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

NOV 29 2006

In response refer to:
F/SWR/2003/02258

Michael Finan
Chief, Delta Office
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Mr. Finan:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of the City of Stockton Delta Water Supply project (DWSP) in San Joaquin County, California, and its effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), threatened southern distinct population segment of North American green sturgeon (*Acipenser medirostris*), and designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your initial request for section 7 consultation on this project was received on November 17, 2004. Subsequently, in January 2005, consultation was suspended when additional sites and fish screen designs were added to the project description. At an April 25, 2005, meeting involving representatives of the applicant (*i.e.*, the City of Stockton), NMFS, the U.S. Fish and Wildlife Service and the California Department of Fish and Game, NMFS staff requested that a single project alternative be chosen before further formal consultation could continue. NMFS received additional information from the applicant describing the project's operations and effects in a Draft Program Environmental Impact Report (PEIR) on April 29, 2005, a final PEIR on October 26, 2005, and a final biological assessment on February 28, 2006, in which a final project alternative was selected. NMFS sent a letter informing the U.S. Army Corps of Engineers (Corps) that formal consultation for the DWSP was initiated with the receipt of the February 28, 2006, final biological assessment.

This biological opinion is based on information provided in the April 29, 2005, draft PEIR, October 26, 2005, final PEIR, and the February 28, 2006, final biological assessment; and, numerous scientific articles and reports from both the peer reviewed literature and agency "gray literature." A complete administrative record of this consultation is on file at the Sacramento Area Office of NMFS.

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Based on the best available scientific and commercial information, the biological opinion concludes that the City of Stockton DWSP, as presented by the Corps and the applicant, is not likely to jeopardize the continued existence of the listed species, or destroy or adversely modify designated critical habitat. NMFS also 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 associated with the project of listed salmonids. The section 9 prohibitions against taking of listed species and the terms and conditions of this biological opinion will not apply to North American green sturgeon until the final section 4(d) ruling under the ESA has been published in the Federal Register.

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

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

Please contact Mr. Jeffrey Stuart in our Sacramento Area Office at (916) 930-3607 or via e-mail at J.Stuart@noaa.gov if you have any questions regarding this response or require additional information.

Sincerely,

Russell M Strach
for Rodney R. McInnis
Regional Administrator

Enclosures (2)

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

cc: Copy to file—ARN# 151422SWR2005SA9037
James Starr, California Department of Fish and Game, 4001 North Wilson Way, Stockton, CA 94205

Ryan Olah, U.S. Fish and Wildlife Service, 2800 Cottage Way, Room W-2605,
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BIOLOGICAL OPINION

ACTION AGENCY: U.S. Army Corps of Engineers, Sacramento District

ACTIVITY: Construction and Operation of the City of Stockton Delta Water Supply Project

CONSULTATION CONDUCTED BY: NOAA's National Marine Fisheries Service, Southwest Region

FILE NUMBER: 2003/02258

DATE ISSUED: NOV 29 2006

I. CONSULTATION HISTORY

On November 6, 2003, staff from the National Marine Fisheries Service (NMFS) attended an interagency pre-application meeting with the U.S. Army Corps of Engineers (Corps) to discuss the City of Stockton Delta Water Supply project (DWSP) and its potential effects upon listed species under the Endangered Species Act (ESA). In attendance were representatives of the City of Stockton (City), their consultants (Environmental Science Associates [Associates]) and the U.S. Environmental Protection Agency (EPA).

On November 13, 2003, the Notice of Preparation for the DWSP was mailed to these agencies by the City.

On January 23, 2004, NMFS provided a list of protected anadromous salmonids potentially found within the action area to the City's environmental consultants.

On May 21 and June 8, 2004, representatives of the City met with staff from NMFS and the California Department of Fish and Game (CDFG) to discuss the design of the DWSP intake structure as well as fish screen requirements.

On November 17, 2004, the Corps initiated formal consultation with NMFS on the DWSP. The project description included two alternative fish screen designs: (1) an in-bank slanted fish screen, or (2) an in-channel vertical fish screen design located on the northern bank of the San Joaquin River at the southwest corner of Empire Tract.

On December 13, 2004, NMFS responded to the Corps with a letter indicating that formal consultation had been initiated on the project, and that the analysis would look at both types of fish screen placements described in the project description.

In January 2005, NMFS was informed by the Corps that the City had modified its project description and was considering an alternative project site located on the western side of Empire project, none of which was designated as the preferred alternative. NMFS requested verbally that the Corps suspend its consultation until a final alternative was selected for the project design by the City of Stockton.

On April 25, 2005, representatives of the City met with staff from NMFS, U.S. Fish and Wildlife Service (FWS), and CDFG to discuss the DWSP biological assessment previously submitted to the agencies by the Corps. At that meeting, NMFS requested that the biological assessment (BA) be resubmitted with only one alternative for the proposed project rather than several alternatives.

The Draft Program Environmental Impact Report (PEIR) (Associates 2005) was mailed to NMFS, FWS, and CDFG on April 29, 2005. This document contained the four design alternatives first identified in January 2005. The Final PEIR was mailed to NMFS, FWS, and CDFG on October 26, 2005. In this document, the design alternatives had been reduced to the original two fish screen designs at the San Joaquin River location originally described.

On February 28, 2006, NMFS received the final BA from the Corps (Associates 2006) which described the final project design for the selected alternative. The preferred project was the in-bank fish screen design on the northern bank of the San Joaquin River at the southwest tip of Empire Tract.

On March 27, 2006, NMFS responded in writing to the Corps that formal consultation for the DWSP was initiated with the receipt of the February 28, 2006, final BA.

II. DESCRIPTION OF THE PROPOSED ACTION

The DWSP is designed as a conjunctive use water supply program for the City of Stockton Metropolitan Area (COSMA), which would integrate surface water and ground water management under one program. The surface water component of the DWSP would include a new screened intake facility on the San Joaquin River, new pipelines to convey Delta water to a new water treatment plant (WTP) located just north of the COSMA, and new treated water pipelines to deliver water to the City's existing water distribution system. Existing interties with the California Water Service Company (Cal Water) would be used to distribute the DWSP's treated water throughout Cal Water's service area within the COSMA. The groundwater component would include coordinated groundwater and surface water management. Initially, groundwater levels would be allowed to recover by in-lieu (natural) recharge. Ultimately, treated Delta surface water would be injected into the groundwater basin underlying the COSMA, for later extraction during periods of limited surface water supply.

The DWSP would be expanded incrementally to keep pace with the COSMA's needs, based on the timing of existing supply reductions and increased demand over time. The initial capacity of the DWSP would be 30 million gallons per day (mgd) (47 cubic feet per second (cfs)), with staged incremental expansions to an ultimate capacity of 160 mgd (250 cfs). The new water intake facility would be designed to facilitate these expansions and to avoid extensive future construction in the river and sloughs.

A. Project facilities

1. Intake Structure and Pump Station Facilities

The proposed intake site is on the southwestern tip of the Empire Tract adjacent to the San Joaquin River (See Figures 1 and 2). The general area designated for the intake structure is on a bend of the river, which creates two shorelines (south and west banks of Empire Tract). The selected intake site is located approximately 350 feet from the edge of the dredged Stockton Deep Water Ship Channel. Water flows at the south bank location average 15,010 cfs (tidally driven), which would assist in maintaining the desired sweeping velocity of 0.4 fps across the intake fish screen.

The proposed in-bank intake and pump station facility will utilize flat plate screens and will be sized to accommodate the ultimate 160 mgd intake capacity predicted for the year 2050. The proposed construction of the intake and pump station will create two individual units, each sized to handle an 80 mgd capacity. The fish screen and intake channel for the pump station facility will be built into the levee bank of the existing levee. The proposed construction footprint for the in-bank facility will encompass approximately 5.7 acres (250 feet wide by 1,000 lineal feet of riverbank).

In order to accomplish this, a setback levee on the land side of the existing levee will be constructed to provide flood protection to Empire Tract. The area between the existing levee and the setback levee will be backfilled with earthen fill (6,900 cubic yards) to provide a level area above the flood elevation for access to the pump station and ancillary facilities and structures. Preconstruction dredging will remove approximately 6,700 cubic yards of native river bank and channel bottom material. The waterside portion of the construction area will then be isolated from the main channel by permanent sheet pile wing walls and a temporary cofferdam of sheet piles driven into the bottom of the channel across the mouth of the water intake channel. Approximately 833 cubic yards of rock riprap will be placed along the permanent wing walls of the intake structure. The area within the cofferdam and the existing levee will be pumped dry to allow for construction activities to occur. The void between the existing levee and the newly placed wing walls will be filled with imported material (1,300 cubic yards) and compacted to provide support for the intake structure. The dredging, cofferdam installation, removal of water from behind the cofferdam and backfilling of soil is expected to take approximately 60 days to complete. A total of 0.44 acres of perennial stream habitat, including 176 feet of river bank shoreline and 1.57 acres of upland terrestrial habitat will be permanently removed from the action area by the finished facility (Figure 3).

Within the area identified as the footprint for the intake structures, a network of 14-inch diameter pre-stressed concrete piles will be driven into the soil to a depth of 75 feet. These concrete piles will provide support to the poured concrete slab foundation of the intake facility and the related concrete structural elements of the fish screen and pumping platform. The number of piles driven will be sufficient for both of the 80 mgd pumping modules. The City anticipates that all piles will be driven during the period July 1 through November 30. The concrete work proposed for the current consultation will allow for only one of the 80 mgd modules to be built. The second intake module, should it be built, will be permitted under a future consultation. However to avoid redeploying the pile driving equipment a second time, all piles for both modules will be driven in on mobilization of the pile driving rig.

Pumps, valves, and manifold piping will be constructed on the north side of the structure at grade for ease of access. Electrical equipment will be located adjacent to the pumps and housed in a building constructed on the operating deck of the intake. The operating deck elevation will be approximately 12 feet mean sea level (msl), with the electrical building height of approximately 23 feet. The roof elevation of 35 feet msl would provide clearance for equipment removal; the structure will extend 27 feet above the 100-year flood water level.

The proposed in-bank intake will extend into the river approximately 60 feet from the levee face and would be approximately 350 feet from the Stockton Deep Water Ship Channel. Placement of the cofferdam during construction would require approximately a 20-foot clearance for working space.

a. *Fish Screen Design*

The vertical screen height of the fish screen will be 15 feet with a nominal structure length of 120 feet. The fish screen may be slightly angled away from vertical to better conform with the established slope of the levee. The fish screen will be designed to meet the current fish screen criteria established by NMFS, FWS, and CDFG. The proposed screen will have the following structural and operational characteristics:

Screen Orientation. The screen will be oriented so that the screen face will be parallel to the ambient river flow. The upstream and downstream transitions from the wing walls to the screen will be constructed so as to minimize the creation of eddies in the flow of water past the structure.

Approach Velocity. A uniform approach velocity of less than 0.2 feet per second (fps) as well as an adjustment for flow patterns will be provided across the face of the fish screen. For an ultimate capacity of 160 mgd, a minimum of 1,240 square feet of screen area will be provided, excluding the area needed for structural support members. The footprint of the water diversion's intake will be large enough to accommodate this future expansion and the required fish screen dimensions to achieve the design approach velocity.

Screen Cleaning. The design of the fish screen will allow for the completion of an automatic cleaning cycle once every 5 minutes. The screen will be cleaned with either an automatic rotating brush or hydraulic screen cleaner.

Sweeping Velocity. The sweeping velocity design criteria for river intakes is at least twice the approach velocity (*i.e.*, 0.4 fps or higher). Except during periods of tidal flow reversal, sweeping flow velocity will be at least two times the approach velocity. With a river channel cross-sectional flow area of approximately 18,000 square feet, flow rates must exceed 7,200 cfs to meet the sweeping velocity criteria of 0.4 fps. This occurs about 80 to 85 percent of the time at the intake site. The City plans to work with the Corps, NMFS, FWS, and CDFG to develop site-specific requirements for the DWSP.

