearing life stage of steelhead in the winter and spring water levels on the Sacramento River reaches. A possible explanation is that the SAM ECT does not produce an output at Year-0. It does not calculate the difference from the baseline to with-Project results. SAM at Year-0 is zero. The relative response for Year-1 is actually the Year-0 results+Year-1 results divided by 2, see pages 5-29 to 5-31 in the SAM Certification Update for SAM formula detailed explanation. In Year-0 revetment will be added, vegetation will be removed and slope will have a positive change. In Year-1 IWM will be added, soil and planting on the bench will occur, and the VVR will kick in. Year-0 habitat deficits would be more than the Year-1 habitat deficits where the positive and negative deficits are equal.

The Sacramento Bypass SAM analysis indicates that repair actions would result in maximum negative WRI values of -174 ft. This value is based on the maximum

\negative WRI value observed for the juvenile migration life stage of steelhead in the spring of year 4. This negative WRI is expected to be adequately compensated through mitigation of a greater negative WRI for Chinook salmon.

4.3 Green Sturgeon

Impacts to green sturgeon were analyzed for the Sacramento and American River SAM and Sacramento Bypass analysis reaches. Green sturgeon critical habitat in the American River extends from the confluence of the Sacramento River to the Highway 160 bridge (ARS_C). Additional SAM elements were incorporated to address potential green sturgeon effects in the American River reaches (ARN_AB and ARS_AB), as per NMFS request, even though use of these reaches by green sturgeon has not been documented. Recently a white sturgeon (161mm) was collected in a rotary screw trap (RST) by the U.S. Fish and Wildlife Service (USFWS) at the Watt Avenue bridge, the first such documented catch of a sturgeon since records have been kept dating back to approximately 1996. There have been no green sturgeon collected, and the correlation of green sturgeon presence to white sturgeon presence is not well understood for larval life stages in this region of the river. This additional analysis allowed for a more conservative estimate of impacts and may not necessarily reflect the true impacts from the project.

The habitat requirements of green sturgeon are not well understood; assumptions built into the SAM on fish response to shoreline features were based on limited information. Habitat use of the American River, Sacramento River, and Sacramento Bypass project reaches by green sturgeon are likely limited to use as a migration corridor by adults and potential rearing area by juvenile life stages. Although the SAM indicates negative response to habitat by adult life stages, it is unlikely that shoreline repair activities would significantly impact the river for residence or as a migration corridor. SRBPP style repairs are designed to mimic naturally occurring habitat types and are not expected to significantly alter the width of the river. USACE does not expect any significant impacts to the adult residence or adult migration life stages in the American or Sacramento River and does not propose any additional mitigation.

No suitable spawning habitat exists in the Sacramento River, American River, and Sacramento Bypass project reaches. Green sturgeon spawning with concurrent egg incubation and early life history primarily takes place upriver of Colusa on the Sacramento River and in the lower Feather River outside of the project area. Because no suitable spawning habitat is present in the project reaches under existing conditions, USACE does not expect any significant impacts to the spawning and egg incubation life stage of green sturgeon and does not propose any additional mitigation.

The American River SAM analysis ARN_AB and ARS_ABC indicates that repair actions would result in a maximum negative WRI values of -7,118 ft. for fry and juvenile rearing in the summer of year one. The Sacramento River SAM analysis ARS_DEFG indicates that repair actions would result in a maximum negative WRI values of -5,009 for fry and juvenile rearing in the summer of year one.

The Sacramento Bypass SAM analysis indicates that repair actions would result in maximum negative WRI values of -8 ft in response to the removal of aquatic vegetation and SRA for the expansion of the Sacramento Bypass and Weir. This value is based on the maximum negative WRI values observed for the adult residence life stage of green sturgeon in the winter/spring /summer of year 1 continuing through the life of the project to year 50.

Little is known about the fry and juvenile rearing and juvenile migration life stages of green sturgeon. The SAM does not evaluate response to specific habitat attributes for the juvenile migration life stage. For the purpose of this analysis it is assumed that these life stages exhibit similar responses to analogous life stages of Chinook and steelhead. This approach assumes that fry and juvenile rearing and juvenile migration life stages of green sturgeon will exhibit a positive response to “good riparian habitat” (*i.e.* increased shoreline coverage of overhanging shade, aquatic vegetation, and IWM). During the planning and design phase of the project, opportunities for the incorporation of additional onsite mitigative features will be evaluated in coordination with resource agencies to ensure the projected longer term impacts are appropriately compensated for green sturgeon. Potential onsite mitigative features include the planting of vegetation at the low water line, the incorporation of additional IWM, and limitations in instream revetment.

Table 6
SAM data summary of existing conditions at site Lower American River RM 10.0L and 10.6L (ARN_AB).

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2024	18,576	18,576	18,576	18,576
	2074	18,576	18,576	18,576	18,576
Bank Slope (dH:dV) [2]	2024	2	2	2	2
	2074	2	2	2	2
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2024	1	1	1	1
	2074	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2024	2.5	2.5	2.5	2.5
	2074	2.5	2.5	2.5	2.5
Instream Structure (% shoreline) [5]	2024	31	31	31	31
	2074	31	31	31	31
Vegetation (% shoreline) [6]	2024	0	88	88	0
	2074	0	88	88	0
Shade (% shoreline) [7]	2024	60	15	45	60
	2074	60	15	45	60

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 2 SRBPP repair sites modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 7
SAM data summary of with-project conditions at site Lower American River RM 10.0L and 10.6L (ARN_AB).

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2024	18,576	18,576	18,576	18,576
	2074	18,576	18,576	18,576	18,576
Bank Slope (dH:dV) [2]	2024	2	3	3	3
	2025	3	10	10	3
	2074	3	10	10	3
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2024	1	1	1	1
	2074	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2024	2.5	18	18	18
	2025	18	0.25	0.25	18
	2074	18	0.25	0.25	18
Instream Structure (% shoreline) [5]	2024	31	0	0	0
	2025	40	40	40	40
	2074	40	40	40	40
Vegetation (% shoreline) [6]	2024	0	0	0	0
	2025	0	25	50	0
	2029	0	88	88	0
	2039	0	88	88	0
	2049	0	88	88	0
	2074	0	88	88	0
Shade (% shoreline) [6]	2024	0	13	38	0
	2025	0	13	40	0
	2029	0	25	75	0
	2039	100	25	75	100
	2049	100	25	75	100
	2074	100	25	75	100

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.
[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Assume no significant change to Bank Slope.
[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.
[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Assume installation of rock revetment at summer/fall (D_{50} of 18 in) and natural substrate at winter/spring (D_{50} of 0.25 in).
[6] Assume installation of 40% shoreline coverage of IWM at summer/fall and winter/spring.
[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee.

Table 8
SAM data summary of existing conditions at site Lower American River RM 10.0L and 10.6L (ARS_A).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2020	14,345	14,345	14,345	14,345
	2070	14,345	14,345	14,345	14,345
Bank Slope (dH:dV) [2]	2020	2.00	2.00	2.00	2.00
	2070	2.00	2.00	2.00	2.00
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2020	1	1	1	1
	2070	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2020	1.2	1.2	1.2	1.2
	2070	1.2	1.2	1.2	1.2
Instream Structure (% shoreline) [5]	2020	1.7	1.7	1.7	1.7
	2070	1.7	1.7	1.7	1.7
Vegetation (% shoreline) [6]	2020	0	63	63	0
	2070	0	63	63	0
Shade (% shoreline) [7]	2020	42	11	32	42
	2070	42	11	32	42

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 2 SRBPP repair sites modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 9

SAM data summary of with-project conditions at site Lower American River RM 10.0L and 10.6L (ARS_A).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2020	14,345	14,345	14,345	14,345
	2070	14,345	14,345	14,345	14,345
Bank Slope (dH:dV) [2]	2020	2.0	3.0	3.0	3.0
	2021	3.0	10.0	10.0	3.0
	2070	3.0	10.0	10.0	3.0
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2020	1	1	1	1
	2070	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2020	1.2	18	18	18
	2021	18	0.25	0.25	18
	2070	18	0.25	0.25	18
Instream Structure (% shoreline) [5]	2020	1.7	0.0	0.0	0
	2021	40	40	40	40
	2070	40	40	40	40
Vegetation (% shoreline) [6]	2020	0	0	0	0
	2021	0	25	50	0
	2025	0	88	88	0
	2035	0	88	88	0
	2045	0	88	88	0
	2070	0	88	88	0
Shade (% shoreline) [6]	2020	0	9	27	0
	2021	0	9	29	0
	2025	0	24	74	0
	2035	100	25	75	100
	2045	100	25	75	100
	2070	100	25	75	100

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).

[2] Assume no significant change to Bank Slope.

[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.

[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.

[5] Assume installation of rock revetment at summer/fall (D_{50} of 18 in) and natural substrate at winter/spring (D_{50} of 0.25 in).

[6] Assume installation of 40% shoreline coverage of IWM at summer/fall and winter/spring.

[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee

Table 10
SAM data summary of existing conditions at site Lower American River RM 2.8L (ARS_B).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2023	5,472	5,472	5,472	5,472
	2073	5,472	5,472	5,472	5,472
Bank Slope (dH:dV) [2]	2023	2	2	2	2
	2073	2	2	2	2
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2023	1	1	1	1
	2073	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2023	1.5	1.5	1.5	1.5
	2073	1.5	1.5	1.5	1.5
Instream Structure (% shoreline) [5]	2023	5	5	5	5
	2073	5	5	5	5
Vegetation (% shoreline) [6]	2023	0	65	65	0
	2073	0	65	65	0
Shade (% shoreline) [7]	2023	30	7	22	30
	2073	30	7	22	30

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 1 SRBPP repair site modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 11
SAM data summary of with-project conditions at site Lower American River RM 2.8L (ARS_B).

Habitat Parameter	Water Year	Seasonal Values			
		Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2023	5,472	5,472	5,472	5,472
	2073	5,472	5,472	5,472	5,472
Bank Slope (dH:dV) [2]	2023	2	3	3	3
	2024	3	10	10	3
	2073	3	10	10	3
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2023	1	1	1	1
	2073	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2023	1.5	18	18	18
	2024	18	0.25	0.25	18
	2073	18	0.25	0.25	18
Instream Structure (% shoreline) [5]	2023	5	0	0	0
	2024	40	40	40	40
	2073	40	40	40	40
Vegetation (% shoreline) [6]	2023	0	0	0	0
	2024	0	25	50	0
	2028	0	88	88	0
	2038	0	88	88	0
	2048	0	88	88	0
	2073	0	88	88	0
Shade (% shoreline) [6]	2023	0	7	20	0
	2024	0	7	22	0
	2028	0	22	67	0
	2038	100	25	75	100
	2048	100	25	75	100
	2073	100	25	75	100

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.
[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Assume no significant change to Bank Slope.
[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.
[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Assume installation of rock revetment at summer/fall (D_{50} of 18 in) and natural substrate at winter/spring (D_{50} of 0.25 in).
[6] Assume installation of 40% shoreline coverage of IWM at summer/fall and winter/spring.
[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee

Table 12
SAM data summary of existing conditions at site Lower American River RM 0.3L (ARS_C).

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2026	3,988	3,988	3,988	3,988
	2076	3,988	3,988	3,988	3,988
Bank Slope (dH:dV) [2]	2026	2	2	2	2
	2076	2	2	2	2
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2026	1	1	1	1
	2076	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2026	0.25	0.25	0.25	0.25
	2076	0.25	0.25	0.25	0.25
Instream Structure (% shoreline) [5]	2026	5	5	5	5
	2076	5	5	5	5
Vegetation (% shoreline) [6]	2026	0	88	88	0
	2076	0	88	88	0
Shade (% shoreline) [7]	2026	67	16	50	67
	2076	67	16	50	67

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 1 SRBPP repair site modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 13
SAM data summary of with-project conditions at site Lower American River RM 0.3L (ARS_C).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2026	3,988	3,988	3,988	3,988
	2076	3,988	3,988	3,988	3,988
Bank Slope (dH:dV) [2]	2026	2	3	3	3
	2027	3	10	10	3
	2076	3	10	10	3
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2026	1	1	1	1
	2076	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2026	0.25	18	18	18
	2027	18	0.25	0.25	18
	2076	18	0.25	0.25	18
Instream Structure (% shoreline) [5]	2026	5	0	0	0
	2027	40	40	40	40
	2076	40	40	40	40
Vegetation (% shoreline) [6]	2026	0	0	0	0
	2027	0	25	50	0
	2031	0	88	88	0
	2041	0	88	88	0
	2051	0	88	88	0
	2076	0	88	88	0
Shade (% shoreline) [6]	2026	0	14	42	0
	2027	0	14	44	0
	2031	0	25	75	0
	2041	100	25	75	100
	2051	100	25	75	100
	2076	100	25	75	100

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.
[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Assume no significant change to Bank Slope.
[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.
[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Assume installation of rock revetment at summer/fall (D_{50} of 18 in) and natural substrate at winter/spring (D_{50} of 0.25 in).
[6] Assume installation of 40% shoreline coverage of IWM at summer/fall and winter/spring.
[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee

Table 14
SAM data summary of existing conditions at site Sacramento River RM 56.7L (ARS_D).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2025	9,131	9,131	9,131	9,131
	2075	9,131	9,131	9,131	9,131
Bank Slope (dH:dV) [2]	2025	1.8	1.8	1.8	1.8
	2075	1.8	1.8	1.8	1.8
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2025	1	1	1	1
	2075	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2025	7.6	7.6	7.6	7.6
	2075	7.6	7.6	7.6	7.6
Instream Structure (% shoreline) [5]	2025	22	22	22	22
	2075	22	22	22	22
Vegetation (% shoreline) [6]	2025	0	88	88	0
	2075	0	88	88	0
Shade (% shoreline) [7]	2025	40	10	30	40
	2075	40	10	30	40

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 1 SRBPP repair site modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 15
SAM data summary of with-project conditions at site Sacramento River RM 56.7L (ARS_D).

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2025	9,131	9,131	9,131	9,131
	2075	9,131	9,131	9,131	9,131
Bank Slope (dH:dV) [2]	2025	2.5	1.5	1.5	1.5
	2026	1.5	6.5	6.5	1.5
	2075	1.5	6.5	6.5	1.5
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2025	1	1	1	1
	2075	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2025	7.6	12	12	12
	2026	12	0.25	0.25	12
	2075	12	0.25	0.25	12
Instream Structure (% shoreline) [5]	2025	22	0	0	0
	2026	0	0	0	0
	2075	0	0	0	0
Vegetation (% shoreline) [6]	2025	0	0	0	0
	2026	0	0	0	0
	2030	10	60	60	10
	2040	10	88	88	10
	2050	10	88	88	10
	2075	10	88	88	10
Shade (% shoreline) [6]	2025	0	8	24	0
	2026	0	8	25	0
	2030	0	9	35	0
	2040	61	13	66	61
	2050	97	15	75	97
	2075	99	15	75	99

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.
[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Assume no significant change to Bank Slope.
[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.
[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Assume installation of rock revetment at summer/fall (D_{50} of 12 in) and natural substrate at winter/spring (D_{50} of 0.25 in).
[6] Assume no installation of shoreline coverage of IWM at summer/fall and winter/spring.
[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee

Table 16
SAM data summary of existing conditions at site Sacramento River RM 53.1L and RM 53.5R (ARS_E).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2021	9,149	9,149	9,149	9,149
	2071	9,149	9,149	9,149	9,149
Bank Slope (dH:dV) [2]	2021	1.7	1.7	1.7	1.7
	2071	1.7	1.7	1.7	1.7
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2021	1	1	1	1
	2071	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2021	7	7	7	7
	2071	7	7	7	7
Instream Structure (% shoreline) [5]	2021	30	30	30	30
	2071	30	30	30	30
Vegetation (% shoreline) [6]	2021	0	88	88	0
	2071	0	88	88	0
Shade (% shoreline) [7]	2021	60	15	45	60
	2071	60	15	45	60

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 2 SRBPP repair sites modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 17
SAM data summary of with-project conditions at site Sacramento River RM 53.1L and 53.5R (ARS_E).

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2021	9,149	9,149	9,149	9,149
	2071	9,149	9,149	9,149	9,149
Bank Slope (dH:dV) [2]	2021	1.7	2	2	2
	2022	2	6	6	2
	2071	2	6	6	2
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2021	1	1	1	1
	2071	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2021	7	12	12	12
	2022	12	0.25	0.25	12
	2071	12	0.25	0.25	12
Instream Structure (% shoreline) [5]	2021	30	0	0	0
	2022	40	40	40	40
	2071	40	40	40	40
Vegetation (% shoreline) [6]	2021	0	0	0	0
	2022	0	50	50	0
	2026	0	88	88	0
	2036	0	88	88	0
	2046	0	88	88	0
	2071	0	88	88	0
Shade (% shoreline) [6]	2021	0	12	36	0
	2022	0	12	37	0
	2026	0	13	42	0
	2036	61	17	75	61
	2046	97	19	75	97
	2071	99	19	75	99

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.
[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Assume no significant change to Bank Slope.
[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.
[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Assume installation of rock revetment at summer/fall (D_{50} of 12 in) and natural substrate at winter/spring (D_{50} of 0.25 in).
[6] Assume installation of 40% shoreline coverage of IWM at summer/fall and winter/spring.
[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee

Table 18
SAM data summary of existing conditions at site Sacramento River RM 48.2L-52.4L (ARS_F).