Screen Openings. The opening size of the screen will not exceed 1.75 millimeters (mm); the minimum open area will be 27 percent of the screen's surface area.

Screen Materials. The screen will be fabricated of rigid, corrosion-resistant material with no sharp edges or projections (*e.g.*, stainless-steel or copper-nickel alloy using wedge wire).

b. *Pumping and Electrical Requirements*

Electric pumps will lift water from the intake and deliver it to the proposed WTP, pumping it 51 feet above sea level in the process. The transfer of this water will be through the initial installation of a 54-inch-diameter pipe to the WTP, which is sufficient to handle volumes from the initial diversion rate of 30 mgd up to a future volume of 60 mgd. Subsequent increases in the volume of pumped water will require the installation of an enlarged 72-inch pipeline to the WTP installed in a parallel tract to the 54-inch pipeline.

For the initial pump station capacity of 30 mgd, the total connected electrical load for the intake facility would be approximately 850 kilovolt-amperes (kVA). Increases in the electrical capacity for the intake pump station and interim phasing would depend on the timing for construction of the parallel 72-inch-diameter raw water pipeline. An upgrade to the electrical infrastructure would be required to efficiently meet the facility's initial and full build out needs. Ultimately, the required electrical load to run the intake facility and WTP could reach as high as 7,000 kVA.

High voltage electrical transmission lines are located west and parallel to I-5. Electrical service for the intake pump station would be routed to a new substation near the intake site from the substation located at Eight Mile Road and I-5. Overhead poles will follow the road right-of-way from the northwest corner of I-5 and Eight Mile Road to the intake site along the Eight Mile Road corridor.

2. Raw Water Pipelines and Water Treatment Plant

Approximately 67,000 lineal feet (12.7 miles) of raw water pipelines will be constructed to connect the water intake facility with the WTP. The alignment of the pipeline will follow the western edge of Empire Tract northwards from the intake facility to Eight Mile Road, paralleling the inside of the levee along Little Connection Slough for approximately 1.5 miles. At Eight Mile Road, the pipeline alignment will turn east and parallel the northern side of the road for approximately 2.1 miles before crossing under Honker Cut. The pipeline will continue east for another 2.25 miles before crossing under Bishop Cut. From this point, the pipeline will continue approximately 6 miles east to Sacramento Road before turning north to the proposed location of the WTP (Figure 4).

The initial pipeline will be 54-inches in diameter and will be sized to accommodate up to 60 mgd of pumping capacity. When the demands for water reach the level that additional capacity in excess of the 60 mgd is needed, an additional 72-inch pipeline will be installed parallel to the existing 54-inch pipeline alignment. The applicant anticipates that this enlargement of the carrying capacity of the raw water pipelines will be considered under a future biological opinion which addresses the co-occurring enlargement of the diversion capacity at the intake structure.

The majority of the raw water pipelines will be installed using open cut trenching techniques. This includes the crossing of minor ditches and waterways on Empire Tract, King Island, and Bishop Tract. However, where the pipeline alignment crosses significant waterways (*i.e.* Honker Cut and Bishop Cut) trenchless construction techniques will be employed. Theses techniques include bore and jack, horizontal directional drilling (HDD), and microtunneling to pass beneath the obstruction or waterway.

Open trenching techniques will entail using conventional cut and cover practices. Trenches will be excavated by backhoe or excavator and the soil stockpiled for future backfilling of the completed pipeline. The stockpiled soil will be protected from the elements, and runoff and sedimentation will be prevented by the implementation of appropriate construction best management practices (BMPs). Construction of the pipeline trench will be limited to a maximum 80-foot wide construction corridor in open agricultural lands, but may be further confined to a 47-foot wide corridor in areas with existing infrastructure or other sensitive conditions. In areas with shallow groundwater levels, dewatering will be required. If the groundwater seepage cannot be contained onsite, it will be pumped into holding tanks (*i.e.*, Baker tanks or other suitable receptacles) where the sediment will be separated from the groundwater and the “clean” groundwater redistributed into surrounding upland areas or irrigation ditches. The return water will comply with water quality standards for construction and trench dewatering activities as promulgated by the California Central Valley Regional Water Quality Control Board (Regional Board) before being discharged. Surface areas disturbed by the open trenching activities will be restored to their original condition. Unpaved areas will be replanted with grasses, shrubs, and trees as required.

Trenchless construction techniques are used when sensitive surface obstructions or otherwise difficult conditions preclude the open trenching techniques previously described. Typically, trenchless construction techniques require that the bore of the tunnel pass under the sensitive surface obstruction, such as the waterways of Bishop and Honker Cuts, and resurface on the opposite side of the obstruction. Bore and jack and microtunnel boring are two of the techniques being considered for channel crossings. Typically, a bore pit would be excavated on each side of the waterway. These pits, approximately 25 to 30 feet long by 10 to 15 feet wide, would be excavated with a backhoe outside of the natural channel boundaries. Depth of the pits would depend on final pipeline depth below grade. The boring equipment is lowered into the pit and the drilling bore is advanced into the substrate. The welded pipe sections and, if needed, a casing, are advanced over the drill shaft into the bore hole. Spoils from the excavation would be placed alongside the pits outside of the channel for future use as backfill. Minimum buffer zones for entry and exit points on either side of the stream and a minimum vertical clearance beneath the streambed would be maintained to avoid or minimize the potential environmental impacts resulting from the crossing activities. At this time the setback distances and minimum boring depths required to maintain this safety margin have not been determined.

Any groundwater encountered during drilling would be pumped out of the bore pits and discharged per Regional Board requirements. The procedure employed would be determined during final design. Upon completion of the pipeline installation, the excavated areas would be backfilled, compacted, re-contoured, and restored to natural conditions.

HDD is a highly specialized boring technique. It could be used to drill an arc that would travel under larger waterbodies such as Honker or Bishop Cuts. HDD is a technique in which a fluid filled pilot bore is drilled and then enlarged to the size required for the pipeline. Lubrication containing water and bentonite clay, referred to as drilling mud, would be used to aid the drilling and to coat the walls to maintain the opening. A wire line magnetic guidance system would be used to ensure that the angle, depth, and exit point abide by the detailed engineering plans drawn up for the crossing. Once the hole is approximately 12 inches larger than the pipe, the pipeline is pulled through the drilled hole from the point of entry to the point of exit. The workspace requirements for the HDDs extend to an area 200 feet wide by 200 feet long. HDD bores would be surface-to-surface; and mud pits may need to be excavated to retain the drilling mud exiting from the bore openings at the either end of the crossing.

The WTP will be built on a 126 acre parcel of agricultural land located 3 miles east of Interstate 5 and 0.5 miles north of Eight Mile Road along Lower Sacramento Road. The actual footprint of the WTP will cover 56 acres. The plant will either utilize (1) conventional treatment using ozone or deep bed granular activated charcoal or (2) a membrane filtration treatment with a pretreatment of powdered activated charcoal. Both treatment types will utilize grit basins, flash mix (coagulation), flocculation/sedimentation basins, and clearwell storage. The City anticipates that the construction of the WTP will take approximately 2 years to complete. The WTP will operate continuously, 24 hours per day, year round at various flow rates during the year with ongoing operation and maintenance protocols. Treated water will be distributed through existing and newly constructed delivery pipelines to supply the water needs of the COSMA.

B. Proposed Conservation Measures

The applicant, the City of Stockton, has described several mitigation actions that will be implemented in the construction and operation of the proposed project. A detailed description of the recommended mitigation measures is found in Section 6 of the applicant's Biological Assessment document delivered to NMFS on February 28, 2006 (Associates 2006). Briefly, a stormwater pollution prevention plan (SWPPP) as well as erosion and sedimentation BMPs will be implemented for all upland construction activities and where practicable, excavation and grading activities will take place during the dry season (*i.e.,* April 15 through October 15). In-water work will commence during the period from July 1 through November 30 for the installation of the cofferdam and wing walls. Work within the dewatered cofferdam will continue year round following the placement of the cofferdam. The cofferdam installation and dewatering process will be monitored by a qualified fisheries biologist. Any stranded fish found during this period will be salvaged and returned to the San Joaquin River according to a fish rescue protocol developed by the applicant. In addition to the construction related mitigation measures, long-term operational procedures will include varying the pumping rates of the intake in response to the 20-mm delta smelt survey data collected in the San Joaquin River at sampling site 906 (*i.e.*, adjacent to the project site). Pumping rates will be reduced or halted dependent on the presence of larval delta smelt in the sampling surveys.

C. Action Area

The action area includes 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 physical location of the DWSP is on the southwestern tip of Empire Tract in the Sacramento-San Joaquin Delta. The intake will be located on the southern shore of Empire Tract, slightly east of Federal navigation marker "11" on the Stockton Deep Water Ship Channel (DWSC). The raw water pipelines will cross Honker Cut and Bishop Cut slightly north of the alignment of the Eight Mile Road bridges over these waterways. These three locations will be the sites of any direct impacts from the construction phase of the project.

The operations phase of the DWSP will affect fish and habitat in several locations but at variable levels. The most direct and significant impacts to fish will be at the site of the intake screen itself, where water is withdrawn from the Delta. Lower levels of effects will be present within the water conveyance systems of the Central Valley (*i.e.*, the Sacramento River below Shasta Dam, the Feather River below Oroville Dam, and the American River below Folsom Dam), and will be dependent upon the changes in water delivery required to meet water delivery obligations and water quality standards required of the state and Federal water programs as they compensate for the additional water being diverted for the DWSP. The computer modeling simulation (CALSIM II) run by the applicant's consultants to compare the impacts of the project on the current and future water delivery operations indicates that small impacts related to the DWSP project can be measured even in the reservoir operations of Lake Shasta. However, it should be noted that these impacts are relatively minor, and deemed insignificant by the applicant, as far as impacts to the water delivery system operations are concerned. The scope and sensitivity of these impacts will be discussed in the effects analysis section of the opinion.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed and proposed species (Evolutionarily Significant Units [ESUs] or Distinct Population Segments [DPSs]) and designated critical habitat occurs in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) ESU
Listed as endangered (70 FR 37160, June 28, 2005), see also (58 FR 33212, June 16, 1993 – critical habitat)

Central Valley spring-run Chinook salmon (*O. tshawytscha*) ESU
Listed as threatened (70 FR 37160, June 28, 2005), see also (70 FR 52488, September 2, 2005 - critical habitat)

Central Valley steelhead (*O. mykiss*)DPS
Listed as threatened (71 FR 834, January 5, 2006) see also (70 FR 52488, September 2, 2005 – critical habitat)

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

A. Species and Critical Habitat Listing Status

NMFS has recently completed an updated status review of 16 salmon ESUs, including Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (70 FR 37160). On January 5, 2006, NMFS published a final listing determination for ten steelhead DPSs, including Central Valley steelhead. The new listing concludes that Central Valley steelhead will remain listed as threatened (71 FR 834).

Sacramento River winter-run Chinook salmon were originally listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. Critical habitat was delineated as the Sacramento River from Keswick Dam 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. The critical habitat designation identifies those physical and biological features of the habitat that are essential to the conservation of the species and that may require special management consideration and protection. Within the Sacramento River this includes the river water, river bottom (including those areas and associated gravel used by winter-run Chinook salmon as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing. In the areas west of Chipps Island, including San Francisco Bay to the Golden Gate Bridge, this designation includes the estuarine water column, essential foraging habitat, and food resources utilized by winter-run Chinook salmon as part of their juvenile outmigration or adult spawning migrations. As governed by the critical habitat definition for winter-run Chinook salmon, critical habitat does not occur at the project location, however critical habitat is found within the action area as defined by the effects of the computer simulation results performed by the applicant's consultant.

Central Valley spring-run Chinook salmon were listed as threatened on September 16, 1999 (50 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the Central Valley spring-run Chinook salmon ESU as of June 28, 2005 (70 FR 37160). Critical habitat was designated for spring-run Chinook salmon in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat does not include the hydrologic unit in which the project is located (San Joaquin Delta), however critical habitat is found within the action area as defined by the effects of the computer simulation results performed by the applicant's consultant.

Central Valley steelhead were listed as threatened under the ESA on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. The Coleman National Fish Hatchery and FRH steelhead populations have been included in the listed population of steelhead as of January 5, 2006 (71 FR 834). These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for steelhead in the Central Valley 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 Calaveras, Mokelumne, Stanislaus, and Tuolumne Rivers in the San Joaquin River basin; and, the Sacramento and San Joaquin Rivers and Delta. The project site is located within the San Joaquin Delta, which is included within the critical habitat designation for Central Valley steelhead. The action area, as defined by the extent of effects modeled by the computer simulation, includes the mainstem of the Sacramento River below Keswick Dam, the Feather River below Oroville Dam, and the American River below Nimbus Dam.

The southern DPS of North American green sturgeon was proposed for listing as threatened on April 6, 2005 (70 FR 17386) and listed as threatened on April 7, 2006 (71 FR 17757). The southern DPS presently contains only a single spawning population in the Sacramento River; and rearing individuals may occur in the action area. No critical habitat has been designated or proposed for the southern DPS of North American green sturgeon.

B. Species Life History and Population Dynamics

1. Chinook Salmon

a. *General Life History*

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

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38 °F to 56 °F (Bell 1991, California Department of Fish and Game (CDFG) 1998). Adult winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate past Red Bluff Diversion Dam (RBDD) from mid-December through early August (NMFS 1997a). 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. Adult spring-run Chinook salmon enter the Delta from the Pacific Ocean beginning in January and enter natal streams from March to July (Myers *et al.* 1998). In Mill Creek, Van Woert (1964) noted that of 18,290 spring-run Chinook salmon observed from 1953 to 1963, 93.5 percent were counted between April 1 and July 14, and 89.3 percent were counted between April 29 and June 30. 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.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (FWS 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Bell (1991) identifies the preferred water temperature for adult spring-run Chinook salmon migration as 38 °F to 56 °F. Boles (1988) recommends water temperatures below 65 °F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70 °F, and that fish can become stressed as temperatures approach 70 °F. The Bureau of Reclamation (Reclamation) reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60 °F; although salmon can tolerate temperatures up to 65 °F before they experience an increased susceptibility to disease. The upper preferred water temperature for spawning Chinook salmon is 55 °F to 57 °F (Chambers 1956, Bjornn and Reiser 1995). Winter-run Chinook salmon spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick dam and RBDD (Vogel and Marine 1991). The majority of winter-run

Chinook salmon spawners are 3 years old. Physical Habitat Simulation Model (PHABSIM) results (FWS 2003a) indicate winter-run Chinook salmon suitable spawning velocities in the upper Sacramento River are between 1.54 feet per second (fps) and 4.10 fps, and suitable spawning substrates are between 1 and 5 inches in diameter. Initial habitat suitability curves (HSCs) show spawning suitability rapidly decreases for water depths greater than 3.13 feet (FWS 2003a). Spring-run Chinook salmon spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994). PHABSIM results indicate spring-run Chinook salmon suitable spawning velocities in Butte Creek are between 0.8 fps and 3.22 fps, and suitable spawning substrates are between 1 and 5 inches in diameter (FWS 2004). The initial HSC showed suitability rapidly decreasing for depths greater than 1.0 feet, but this effect was most likely due to the low availability of deeper water in Butte Creek with suitable velocities and substrates rather than a selection by spring-run Chinook salmon of only shallow depths for spawning (FWS 2004).

The optimal water temperature for egg incubation is 44 °F to 54 °F (Rich 1997). Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The length of time required for eggs to develop and hatch is dependent on water temperature and is quite variable. Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61 °F and 37 °F, respectively, when the incubation temperature was held constant.

Winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence occurring generally at night. Spring-run Chinook salmon fry emerge from the gravel from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean (Kjelson *et al.* 1981). Post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

When juvenile Chinook salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration. Emigration of juvenile winter-run Chinook salmon past RBDD may begin as early as mid-July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997a). From 1995 to 1999, all winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). The emigration timing of Central Valley spring-run Chinook salmon is highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998). The emigration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, Central Valley spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001; MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54 ºF to 57 ºF (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54 ºF by February in a typical year. Other portions of the Delta (*i.e.*, South Delta and Central Delta) can reach 70 ºF by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

As Chinook salmon fry and fingerlings mature, they prefer to rear further downstream where ambient salinity may reach 1.5 to 2.5 parts per thousand (Healy 1980, 1982; Levings *et al.* 1986). Juvenile winter-run Chinook salmon occur in the Delta from October through early May based on data collected from trawls, beach seines, and salvage records at the Central Valley Project (CVP) and State Water Project (SWP) pumping facilities (CDFG 1998). The peak of listed juvenile salmon arrivals in the Delta generally occurs from January to April, but may extend into June. Upon arrival in the Delta, winter-run Chinook salmon spend the first 2 months rearing in the more upstream, freshwater portions of the Delta (Kjelson *et al.* 1981, 1982). Data from the CVP and SWP salvage records indicate that most spring-run Chinook salmon smolts are present in the Delta from mid-March through mid-May depending on flow conditions (CDFG 2000a).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1986) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicates that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Winter-run Chinook salmon fry remain in the estuary (Delta/Bay) until they reach a fork length of about 118 mm (*i.e.*, 5 to 10 months of age) and then begin emigrating to the ocean perhaps as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998). Little is known about estuarine residence time of spring-run Chinook salmon. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry. Spring-run yearlings are larger in size than fall-run yearlings and are ready to smolt upon entering the Delta; therefore, they are believed to spend little time rearing in the Delta.

b. *Population Trend – Sacramento River Winter-run Chinook Salmon*

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

Following the construction of Shasta Dam, the number of winter-run Chinook salmon initially declined but recovered during the 1960s. The initial recovery was followed by a steady decline from 1969 through the late 1980s following the construction of the RBDD. Since 1967, the estimated adult winter-run Chinook salmon population ranged from 117,808 in 1969, to 186 in 1994 (FWS 2001a,b; CDFG 2002b). The population declined from an average of 86,000 adults in 1967 to 1969 to only 1,900 in 1987 to 1989, and continued to remain low, with an average of 2,500 fish for the period from 1998 to 2000 (see Appendix B: Figure 5). Between the time Shasta Dam was built and the listing of winter-run Chinook salmon as endangered, major impacts to the population occurred from warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, acid mine drainage from Iron Mountain Mine, and entrainment at a large number of unscreened or poorly-screened water diversions (NMFS 1997a, 1998).

Population estimates in 2001 (8,224), 2002 (7,441), 2003 (8,218), 2004 (7,701) and 2005 (15,730) show a recent increase in the escapement of winter-run Chinook salmon. The 2005 run was the highest since the listing. Winter-run Chinook salmon abundance estimates and cohort replacement rates since 1986 are shown in Table 1. The population estimates from the RBDD counts has increased since 1986 (CDFG 2004a), there is an increasing trend in the 5 year moving average (491 from 1990-1994 to 5,451 from 1999-2003); and the 5 year moving average of cohort replacement rates has increased and appears to have stabilized over the same period (Table 1).

Table 1. Winter-run Chinook salmon population estimates from RBDD counts, and corresponding cohort replacement rates for the years since 1986 (CDFG 2004a, Grand Tab CDFG February 2005).

Year	Population Estimate (RBDD)	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated Juvenile Production Estimate (JPE)[a]
1986	2,596	-	-	-	
1987	2,186	-	-	-	
1988	2,885	-	-	-	
1989	696	-	0.27	-	
1990	433	1,759	0.20	-	
1991	211	1,282	0.07	-	40,100
1992	1,240	1,092	1.78	-	273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	3,002	1,340	2.31	2.48	454,792
1999	3,288	1,961	2.46	2.80	289,724
2000	1,352	1,972	1.54	2.90	370,221
2001	8,224	3,349	2.74	2.76	1,864,802
2002	7,441	4,661	2.26	2.22	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,701	6,587	0.94	2.71	881,719
2005	15,730	9,463	2.11	2.83	3,831,286
median	1,769	1,550	1.78	2.49	338,107

[a] JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

c. *Status - Sacramento River Winter-run Chinook Salmon*

Numerous factors have contributed to the decline of winter-run Chinook salmon through degradation of spawning, rearing and migration habitats. The primary impacts include blockage of historical habitat by Shasta and Keswick Dams, warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, heavy metal contamination from Iron Mountain Mine, high ocean harvest rates, and entrainment in a large number of unscreened or poorly screened water diversions within the Central Valley. Secondary factors include smaller water manipulation facilities and dams, loss of rearing habitat in the lower Sacramento River and Delta from levee construction, marshland reclamation, and interactions with, and predation by, introduced non-native species (NMFS 1997a, 1998).

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stem primarily from the following: (1) ESA section

7 consultation Reasonable and Prudent Alternatives (RPAs) on temperature, flow, and operations of the CVP and SWP; (2) Regional Board decisions requiring compliance with Sacramento River water temperatures objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from the California Bay Delta Authority (CBDA) Bay-Delta Program (*e.g.*, installation of a fish screen on the Glenn-Colusa Irrigation District (GCID) diversion); (5) establishment of the CBDA Environmental Water Account (EWA); (6) EPA actions to control acid mine runoff from Iron Mountain Mine; and (7) ocean harvest restrictions implemented in 1995.

The susceptibility of winter-run Chinook salmon to extinction remains linked to the elimination of access to most of their historical spawning grounds and the reduction of their population structure to a small population size. Recent trends in winter-run Chinook salmon abundance and cohort replacement are positive and may indicate some recovery since the listing. Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the recovery goals established for the run (NMFS 1997a, 1998) and the naturally spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0.

d. *Population Trend – Central Valley Spring-run Chinook Salmon*

Historically, the predominant salmon run in the Central Valley was the spring-run Chinook salmon, which occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne and Merced Rivers extirpated Central Valley spring-run Chinook salmon from these watersheds. Naturally-spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon are spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from two fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (NMFS 2003, Good *et al.* 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

Since 1969, the Central Valley spring-run Chinook salmon ESU (excluding Feather River fish) has displayed broad fluctuations in abundance ranging from 25,890 in 1982 to 1,403 in 1993 (CDFG unpublished data). Even though the abundance of fish may increase from one year to the next, the overall average population trend has a negative slope during this time period (see Appendix B: Figure 6). The average abundance for the ESU was 12,499 for the period of 1969 to 1979, 12,981 for the period of 1980 to 1990, and 6,542 for the period of 1991 to 2001. In 2002 and 2003, total run size for the ESU was 13,218 and 8,775 adults respectively, well above the 1991-2001 average.

Evaluating the ESU as a whole masks significant changes that are occurring among basin metapopulations. For example, while the mainstem Sacramento River population has undergone a significant decline, the tributary populations have demonstrated substantial increases. The average population abundance of Sacramento River mainstem spring-run Chinook salmon has recently declined from a high of 12,107 fish for the period 1980 to 1990, to a low of 609 for the period between 1991 and 2001, while the average abundance of Sacramento River tributary populations increased from a low of 1,227 to a high of 5,925 over the same period. Although tributaries such as Mill and Deer Creeks have shown positive escapement trends since 1991, recent escapements to Butte Creek, including 20,259 in 1998, 9,605 in 2001 and 8,785 in 2002, are responsible for the overall increase in tributary abundance (CDFG 2002a, 2004b; CDFG, unpublished data). The Butte Creek estimates, which account for the majority of this ESU, do not include prespawning mortality. In the last several years as the Butte Creek population has increased, mortality of adult spawner has increased from 21 percent in 2002 to 60 percent in 2003 due to over-crowding and diseases associated with high water temperatures. This trend may indicate that the population in Butte Creek may have reached its carrying capacity (Ward *et al.* 2003) or has reached historical population levels (*i.e.*, Deer and Mill creeks). Table 2 shows the population trends from the three tributaries since 1986, including the moving 5 year average, cohort replacement rate, and estimated JPE.