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2020	21,379	21,379	21,379	21,379
	2070	21,379	21,379	21,379	21,379
Bank Slope (dH:dV) [2]	2020	1.8	1.8	1.8	1.8
	2070	1.8	1.8	1.8	1.8
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2020	1	1	1	1
	2070	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2020	8.7	8.7	8.7	8.7
	2070	8.7	8.7	8.7	8.7
Instream Structure (% shoreline) [5]	2020	17	17	17	17
	2070	17	17	17	17
Vegetation (% shoreline) [6]	2020	0	88	88	0
	2070	0	88	88	0
Shade (% shoreline) [7]	2020	73	18	54	73
	2070	73	18	54	73

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 10 SRBPP repair sites modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 19

SAM data summary of with-project conditions at site Sacramento River RM 48.2L-52.4L (ARS_F).

Habitat Parameter	Water Year	Seasonal Values			
		Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2020	21,379	21,379	21,379	21,379
	2070	21,379	21,379	21,379	21,379
Bank Slope (dH:dV) [2]	2020	1.8	2.0	2.0	2
	2021	2	6	6	2
	2070	2	6	6	2
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2020	1	1	1	1
	2070	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2020	8.7	12	12	12
	2021	12	0.25	0.25	12
	2070	12	0.25	0.25	12
Instream Structure (% shoreline) [5]	2020	17	0	0	0
	2021	40	40	40	40
	2070	40	40	40	40
Vegetation (% shoreline) [6]	2020	0	0	0	0
	2021	0	50	50	0
	2025	0	88	88	0
	2035	0	88	88	0
	2045	0	88	88	0
	2070	0	88	88	0
Shade (% shoreline) [6]	2020	0	14	43	0
	2021	0	14	44	0
	2025	0	15	54	0
	2035	61	19	75	61
	2045	97	21	75	97
	2070	99	21	75	99

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).

[2] Assume no significant change to Bank Slope.

[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.

[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.

[5] Assume installation of rock revetment at summer/fall (D_{50} of 12 in) and natural substrate at winter/spring (D_{50} of 0.25 in).

[6] Assume installation of 40% shoreline coverage of IWM at summer/fall and winter/spring.

[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee

Table 20

SAM data summary of existing conditions at site Sacramento River RM 47.0L and 47.9R (ARS_G).

Habitat Parameter	Water Year	Seasonal Values			
		Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2024	11,066	11,066	11,066	11,066
	2074	11,066	11,066	11,066	11,066
Bank Slope (dH:dV) [2]	2024	2	2	2	2
	2074	2	2	2	2
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2024	1	1	1	1
	2074	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2024	9.40	9.40	9.40	9.40
	2074	9.40	9.40	9.40	9.40
Instream Structure (% shoreline) [5]	2024	5.5	5.5	5.5	5.5
	2074	5.5	5.5	5.5	5.5
Vegetation (% shoreline) [6]	2024	0	88	88	0
	2074	0	88	88	0
Shade (% shoreline) [7]	2024	90	22	67	90
	2074	90	22	67	90

[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Existing slopes taken from 2 SRBPP repair sites modeled by SAM.
[3] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of one for all seasons in all ARCF GRR Reaches.
[4] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[5] Instream Structure data taken from USACE Revetment Database (2007).
[6] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[7] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 21

SAM data summary of with-project conditions at site Sacramento River RM 47.0L and 47.9R (ARS_G).

Habitat Parameter	Water Year	Seasonal Values			
		Fall	Winter	Spring	Summer
Shoreline Length (feet) [1]	2024	11,066	11,066	11,066	11,066
	2074	11,066	11,066	11,066	11,066
Bank Slope (dH:dV) [2]	2024	2.5	3	3	3
	2025	3	10	10	3
	2074	3	10	10	3
Floodplain Inundation Ratio (AQ2:AQavg) [3]	2024	1	1	1	1
	2074	1	1	1	1
Bank Substrate Size (D50 in inches) [4]	2024	9.4	12	12	12
	2025	12	0.25	0.25	12
	2074	12	0.25	0.25	12
Instream Structure (% shoreline) [5]	2024	5.5	0	0	0
	2025	40	40	40	40
	2074	40	40	40	40
Vegetation (% shoreline) [6]	2024	0	0	0	0
	2025	0	50	50	0
	2029	0	88	88	0
	2039	0	88	88	0
	2049	0	88	88	0
	2074	0	88	88	0
Shade (% shoreline) [6]	2024	0	18	54	0
	2025	0	18	55	0
	2029	0	19	65	0
	2039	100	23	75	100
	2049	100	25	75	100
	2074	100	25	75	100

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.
[1] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[2] Assume no significant change to Bank Slope.
[3] Assume no significant increase in floodplain between seasonal water surface elevations or as a result of project construction.
[4] Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Assume installation of rock revetment at summer/fall (D_{50} of 12 in) and natural substrate at winter/spring (D_{50} of 0.25 in).
[6] Assume installation of 40% shoreline coverage of IWM at summer/fall and winter/spring.
[6] Assume a variance in place allowing existing woody vegetation to remain in place on bottom 2/3 of levee

Table 22

SAM data summary of existing conditions at site Sacramento River 50.0L (SBP Levee).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Wetted Area (square feet) [1]	2012	8,799,296	8,799,296	8,799,296	8,799,296
	2062	8,799,296	8,799,296	8,799,296	8,799,296
Shoreline Length (feet) [2]	2012	9,047	9,047	9,047	9,047
	2062	9,047	9,047	9,047	9,047
Bank Slope (dH:dV) [3]	2012	2	2	2	2
	2062	2	2	2	2
Floodplain Inundation Ratio (AQ2:AQavg) [4]	2012	1	1	1	1
	2062	1	1	1	1
Bank Substrate Size (D50 in inches) [5]	2012	2.4	2.4	2.4	2.4
	2062	2.4	2.4	2.4	2.4
Instream Structure (% shoreline) [6]	2012	3.9	3.9	3.9	3.9
	2062	3.9	3.9	3.9	3.9
Vegetation (% shoreline) [7]	2012	0	71	71	0
	2062	0	71	71	0
Shade (% shoreline) [8]	2012	48	12	36	48
	2062	48	12	36	48

[1] Wetted area estimated from aerial images in Google Earth Pro. Length x Width

[2] USACE Revetment Database (2007) and Google Earth Pro.

[3] Repairs not expected to affect slope, assume slope of 2 for consistency with USACE standards.

[4] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.

[5] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.

[6] Instream Structure data taken from USACE Revetment Database (2007).

[7] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.

[8] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation.

Table 23
SAM data summary of with-project conditions at site Sacramento River RM 50.0L (SBP Levee).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Wetted Area (square feet) [1]	2012	23,022,296	23,022,296	23,022,296	23,022,296
	2062	23,022,296	23,022,296	23,022,296	23,022,296
Shoreline Length (feet) [2]	2012	9,047	9,047	9,047	9,047
	2062	9,047	9,047	9,047	9,047
Bank Slope (dH:dV)	2012	2.5	2.5	2.5	2.5
	2013	2.5	2.5	2.5	2.5
	2062	2.5	2.5	2.5	2.5
Floodplain Inundation Ratio (AQ2:AQavg)	2012	1	1	1	1
	2062	1	1	1	1
Bank Substrate Size (D50 in inches) [3]	2012	2.4	2.4	2.4	2.4
	2013	2.4	2.4	2.4	2.4
	2062	2.4	2.4	2.4	2.4
Instream Structure (% shoreline) [3]	2012	3.9	3.9	3.9	3.9
	2013	3.9	3.9	3.9	3.9
	2062	3.9	3.9	3.9	3.9
Vegetation (% shoreline) [3]	2012	0	71	71	0
	2013	0	71	71	0
	2017	0	71	71	0
	2027	0	71	71	0
	2037	0	71	71	0
	2062	0	71	71	0
Shade (% shoreline)[3]	2012	48	12	36	48
	2013	48	12	36	48
	2017	48	12	36	48
	2027	48	12	36	48
	2037	48	12	36	48
	2062	48	12	36	48

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.

[1] Wetted area calculated by aerial images and a length x width with-project conditions

[2] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).

[3] Assumed to stay the same due to only degrading and moving levee

Table 24
SAM data summary of existing conditions at site Sacramento River RM 50.0L (SBP Weir).

Habitat Parameter	Water Year	Seasonal Values: Fall	Winter	Spring	Summer
Wetted Area (square feet) [1]	2012	283,968	283,968	283,968	283,968
	2062	283,968	283,968	283,968	283,968
Shoreline Length (feet) [2]	2012	1,500	1,500	1,500	1,500
	2062	1,500	1,500	1,500	1,500
Bank Slope (dH:dV) [3]	2012	2.5	2.5	2.5	2.5
	2062	2.5	2.5	2.5	2.5
Floodplain Inundation Ratio (AQ2:AQavg) [4]	2012	1	1	1	1
	2062	1	1	1	1
Bank Substrate Size (D50 in inches) [5]	2012	10	10	10	10
	2062	10	10	10	10
Instream Structure (% shoreline) [6]	2012	0	0	0	0
	2062	0	0	0	0
Vegetation (% shoreline) [7]	2012	0	88	88	0
	2062	0	88	88	0
Shade (% shoreline) [8]	2012	48	12	36	48
	2062	48	12	36	48

[1] Wetted area estimated from aerial images in Google Earth Pro. Length x Width
[2] USACE Revetment Database (2007) and Google Earth Pro.
[3] Repairs not expected to affect slope, assume slope of 2 for consistency with USACE standards.
[4] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Bank substrate data taken from USACE Revetment Database (2007) and confirmed with aerial imagery. Natural substrate assigned a D50 of 0.25 inches. Revetment substrate assigned a D_{50} of 10 inches.
[6] Instream Structure data taken from USACE Revetment Database (2007).
[7] Shoreline coverage of Vegetation taken from USACE Revetment Database and evaluated against aerial imagery. Summer/Fall values taken from "Emergent Veg" attribute. Winter/ Spring values taken from "Veg Cover%" attribute.
[8] Attribute coverage determined from analysis of aerial imagery. Winter/ Spring values modified by 0.25/ 0.75 respectively to represent seasonal defoliation

Table 25
SAM data summary of with-project conditions at site Sacramento River RM 50.0L (SBP Weir).

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Wetted Area (square feet) [1]	2012	742,968	742,968	742,968	742,968
	2062	742,968	742,968	742,968	742,968
Shoreline Length (feet) [2]	2012	1,500	1,500	1,500	1,500
	2062	1,500	1,500	1,500	1,500
Bank Slope (dH:dV) [3]	2012	2.5	2.5	2.5	2.5
	2013	2.5	2.5	2.5	2.5
	2062	2.5	2.5	2.5	2.5
Floodplain Inundation Ratio (AQ2:AQavg) [4]	2012	1	1	1	1
	2062	1	1	1	1
Bank Substrate Size (D50 in inches) [5]	2012	10	10	10	10
	2013	10	10	10	10
	2062	10	10	10	10
Instream Structure (% shoreline) [6]	2012	0	0	0	0
	2013	0	0	0	0
	2062	0	0	0	0
Vegetation (% shoreline) [6]	2012	0	0	0	0
	2013	0	0	0	0
	2017	0	0	0	0
	2027	0	0	0	0
	2037	0	0	0	0
	2062	0	0	0	0
Shade (% shoreline) [6]	2012	0	0	0	0
	2013	0	0	0	0
	2017	0	0	0	0
	2027	0	0	0	0
	2037	0	0	0	0
	2062	0	0	0	0

-WY = water year; spans fall, winter, spring and summer; rock and soil placement and IWM installation assumed during Winter in the initial WY and revegetation planting assumed during Spring of the initial WY.
[1] Wetted area calculated by aerial images and a length x width with-project conditions
[2] Shoreline Length Estimated from Aerial images. Attribute surveyed in the field following the field data collection protocol for the USACE Revetment Database (2007).
[3] Repairs not expected to affect slope, assume slope of 2.5 for consistency with USACE standards.
[4] Assume no significant increase in floodplain between seasonal water surface elevations. Assume floodplain inundation ratio of 1 for all seasons in all ARCF GRR Reaches.
[5] Assume installation of rock revetment at summer/fall (D_{50} of 12 in) and natural substrate at winter/spring (D_{50} of 0.25 in).
[6] Assume no vegetation variance and no placement of IWM and O&M activities

Table 26
American River SAM Analysis Reach
ARN_AB
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Spring-run Chinook																				
0			0	0				0	0				0					0		
1			-366	-1,945				59	-3,002				124					-421		
2			-365	-2,166				411	-1,357				634					-392		
3			-365	-2,240				564	-662				827					-383		
4			-364	-2,277				667	-201				941					-378		
5			-364	-2,299				751	167				1,024					-375		
6			-361	-2,303				816	450				1,085					-370		
7			-353	-2,288				863	653				1,129					-360		
8			-341	-2,260				897	805				1,161					-348		
9			-328	-2,225				925	924				1,187					-334		
10			-314	-2,183				946	1,018				1,207					-319		
11			-298	-2,138				964	1,096				1,224					-303		
12			-282	-2,089				979	1,160				1,238					-287		
13			-265	-2,038				991	1,215				1,250					-270		
14			-248	-1,985				1,002	1,261				1,260					-252		
15			-230	-1,930				1,011	1,302				1,268					-234		
25			-124	-1,600				1,063	1,529				1,317					-126		
50			-44	-1,352				1,102	1,699				1,354					-45		
Fall-run Chinook																				
0	0	0	0	0		0	0	0	0			0	0	0					0	
1	-877	0	-366	-1,945		-759	0	59	-3,002			0	124	-2,681					-3,129	
2	-853	0	-365	-2,166		-339	0	411	-1,357			0	634	-755					-2,759	
3	-845	0	-365	-2,240		-180	0	564	-662			0	827	-80					-2,635	
4	-841	0	-364	-2,277		-87	0	667	-201			0	941	282					-2,573	
5	-839	0	-364	-2,299		-20	0	751	167			0	1,024	519					-2,536	
6	-828	0	-361	-2,303		29	0	816	450			0	1,085	686					-2,501	
7	-804	0	-353	-2,288		64	0	863	653			0	1,129	805					-2,457	
8	-773	0	-341	-2,260		90	0	897	805			0	1,161	894					-2,408	
9	-736	0	-328	-2,225		111	0	925	924			0	1,187	963					-2,356	
10	-695	0	-314	-2,183		127	0	946	1,018			0	1,207	1,018					-2,302	
11	-652	0	-298	-2,138		141	0	964	1,096			0	1,224	1,064					-2,245	
12	-606	0	-282	-2,089		152	0	979	1,160			0	1,238	1,102					-2,188	
13	-559	0	-265	-2,038		161	0	991	1,215			0	1,250	1,134					-2,129	
14	-511	0	-248	-1,985		170	0	1,002	1,261			0	1,260	1,161					-2,069	
15	-462	0	-230	-1,930		177	0	1,011	1,302			0	1,268	1,185					-2,009	
25	-164	0	-124	-1,600		216	0	1,063	1,529			0	1,317	1,318					-1,647	
50	59	0	-44	-1,352		245	0	1,102	1,699			0	1,354	1,418					-1,375	

4.0 defaults used for all response curves
Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