Table 2. Spring-run Chinook salmon population estimates from CDFG Grand Tab (February 2005) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated JPE[a]
1986	24,263	-	-	-	4,396,998
1987	12,675	-	-	-	2,296,993
1988	12,100	-	-	-	2,192,790
1989	7,085	-	0.29	-	1,283,960

1990	5,790	12,383	0.46	-	1,049,277
1991	1,623	7,855	0.13	-	294,124
1992	1,547	5,629	0.22	-	280,351
1993	1,403	3,490	0.24	0.27	254,255
1994	2,546	2,582	1.57	0.52	461,392
1995	9,824	3,389	6.35	1.70	1,780,328
1996	2,701	3,604	1.93	2.06	489,482
1997	1,431	3,581	0.56	2.13	259,329
1998	24,725	8,245	2.52	2.58	4,480,722
1999	6,069	8,950	2.25	2.72	1,099,838
2000	5,457	8,077	3.81	2.21	988,930
2001	13,326	10,202	0.54	1.94	2,414,969
2002	13,218	12,559	2.18	2.26	2,395,397
2003	8,902	9,9394	1.63	2.08	1,613,241
2004	9,872	10,155	0.74	1.78	1,789,027
2005	14,312	11,926	1.08	1.23	2,593,654
median	7,994	9,172	1.33	1.74	1,448,601

[a] NMFS calculated the spring-run JPE using returning adult escapement numbers to the Sacramento River basin prior to the opening of the RBDD for spring-run migration, and then escapement to Mill, Deer, and Butte Creeks for the remaining period, and assuming a female to male ratio of 6:4 and pre-spawning mortality of 25 percent. NMFS utilized the female fecundity values in Fisher (1994) for spring-run Chinook salmon (4,900 eggs/female). The remaining survival estimates used the winter-run values for calculating JPE.

The extent of spring-run Chinook salmon spawning in the mainstem of the upper Sacramento River is unclear. Very few spring-run Chinook salmon redds (less than 15 per year) were observed from 1989 through 1993, and none in 1994, during aerial redd counts (FWS 2003a). Recently, the number of redds in September has varied from 29 to 105 during 2001 though 2003 depending on the number of survey flights (CDFG, unpublished data). In 2002, based on RBDD ladder counts, 485 spring-run Chinook salmon adults may have spawned in the mainstem Sacramento River or entered upstream tributaries such as Clear or Battle Creek (CDFG 2004b). In 2003, no adult spring-run Chinook salmon were believed to have spawned in the mainstem Sacramento River. Due to geographic overlap of ESUs and resultant hybridization since the construction of Shasta Dam, Chinook salmon that spawn in the mainstem Sacramento River during September are more likely to be identified as early fall-run rather than spring-run Chinook salmon.

e. *Status of Spring-run Chinook Salmon*

The initial factors that led to the decline of spring-run Chinook salmon in the Central Valley were related to the loss of upstream habitat behind impassable dams. Since this initial loss of habitat, other factors have contributed to the instability of the spring-run Chinook salmon population and have negatively affected the ESU's ability to recover. These factors include a combination of physical, biological, and management factors such as climatic variation, water management activities, hybridization with fall-run Chinook salmon, predation, and over-harvesting (CDFG 1998). Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures.

During the drought from 1986 to 1992, Central Valley spring-run Chinook salmon populations declined substantially. Reduced flows resulted in warm water temperatures that impacted adults, eggs, and juveniles. For adult spring-run Chinook salmon, reduced instream flows delayed or completely blocked access to holding and spawning habitats. Water management operations (*i.e.,* reservoir release schedules and volumes) and the unscreened and poorly-screened diversions in the Sacramento River, Delta, and tributaries compounded drought-related problems by reducing river flows, elevating river temperatures, and entraining juveniles into the diversions.

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

2. Steelhead

a. *General Life History*

Steelhead can be divided into two life history types, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.,* summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

Winter steelhead generally leave the ocean from August through April, and spawn between December and May (Busby *et al.* 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. In general, the preferred water temperature for adult steelhead migration is 46 ^{o}F to 52 ^{o}F (McEwan and Jackson 1996, Myrick 1998, and Myrick and Cech 2000). Thermal stress may occur at temperatures beginning at 66 ^{o}F and mortality has been demonstrated at temperatures beginning at 70 ^{o}F, although some races of steelhead may have higher or lower temperature tolerances depending upon their evolutionary history. Lower latitudes and elevations would tend to favor fish tolerant of higher ambient temperatures (see Matthews and Berg (1997) for discussion of *O. mykiss* from Sespe Creek in Southern California). The preferred water temperature for steelhead spawning is 39 ^{o}F to 52 ^{o}F, and the preferred water temperature for steelhead egg incubation is 48 ^{o}F to 52 ^{o}F (McEwan and Jackson 1996, Myrick 1998, Myrick and Cech 2000). The minimum stream depth necessary for successful upstream migration is 13 cm (Thompson 1972). Preferred water velocity for upstream migration is in the range of 40-90 cm/s, with a maximum velocity, beyond which upstream migration is not likely to occur, of 240 cm/s (Thompson 1972, Smith 1973).

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Nickelson *et al.* 1992, Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams. Most steelhead spawning takes place from late December through April, with peaks from January though March (Hallock *et al.* 1961). Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity, and may spawn in intermittent streams as well (Everest 1973, Barnhart 1986).

The length of the incubation period for steelhead eggs is dependent on water temperature, dissolved oxygen (DO) concentration, and substrate composition. In late spring and following yolk sac absorption, fry emerge from the gravel and actively begin feeding in shallow water along stream banks (Nickelson *et al.* 1992).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Shirvell 1990, Meehan and Bjornn 1991). Some older juveniles move downstream to rear in large tributaries and mainstem rivers (Nickelson *et al.* 1992). Juveniles feed on a wide variety of aquatic and terrestrial insects (Chapman and Bjornn 1969), and older juveniles sometimes prey upon emerging fry.

Steelhead generally spend two years in freshwater before emigrating downstream (Hallock *et al.* 1961, Hallock 1989). Rearing steelhead juveniles prefer water temperatures of 45 EF to 58 EF and have an upper lethal limit of 75 EF. They can survive up to 81 EF with saturated DO conditions and a plentiful food supply. Reiser and Bjornn (1979) recommended that DO concentrations remain at or near saturation levels with temporary reductions no lower than 5.0 mg/l for successful rearing of juvenile steelhead. During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Bell (1973) found that silt loads of less than 25 mg/l permit good rearing conditions for juvenile salmonids.

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Barnhart (1986) reported that steelhead smolts in California range in size from 140 to 210 mm (fork length). Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River Basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall.

b. *Population Trends – Central Valley Steelhead*

Steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996). Steelhead were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alterations from numerous water diversion projects) and in both east and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996). The California Advisory Committee on Salmon and Steelhead (1988) reported a reduction of steelhead habitat from 6,000 miles historically to 300 miles currently. Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama *et al.* 1996).

Historic Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially (see Appendix B: Figure 7). Hallock *et al.* (1961) estimated an annual average of 20,540 adult steelhead in the Sacramento River upstream of the Feather River, up through 1960. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Nobriga and Cadrett (2003) compared CWT and untagged (wild) steelhead smolt catch ratios at Chipps Island trawl from 1998 through 2001 to estimate that about 100,000 to 300,000 steelhead juveniles are produced naturally each year in the Central Valley. In the draft *Updated Status Review of West Coast Salmon and Steelhead* (NMFS 2003), the Biological Review Team (BRT) made the following conclusion based on the Chipps Island data:

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

> compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s".

The only consistent data available on steelhead numbers in the San Joaquin River basin come from CDFG mid-water trawling samples collected on the lower San Joaquin River at Mossdale. These data (see Appendix B, Figure 8) indicate a decline in steelhead numbers in the early 1990s, which have remained low through 2002 (CDFG 2003). In 2003, a total of 12 steelhead smolts were collected at Mossdale (CDFG, unpublished data).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996).

Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, FWS, pers. comm. 2002, as reported in NMFS 2003, Good *et al*. 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, 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 (Demko *et al.* 2000). After 4 years of operating a fish counting weir on the Stanislaus River only two adult steelhead have been observed moving upstream, although several large rainbow trout have washed up on the weir in late winter (S.P. Cramer 2005). It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, if not abundant, throughout accessible streams and rivers in the Central Valley (NMFS 2003, Good *et al*. 2005).

c. *Status - Central Valley Steelhead*

Both the BRT (NMFS 2003, Good *et al*. 2005) and the Artificial Propagation Evaluation Workshop (69 FR 33102) concluded that the Central Valley steelhead DSP presently is "in danger of extinction". Steelhead have been extirpated from most of their historical range in this region. Habitat concerns in this DSP focus on the widespread degradation, destruction, and blockage of freshwater habitat within the region, and water allocation problems. Widespread hatchery steelhead production within this DSP also raises concerns about the potential ecological interactions between introduced stocks and native stocks. Because the Central Valley steelhead population has been fragmented into smaller isolated tributaries without any large source population and the remaining habitat continues to be degraded by water diversions, the population remains at an elevated risk for future population declines.

3. North American Green Sturgeon

a. *General Life History*

The North American green sturgeon have morphological characteristics of both cartilaginous fish and bony fish. The fish has some morphological traits similar to sharks, such as a cartilaginous skeleton, heterocercal caudal fin, spiracles, spiral valve intestine, electro-sensory pores on its snout and an enlarged liver. However, like more modern teleosts, it has five gill arches contained within one branchial chamber, covered by one opercular plate and a functional swim bladder for bouyancy control, Adult green sturgeon have a maximum fork length of 2.3 meters and 159 kg body weight (Miller and Lee 1980, Moyle *et al.* 1992). It is believed that green sturgeon can live at least 60 years, based on data from the Klamath River (Emmett *et al.* 1991).

The green sturgeon is the most widely distributed of the *acipenseridae*. They are amphi-Pacific and circumboreal, ranging from the inshore waters of Baja California northwards to the Bering Sea and then southwards to Japan. They have been recorded from at least six different countries: Mexico, United States, Canada, Russia (Sakhalin Island), Japan and Korea (Emmett *et al.* 1991, Moyle *et al.* 1992). Although widely distributed, they are not very abundant in comparison to the sympatric white sturgeon (*Acipenser transmontanus*).

(1) *Adult Distribution and Feeding*. In North America, spawning populations of green sturgeon are currently found in only three river systems: the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon. Spawning has only been reported in one Asian river, the Tumin River in eastern Asia. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (NMFS 2005a). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo Bays (Emmett *et al* 1991, Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Recent acoustical tagging studies on the Rogue River (Erickson *et al.* 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 15 ^{o}C and 23 ^{o}C. When ambient temperatures in the river dropped in autumn and early winter (<10 ^{o}C) and flows increased, fish moved downstream and into the ocean.

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, J. Stuart, unpublished data). Adult sturgeon caught in Washington state waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

(2) *Spawning*. Adult green sturgeon are gonochoristic (sex genetically fixed), oviparous and iteroparous. They are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (10 to 15 years based on sympatric white sturgeon sexual maturity). Younger females may not spawn the first time they undergo oogenesis and subsequently they reabsorb their gametes. Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al*. 2001). They have the largest egg size of any sturgeon, and the volume of yolk ensures an ample supply of energy for the developing embryo. The eggs themselves are slightly adhesive, much less so than the sympatric white sturgeon, and are more dense than than those of white sturgeon (Kynard *et al.* 2005). Adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July. Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates with crevices and interstices. Females broadcast spawn their eggs over this substrate, and the fertilized eggs sink into the interstices of the substrate where they develop further (Kynard *et al.* 2005).

(3) *Egg Development.* Green sturgeon larvae hatched from fertilized eggs after approximately 169 hours at a water temperature of 15 ^{o}C (Van Eenennaam *et al*. 2001, Deng *et al*. 2002), which is similar to the sympatric white sturgeon development rate (176 hours). Studies conducted at the University of California, Davis by Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14 ^{o}C and 17 ^{o}C. Temperatures over 23 ^{o}C resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5 ^{o}C and 22 ^{o}C resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14 ^{o}C, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

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

Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al*. 2002).

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other *acipenseridae*. The are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*.'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8 ^{o}C, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

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

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

b. *Population Trends –Southern population of North American Green Sturgeon*

Known historic and current spawning occurs in the Sacramento River (Adams *et al.* 2002, Beamesderfer *et al.* 2004). Currently, upstream migrations of sturgeon are halted by Keswick and Shasta Dams on the mainstem of the Sacramento River. Although no historical accounts exist for identified green sturgeon spawning occuring above the current dam sites, suitable spawning habitat existed and based on habitat assessments done for Chinook salmon, the geographic extent of spawning has been reduced due to the impassable barriers constructed on the river.

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

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

The size of the population of green sturgeon is difficult to estimate due to a lack of data specific for this fish. However, inferences from the commercial and sport fisheries harvest can be used to estimate population trends over time. Based on the harvest numbers, green sturgeon catch has decreased from a high of 9,065 in 1986 to 512 in 2003. The greatest decreases in harvest were for commercial gears in the Columbia River, Willapa Bay, and Greys Harbor. The decrease was attributed to changes in the regulatory statutes for sturgeon harvest (Adams *et al*. 2002). Catch rates for the Hoopa and Yurok tribal harvests remained unchanged during this same period and accounted for approximately 59 percent of the total harvest in 2003 (NMFS 2005a). Entrainment numbers at the SWP and CVP pumping facilities in the south Delta have been consistently lower than their levels in the mid -1970s (SWP) and the mid-1980s (CVP). Prior to 1986, the SWP (1968 -2001) averaged 732 green sturgeon salvaged per year, which dropped to 47 per year after 1986. The CVP (1980-2001) showed similar declines in its salvage rate for green sturgeon, 889 per year prior to 1986 and 32 per year after 1986.

c. *Status –Southern population of North American Green Sturgeon*

The southern population of green sturgeon historically was smaller than the sympatric population of white sturgeon in the San Francisco Bay estuary and its associated tributaries. The population has apparently been declining over the past several decades based on harvest numbers from sport and commercial fisheries and the entrainment rates at the CVP and SWP. The principle factor for this decline is the reduction of green sturgeon spawning habitat to a limited area below Keswick Dam on the Sacramento River. The construction of impassable barriers, particularly large dams, has greatly reduced the access of green sturgeon to their historical spawning areas. These barriers and their manipulation of the normal hydrograph for the river also have had detrimental effects on the natural life history of green sturgeon. Reduced flows have corresponded with weakened year class recruitment in the sympatric white sturgeon population and it is believed to have the same effect upon green sturgeon recruitment. Obstruction of natural sedmiment recruitment below large impoundments potentially has increased predation on larval and juvenile sturgeon due to a reduction in turbidity and loss of larger diameter substrate. In addition to the adverse effects of impassable barriers, numerous agricultural water diversions exist in the Sacramento River and the Delta along the migratory route of larval and juvenile sturgeon. Entrainment, or, if equipped with a fish screen, impingement are considered serious threats to sturgeon during their downstream migration. Fish screens have not been designed with criteria that address sturgeon behavior or swimming capabilities. The benthic oriented sturgeon are also more susceptible to contaminated sediments through dermal contact and through their feeding behavior of ingesting prey along with contaminated sediments before winnowing out the sediment. Their long life spans allow them to accumulate high body burdens of contaminants, that potentially will reach concentrations with deleterious physiological effects.

C. Habitat Condition and Function for Species' Conservation

The freshwater habitat of salmon, steelhead, and sturgeon in the Sacramento River, San Joaquin River, and Suisun Marsh watershed drainages varies in function depending on location. Spawning areas are located in accessible, upstream reaches of the Sacramento or San Joaquin Rivers and their watersheds where viable spawning gravels and water quality are found. Spawning habitat condition is strongly affected by water flow and quality, especially temperature, DO, and silt load, all of which can greatly affect the survival of eggs and larvae. High quality spawning habitat is now inaccessible behind large dams in these watersheds, which limits salmonids to spawning in marginal tailwater habitat below the dams. Despite often intensive management efforts, the existing spawning habitat below dams is highly susceptible to inadequate flows and high temperatures due to competing demands for water, which impairs the habitat function.

Migratory corridors are downstream of the spawning area and include the Delta and Suisun Marsh. These corridors allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions are impaired in each of these drainages by the presence of barriers, which can include dams, unscreened or poorly-screened diversions, inadequate water flows, and degraded water quality.

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 by salmonids, but such use has not been documented for sturgeon. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids and sturgeon. Some complex, productive habitats with floodplains remain in the Sacramento and San Joaquin River systems (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and the Yolo and Sutter bypasses). However, the channelized, leveed, and rip-rapped river reaches and sloughs that are common in the Delta and Suisun Marsh systems typically have lower habitat complexity, lower abundance of food organisms, and offer little protection from either fish or avian predators.

IV. ENVIRONMENTAL BASELINE

A. Factors Affecting the Species and Habitat

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley and Suisun Marsh. For example, NMFS prepared range-wide status reviews for West coast Chinook salmon (Myers *et al.* 1998), steelhead (Busby *et al.* 1996) and green sturgon (Adams *et al*. 2002, NMFS 2005a). Also, the NMFS BRT published a draft updated status review for West coast Chinook salmon and steelhead in November 2003 (NMFS 2003) and a final review in June 2005 (Good *et al*. 2005). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212, 59 FR 440, 62 FR 24588, 62 FR 43937, 63 FR 13347, 64 FR 24049, 64 FR 50394, 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Bay-Delta Program (CALFED 1999), and the

Final Programmatic EIS for the CVPIA (Department of Interior (DOI) 1999), provide an excellent summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley.

The following general description of the factors affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, North American green sturgeon and their habitat is based on a summary of these documents.

In general, the human activities that have affected the listed anadromous salmonids and their habitats consist of: (1) dam construction that blocks previously accessible habitat; (2) water development and management activities that affect water quantity, flow timing, quality, and stream function; (3) land use activities such as agriculture, flood control, urban development, mining, road construction, and logging that degrade aquatic and riparian habitat; (4) hatchery operation and practices; (5) harvest activities; and (6) ecosystem restoration actions.

1. Habitat Blockage

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

In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of the respective watersheds. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid-1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River (DOI 1999). On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon (CDFG 2001) as well as Central Valley steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967). These dams also had the potential to block any spawning populations of green sturgeon in these tributaries.

As a result of the dams, winter-run Chinook salmon, spring-run Chinook salmon, and steelhead populations on these rivers have been confined to lower elevation mainstems that historically only were used for migration. Population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Higher temperatures at these lower elevations during late-summer and fall are a major stressor to adults and juvenile salmonids. Green sturgeon populations would be similarly affected by these barriers and alterations to the natural hydrology.

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

2. Water Development

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids base their migrations. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses. Depleted flows have contributed to higher temperatures, lower DO levels, and decreased recruitment of gravel and large woody debris (LWD). More uniform flows year round have resulted in diminished natural channel formation, altered foodweb processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement (Mount 1995, Ayers 2001), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (FWS 2003b).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the Central Delta via the Delta Cross Channel; (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.).

3. Land Use Activities

Land use activities continue to have large impacts on salmonid habitat in the Central Valley watershed. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The degradation and fragmentation of riparian habitat had resulted mainly from flood control and bank protection projects, together with the conversion of riparian land to agriculture. Removal of snags and driftwood in the Sacramento and San Joaquin River basins has reduced sources of LWD needed to form and maintain stream habitat that salmon depend on in their various life stages.

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

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and removal of riparian vegetation, resulting in increased streambank erosion (Meehan 1991). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, *etc.* Agricultural practices in the Central Valley have eliminated large trees and logs and other woody debris that would otherwise be recruited into the stream channel (NMFS 1998). LWD influences stream morphology by affecting channel pattern, position, and geometry, as well as pool formation (Keller and Swanson 1979, Bilby 1984, Robison and Beschta 1990).

Since the 1850s, wetlands reclamation for urban and agricultural development has caused the cumulative loss of 79 and 94 percent of the tidal marsh habitat in the Delta downstream and upstream of Chipps Island, respectively (Conomos *et al.* 1985, Nichols *et al.* 1986, Wright and Phillips 1988, Monroe *et al.* 1992, Goals Project 1999). Prior to 1850, approximately 1400 km^2 of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin Rivers, and another 800 km^2 of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 of tidally influenced marsh, only about 125 km^2 of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999).

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

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years show a steady decline in the food sources available for juvenile salmonids and sturgeon and an increase in the clarity of the water due to a reduction in phytoplankton and zooplankton. These conditions have contributed to increased mortality of juvenile Chinook salmon, steelhead, and sturgeon as they move through the Delta.

4. Water Quality

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

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

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995).

Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids or the threatened green sturgeon. This may occur if a fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (EPA 1994). However, the more likely route of exposure to salmonids or sturgeon is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids and green sturgeon depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids and green sturgeon to contaminated sediments is similar to water borne exposures.

Low DO levels frequently are observed in the portion of the DWSC extending from Channel Point, downstream to Turner and Columbia Cuts. Over a 5-year period, starting in August 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). Over the course of this time period, there have been 297 days in which violations of the 5 mg/l DO criteria for the protection of aquatic life in the San Joaquin River between Channel Point and Turner and Columbia Cuts have occurred during the September through May migratory period for salmonids in the San Joaquin River. The data derived from the California Data Exchange Center files indicate that DO depressions occur during all migratory months, with significant events occurring from November through March when listed Central Valley steelhead adults and smolts would be utilizing this portion of the San Joaquin River as a migratory corridor (see Appendix A, Table 3).

Potential factors that contribute to these DO depressions are reduced river flows through the ship channel, released ammonia from the City of Stockton Wastewater Treatment Plant, upstream contributions of organic materials (*e.g.*, algal loads, nutrients, agricultural discharges) and the increased volume of the dredged ship channel. During the winter and early spring emigration period, increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility lowers the DO in the adjacent DWSC near the West Complex. In addition to the adverse effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations. Likewise, adult fish migrating upstream will encounter lowered DO in the DWSC as they move upstream in the fall and early winter due to low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed. Levels of DO below 5 mg/L have been reported as delaying or blocking fall-run Chinook salmon in studies conducted by Hallock *et al.* (1970). As the river water and its constituents move downstream from the San Joaquin River channel to the DWSC, the channel depth increases from approximately 8 to 10 feet to over 35 feet. The water column is no longer mixed adequately to prevent DO from decreasing by contact with the air–water interface only. Photosynthesis by suspended algae is diminished by increased turbidity and circulation below the photosynthetic compensation depth. This is the depth to which light penetrates with adequate intensity to carry on photosynthesis in excess of the oxygen demands of respiration. As the oxygen demand from respiration, defined as biological oxygen demand, exceeds the rate at which oxygen can be produced by photosynthesis and mixing, then the level of DO in the water column will decrease. Additional demands on oxygen are also exerted in non-biological chemical reactions in which compounds consume oxygen in an oxidation-reduction reaction.

5. Hatchery Operations and Practices

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (DOI 1999). For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

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

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

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

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

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

6. Commercial and Sport Harvest

a. *Ocean Harvest*

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

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

Ocean fisheries have affected the age structure of spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). There are limited data on spring-run Chinook salmon ocean harvest rates. An analysis of 6 tagged groups of FRH spring-run Chinook salmon by Cramer and Demko (1997) indicated that harvest rates of 3-year-old fish ranged from 18 percent to 22 percent, 4-year-old fish ranged from 57 percent to 84 percent, and 5-year-olds ranged from 97 percent to 100 percent. The almost complete removal of 5-year-olds from the population effectively reduces the age structure of the species, which reduces its resiliency to factors that may impact a particular year class (*e.g.*, pre-spawning mortality from lethal instream water temperatures).