Table 26 (cont.)
American River SAM Analysis Reach
ARN_AB
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Steelhead																				
0	0		0		0	0	0	0		0	0	0	0	0	0			0	0	0
1	-1,554		-701		-1,554	-1,558	0	-36		-1,558	-1,635	0	-1	-2,096	-1,635			-833	-3,013	-3,061
2	-1,508		-708		-1,508	-701	0	519		-701	-739	0	734	-520	-739			-774	-2,634	-2,262
3	-1,493		-711		-1,493	-381	0	750		-381	-411	0	1,009	23	-411			-755	-2,507	-1,996
4	-1,486		-712		-1,486	-195	0	900		-195	-225	0	1,168	309	-225			-745	-2,444	-1,862
5	-1,481		-712		-1,481	-63	0	1,018		-63	-96	0	1,282	491	-96			-739	-2,406	-1,782
6	-1,463		-707		-1,463	34	0	1,109		34	-3	0	1,365	617	-3			-729	-2,369	-1,714
7	-1,423		-693		-1,423	103	0	1,174		103	63	0	1,424	708	63			-712	-2,323	-1,639
8	-1,371		-674		-1,371	155	0	1,222		155	113	0	1,469	775	113			-691	-2,271	-1,559
9	-1,309		-651		-1,309	196	0	1,260		196	152	0	1,504	828	152			-666	-2,215	-1,477
10	-1,242		-626		-1,242	228	0	1,290		228	183	0	1,531	870	183			-639	-2,156	-1,392
11	-1,170		-599		-1,170	254	0	1,315		254	209	0	1,554	904	209			-611	-2,095	-1,307
12	-1,095		-571		-1,095	276	0	1,335		276	230	0	1,573	933	230			-582	-2,033	-1,220
13	-1,017		-541		-1,017	295	0	1,353		295	248	0	1,589	957	248			-551	-1,970	-1,133
14	-937		-511		-937	311	0	1,367		311	263	0	1,603	978	263			-520	-1,906	-1,044
15	-855		-480		-855	325	0	1,380		325	276	0	1,615	996	276			-489	-1,841	-956
25	-362		-293		-362	402	0	1,453		402	351	0	1,681	1,097	351			-298	-1,450	-422
50	8		-153		8	460	0	1,507		460	407	0	1,731	1,173	407			-156	-1,157	-22
Green Sturgeon																				
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	-3,250	-2,873	0	-11	0	-3,250	-5,020	0	-2,750	0	-3,250	-5,020	0	-2,750	0	-6,500	-7,118	0	-942
2	0	-4,875	-4,304	0	-16	0	-1,625	-3,280	0	-3,194	0	-1,625	-3,280	0	-3,194	0	-6,500	-6,426	0	-482
3	0	-5,417	-4,781	0	-18	0	-1,083	-2,699	0	-3,343	0	-1,083	-2,699	0	-3,343	0	-6,500	-6,196	0	-328
4	0	-5,688	-5,019	0	-19	0	-812	-2,409	0	-3,417	0	-812	-2,409	0	-3,417	0	-6,500	-6,081	0	-252
5	0	-5,850	-5,162	0	-20	0	-650	-2,235	0	-3,461	0	-650	-2,235	0	-3,461	0	-6,500	-6,011	0	-206
6	0	-5,958	-5,258	0	-20	0	-541	-2,119	0	-3,491	0	-541	-2,119	0	-3,491	0	-6,500	-5,965	0	-175
7	0	-6,036	-5,326	0	-20	0	-464	-2,036	0	-3,512	0	-464	-2,036	0	-3,512	0	-6,500	-5,932	0	-153
8	0	-6,094	-5,377	0	-20	0	-406	-1,974	0	-3,528	0	-406	-1,974	0	-3,528	0	-6,500	-5,908	0	-137
9	0	-6,139	-5,417	0	-20	0	-361	-1,926	0	-3,540	0	-361	-1,926	0	-3,540	0	-6,500	-5,888	0	-124
10	0	-6,175	-5,448	0	-21	0	-325	-1,887	0	-3,550	0	-325	-1,887	0	-3,550	0	-6,500	-5,873	0	-114
11	0	-6,205	-5,475	0	-21	0	-295	-1,855	0	-3,558	0	-295	-1,855	0	-3,558	0	-6,500	-5,860	0	-105
12	0	-6,229	-5,496	0	-21	0	-271	-1,829	0	-3,565	0	-271	-1,829	0	-3,565	0	-6,500	-5,850	0	-98
13	0	-6,250	-5,515	0	-21	0	-250	-1,807	0	-3,570	0	-250	-1,807	0	-3,570	0	-6,500	-5,841	0	-92
14	0	-6,268	-5,530	0	-21	0	-232	-1,787	0	-3,575	0	-232	-1,787	0	-3,575	0	-6,500	-5,833	0	-87
15	0	-6,283	-5,544	0	-21	0	-216	-1,771	0	-3,579	0	-216	-1,771	0	-3,579	0	-6,500	-5,827	0	-83
25	0	-6,370	-5,620	0	-21	0	-130	-1,678	0	-3,603	0	-130	-1,678	0	-3,603	0	-6,500	-5,790	0	-58
50	0	-6,435	-5,677	0	-21	0	-65	-1,608	0	-3,621	0	-65	-1,608	0	-3,621	0	-6,500	-5,762	0	-40

4.0 defaults used for all response curves

Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

4.0 defaults used for all response curves
Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

Table 27
American River SAM Analysis Reach
ARS_ABC
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Spring-run Chinook																				
0			0	0				0	0				0					0		
1			-200	-620				114	-333				194					-229		
2			-192	-507				366	912				561					-207		
3			-201	-522				467	1,280				689					-214		
4			-212	-557				571	1,647				816					-225		
5			-217	-568				691	2,137				965					-228		
6			-224	-588				779	2,453				1,068					-234		
7			-229	-602				861	2,736				1,169					-239		
8			-229	-595				947	3,058				1,278					-237		
9			-224	-577				1,019	3,328				1,368					-232		
10			-216	-549				1,079	3,554				1,441					-223		
11			-206	-513				1,131	3,748				1,502					-212		
12			-193	-471				1,175	3,915				1,553					-199		
13			-179	-422				1,213	4,056				1,596					-184		
14			-163	-369				1,246	4,177				1,634					-167		
15			-145	-312				1,275	4,283				1,666					-150		
25			-11	126				1,440	4,881				1,849					-14		
50			100	488				1,564	5,329				1,986					99		
Fall-run Chinook																				
0	0	0	0	0		0	0	0	0			0	0	0					0	
1	9	0	-200	-620		456	0	114	-333			0	194	52					-967	
2	284	0	-192	-507		783	0	366	912			0	561	1,529					-681	
3	347	0	-201	-522		886	0	467	1,280			0	689	1,860					-694	
4	399	0	-212	-557		994	0	571	1,647			0	816	2,176					-728	
5	463	0	-217	-568		1,119	0	691	2,137			0	965	2,612					-705	
6	497	0	-224	-588		1,202	0	779	2,453			0	1,068	2,845					-723	
7	536	0	-229	-602		1,282	0	861	2,736			0	1,169	3,072					-735	
8	592	0	-229	-595		1,367	0	947	3,058			0	1,278	3,353					-712	
9	646	0	-224	-577		1,436	0	1,019	3,328			0	1,368	3,577					-681	
10	701	0	-216	-549		1,492	0	1,079	3,554			0	1,441	3,758					-642	
11	758	0	-206	-513		1,539	0	1,131	3,748			0	1,502	3,908					-598	
12	815	0	-193	-471		1,580	0	1,175	3,915			0	1,553	4,034					-548	
13	875	0	-179	-422		1,614	0	1,213	4,056			0	1,596	4,141					-494	
14	936	0	-163	-369		1,643	0	1,246	4,177			0	1,634	4,232					-436	
15	999	0	-145	-312		1,669	0	1,275	4,283			0	1,666	4,311					-374	
25	1,452	0	-11	126		1,815	0	1,440	4,881			0	1,849	4,755					89	
50	1,821	0	100	488		1,926	0	1,564	5,329			0	1,986	5,088					469	

4.0 defaults used for all response curves
Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

Table 27 (cont.)
American River SAM Analysis Reach
ARS_ABC
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Steelhead																				
0	0		0		0	0	0	0		0	0	0	0	0	0			0	0	0
1	203		-406		203	979	0	83		979	1,019	0	146	-10	1,019			-482	-970	90
2	763		-399		763	1,642	0	489		1,642	1,715	0	686	1,201	1,715			-437	-677	707
3	899		-419		899	1,857	0	633		1,857	1,938	0	857	1,465	1,938			-454	-688	821
4	1,016		-444		1,016	2,080	0	779		2,080	2,169	0	1,026	1,715	2,169			-477	-720	926
5	1,156		-458		1,156	2,337	0	955		2,337	2,437	0	1,231	2,066	2,437			-485	-694	1,084
6	1,235		-474		1,235	2,507	0	1,077		2,507	2,615	0	1,366	2,250	2,615			-500	-711	1,160
7	1,325		-487		1,325	2,673	0	1,190		2,673	2,789	0	1,497	2,431	2,789			-512	-722	1,248
8	1,442		-489		1,442	2,849	0	1,312		2,849	2,974	0	1,643	2,656	2,974			-511	-697	1,375
9	1,552		-484		1,552	2,990	0	1,414		2,990	3,122	0	1,762	2,835	3,122			-504	-663	1,492
10	1,660		-472		1,660	3,106	0	1,499		3,106	3,243	0	1,859	2,980	3,243			-490	-621	1,606
11	1,765		-456		1,765	3,203	0	1,571		3,203	3,343	0	1,939	3,099	3,343			-472	-573	1,716
12	1,872		-435		1,872	3,286	0	1,634		3,286	3,427	0	2,007	3,198	3,427			-450	-519	1,827
13	1,980		-411		1,980	3,356	0	1,687		3,356	3,499	0	2,065	3,283	3,499			-425	-460	1,938
14	2,089		-384		2,089	3,416	0	1,732		3,416	3,560	0	2,114	3,355	3,560			-396	-397	2,051
15	2,200		-354		2,200	3,468	0	1,773		3,468	3,614	0	2,157	3,418	3,614			-366	-330	2,164
25	2,988		-124		2,988	3,766	0	2,002		3,766	3,914	0	2,399	3,769	3,914			-131	171	2,967
50	3,627		67		3,627	3,991	0	2,175		3,991	4,140	0	2,581	4,033	4,140			64	583	3,616
Green Sturgeon																				
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	-2,510	-714	0	564	0	-2,510	-876	0	-980	0	-2,510	-876	0	-980	0	-5,020	-2,496	0	417
2	0	-3,765	-1,071	0	846	0	-1,255	468	0	-1,323	0	-1,255	468	0	-1,323	0	-5,020	-1,962	0	772
3	0	-4,183	-1,190	0	940	0	-1,156	654	0	-1,482	0	-1,156	654	0	-1,482	0	-5,339	-2,046	0	846
4	0	-4,632	-1,344	0	1,021	0	-1,106	807	0	-1,661	0	-1,106	807	0	-1,661	0	-5,738	-2,183	0	916
5	0	-5,092	-1,512	0	1,096	0	-885	1,104	0	-1,821	0	-885	1,104	0	-1,821	0	-5,977	-2,183	0	1,013
6	0	-5,399	-1,624	0	1,147	0	-854	1,249	0	-1,943	0	-854	1,249	0	-1,943	0	-6,253	-2,236	0	1,061
7	0	-5,718	-1,707	0	1,197	0	-831	1,416	0	-2,072	0	-831	1,416	0	-2,072	0	-6,550	-2,276	0	1,109
8	0	-6,045	-1,771	0	1,247	0	-727	1,634	0	-2,193	0	-727	1,634	0	-2,193	0	-6,772	-2,268	0	1,171
9	0	-6,299	-1,820	0	1,286	0	-647	1,803	0	-2,287	0	-647	1,803	0	-2,287	0	-6,945	-2,263	0	1,218
10	0	-6,502	-1,860	0	1,317	0	-582	1,939	0	-2,362	0	-582	1,939	0	-2,362	0	-7,084	-2,258	0	1,256
11	0	-6,668	-1,893	0	1,343	0	-529	2,050	0	-2,423	0	-529	2,050	0	-2,423	0	-7,197	-2,254	0	1,287
12	0	-6,807	-1,920	0	1,364	0	-485	2,142	0	-2,475	0	-485	2,142	0	-2,475	0	-7,292	-2,251	0	1,313
13	0	-6,924	-1,943	0	1,382	0	-448	2,220	0	-2,518	0	-448	2,220	0	-2,518	0	-7,371	-2,249	0	1,335
14	0	-7,024	-1,962	0	1,397	0	-416	2,287	0	-2,555	0	-416	2,287	0	-2,555	0	-7,440	-2,247	0	1,354
15	0	-7,111	-1,979	0	1,411	0	-388	2,346	0	-2,587	0	-388	2,346	0	-2,587	0	-7,499	-2,245	0	1,370
25	0	-7,599	-2,075	0	1,486	0	-233	2,671	0	-2,767	0	-233	2,671	0	-2,767	0	-7,832	-2,234	0	1,461
50	0	-7,964	-2,146	0	1,542	0	-116	2,915	0	-2,902	0	-116	2,915	0	-2,902	0	-8,081	-2,226	0	1,529

4.0 defaults used for all response curves

Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

Table 28
Sacramento River SAM Analysis Reach
ARS_DEFG
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Spring-run Chinook																				
0	0		0	0		0		0	0		0		0	0		0		0	0	
1	-1,101		-400	-2,119		-892		97	-3,451		-946		193	-3,484		-2,136		-460	-3,759	
2	-1,075		-427	-2,526		-415		571	-1,306		-453		900	-1,147		-1,776		-468	-3,638	
3	-1,058		-434	-2,738		-121		836	15		-141		1,302	289		-1,525		-462	-3,479	
4	-1,125		-459	-2,923		-16		940	430		-23		1,470	753		-1,514		-483	-3,555	
5	-1,197		-498	-3,127		44		1,046	642		47		1,638	990		-1,604		-526	-3,809	
6	-1,266		-532	-3,373		110		1,183	999		124		1,847	1,366		-1,659		-559	-4,037	
7	-1,342		-551	-3,601		160		1,296	1,340		187		2,017	1,726		-1,679		-575	-4,171	
8	-1,381		-558	-3,738		200		1,390	1,645		241		2,159	2,045		-1,676		-578	-4,237	
9	-1,394		-555	-3,815		233		1,472	1,926		289		2,282	2,337		-1,656		-573	-4,258	
10	-1,385		-544	-3,845		261		1,545	2,187		333		2,393	2,608		-1,621		-561	-4,244	
11	-1,357		-527	-3,838		286		1,611	2,421		374		2,490	2,847		-1,571		-542	-4,201	
12	-1,311		-504	-3,806		308		1,668	2,621		411		2,574	3,047		-1,507		-518	-4,138	
13	-1,252		-478	-3,752		329		1,719	2,797		446		2,648	3,218		-1,433		-490	-4,059	
14	-1,183		-448	-3,683		348		1,765	2,952		480		2,714	3,366		-1,351		-459	-3,968	
15	-1,105		-415	-3,602		366		1,807	3,091		512		2,774	3,495		-1,263		-426	-3,867	
25	-396		-144	-2,879		497		2,094	3,968		731		3,136	4,242		-491		-150	-3,038	
50	298		94	-2,269		631		2,366	4,728		914		3,419	4,810		251		91	-2,349	
Fall-run Chinook																				
0	0		0	0		0		0	0				0	0		0		0	0	
1	-1,101		-400	-2,119		-892		97	-3,451				193	-3,484		-2,136		-460	-3,759	
2	-1,075		-427	-2,526		-415		571	-1,306				900	-1,147		-1,776		-468	-3,638	
3	-1,058		-434	-2,738		-121		836	15				1,302	289		-1,525		-462	-3,479	
4	-1,125		-459	-2,923		-16		940	430				1,470	753		-1,514		-483	-3,555	
5	-1,197		-498	-3,127		44		1,046	642				1,638	990		-1,604		-526	-3,809	
6	-1,266		-532	-3,373		110		1,183	999				1,847	1,366		-1,659		-559	-4,037	
7	-1,342		-551	-3,601		160		1,296	1,340				2,017	1,726		-1,679		-575	-4,171	
8	-1,381		-558	-3,738		200		1,390	1,645				2,159	2,045		-1,676		-578	-4,237	
9	-1,394		-555	-3,815		233		1,472	1,926				2,282	2,337		-1,656		-573	-4,258	
10	-1,385		-544	-3,845		261		1,545	2,187				2,393	2,608		-1,621		-561	-4,244	
11	-1,357		-527	-3,838		286		1,611	2,421				2,490	2,847		-1,571		-542	-4,201	
12	-1,311		-504	-3,806		308		1,668	2,621				2,574	3,047		-1,507		-518	-4,138	
13	-1,252		-478	-3,752		329		1,719	2,797				2,648	3,218		-1,433		-490	-4,059	
14	-1,183		-448	-3,683		348		1,765	2,952				2,714	3,366		-1,351		-459	-3,968	
15	-1,105		-415	-3,602		366		1,807	3,091				2,774	3,495		-1,263		-426	-3,867	
25	-396		-144	-2,879		497		2,094	3,968				3,136	4,242		-491		-150	-3,038	
50	298		94	-2,269		631		2,366	4,728				3,419	4,810		251		91	-2,349	

4.0 defaults used for all response curves
Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