(2) ***Green sturgeon***. Ocean harvest of green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries. A commercial fishery for sturgeon still exists within the Columbia River, where they are caught in gill nets along with the more commercially valuable white sturgeon. Since the southern population of green sturgeon migrates along the western coast of the United States and Canada, individuals of this DPS can be found along the entire coastline and thus are susceptible to commercial harvest in the waters of the northwest. A relatively significant proportion of the Columbia River population of green sturgeon has their origins in the southern population spawning areas, as determined by genetic markers. Green sturgeon are also caught by recreational fisherman, and it is the primary bottomfish landed in Willapa Bay, Washington. Within the San Francisco Bay estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun Bays (Emmett *et al.* 1991).

b. *Freshwater Sport Harvest*

(1) ***Chinook salmon.*** Historically in California, almost half of the river sportfishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on winter-run Chinook salmon caused by recreational angling in freshwater.

In 1992, the California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken spring-run Chinook salmon throughout the species' range. During the summer, holding adult spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of spring-run Chinook salmon in Mill, Deer, Butte and Big Chico creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for winter-run Chinook salmon; provide some level of protection for spring-run fish (CDFG 1998).

(2) ***Steelhead***. There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. Staley (1975) estimated the harvest rate in the American River during the 1971-1972 and 1973-1974 seasons to be 27 percent. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams (CDFG 2004c). Overall, this regulation has greatly increased protection of naturally produced adult steelhead.

(3) ***Green sturgeon.*** Green Sturgeons are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. As of March 2006, CDFG changed their fishing regulation so that no green sturgeon may be retained by fisherman in California waters. In July 2006, the CDFG reversed their earlier prohibition on the take of green sturgeon in California waters by sportfisherman. Currently the slot limits for sturgeon caught by sportfisherman in California waters are 46 to 72 inches with a daily bag limit of one fish. This protects the stocks of green sturgeon that are found within the same waters as the targeted white sturgeon.

7. Predation

Accelerated predation also may be a factor in the decline of winter-run Chinook salmon and spring-run Chinook salmon, and to a lesser degree steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961, Decato 1978, Vogel *et al.* 1988, Garcia 1989).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson Cottonwood Irrigation District's diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural riverbank vegetation, and at south Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to factors such as water quality and flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall (Vogel *et al.* 1988). In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters.

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

Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the State and Federal fish facilities, and the SMSCG. Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967, Pickard *et al.* 1982); however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997a).

8. Environmental Variation

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al.* 1999, Mantua and Hare 2002). This phenomenon has been referred to as the Pacific Decadal Oscillation. In addition, large-scale climatic regime shifts, such as the El NiZo condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

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

Salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Predation rates on juvenile and adult green sturgeon have not been adequately studied to date. Ocean predation may also contribute to significant natural mortality, although it is not known to what extent. In general, salmonids are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebound of seal and sea lion populations following their protection under the Marine Mammal Protection Act of 1972 has increased the number of salmonid deaths. This may be further exacerbated by the decline of other fisheries stocks (*i.e.* haddock, Pollock, and members of the genus *Sebastes*) which provided alternative forage resources to marine mammals.

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

The future effects of global warming are of key interest to salmonid and green sturgeon survival. It is predicted that Sierra snow packs will dwindle with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be rationally hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.,* winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods. Similar, although potentially to a lesser degree, declines in green sturgeon populations are anticipated with reduced cold water flows. Green sturgeon egg and larval development are optimized at water temperatures that are only slightly higher than those for salmonids. Lethal temperatures are similar to salmonids, although slightly higher than those for salmonids.

9. Ecosystem Restoration

a. *California Bay-Delta Authority*

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

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

The EWA is designed to provide water at critical times to meet ESA requirements and incidental take limits without water supply impacts to other users. In early 2001, the EWA released 290 thousand acre feet of water from San Luis Reservoir at key times to offset reductions in south Delta pumping implemented to protect winter-run Chinook salmon, delta smelt, and splittail. However, the benefit derived by this action to winter-run Chinook salmon in terms of number of fish saved was very small. The anticipated benefits to other Delta fisheries from the use of the EWA water are much higher than those benefits ascribed to listed salmonids by the EWA release.

b. *Central Valley Project Improvement Act*

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

c. *Iron Mountain Mine Remediation*

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

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

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

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Bay Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant, but unquantified benefits; to spring-run Chinook salmon attributed by CDFG (see Chapter 15, Reclamation 2004).

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District (OCID), CDFG, and DWR allows DWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cfs, only 12 cfs has been developed to date (Reclamation and OCID 1999). In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek (Reclamation and OCID 1999). In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. DWR, CDFG, and FWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

10. Non-native Invasive Species

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

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

11. Summary

For Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, the construction of high dams for hydropower, flood control, and water supply resulted in the loss of vast amounts of upstream habitat (*i.e.*, approximately 80 percent, or a minimum linear estimate of over 1,000 stream miles), and often resulted in precipitous declines in affected salmonid populations. For example, the completion of Friant Dam in 1947 has been linked with the extirpation of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River within just a few years. The reduced populations that remain below Central Valley dams are forced to spawn in lower elevation tailwater habitats of the mainstem rivers and tributaries that were previously not used for this purpose. This habitat is entirely dependent on managing reservoir releases to maintain cool water temperatures suitable for spawning, and/or rearing of salmonids. This requirement has been difficult to achieve in all water year types and for all life stages of affected salmonid species. Steelhead, in particular, seem to require the qualities of small tributary habitat similar to what they historically used for spawning; habitat that is largely unavailable to them under the current water management scenario. All salmonid species considered in this consultation have been adversely affected by the production of hatchery fish associated with the mitigation for the habitat lost to dam construction (*e.g.*, from genetic impacts, increased competition, exposure to novel diseases, *etc*.).

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

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

B. Existing Monitoring Programs

Salmon-focused monitoring efforts are taking place throughout the Sacramento and San Joaquin River basins, and the Suisun Marsh. Many of these programs incidentally gather information on steelhead but a focused, comprehensive steelhead monitoring program has not been funded or implemented in the Central Valley. The existing salmonid monitoring efforts are summarized in Table 4 (Appendix A) by geographic area and target species. Information for this summary was derived from a variety of sources:

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

Studies focused on the life history of green sturgeon are currently being implemented by researchers at academic institutions such as University of California. Davis. Future plans include radio-telemetry studies to track the movements of green sturgeon within the Delta and

Sacramento River systems. Additional studies concerning the basic biology and physiology of the fish are also being conducted to better understand the fish's niche in the aquatic system.

C. Presence of Listed Salmonids in the Action Area

Based on fish monitoring studies, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead juveniles and smolts from the Sacramento River watershed frequently enter into the central Delta system based on river flows and SWP and CVP pumping rates. Fish from the Sacramento River can access the interior of the Delta via the Mokelumne River and Georgiana Slough channels from the north. Three Mile Slough, and the mouth of the San Joaquin River near Antioch and Sherman Island provide access from the west to the interior of the Delta. Central Valley steelhead emigrating downstream in the San Joaquin River system have a high potential to move through the action area due to the flow split at the Head of Old River and the timing of their emigration in relation to the installation of the Head of Old River barrier (HORB).

The acute action area for the DWSP includes those portions of the San Joaquin River immediately adjacent to the intake structure in which the influence of the water withdrawal can reasonably be shown to affect fish transiting the area. Additional areas of minor impact, based on the CALSIM II modeling, and related to the slight changes in the hydrology and water quality characteristics of the instream flows, includes those reaches of rivers below state and federal water supply reservoirs, and in the conveyance channels leading to the state and federal water diversions facilities in the south Delta. Therefore, all listed salmonid populations in the Central Valley have the potential to experience the effects of the DWSP during their movements in the mainstems of the Sacramento and San Joaquin Rivers, as well as those tributaries which contain reservoirs operated by DWR or the CVP.

D. Presence of Green Sturgeon in the Action Area

Although the Sacramento River watershed is the identified migration route and spawning area for green sturgeon, both adult and juvenile green sturgeon are known to occur within the lower reaches of the San Joaquin River and into the interior of the Delta. Juveniles have been captured in the vicinity of Santa Clara Shoals, Brannan Island State Recreational Area and in the channels of the south Delta (Moyle *et al*. 1992, Beamesderfer *et al*. 2004). Green sturgeon also have been recovered at both the SWP and CVP pumping facilities on Old River near Tracy, indicating that they must have transited through one of the many channels of the south Delta to reach that location. Both adult and juvenile green sturgeon may use the Delta as a migratory, resting, or rearing habitat. Occurrence in the Delta could occur in any month, as juveniles may reside there during their first few years of growth. Adults are likely to be present in the winter and early spring as they move through the Delta towards their spawning grounds in the upper Sacramento River watershed. Following spawning, the fish will pass through the Delta again on their way back to the ocean, but the duration and timing of this event is not well understood in the Sacramento River system.

Those green sturgeons that make spawning runs up the Sacramento River may experience slight changes in the hydrology of the river due to the DWSP, as indicated by the computer simulation.

Likewise, larval and juvenile sturgeon would also experience the effects of the DWSP operations through the slight changes in the hydrology of the Sacramento River.

V. EFFECTS OF THE ACTION

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion assesses the effects of the City of Stockton DWSP on the endangered Sacramento winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon ESUs, the threatened Central Valley steelhead DPS and the southern population of North American green sturgeon DPS. The biological opinion also assesses the effects of the City of Stockton DWSP upon the critical habitat of these two Chinook salmon ESUs and the one steelhead DPS. The City of Stockton DWSP is likely to adversely affect listed species and critical habitat through disruption of aquatic habitat related to its construction, impingement of listed fish upon the fish screen during its operation resulting in morbidity and mortality and alterations in the flow and hydrological characteristics of waters within the Delta and in reaches of rivers and tributaries entering the Delta which convey SWP and CVP waters. In the *Description of the Proposed Action* section of this Opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this Opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

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

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

The regulatory definition of adverse modification has been invalidated by the courts. Until a new definition is adopted, NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species.

A. Approach to Assessment

1. Information Available for the Assessment

To conduct the assessment, NMFS examined evidence from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, governmental and non-governmental reports, and scientific meetings as well as the supporting information supplied with the action's environmental documents.

2. Assumptions Underlying This Assessment

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

The applicant and their consultants have made extensive use of the computer simulation programs CALSIM II and Delta Simulation Model (DSM2) in their analysis of the project's effects on hydrology and water quality. As described in Modeling Technical Appendix to the Draft EIR (Montgomery Watson Harza [MWH] 2005), the CALSIM II model represents the physical setup of the Central Valley water supply system as a network of nodes and arcs. The inputs of data to describe the physical and operational constraints of the system are based on modeler's mathematical interpretations of the system's behavior. The CALSIM II program optimizes the routing of water through the network via a linear program solver which determines the optimal set of decisions for each time step for a set of user defined priorities and system constraints. The primary purpose of the CALSIM II model is to evaluate the water supply reliability of the CVP and SWP at current levels of development. However, the model is a water allocation model that uses monthly mass balance accounting and cannot simulate the flow dynamics of the Delta that occur at temporal scales less than the 30 day monthly time step. This would include such phenomena as daily tidal oscillations or short-term rain driven events that occur at temporal scales less than the monthly time step. Since the model uses electrical conductivity (EC) as its surrogate for water quality, it has limited ability to represent water quality of other nonconservative water quality parameters such as DO or temperature. The model is not considered to be a reliable indicator of absolute values obtained under specific conditions, but is more useful in a comparative mode which looks at a project's impacts compared to the "no project" impacts in a relative fashion (MWH 2005, CALFED 2003, 2006).

Due to the reliance of the model's output on the software modeler's mathematical representation of the system, the accuracy of the output is dependent on the "trueness" of the mathematical algorithms to reality.

Likewise, the use of DSM2 is dependent on the mathematical representation of the physical characteristics and functions of the Delta hydrology. DSM2 is a branched, one-dimensional, physically-based numerical model of the Delta. The representation of tidal forcing in the western Delta is a mathematical representation of the tidal history over a 19-year period, which has been further modified to reflect the spring-neap tide fluctuations of the astronomical tide (MWH 2005). The DSM2 model further relies on the monthly averages of delta inflows derived in the CALSIM II model for its source of input data. Therefore, errors propagated in the CALSIM II modeling process are carried forward into the DSM 2 model.