Table 28 (cont.)
Sacramento River SAM Analysis Reach
ARS_DEFG
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Late-fall-run Chinook																				
0	0		0	0		0		0	0		0		0					0		
1	-1,101		-400	-2,119		-892		97	-3,451		-946		193					-460		
2	-1,075		-427	-2,526		-415		571	-1,306		-453		900					-468		
3	-1,058		-434	-2,738		-121		836	15		-141		1,302					-462		
4	-1,125		-459	-2,923		-16		940	430		-23		1,470					-483		
5	-1,197		-498	-3,127		44		1,046	642		47		1,638					-526		
6	-1,266		-532	-3,373		110		1,183	999		124		1,847					-559		
7	-1,342		-551	-3,601		160		1,296	1,340		187		2,017					-575		
8	-1,381		-558	-3,738		200		1,390	1,645		241		2,159					-578		
9	-1,394		-555	-3,815		233		1,472	1,926		289		2,282					-573		
10	-1,385		-544	-3,845		261		1,545	2,187		333		2,393					-561		
11	-1,357		-527	-3,838		286		1,611	2,421		374		2,490					-542		
12	-1,311		-504	-3,806		308		1,668	2,621		411		2,574					-518		
13	-1,252		-478	-3,752		329		1,719	2,797		446		2,648					-490		
14	-1,183		-448	-3,683		348		1,765	2,952		480		2,714					-459		
15	-1,105		-415	-3,602		366		1,807	3,091		512		2,774					-426		
25	-396		-144	-2,879		497		2,094	3,968		731		3,136					-150		
50	298		94	-2,269		631		2,366	4,728		914		3,419					91		
Winter-run Chinook																				
0	0		0	0		0		0	0		0		0	0		0		0		
1	-1,101		-400	-2,119		-892		97	-3,451		-946		193	-3,484		-2,136		-460		
2	-1,075		-427	-2,526		-415		571	-1,306		-453		900	-1,147		-1,776		-468		
3	-1,058		-434	-2,738		-121		836	15		-141		1,302	289		-1,525		-462		
4	-1,125		-459	-2,923		-16		940	430		-23		1,470	753		-1,514		-483		
5	-1,197		-498	-3,127		44		1,046	642		47		1,638	990		-1,604		-526		
6	-1,266		-532	-3,373		110		1,183	999		124		1,847	1,366		-1,659		-559		
7	-1,342		-551	-3,601		160		1,296	1,340		187		2,017	1,726		-1,679		-575		
8	-1,381		-558	-3,738		200		1,390	1,645		241		2,159	2,045		-1,676		-578		
9	-1,394		-555	-3,815		233		1,472	1,926		289		2,282	2,337		-1,656		-573		
10	-1,385		-544	-3,845		261		1,545	2,187		333		2,393	2,608		-1,621		-561		
11	-1,357		-527	-3,838		286		1,611	2,421		374		2,490	2,847		-1,571		-542		
12	-1,311		-504	-3,806		308		1,668	2,621		411		2,574	3,047		-1,507		-518		
13	-1,252		-478	-3,752		329		1,719	2,797		446		2,648	3,218		-1,433		-490		
14	-1,183		-448	-3,683		348		1,765	2,952		480		2,714	3,366		-1,351		-459		
15	-1,105		-415	-3,602		366		1,807	3,091		512		2,774	3,495		-1,263		-426		
25	-396		-144	-2,879		497		2,094	3,968		731		3,136	4,242		-491		-150		
50	298		94	-2,269		631		2,366	4,728		914		3,419	4,810		251		91		

4.0 defaults used for all response curves
Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

Table 28 (cont.)
Sacramento River SAM Analysis Reach
ARS_DEFG
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Steelhead																				
0	0		0	0	0	0		0	0	0	0		0	0	0	0		0		0
1	-1,747		-820	-2,239	-1,747	-1,747		-77	-3,044	-1,747	-1,801		-36	-3,082	-1,801	-3,793		-964		-3,793
2	-1,656		-871	-2,645	-1,656	-772		649	-1,266	-772	-774		946	-1,173	-774	-3,047		-970		-3,047
3	-1,609		-887	-2,848	-1,609	-170		1,060	-188	-170	-132		1,508	-16	-132	-2,536		-952		-2,536
4	-1,702		-938	-3,038	-1,702	56		1,206	116	56	119		1,722	324	119	-2,465		-998		-2,465
5	-1,780		-1,021	-3,256	-1,780	195		1,339	234	195	280		1,917	463	280	-2,574		-1,089		-2,574
6	-1,865		-1,094	-3,513	-1,865	345		1,525	482	345	450		2,177	731	450	-2,634		-1,161		-2,634
7	-1,984		-1,139	-3,749	-1,984	457		1,684	735	457	581		2,397	1,002	581	-2,644		-1,196		-2,644
8	-2,040		-1,156	-3,887	-2,040	545		1,818	961	545	688		2,583	1,244	688	-2,617		-1,206		-2,617
9	-2,053		-1,154	-3,961	-2,053	617		1,936	1,170	617	779		2,747	1,467	779	-2,566		-1,199		-2,566
10	-2,030		-1,137	-3,985	-2,030	678		2,042	1,367	678	858		2,896	1,675	858	-2,492		-1,177		-2,492
11	-1,974		-1,106	-3,971	-1,974	732		2,137	1,544	732	928		3,027	1,861	928	-2,394		-1,143		-2,394
12	-1,890		-1,065	-3,929	-1,890	780		2,220	1,696	780	991		3,141	2,017	991	-2,274		-1,098		-2,274
13	-1,784		-1,016	-3,866	-1,784	824		2,293	1,828	824	1,048		3,240	2,152	1,048	-2,139		-1,047		-2,139
14	-1,661		-960	-3,786	-1,661	864		2,359	1,946	864	1,101		3,329	2,269	1,101	-1,990		-989		-1,990
15	-1,524		-900	-3,692	-1,524	901		2,420	2,051	901	1,151		3,409	2,372	1,151	-1,832		-926		-1,832
25	-343		-391	-2,871	-343	1,167		2,823	2,718	1,167	1,472		3,899	2,973	1,472	-528		-407		-528
50	734		58	-2,166	734	1,431		3,200	3,301	1,431	1,733		4,282	3,433	1,733	641		50		641
Green Sturgeon																				
0			0	0		0		0		0	0		0	0	0	0		0	0	0
1			-708	0		0		-4,397		-1,551	0		-4,397	0	-1,551	0		-5,009	0	-1,298
2			-1,391	0		0		-3,248		-1,199	0		-3,248	0	-1,199	0		-4,297	0	-765
3			-1,830	0		0		-2,485		-966	0		-2,485	0	-966	0		-3,767	0	-436
4			-2,032	0		0		-2,310		-923	0		-2,310	0	-923	0		-3,709	0	-344
5			-2,076	0		0		-2,380		-1,146	0		-2,380	0	-1,146	0		-3,899	0	-323
6			-2,305	0		0		-2,394		-1,476	0		-2,394	0	-1,476	0		-4,077	0	-288
7			-2,685	0		0		-2,368		-1,731	0		-2,368	0	-1,731	0		-4,203	0	-264
8			-2,970	0		0		-2,348		-1,923	0		-2,348	0	-1,923	0		-4,298	0	-245
9			-3,191	0		0		-2,333		-2,072	0		-2,333	0	-2,072	0		-4,372	0	-231
10			-3,369	0		0		-2,321		-2,191	0		-2,321	0	-2,191	0		-4,431	0	-220
11			-3,514	0		0		-2,311		-2,288	0		-2,311	0	-2,288	0		-4,480	0	-210
12			-3,634	0		0		-2,302		-2,369	0		-2,302	0	-2,369	0		-4,520	0	-203
13			-3,737	0		0		-2,295		-2,438	0		-2,295	0	-2,438	0		-4,554	0	-196
14			-3,824	0		0		-2,289		-2,497	0		-2,289	0	-2,497	0		-4,583	0	-190
15			-3,900	0		0		-2,284		-2,548	0		-2,284	0	-2,548	0		-4,609	0	-185
25			-4,326	0		0		-2,255		-2,834	0		-2,255	0	-2,834	0		-4,751	0	-158
50			-4,645	0		0		-2,233		-3,048	0		-2,233	0	-3,048	0		-4,857	0	-138

4.0 defaults used for all response curves
Non-default timing tables (see sheet [Custom Timing Tables] in this workbook)

Table 29
Sacramento Bypass Levee and Weir SAM Analysis Reach
SBP Weir and Levee
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Spring-run Chinook																				
0	0		0	0		0		0	0		0		0	0		0		0	0	
1	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
2	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
3	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
4	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
5	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
6	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
7	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
8	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
9	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
10	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
11	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
12	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
13	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
14	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
15	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
25	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
50	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4	-26	
Fall-run Chinook																				
0	0		0			0		0	0				0			0		0		
1	-60		-4			-21		-9	-146				-21			-60		-4		
2	-60		-4			-21		-9	-146				-21			-60		-4		
3	-60		-4			-21		-9	-146				-21			-60		-4		
4	-60		-4			-21		-9	-146				-21			-60		-4		
5	-60		-4			-21		-9	-146				-21			-60		-4		
6	-60		-4			-21		-9	-146				-21			-60		-4		
7	-60		-4			-21		-9	-146				-21			-60		-4		
8	-60		-4			-21		-9	-146				-21			-60		-4		
9	-60		-4			-21		-9	-146				-21			-60		-4		
10	-60		-4			-21		-9	-146				-21			-60		-4		
11	-60		-4			-21		-9	-146				-21			-60		-4		
12	-60		-4			-21		-9	-146				-21			-60		-4		
13	-60		-4			-21		-9	-146				-21			-60		-4		
14	-60		-4			-21		-9	-146				-21			-60		-4		
15	-60		-4			-21		-9	-146				-21			-60		-4		
25	-60		-4			-21		-9	-146				-21			-60		-4		
50	-60		-4			-21		-9	-146				-21			-60		-4		

4.0 defaults used for all response curves
4.0 defaults used for all timing tables

Table 29 (cont.)
Sacramento Bypass Levee and Weir SAM Analysis Reach
SBP Weir and Levee
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Late-fall-run Chinook																				
0	0		0	0		0		0	0		0		0					0		
1	-60		-4	-26		-21		-9	-146		-51		-21					-4		
2	-60		-4	-26		-21		-9	-146		-51		-21					-4		
3	-60		-4	-26		-21		-9	-146		-51		-21					-4		
4	-60		-4	-26		-21		-9	-146		-51		-21					-4		
5	-60		-4	-26		-21		-9	-146		-51		-21					-4		
6	-60		-4	-26		-21		-9	-146		-51		-21					-4		
7	-60		-4	-26		-21		-9	-146		-51		-21					-4		
8	-60		-4	-26		-21		-9	-146		-51		-21					-4		
9	-60		-4	-26		-21		-9	-146		-51		-21					-4		
10	-60		-4	-26		-21		-9	-146		-51		-21					-4		
11	-60		-4	-26		-21		-9	-146		-51		-21					-4		
12	-60		-4	-26		-21		-9	-146		-51		-21					-4		
13	-60		-4	-26		-21		-9	-146		-51		-21					-4		
14	-60		-4	-26		-21		-9	-146		-51		-21					-4		
15	-60		-4	-26		-21		-9	-146		-51		-21					-4		
25	-60		-4	-26		-21		-9	-146		-51		-21					-4		
50	-60		-4	-26		-21		-9	-146		-51		-21					-4		
Winter-run Chinook																				
0	0		0	0		0		0	0		0		0	0		0		0		
1	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
2	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
3	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
4	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
5	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
6	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
7	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
8	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
9	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
10	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
11	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
12	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
13	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
14	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
15	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
25	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		
50	-60		-4	-26		-21		-9	-146		-51		-21	-188		-60		-4		

4.0 defaults used for all response curves
4.0 defaults used for all timing tables

Table 29 (cont.)
Sacramento Bypass Levee and Weir SAM Analysis Reach
SBP Weir and Levee
Bankline weighted relative response (feet)

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Steelhead																				
0	0		0	0	0	0		0	0	0	0		0	0	0	0		0		0
1	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
2	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
3	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
4	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
5	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
6	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
7	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
8	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
9	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
10	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
11	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
12	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
13	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
14	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
15	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
25	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
50	-100		-17	-35	-100	-40		-29	-127	-40	-87		-55	-174	-87	-100		-17		-100
Green Sturgeon																				
0			0	0		0		0		0	0	0	0	0	0	0	0	0	0	0
1			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
2			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
3			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
4			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
5			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
6			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
7			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
8			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
9			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
10			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
11			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
12			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
13			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
14			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
15			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
25			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8
50			115	0		0		115		-8	0	0	115	0	-8	0	0	115	0	-8

4.0 defaults used for all response curves
4.0 defaults used for all timing tables

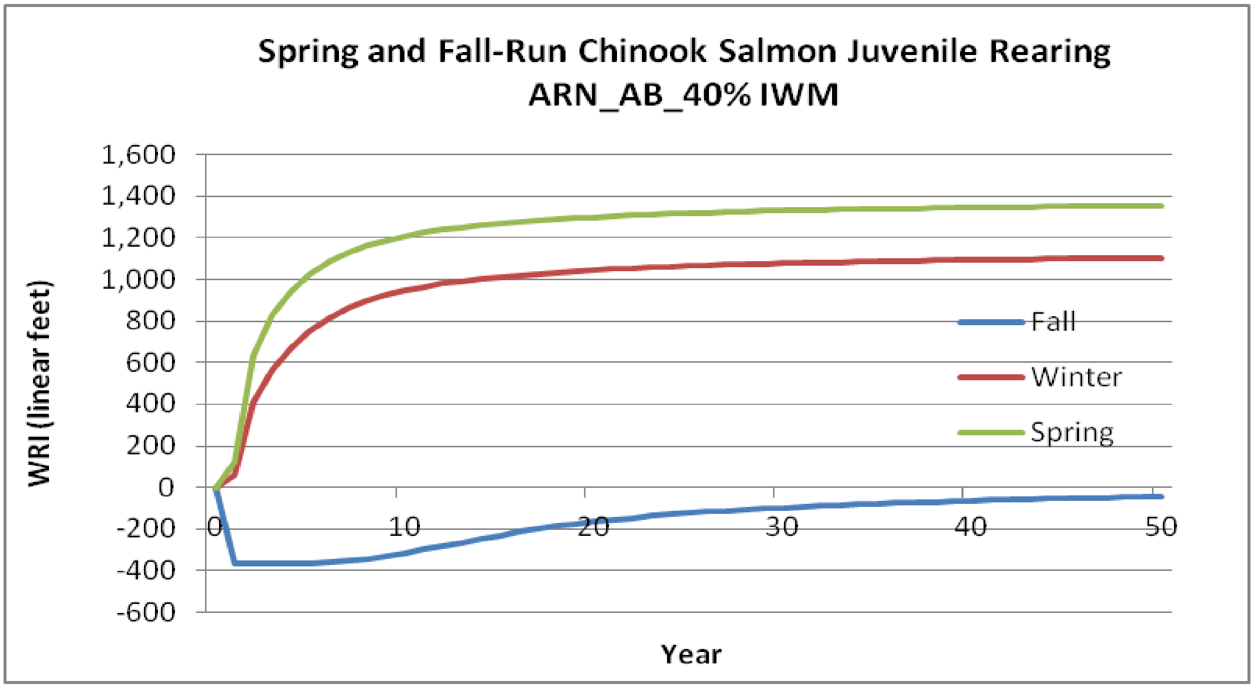

Figure 2. Weighted response indices at 40% IWM placement on the American River (ARN_AB) for spring and fall-run Chinook salmon juvenile rearing.

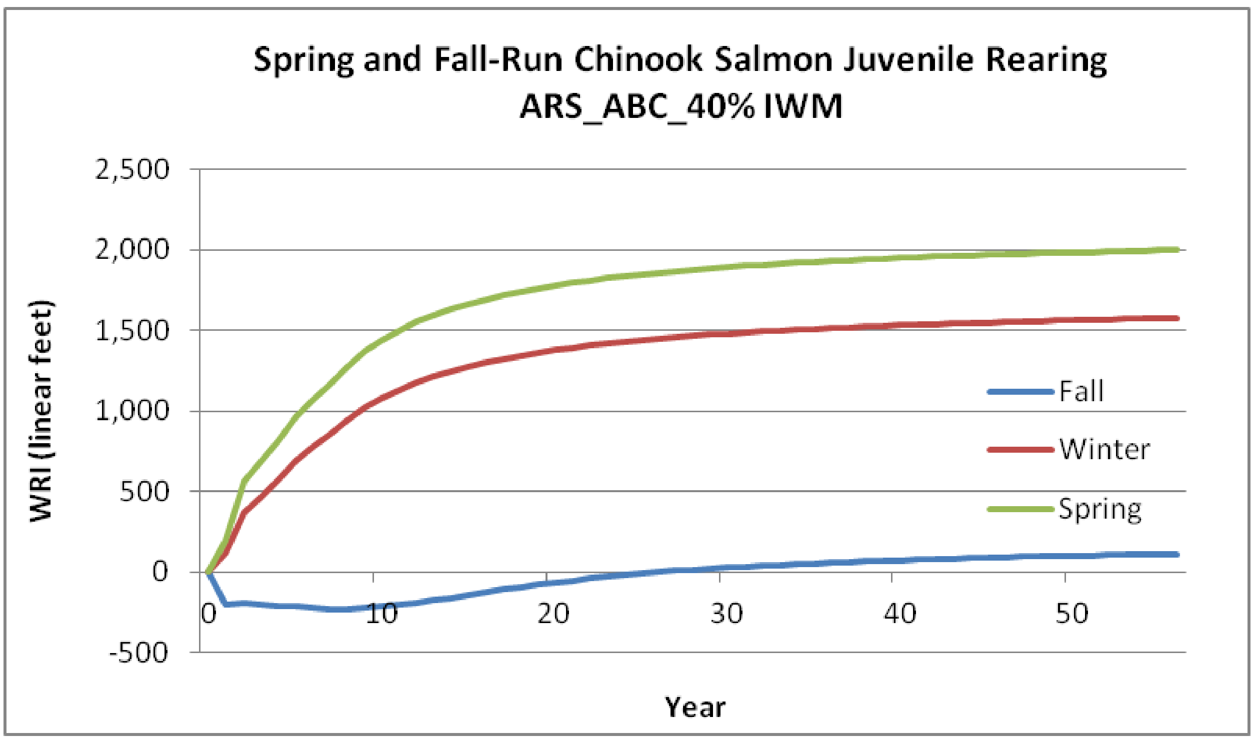

Figure 3. Weighted response indices at 40% IWM placement on the American River (ARS_ABC) for spring and fall-run Chinook salmon juvenile rearing.