NMFS understands that these models are currently the best available tools for hydrology modeling in the Central Valley, but also recognizes that these models have certain drawbacks and inadequacies in representing hydrological effects on listed salmonids. In particular, the fine temporal and spatial scales frequently needed to make informed decisions on the impacts of projects upon listed fish are not readily available from the computer simulations. The degree of resolution needed to make biologically relevant determinations is not provided by these planning tools in their current configuration. Rather the model output represents a homogenized averaging of values. This smoothing of data points starts with the 30-day time step in the CALSIM II modeling approach and is propagated through the DSM2 model where it serves as the delta inflow data point for the subsequent DSM2 calculations for the current month's simulation run. Additionally, the models assume that flow is the same across the entire cross section of a given channel (one-dimensional) and that water quality constituents, as represented by the EC parameter, behave in the same manner as the salts that compose the EC parameter.

Due to the lack of data for Pacific salmonids, NMFS will use the Atlantic salmon, as well as other fish species, as surrogates for the hearing sensitivities of Chinook salmon and steelhead. NMFS does not have any data available to it to determine the hearing sensitivities of green sturgeon, and thus will use the values for salmonids in its analysis of effects.

B. Assessment

The effects of the proposed project will fall into two main categories: the short-term construction related effects and the persistent long-term effects of the DWSP operations. NMFS considers that the short-term in-water construction related effects will be minor due to the application of the work window of July 1 through November 30 and the isolation of future structural work on the water intake in a dewatered area behind the installed cofferdam. This work window will avoid the vast majority of listed salmonids that have the potential to be present in the channel of the San Joaquin River during their migration through the Delta but will invariably overlap with the presence of green sturgeon in the Delta, which are believed to reside there year-round. As part of the construction related effects, NMFS has also considered the disruption of the benthic and riparian habitat in the action area due to the installation of the diversion facility's cofferdam and wing walls and the potential for frac-outs during the crossings of Honker Cut and Bishop Cut by the raw water pipeline. The effects of long-term operations of the DWSP are more difficult to assess. NMFS will examine the impacts of the water diversion's fish screen in a hydrologic environment that will have an oscillatory behavior due to natural tidal and river flow variables. These hydraulic variables will move the sweeping current in both an upstream and downstream direction relative to the fish screen location creating periods of zero sweeping velocity during the periods of slack tide. In addition to the effects of the proposed project in the immediate vicinity of the diversion on the San Joaquin River, the effects of the DWSP's water diversion on flows in other portions of the Central Valley's water supply network will be examined.

1. Short-term Construction Effects

a. Water Intake Construction

The timeline and physical aspects of the construction phase of the DWSP water intake facility will help to avoid or minimize adverse impacts to listed fish, particularly the listed salmonids that inhabit the project area. The project's in-water work is scheduled to occur during the dry season (July 1 through November 30) when the different runs of Chinook salmon and steelhead in the Central Valley are most likely to be absent from the construction area. However, individuals of the southern population of North American green sturgeon may potentially be present in the project construction area year round.

Other aspects of the construction action will contribute to the avoidance and minimization of adverse impacts to listed salmonids and green sturgeon. The timeline for the in-water work component of the excavation and site work is of a short duration, scheduled to last approximately 11 weeks. These activities include dredging of the river channel bottom and bank, installation of wing walls and a cofferdam, application of rock rip-rap to the wing walls, and dewatering of the construction zone. Furthermore, the volume of material to be dredged (6,900 cubic yards) and rip rap to be positioned (833 cubic yards) is a comparatively small volume compared to other dredging and levee maintenance projects in the region. The footprint of the project is also relatively small. The entire intake project area is situated on 5.7 acres. The project in-water construction area measures 250 feet wide by 1000 feet long. However, if the timeline of the construction activities slips so that construction is initiated later in the work window (*i.e.*, September through November), the risk of exposing listed salmonids to the adverse conditions of the construction activities increases due to the higher probability of listed salmonids (*i.e.*, Central Valley steelhead adults and Sacramento River winter-run Chinook salmon juveniles) entering the action area during their migrational movements in late fall.

The following sections will describe the specific actions of the project that are likely to have adverse effects upon the aquatic habitat and the listed southern population of North American green sturgeon. Impacts to listed salmonids are also included in light of the potential for these fish to be present later in the work window (*i.e.* September through November).

(1) *Pile Driving and Sheet Pile Driving.* The installation of the sheet pile cofferdam and wing walls along the perimeter of the intake structure work zone will require the use of a percussion pile driver or vibratory pile driver to drive the steel sheets into the substrate of the river bottom. The wing walls will extend out 60 feet from the existing levee bank into the channel of the San Joaquin River at an angle. The cofferdam will close off the mouth of the intake structure, allowing the workspace behind it to be dewatered. Following the installation and dewatering of the work area, concrete pilings will be driven into the excavated work area to support the intake structure and fish screen racks (see table 2-3 in Associates 2006).

High levels of underwater acoustic noises have been shown to have adverse impacts upon fish within close proximity of the noise source. The City of Stockton has indicated that the pile driving activity for the sheet pile installation will take place over a period of 3 weeks. Sheet piles are driven into the substrate until a predetermined level of resistance is encountered by the hammer. This typically is measured as the number of hammer blows required to move the sheet pile (or concrete pile) a certain distance into the substrate (*e.g.* number of blows to move 1 foot in depth). Energy transferred to the sheet pile by the hammer is partially redirected as acoustic energy and heat as the pile loses energy to the surrounding medium (*i.e.,* soil or rock). As sound propagates away from the source, several factors change its amplitude (Burgess and Blackwell 2003). These factors include the spreading of the sound wave over a wider area (spreading loss), losses to friction between water or sediment particles that vibrate with the passing sound wave (absorption), scattering and reflections from boundaries and objects in the sound's path and constructive and destructive interference with one or more reflections of the sound off "solid" surfaces such as the seafloor or water surface. The sound level measured at any given point along the path of the propagated sound wave includes all of these effects and is termed the received level. The sum of all of the propagation and loss effects on a signal is called the transmission loss and is the difference between the received level and the source level.

The project location has several factors which may alter the transmission of the propagated sound waves into the channel of the San Joaquin River during the pile driving activities. The channel depth varies over a wide range in the reach adjacent to the project site. Along the levee bank, the depth drops off rapidly to approximately 20 feet in depth. The dredged ship channel, which is approximately 35 feet in depth at low tide, passes to the south of the project site, while a secondary channel and shoal formation lies to the southeast of the project site (see Figure 3). These changes in bottom contours will create conditions that will attenuate the propagation of sound through the channel (null spots). In addition, ambient noise from river flow, boat traffic, and irregular surfaces such as the rip rapped surface of the levees may create additional acoustic signals that muffle or cancel out the acoustic signal from the pile driving actions (masking). Installation of the concrete support pilings for the intake structure is anticipated to take place in the dewatered work area behind the coffer dam. The acoustic noise derived from the pile driving of the concrete support piles is expected to primarily be propagated through the soil to the aquatic environment, rather than through the air (coupled transmission).

Based on previous pile driving consultations, NMFS believes that the source acoustic signal will be in excess of 180 dB (re: 1 µPa) for percussion hammers. Data derived from concrete piles driven at the Pier 95 Amport facility and the Concord Naval Weapons Depot in Suisun Bay both indicated pile driving noise levels exceeded 170 to 180 dB (re: 1 µPa) 10 meters from the pile at a depth of 3 meters. A report by Burgess and Blackwell (2003) indicated that vibratory installation of a sheet pile wall in an upland position generated sound levels of approximately 140 dB (re: 1µPa) in the adjacent waterway at a distance of 200 feet, indicating that the noise was coupled through the soil to the water column.

Based on available reports, salmonids (Atlantic salmon-*Salmo salar*) hear within the range of 10 Hz to approximately 400 Hz (Hawkins and Johnstone 1978). The greatest sensitivity (lowest threshold for sound detection) for Atlantic salmon was 95 dB at 150 Hz; from there threshold levels increased for both higher and lower frequencies, to 107 dB at 32 Hz and 132 dB at approximately 360 Hz. Above approximately 400 Hz, Atlantic salmon are functionally deaf.

Recent studies by Scholik and Yan (2002) studied the effects of boat engine noise on the auditory sensitivity of the fathead minnow. The majority of noise generated from the motor is derived from the cavitation of the propeller as it spins in the water. Fish were exposed to a recording of the noise generated by a 55 hp outboard motor over a period of two hours. The noise level was adjusted to 142 dB (re: 1μPa), which was equivalent to the noise levels measured at 50 meters from a 70 hp outboard motor. The experimental fish suffered a drop in hearing sensitivity over the range of frequencies normally associated with their hearing capabilities. These responses were measured using electrophysiological responses of their auditory nerves under general anesthesia. Studies by McCauley, Fewtrell, and Popper (2003) on the marine pink snapper, indicated that high-energy noise sources (approximately 180 dB [re: 1μPa] maximum) can damage the inner ears of aquatic vertebrates by ablating the sensory hairs on their inner ear epithelial tissue as revealed by electron microscopy. Damage remained apparent in fish held up to 58 days after exposure to the intense sound. Although little data from studies utilizing salmonids is available, NMFS assumes that some level of adverse impacts to salmonids can be inferred from the above results. Exposures of these other fish species can serve as surrogates for salmonids. Adverse effects were measured in these surrogates following as little as 2 hours of exposure to 142 dB (re: 1μPa) sound energy.

The loss of hearing sensitivity may adversely affect a salmonid's ability to orient itself (*i.e.,* due to vestibular damage), detect predators, locate prey, or sense their acoustic environment. Fish also may exhibit noise-induced avoidance behavior that causes them to move into less-suitable habitat. In the City of Stockton's DWSP, this may result in salmonids fleeing the channel edge near the pile driving activities and moving into the central channel habitat which harbors open water predators such as striped bass. Likewise, chronic noise exposure can reduce their ability to detect piscine predators either by reducing the sensitivity of the auditory response in the exposed salmonid or masking the noise of an approaching predator. Disruption of the exposed salmonid's ability to maintain position or swim with the school will enhance its potential as a target for predators. Unusual behavior or swimming characteristics single out an individual fish and allow a predator to focus its attack upon that fish more effectively.

Green sturgeon are benthically oriented fish and spend considerable time in contact with the bottom. Acoustic noise generated by the pile driving and sheet pile installation activities will expose these fish to elevated noise both through water conducted sound waves, and those propagated through the substrate (coupled transmission). It is unclear to what degree the two pathways of sound conduction will affect exposed green sturgeon. NMFS assumes that fish so exposed will experience a drop in their hearing sensitivity, but due to differences in the behavior of sturgeon compared to salmonids the level of effects may be dissimilar in how the fish respond to this drop in hearing sensitivity.

(2) *Turbidity and Sediment Resuspension.* The pile driving and dredging activities will create conditions that will increase local turbidity through the resuspension of sediment. Using data from previous dredging actions, estimates of dredge created turbidity have indicated that dredging will result in an approximately 10 percent increase in total suspended solids downstream of the dredging action (Regional Board 2004). NMFS will also use this estimate for the installation of the sheet piles and the placement of the rock rip-rap along the wing walls. This additional level of turbidity should not greatly change conditions in the San Joaquin River compared to background turbidity levels except within the immediate area of the construction activities.