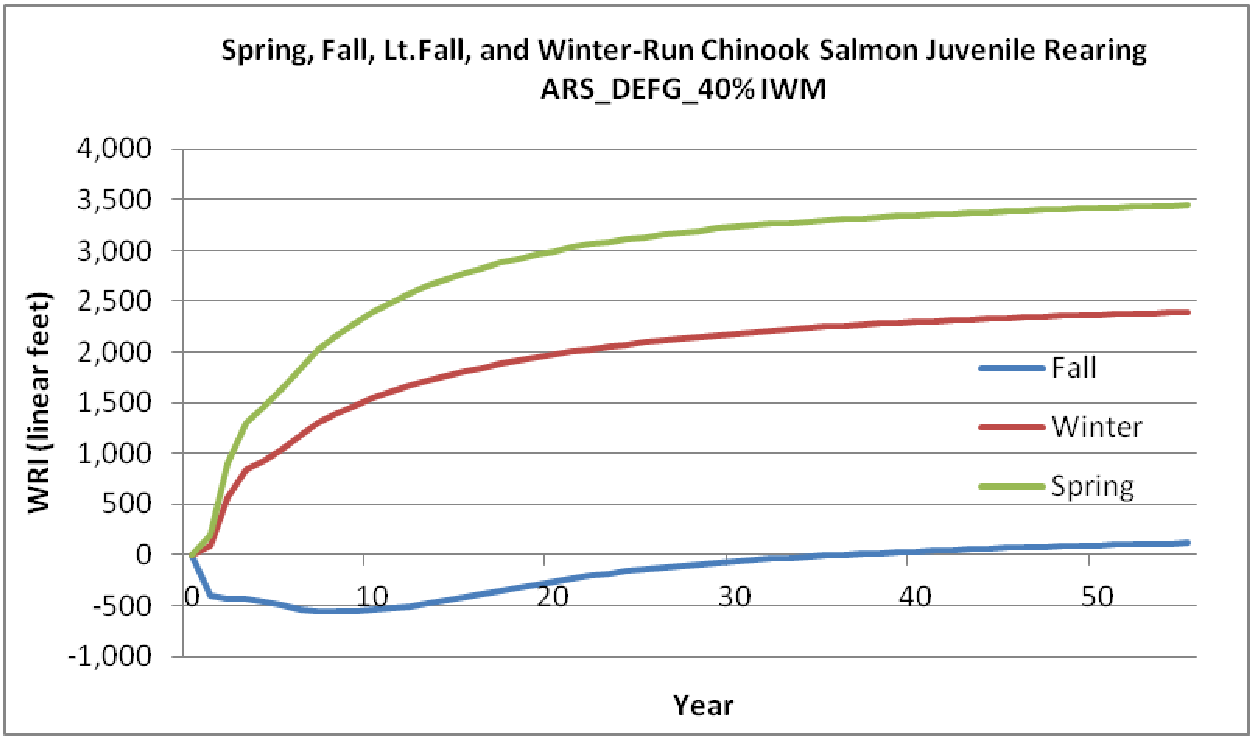

Figure 4. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_DEFG) for Chinook salmon juvenile rearing.

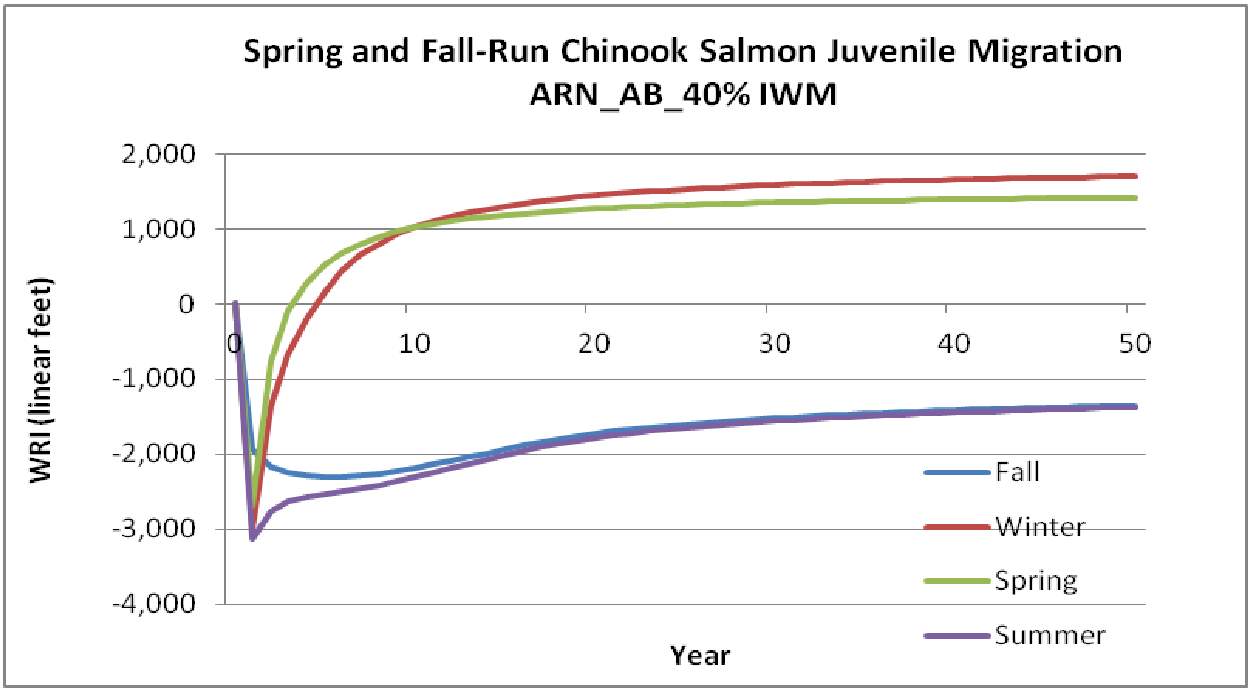

Figure 5. Weighted response indices at 40% IWM placement on the American River (ARN_AB) for spring and fall-run Chinook salmon juvenile migration.

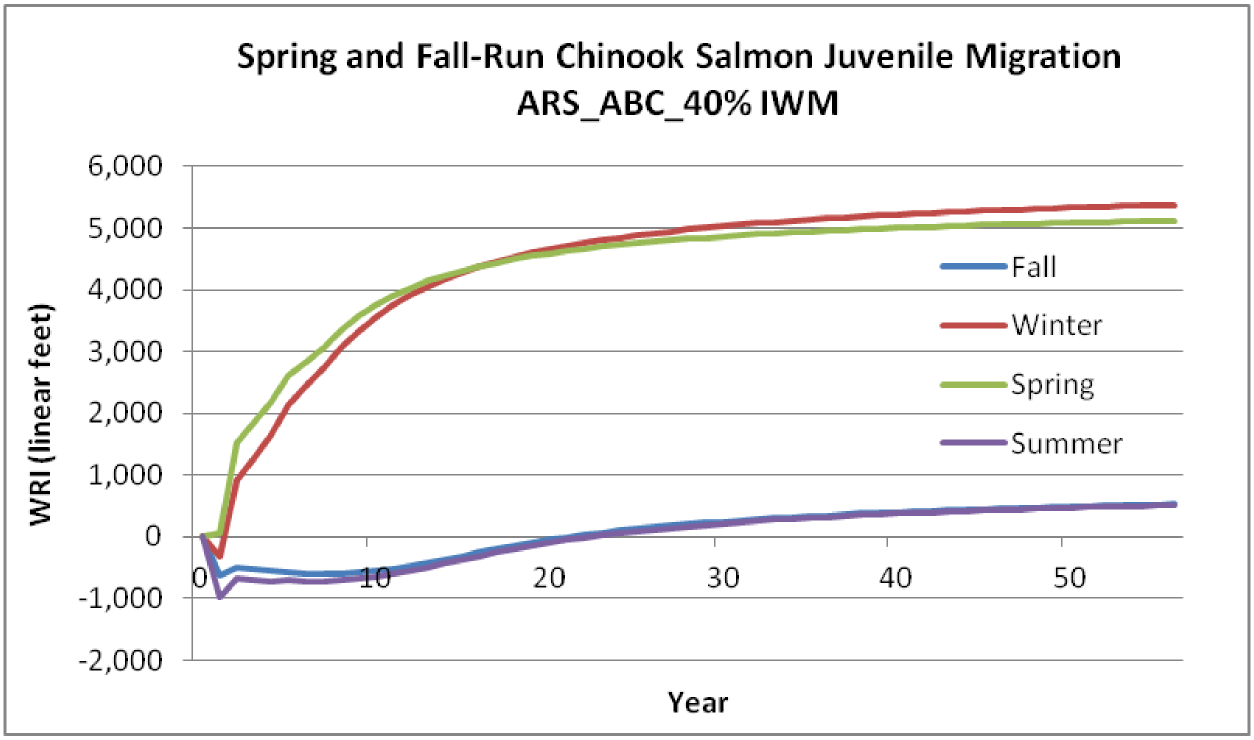

Figure 6. Weighted response indices at 40% IWM placement on the American River (ARS_ABC) for spring and fall-run Chinook salmon juvenile migration.

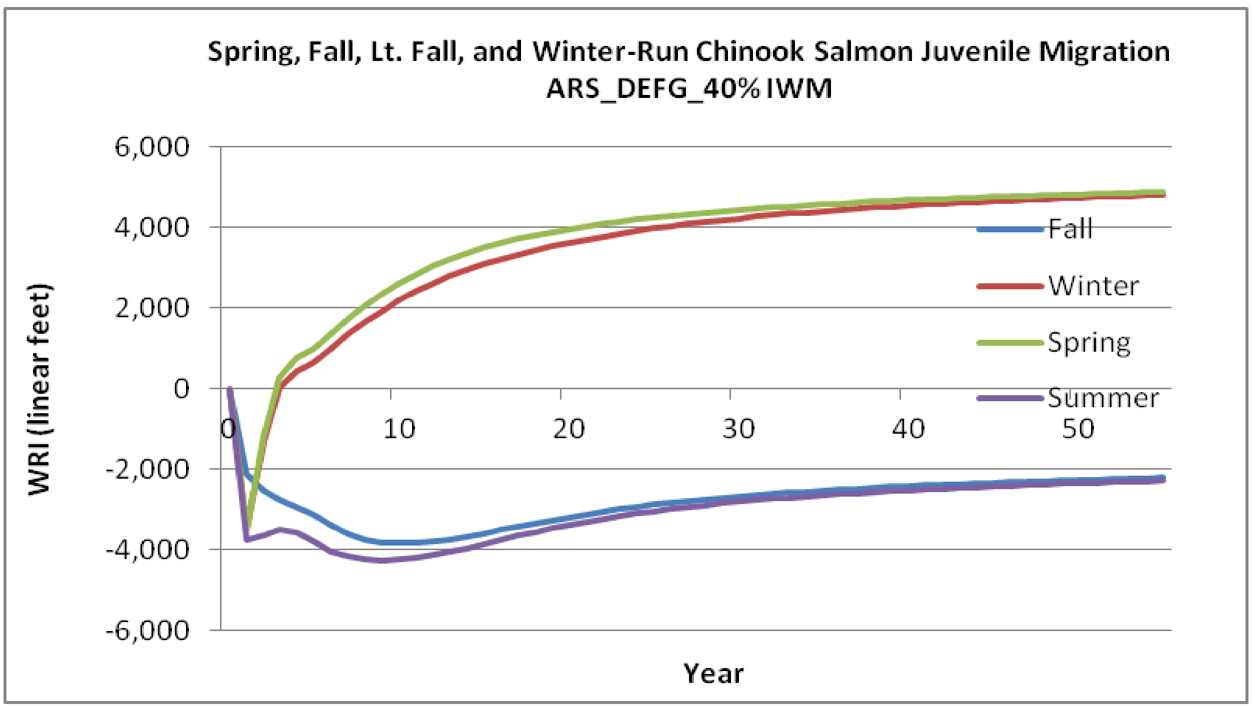

Figure 7. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_DEFG) for Chinook salmon juvenile migration.

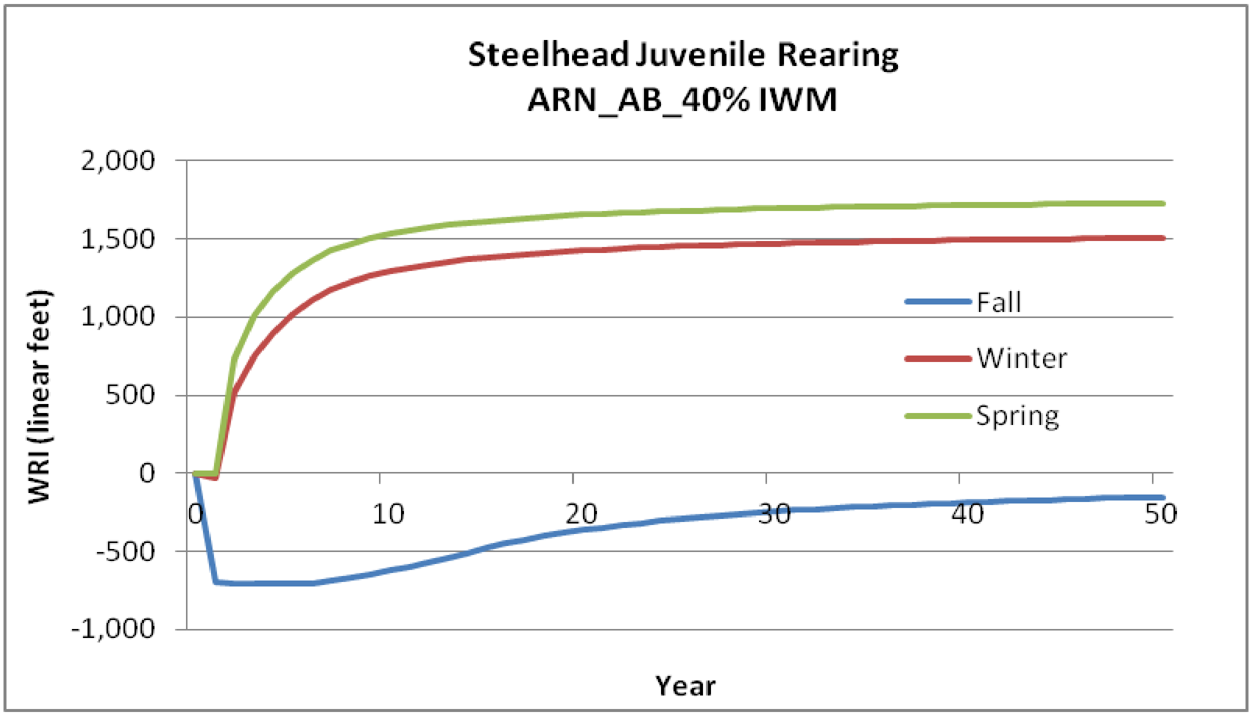

Figure 8. Weighted response indices at 40% IWM placement on the American River (ARN_AB) for steelhead juvenile rearing.

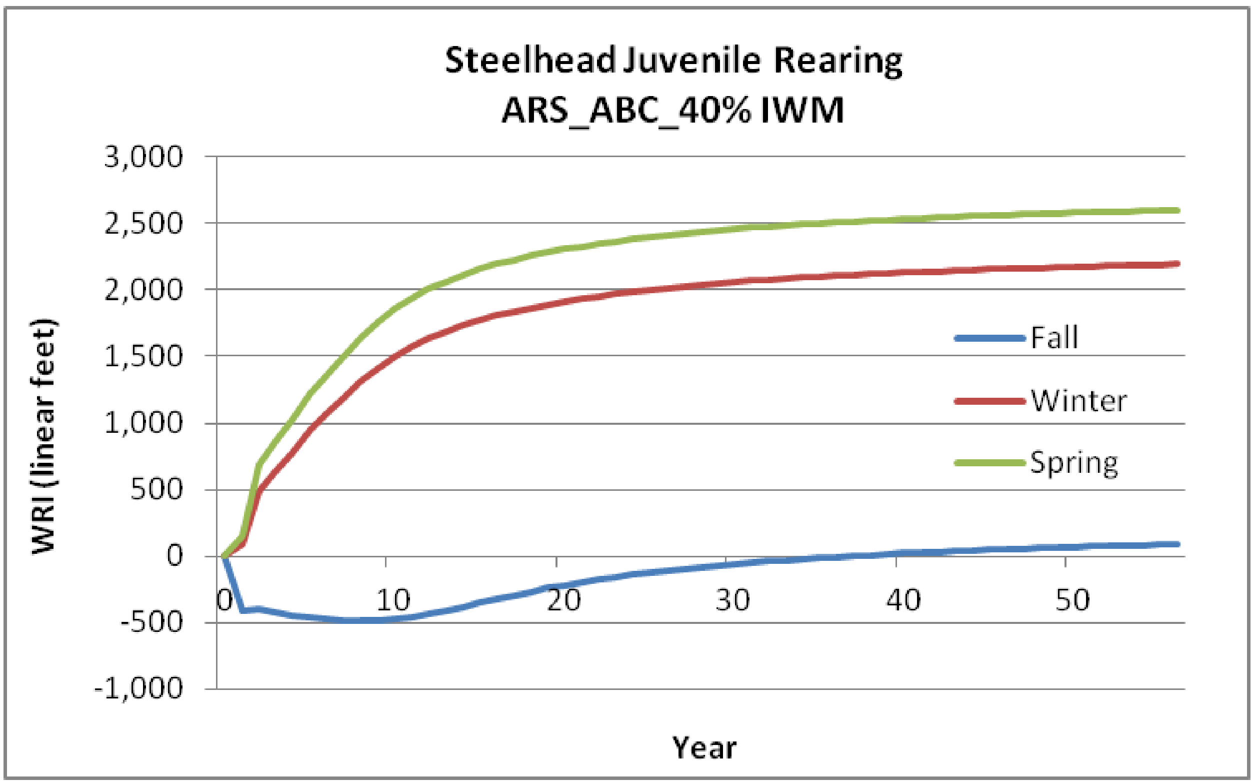

Figure 9. Weighted response indices at 40% IWM placement on the American River (ARS_ABC) for steelhead juvenile rearing.

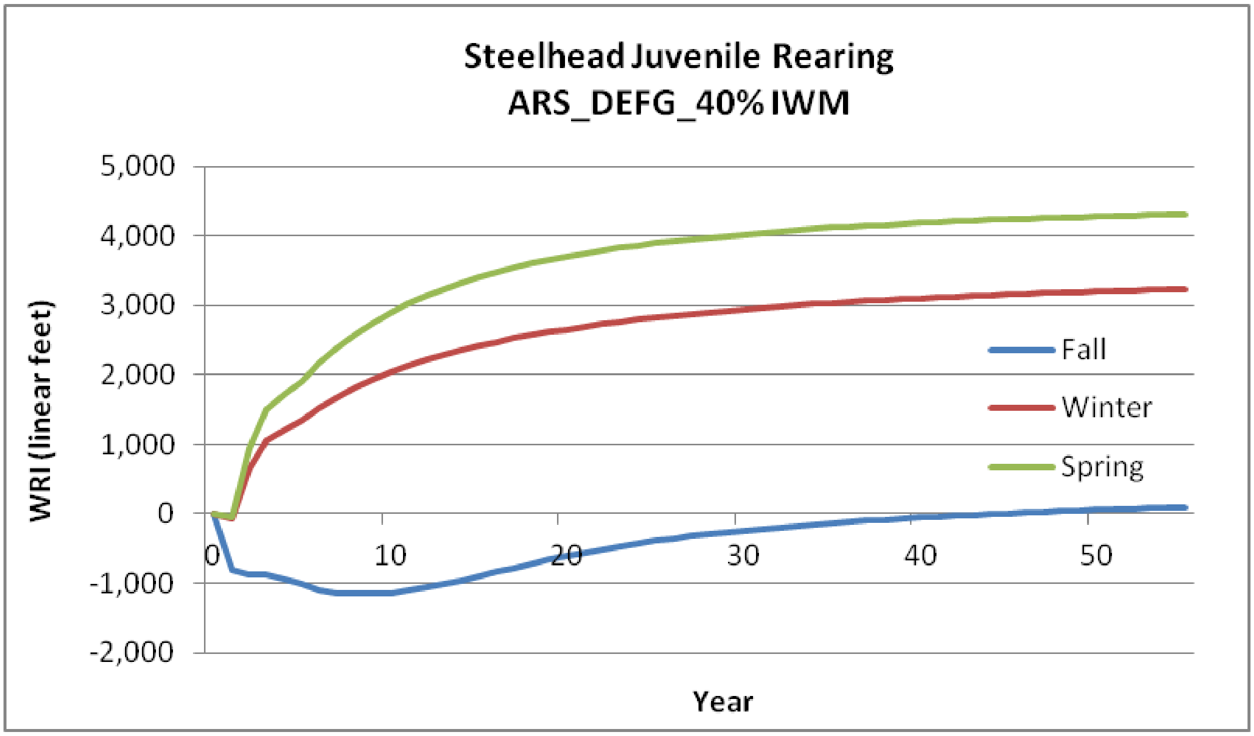

Figure 10. Weighted response indices at 40% IWM placement on the American River (ARS_DEFG) for steelhead juvenile rearing.

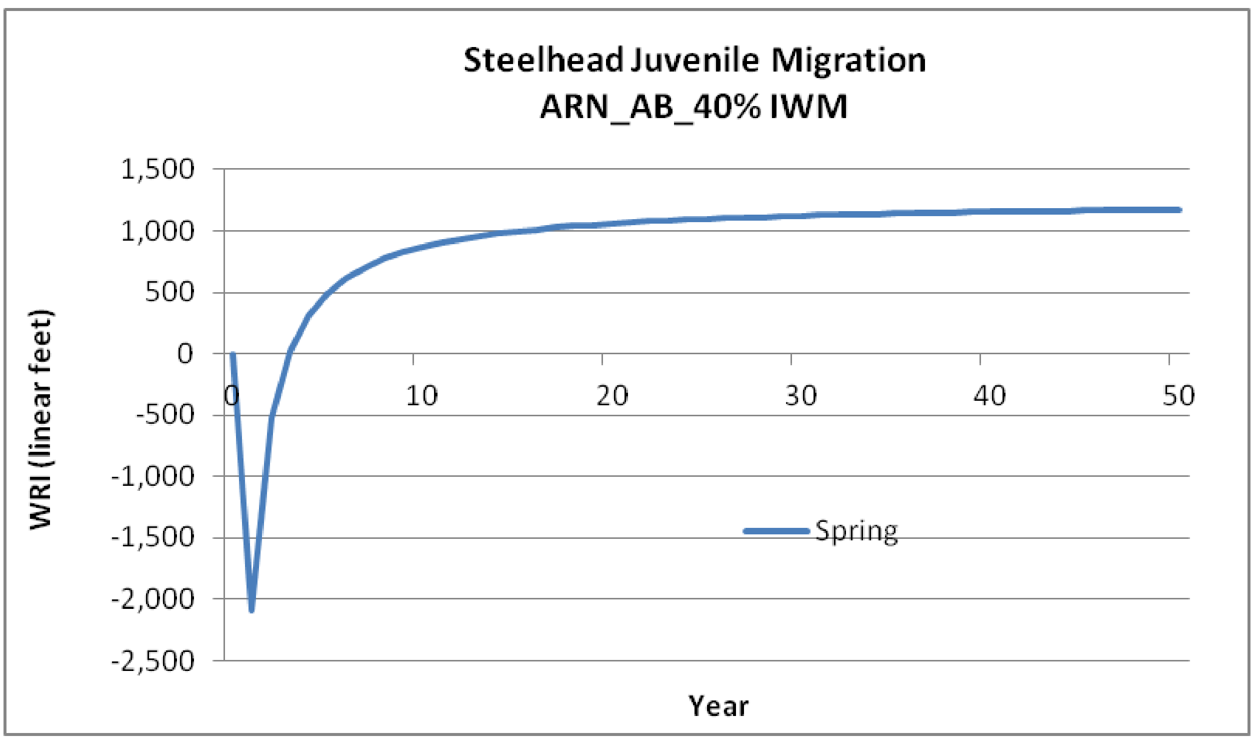

Figure 11. Weighted response indices at 40% IWM placement on the American River (ARN_AB) for steelhead juvenile migration.

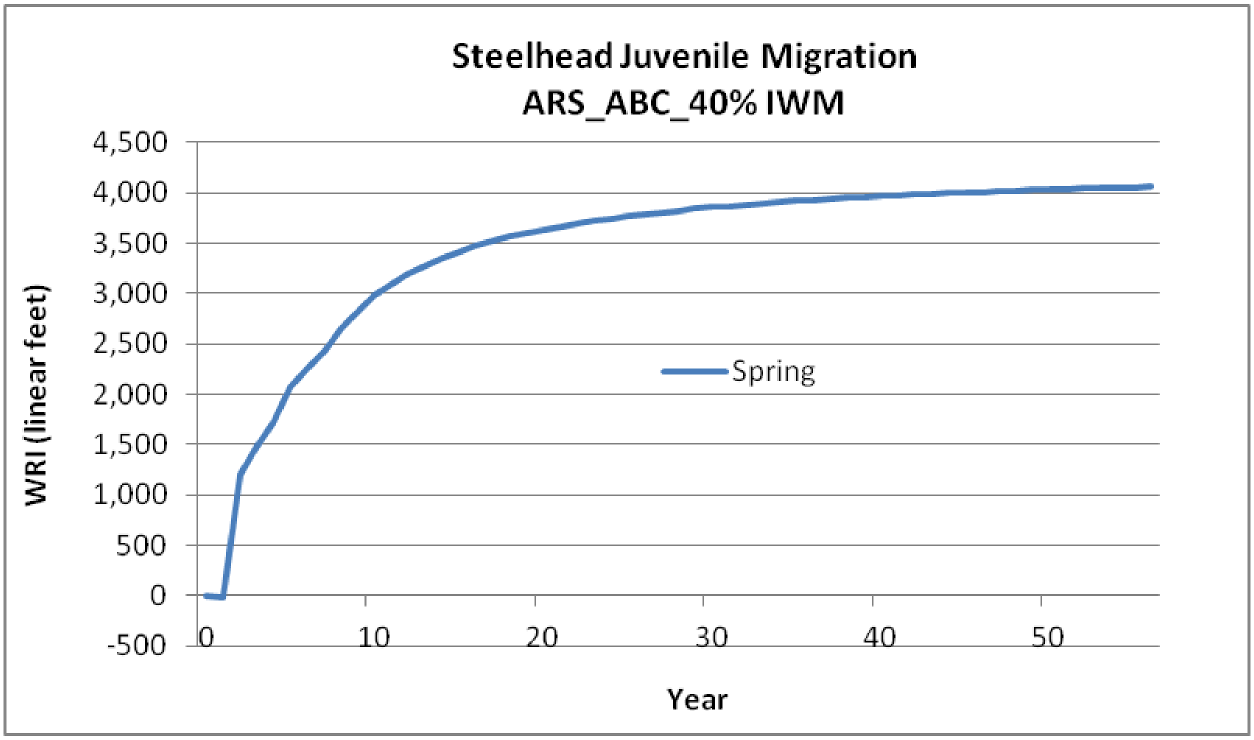

Figure 12. Weighted response indices at 40% IWM placement on the American River (ARS_ABC) for steelhead juvenile migration.

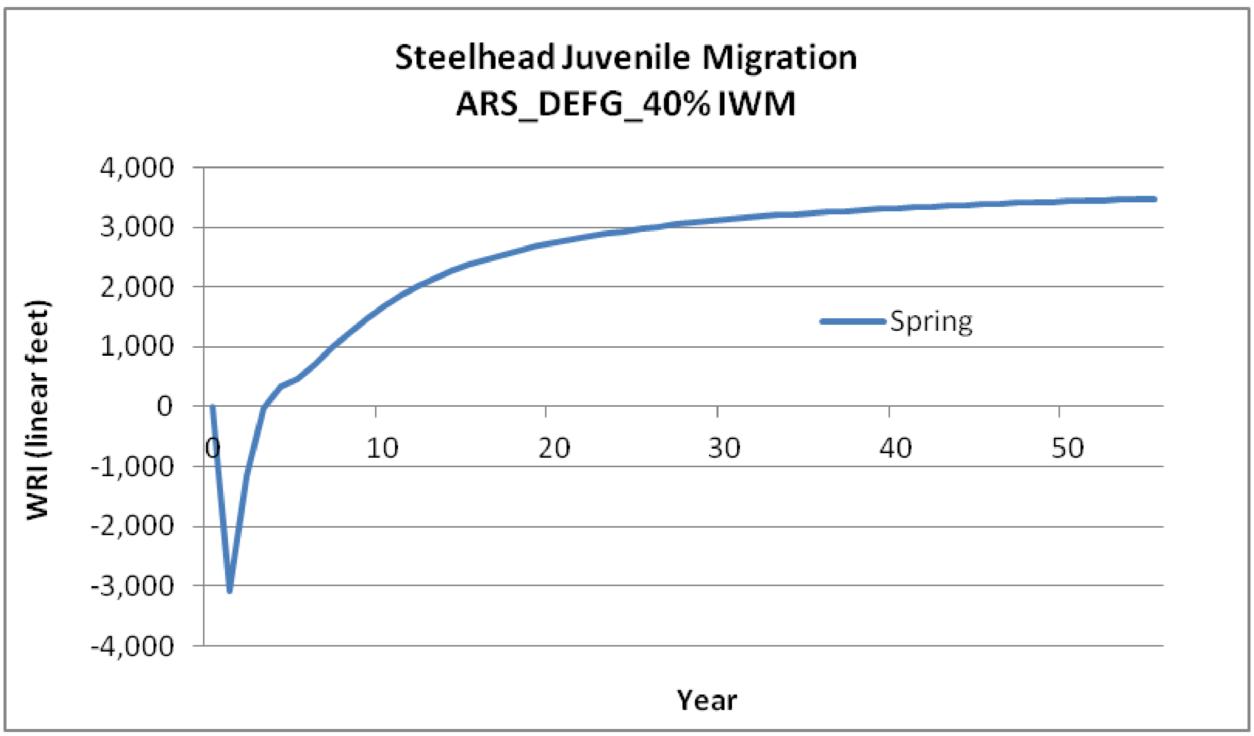

Figure 13. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_DEFG) for steelhead juvenile migration.

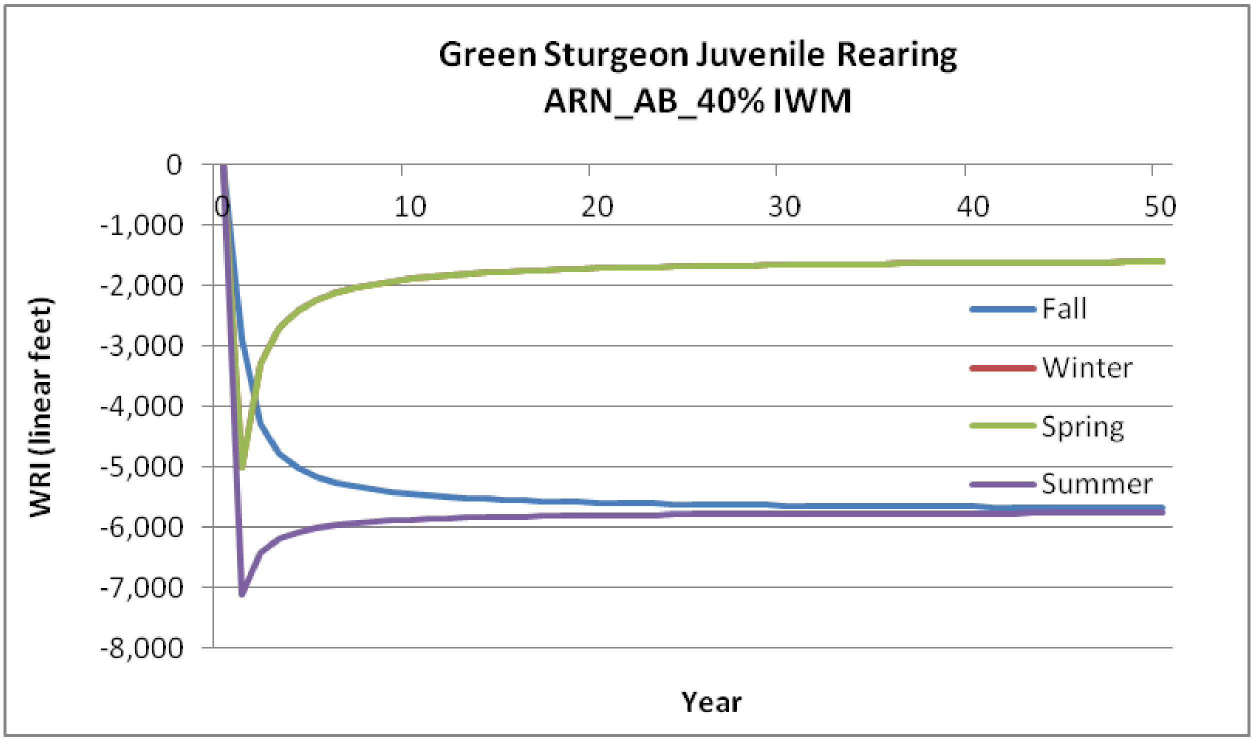

Figure 14. Weighted response indices at 40% IWM placement on the American River (ARN_AB) for green sturgeon juvenile rearing.

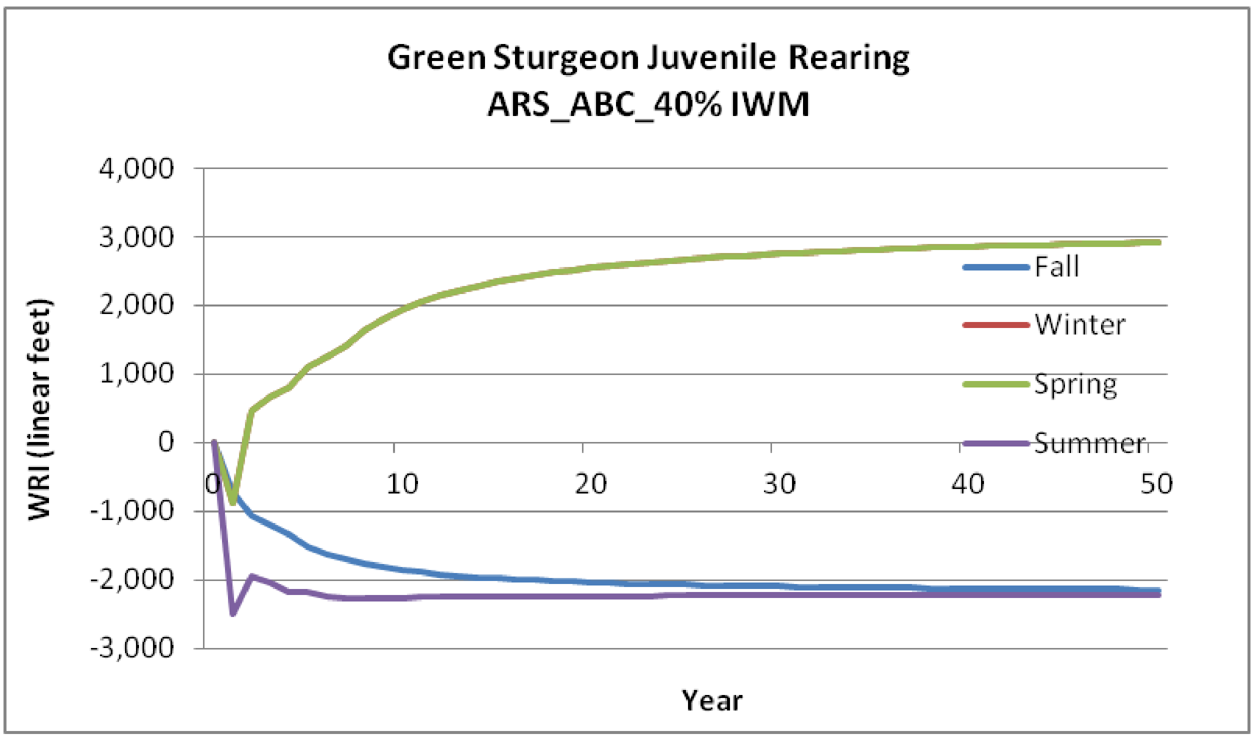

Figure 15. Weighted response indices at 40% IWM placement on the American River (ARS_ABC) for green sturgeon juvenile rearing.

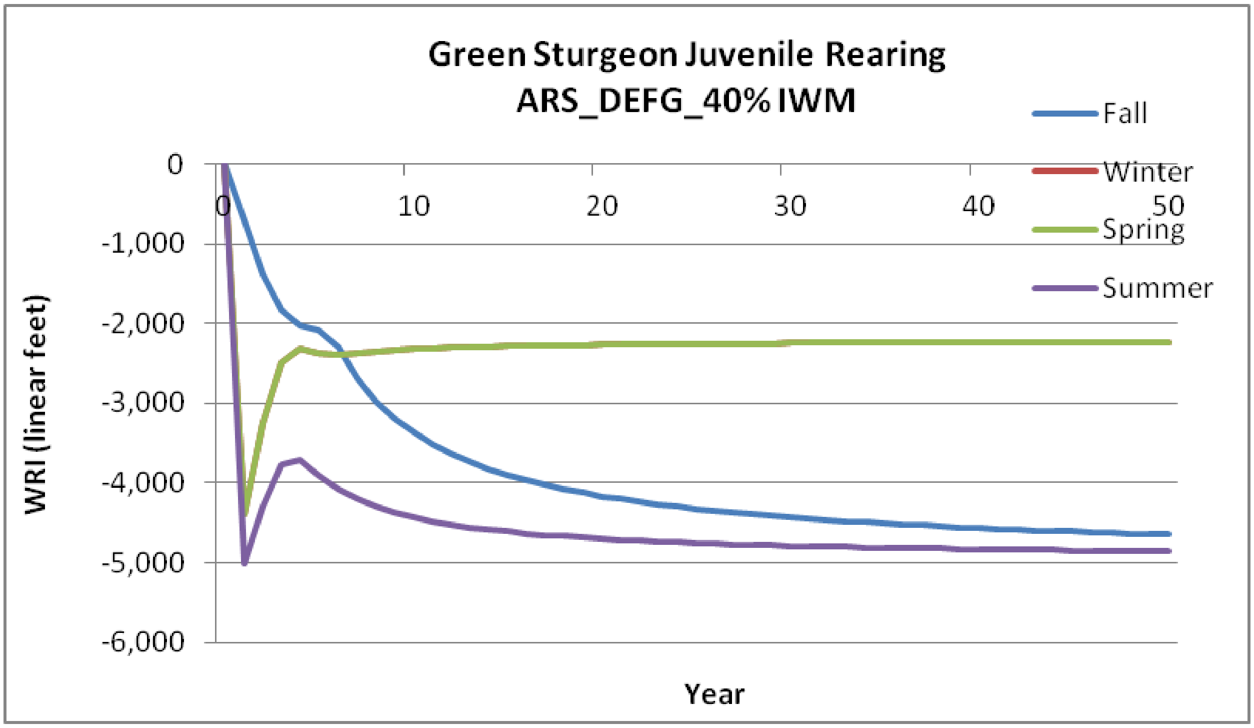

Figure 16. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_DEFG) for green sturgeon juvenile rearing.

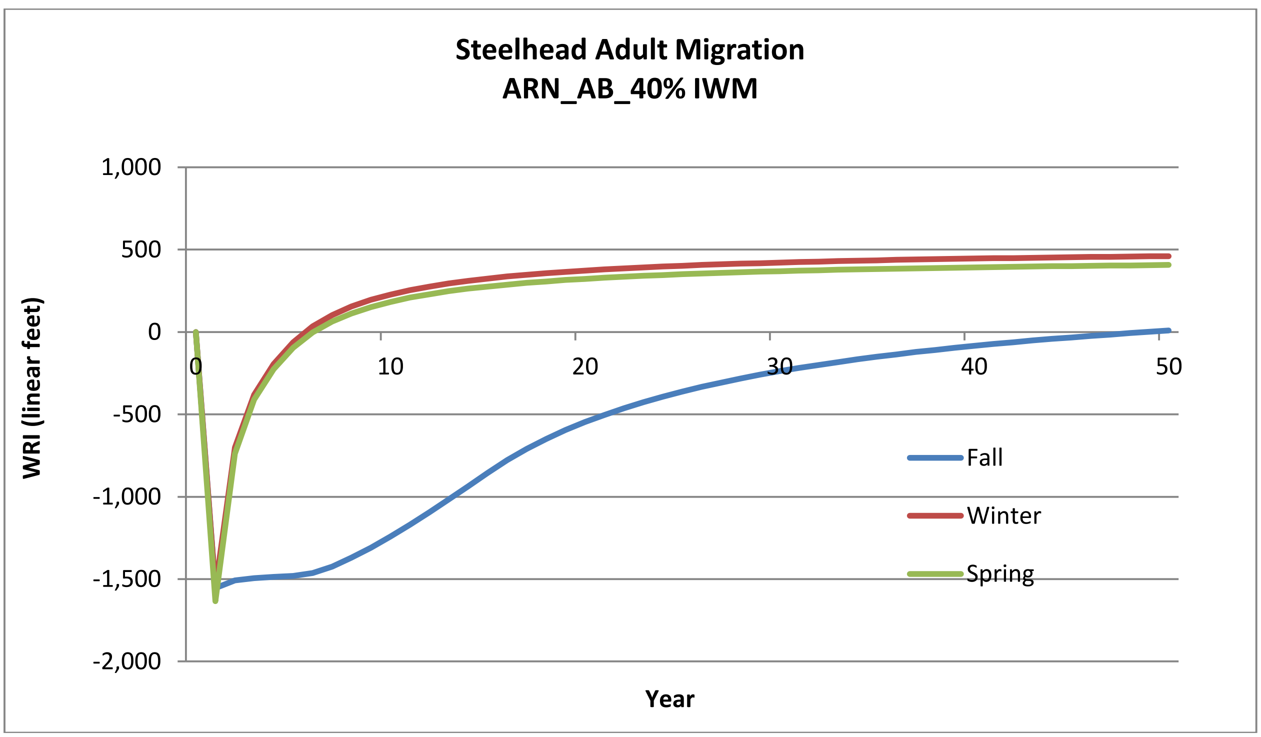

Figure 17. Weighted response indices at 40% IWM placement on the Sacramento River (ARN_AB) for steelhead adult migration.

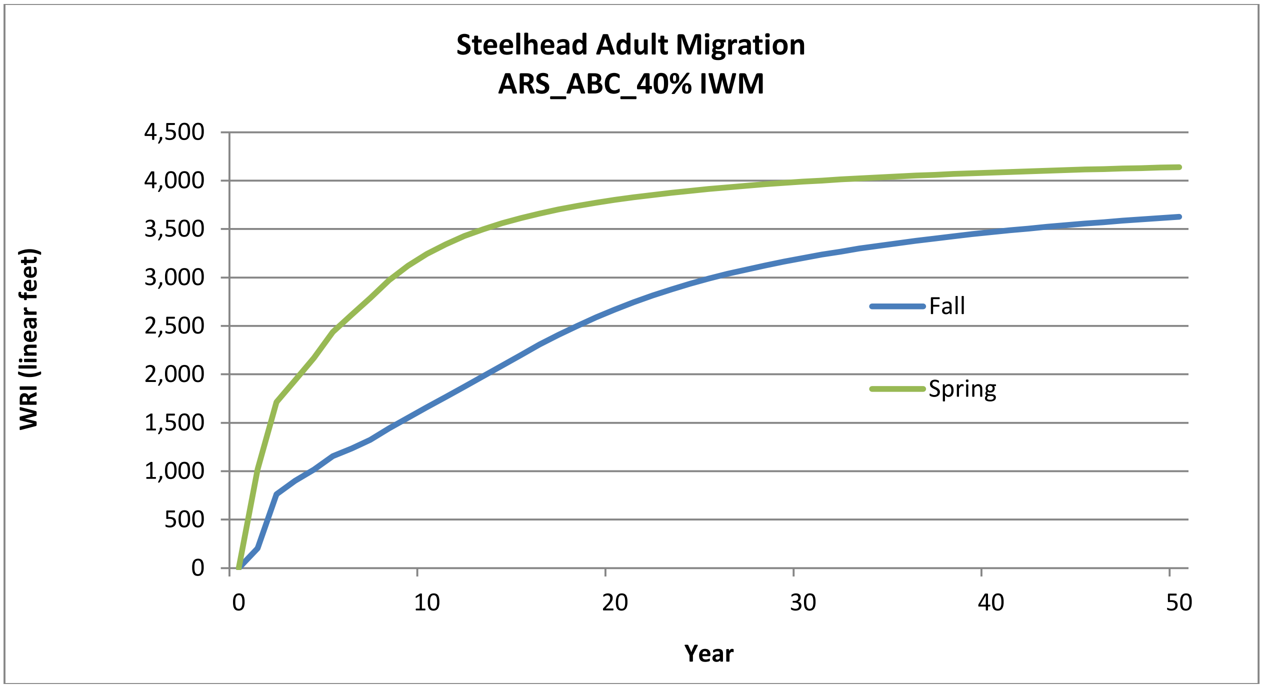

Figure 18. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_ABC) for steelhead adult migration.

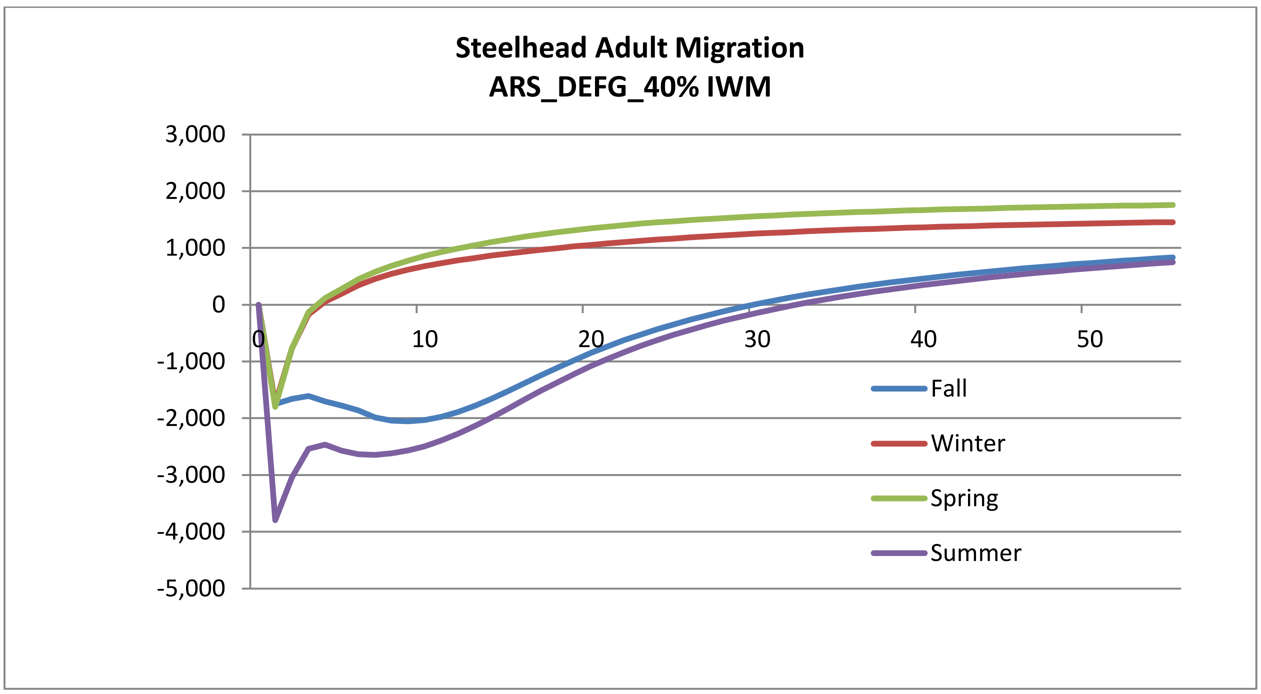

Figure 19. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_DEFG) for steelhead adult migration.

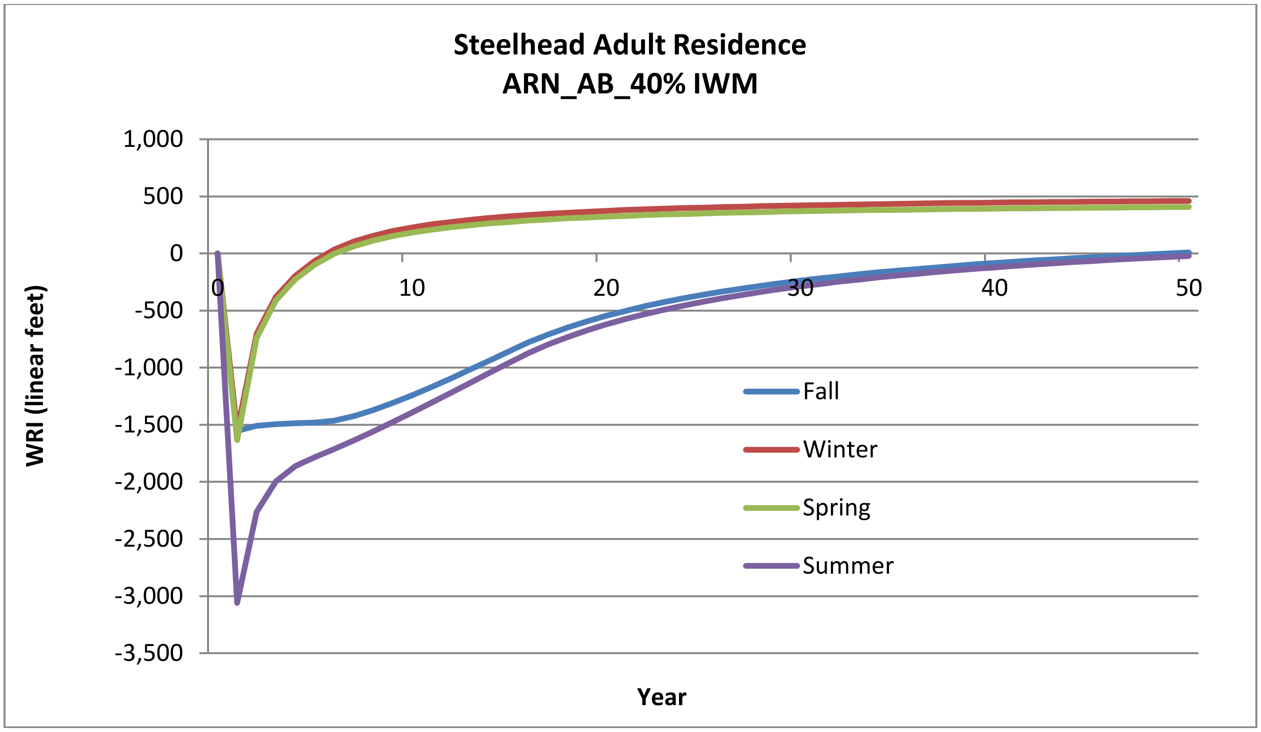

Figure 20. Weighted response indices at 40% IWM placement on the Sacramento River (ARN_AB) for steelhead adult residence.

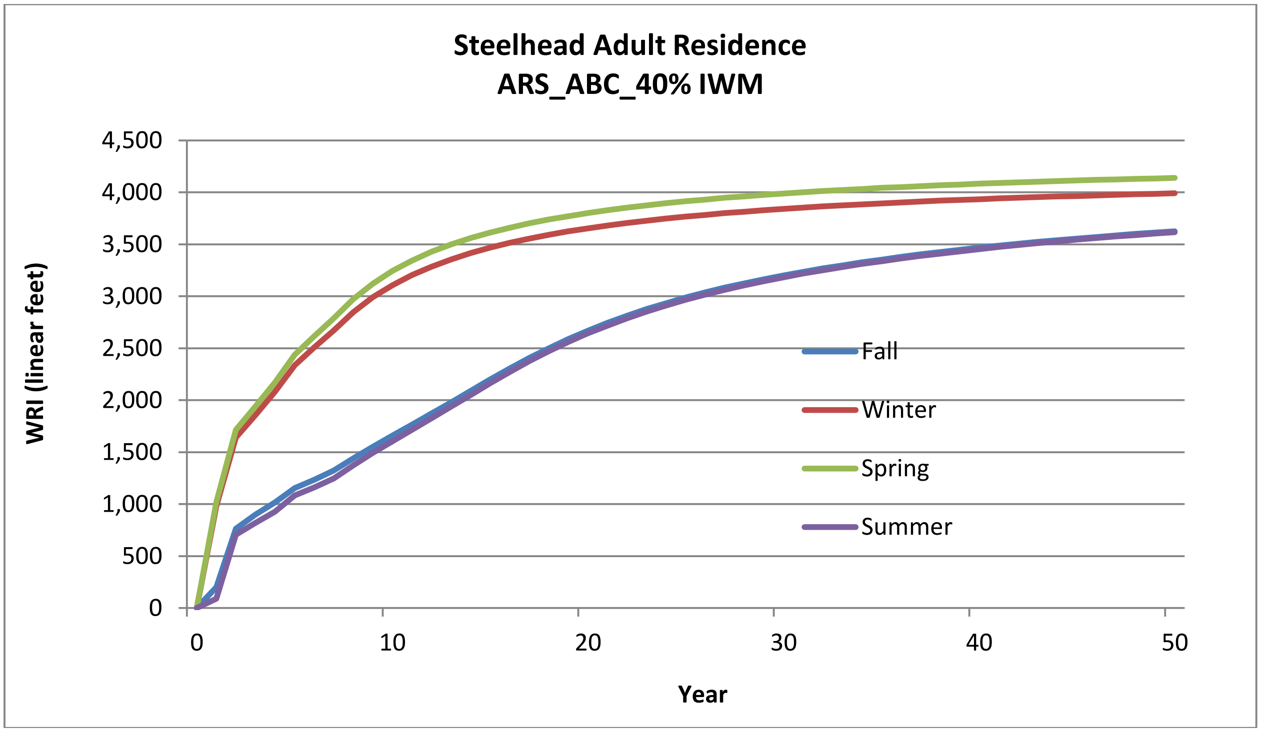

Figure 21. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_ABC) for steelhead adult residence.

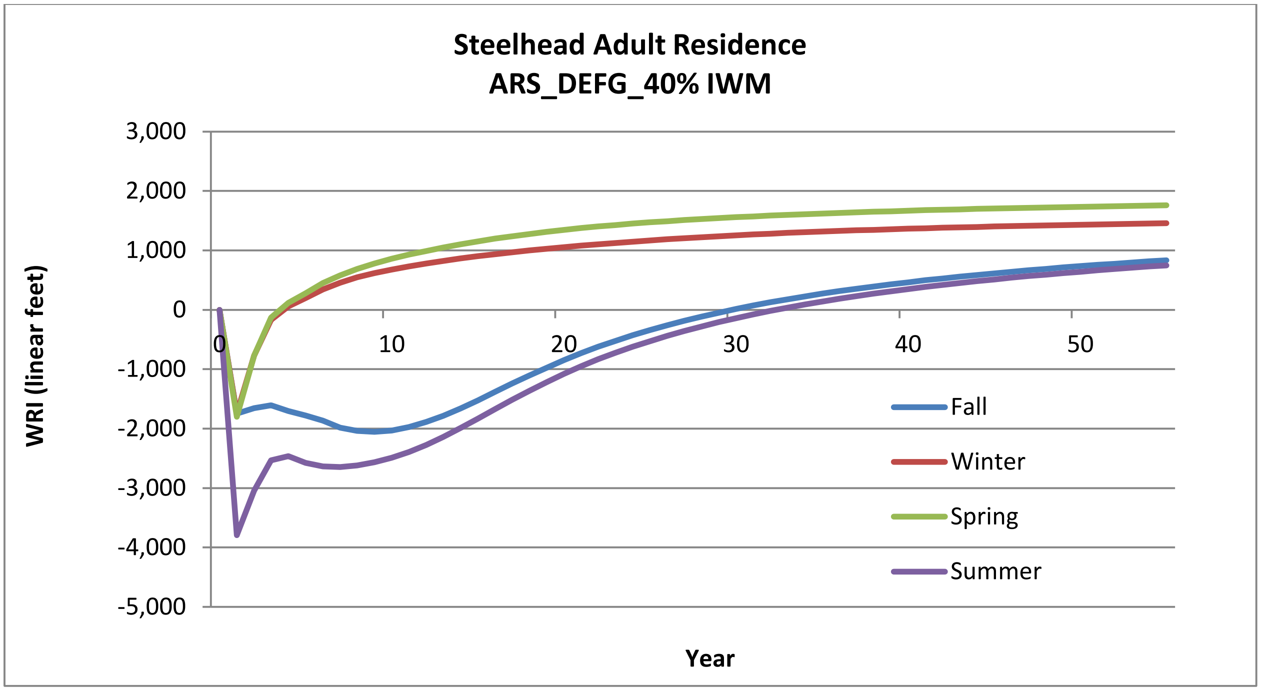

Figure 22. Weighted response indices at 40% IWM placement on the Sacramento River (ARS_DEFG) for steelhead adult residence.

Table 30
ARN_AB_40% IWM

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Spring-Run Chinook Salmon				
Fall	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-366	50	0
	Juvenile Migration	-2,303	50	0
Winter	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	1,102
	Juvenile Migration	-3,002	2	1,699
Spring	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	1,354
	Juvenile Migration	-2,681	4	1,699
Summer	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-421	50	0
	Juvenile Migration	-3,129	50	0
Fall-Run Chinook Salmon				
Fall	Adult Migration	-877	39	59
	Fry and Juvenile Rearing	-366	50	0
	Juvenile Migration	-2,303	50	0
Winter	Adult Migration	-759	5	245
	Fry and Juvenile Rearing	0	0	1,102
	Juvenile Migration	-3,002	4	1,699
Spring	Adult Migration	**	**	**
	Fry and Juvenile Rearing	0	0	1,354
	Juvenile Migration	-2,681	3	1,418
Summer	Adult Migration	**	**	**
	Fry and Juvenile Rearing	-421	50	0
	Juvenile Migration	-3,129	50	0
Steelhead				
Fall	Adult Migration	-1,554	48	8
	Fry and Juvenile Rearing	-712	50	0
	Juvenile Migration	***	***	***
	Adult Residence	-1,554	48	8
Winter	Adult Migration	-1,558	5	460
	Fry and Juvenile Rearing	-36	1	1,507
	Juvenile Migration	***	***	***

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
	Adult Residence	-1,558	5	460
Spring	Adult Migration	-1,635	6	407
	Fry and Juvenile Rearing	-1	1	1,731
	Juvenile Migration	-2,096	2	1,173
	Adult Residence	-1,635	6	407
Summer	Fry and Juvenile Rearing	-833	50	0
	Juvenile Migration	-3,013	50	0
	Adult Residence	-3,061	50	0
Green Sturgeon				
Fall	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-5,677	50	0
	Juvenile Migration	0	0	0
	Adult Residence	-21	50	0
Winter	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-5,020	50	0
	Juvenile Migration	0	0	0
	Adult Residence	-3,621	50	0
Spring	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-5,020	50	0
	Juvenile Migration	0	0	0
	Adult Residence	-3,621	50	0
Summer	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-7,118	0	0
	Juvenile Migration	0	0	0
	Adult Residence	-942	50	0

* Not applicable, adult spring-run Chinook salmon are not present on the American River

** Not applicable, adult migration of fall-run Chinook begins in early fall.
*** Not applicable, historically juvenile steelhead migration occurs in spring and summer.

Table 31
ARS_ABC_40% IWM

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Spring-Run Chinook Salmon				
Fall	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-229	26	112
	Juvenile Migration	-620	21	526
Winter	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	1,578
	Juvenile Migration	-333	1	5,377
Spring	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	2,001
	Juvenile Migration	0	0	5,123
Summer	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-239	26	111
	Juvenile Migration	-967	22	510
Fall-Run Chinook Salmon				
Fall	Adult Migration	0	0	1,860
	Fry and Juvenile Rearing	-229	26	112
	Juvenile Migration	-620	21	526
Winter	Adult Migration	0	0	1,937
	Fry and Juvenile Rearing	0	0	1,578
	Juvenile Migration	-333	1	5,377
Spring	Adult Migration	**	**	**
	Fry and Juvenile Rearing	0	0	965
	Juvenile Migration	0	0	5,123
Summer	Adult Migration	**	**	**
	Fry and Juvenile Rearing	-239	26	111
	Juvenile Migration	-967	22	510
Steelhead				
Fall	Adult Migration	0	0	3,696
	Fry and Juvenile Rearing	-489	36	88
	Juvenile Migration	***	***	***
	Adult Residence	0	0	3,696
Winter	Adult Migration	0	0	4,015
	Fry and Juvenile Rearing	0	0	2,194
	Juvenile Migration	***	***	***

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
	Adult Residence	0	0	4,015
Spring	Adult Migration	0	0	4,164
	Fry and Juvenile Rearing	0	0	2,601
	Juvenile Migration	0	0	4,061
	Adult Residence	0	0	4,164
Green Sturgeon				
Fall	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-2,154	50	0
	Juvenile Migration	0	0	0
	Adult Residence	0	0	1,548
Winter	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-876	1	2,941
	Juvenile Migration	0	0	0
	Adult Residence	-2,917	50	0
Spring	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-876	1	2,941
	Juvenile Migration	0	0	0
	Adult Residence	-2,917	50	0
Summer	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-2,496	50	0
	Juvenile Migration	0	0	0
	Adult Residence	0	0	1,537

* Not applicable, adult spring-run Chinook salmon are not present on the American River

** Not applicable, adult migration of fall-run Chinook begins in early fall.

*** Not applicable, historically juvenile steelhead migration occurs in spring and summer.

Table 32
ARS_DEFG_40% IWM

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Spring-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	-946	4	931
	Fry and Juvenile Rearing	0	0	3,445
	Juvenile Migration	-3,484	2	4,862
Summer	Adult Migration	-2,136	37	319
	Fry and Juvenile Rearing	-578	36	113
	Juvenile Migration	-4,258	50	0
Fall-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	*	*	*
	Fry and Juvenile Rearing	0	0	3,445
	Juvenile Migration	-3,484	2	4,862
Summer	Fry and Juvenile Rearing	-578	36	113
	Juvenile Migration	-4,258	50	0
Late-Fall-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	-946	4	931

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
	Fry and Juvenile Rearing	0	0	3,445
Summer	Fry and Juvenile Rearing	-578	36	113
Winter-Run Chinook Salmon				
Fall	Adult Migration	-1,394	35	362
	Fry and Juvenile Rearing	-558	35	116
	Juvenile Migration	-3,845	50	0
Winter	Adult Migration	-892	4	643
	Fry and Juvenile Rearing	0	0	2,390
	Juvenile Migration	-3,451	2	4,797
Spring	Adult Migration	-946	4	931
	Fry and Juvenile Rearing	0	0	3,445
	Juvenile Migration	-3,484	2	4,862
Summer	Adult Migration	-2,136	37	319
	Fry and Juvenile Rearing	-578	36	113
Steelhead				
Fall	Adult Migration	-2,053	29	832
	Fry and Juvenile Rearing	-1,156	44	99
	Juvenile Migration	-3,985	50	0
	Adult Residence	-2,053	29	832
Winter	Adult Migration	-1,747	3	1,455
	Fry and Juvenile Rearing	-77	1	3,234
	Juvenile Migration	-3,044	3	3,355
	Adult Residence	-1,747	3	1,455
Spring	Adult Migration	-1,801	3	1,757
	Fry and Juvenile Rearing	-36	1	4,317
	Juvenile Migration	-3,082	3	3,474
	Adult Residence	-1,801	3	1,757
Summer	Adult Migration	-3,793	32	748
	Fry and Juvenile Rearing	-1,206	45	92
	Adult Residence	-3,793	32	748
sDPS Green Sturgeon				
Fall	Fry and Juvenile Rearing	-4,674	50	0

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
	Juvenile Migration	0	0	0
Winter	Adult Migration	0	0	0
	Fry and Juvenile Rearing	-4,397	50	0
	Adult Residence	-3,068	50	0
Spring	Fry and Juvenile Rearing	-4,397	50	0
	Juvenile Migration	0	0	0
	Adult Residence	-3,068	50	0
	Adult Migration	0	0	0
Summer	Fry and Juvenile Rearing	-5,009	50	0
	Juvenile Migration	0	0	0
	Adult Residence	-1,298	50	0

* Not applicable because adult fall-run Chinook salmon migrate in early fall.

Table 33
SBP

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Spring-Run Chinook Salmon				
Fall	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-4	50	0
	Juvenile Migration	-26	50	0
Winter	Adult Migration	*	*	*
	Fry and Juvenile Rearing	-9	50	0
	Juvenile Migration	-146	50	0
Spring	Adult Migration	-51	50	0
	Fry and Juvenile Rearing	-21	50	0
	Juvenile Migration	-188	50	0
Winter-Run Chinook Salmon				
Fall	Adult Migration	**	**	**
	Fry and Juvenile Rearing	-4	50	0
	Juvenile Migration	-26	50	0
Winter	Adult Migration	-21	50	0
	Fry and Juvenile Rearing	-9	50	0
	Juvenile Migration	-146	50	0
Spring	Adult Migration	-51	50	0
	Fry and Juvenile Rearing	-21	50	0
	Juvenile Migration	-188	50	0
Fall-Run Chinook Salmon				
Fall	Adult Migration	-60	50	0
	Fry and Juvenile Rearing	-4	50	0
	Juvenile Migration	-26	50	0
Winter	Adult Migration	-21	50	0
	Fry and Juvenile Rearing	-9	50	0
	Juvenile Migration	-146	50	0
Spring	Adult Migration	***	***	***
	Fry and Juvenile Rearing	-21	50	0
	Juvenile Migration	-188	50	0
Late-Fall-Run Chinook Salmon				
Fall	Adult Migration	-60	50	0
	Fry and Juvenile Rearing	-4	50	0
	Juvenile Migration	-26	50	0

Season	Life Stage	Maximum WRI Deficits	Duration of Deficit (in years)	Maximum WRI Benefits
Winter	Adult Migration	-21	50	0
	Fry and Juvenile Rearing	-9	50	0
	Juvenile Migration	-146	50	0
Spring	Adult Migration	****	****	****
	Fry and Juvenile Rearing	-21	50	0
	Juvenile Migration	-188	50	0
Steelhead				
Fall	Adult Migration	-100	50	0
	Fry and Juvenile Rearing	-17	50	0
	Juvenile Migration	-35	50	0
Winter	Adult Migration	-40	50	0
	Fry and Juvenile Rearing	-29	50	0
	Juvenile Migration	-127	50	0
Spring	Adult Migration	-87	50	0
	Fry and Juvenile Rearing	-55	50	0
	Juvenile Migration	-174	50	0
sDPS Green Sturgeon				
Fall	Fry and Juvenile Rearing	0	0	115
	Juvenile Migration	0	0	0
Winter	Adult Migration	0	0	0
	Fry and Juvenile Rearing	0	0	115
Spring	Adult Migration	0	0	0
	Fry and Juvenile Rearing	0	0	115
	Juvenile Migration	0	0	0

* Not applicable, adult spring-run Chinook salmon migrate upstream in the spring

** Not applicable, adult winter-run Chinook salmon migrate upstream in the winter

*** Not applicable, adult fall-run Chinook salmon migrate upstream in the fall

**** Not applicable, adult lt.fall-run Chinook salmon migrate upstream in the late fall and winter

7.0 References

USACE (U. S. Army Corps of Engineers). 2008. Standard assessment methodology (SAM) analysis of 29 constructed bank repair sites for the Sacramento River Bank Protection Project. Final. Contract No. W91238-07-C-0002. Prepared by Stillwater Sciences, Berkeley, California for USACE, Sacramento District, Sacramento, California. July.

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USACE (U. S. Army Corps of Engineers). 2013. Standard Assessment Methodology (SAM) for the Sacramento River Bank Protection Project (SRBPP), Cumulative Analysis of 22 Sites. Final June 2013.