Suspended sediments can adversely affect salmonids in the area by clogging sensitive gill structures (Nightingale and Simenstad 2001) but are generally confined to turbidity levels in excess of 4,000 mg/L. Based on the best available information, NMFS does not anticipate that turbidity levels associated with the sheet pile installation or dredging action itself will increase to these deleterious levels. However, responses of salmonids to elevated levels of suspended sediments often fall into three major categories: physiological effects, behavioral effects, and habitat effects (Bash *et al.* 2001). The severity of the effect is a function of concentration and duration (Newcombe and MacDonald 1991, Newcombe and Jensen 1996) so that low concentrations and long exposure periods are frequently as deleterious as short exposures to high concentrations of suspended sediments. A review by Lloyd (1987) indicated that several behavioral characteristics of salmonids can be altered by even relatively small changes in turbidity (10 to 50 nephelometric turbidity units (NTUs)) that are expected to result from this project. Salmonids exposed to slight to moderate increases in turbidity exhibited avoidance, loss of station in the stream, reduced feeding rates and reduced use of overhead cover. Reaction distances of rainbow trout to prey were reduced with increases of turbidity of only 15 NTUs over an ambient level of 4 to 6 NTUs in experimental stream channels (Barret *et al.* 1992). Increased turbidity, used as an indicator of increased suspended sediments, also is correlated with a decline in primary productivity, a decline in the abundance of periphyton, and reductions in the abundance and diversity of invertebrate fauna in the affected area (Lloyd 1987, Newcombe and MacDonald 1991). These impacts to the aquatic environment decrease the availability of food resources for salmonids and sturgeon through trophic energy transfers from the lowest trophic levels (*i.e.,* phytoplankton and periphyton) through intermediate levels (*e.g.,* invertebrates) to higher trophic levels (*i.e.*, salmonids and sturgeon).

Resuspension of contaminated sediments may have adverse effects upon salmonids or green sturgeon that encounter the sediment plume, even at low turbidity levels. Lipophilic compounds in the fine organic sediment, such as toxic polyaromatic hydrocarbons (PAHs), can be preferentially absorbed through the lipid membranes of the gill tissue, providing an avenue of exposure to salmonids or green sturgeon experiencing the sediment plume (Newcombe and Jensen 1996). Such exposures to PAHs have been linked with declines in the immune systems of exposed fish as well as damage to genetic material through formation of breaks or adducts on the DNA strands. Similarly, charged particles such as metals (*e.g.*, copper), may interfere with ion exchange channels on sensitive membrane structures like gills or olfactory rosettes. This reduces the sensitivity of fish to detect smells or chemical cues in their environment and may interfere with ion exchange metabolism across cellular membranes necessary for osmoregulation. Increases in ammonia from the sediment may create acutely toxic conditions for salmonids or green sturgeon present in the channel's margins.

Based on the timing of the dredging and pile driving actions (July 1 through November 30), NMFS expects the majority of the direct impacts created by these activities to be experienced by adult and juvenile green sturgeon, which are present in the Delta year round, adult Central Valley steelhead migrating upstream into the watersheds of the Mokelumne, Calaveras and San Joaquin Rivers in fall (October and November), and early migrating Sacramento winter-run Chinook salmon juveniles passing into the Central Delta from the Sacramento River system during the later portion of the in-water work window (November). Passage of winter-run Chinook salmon juveniles into the Central Delta and the San Joaquin River system is through one of the interconnecting channels from the Sacramento River (*i.e.*, Georgiana Slough, the Mokelumne River system via the Delta Cross Channel Gates near Walnut Grove, and Three Mile Slough) and by tidal circulation near Chipps Island in the West Delta. Although some steelhead smolts may be migrating downstream at this time too, their numbers are expected to be low compared to the peak of migration in spring and would tend to be associated with rain events or pulse flow operations on the tributaries.

Increased flows in the main channel of the San Joaquin River, as a result of pulse flows or precipitation in October and November, are expected to ameliorate the negative effects of increased turbidity by shortening the duration of migration through the action area and diluting the resuspended sediments in the water column. Similarly, winter-run Chinook salmon juveniles often exhibit early migrational behaviors that are correlated with rainfall events and increased turbidity in the Sacramento River. Increased turbidity due to rain run off is expected to be similar to or greater than that generated within the construction area by dredging and pile driving activities. However, it should be noted that precipitation events in the upper Sacramento River watershed (*i.e.*, near Redding or Red Bluff, California) are not indicative of precipitation events occurring concurrently in the Delta or San Joaquin River watersheds. Thus, flows and hence ambient turbidity, may be markedly different between the two watersheds at the same point in time.

Therefore, actions that take place early in the work window are expected to have negligible effects on listed salmonids since the likelihood of their presence in the action area is considered low. Should in-water work be postponed or started later in the work window (*i.e.*, September, October or November), then the probability of in-water work overlapping with listed fish presence increases as previously explained.

The exposure risk to green sturgeon is less clear. It can be anticipated that juvenile and adolescent green sturgeon could be found year-round in the central Delta, particularly in the deeper sections of the DWSC based on sturgeon behavior and their preference for deep holes in river channels. Presence on the shallower margins of the river is likely to occur at night, when fish are foraging in those areas. Therefore, the elevated turbidity levels created by the dredging and sheet pile installation during the daylight construction period may not persist into the night when sturgeon could be anticipated to move into the work area, thus reducing their exposure potential.

b. *Raw Water Pipeline*

The installation of the raw water pipeline is expected to have minimal direct effects upon listed salmonids or green sturgeon. The work window for the drilling of the pipeline under Honker and Bishop Cuts is scheduled to occur during the dry summer period, when listed salmonids are not expected to be present in the project area. However, green sturgeon may be present during that time period based on their year-round residency in the waterways of the Delta. The crossing of these two waterways (*i.e.*, Honker Cut and Bishop Cut) will necessitate two separate bores under the channels of the two waterways. These bores will utilize one of the two trenchless construction methods; bore and jack, or HDD (see Section II. Project Description).

The concern for habitat disruption resulting from the crossing of the waterways arises from the loss of riparian habitat at the crossing alignment and from the potential for a "frac-out" to occur. In a typical crossing, vegetation along the alignment is cleared to allow for visual inspection of the pipeline route. In the application of HDD or bore and jack techniques, vegetation clearing occurs only in a finite area surrounding the entrance and exit points of the crossing. The siting of the entrance and exit points for a HDD crossing typically occurs at a substantial distance away from the banks of the waterbody to be crossed. This accommodates the curvature of the pipeline as it crosses under the waterway along the lumen of the bore hole. The pits dug for the entrance and exit points of a bore and jack crossing usually are closer to the banks of the waterway than in the HDD method, but are relatively smaller in surface area.

The potential for a "frac-out" to occur is highest for the HDD method. The drill bit used to bore the lumen of the pipeline hole is lubricated by a slurry of bentonite mud. Bentonite is a non-toxic mud made of mineral clays but its particle size is very fine in diameter. This can make respiration difficult for organisms exposed to this compound. The particles adhere to the cellular surface of gill structures and block gas transfer across the membrane. In addition, the bentonite clays can form a dense layer along the bottom of the waterway in the vicinity of a frac-out which will smother organisms that cannot move out of the impacted area. Frac-outs occur when a fissure or other weakness in the integrity of the overlying soil along the pipeline alignment is encountered. The high pressure of the pumped slurry ruptures through the fissure and is carried towards the surface. If the fissure is large enough, then the bentonite mud is dispersed into the overlying water column; otherwise the mud forms a "clot" in the fissure and seals the fissure. The techniques for dealing with frac-outs typically are addressed in the contingency plan. The operators of the drill may reduce operating pressure on the mud, change the density of the mud to achieve better sealing of the fissure, or in a worst-case scenario, abandon the bore, and select a new alignment. If the frac-out is large and a significant volume of mud has been spilled, then a clean up protocol is implemented to remove the bentonite mud from the bottom of the river channel.

Frac-outs as described above do not occur with bore and jack techniques. The pieces of equipment required for a bore and jack operations are lowered into the pits on either side of the water crossing and the bore is progressed through the substrate under the waterway in sections. Since the bore is conducted at atmospheric pressure, there is no chance for materials to be forced into the overlying waterbody through a fissure in the overlying substrate. If such a fissure were encountered, water from the overlying waterbody would leak down into the bore and would need to be pumped out of the bore pit to an upland area. Therefore, if both bores are conducted using bore and jack techniques, adverse effects to listed salmonids, or green sturgeon are not anticipated.

2. Long-term Operational Effects

a. *Water Intake Fish Screen*

(1) ***Fish Screen Characteristics*** - The fish screens for the Stockton DWSP were designed utilizing the criteria recommended by NMFS engineering staff, as well as those from the CDFG and the FWS (NMFS 1997b, CDFG 2000b). As designed, the screens will exceed the criteria for juvenile salmonids by being protective of Delta smelt (*Hypomesus transpacificus*), a fish with inferior swimming capabilities compared to juvenile salmonids. The flat plate style fish screens will be installed at a slight angle from vertical, facilitating cleaning and debris removal. It will be oriented parallel to the ambient flow in the river for both upstream and downstream directions of tidal flow (*i.e.* essentially parallel to the bank). Transitions from the upstream and downstream wing walls will be constructed so as to minimize the creation of eddies or turbulent flow that could concentrate juvenile fish or provide a predator holding zone for ambush attacks of juvenile salmonids passing by the screen. The screen is designed to have an approach velocity equal to or less than 0.2 fps. Tuning vanes behind the screen will allow for adjustment of the approach velocity to equalize flow patterns across the face of the screen and to minimize any "hot" spots which may occur. The screen will be designed to have openings no more than 1.75 mm wide which will prevent fish larger than 25 mm from becoming entrained or wedged into the screen openings.

The NMFS fish screen criteria for salmonids require that the sweeping velocity be greater than the approach velocity, while the CDFG criteria require that the sweeping velocity be twice the approach velocity. The design sweeping velocity for the Stockton DWSP is 0.4 fps. However due to tidal flow in the San Joaquin River at the site of the DWSP, the sweeping velocity can only be met approximately 80 to 85 percent of the time at the intake site. These departures from the necessary sweeping velocity occur during slack tide periods when the tidal flow changes from flood tide to ebb tide and again from ebb tide to flood tide. This occurs essentially 4 times a day at the turn of the tide. The amount of time during the day when the sweeping velocity does not meet the design criteria of the fish screen is equal to approximately 4 hours, with approximately 2 hours of no demonstrable sweeping velocity at all (15 minutes of slack water before and after the peak tidal oscillation, four times a day).

The amount of exposure time to the fish screen is based on the sweeping velocity and the length of the fish screen. At the initial operating capacity of 30 mgd, NMFS estimates that the screen length will be 30 feet and the time of exposure will be 75 seconds, based on the 0.4 fps sweeping velocity. The time of exposure to the screen will increase to 300 seconds (5 minutes) when the diversion rate is at full capacity (*i.e.*, 160 mgd and the proposed length of the fish screen face is 120 feet),. The distance a "passive" particle is affected by the water intake is a function of pumping capacity and the effective surface area that the particle is passing through, which determines its approach velocity at that point in space. NMFS developed a series of calculations to determine the approach velocity of particles at different distances from the screen face and under different pumping rates. For example, according to calculations performed by NMFS staff, at the initial pumping capacity of 30 mgd, the approach velocity at a distance of 5 feet from the screen is approximately 0.067 fps. A "passive" particle entering at the upstream side of the screen will be pulled approximately 5 feet towards the screen (0.067 fps * 75 seconds). When the pumping capacity is at full design, 160 mgd, the same particle at 25 feet will be pulled into the screen (0.083 fps * 300 seconds = 24.95 feet). However during the 15 to 20 percent of the time when sweeping velocities are below the design criteria of 0.4 fps, the exposure time increases significantly. Thus, particles will be affected at a greater distance from the screen than during the design flows. Conversely when flows in the river are greater than 7,200 cfs, then the sweeping flows will be greater than 0.4 fps.

Another significant factor affecting the duration of exposure to the screen is the influence of the tidal oscillations in the channel. Fish moving downstream on their emigration to the ocean may experience several exposures to the screen as they move back and forth with the tidal flow. It is expected that fish will exhibit some type of behavioral response to the tidal flow and hold in sections of the river with reduced flow velocities when the tides begin to push back upstream (Webb 1995). Juvenile salmonids likely will move either to the margins of the river channel or move deeper in the water column to take advantage of breaks in the flow field where tidal velocities are reduced, thus conserving energy and maximizing the efficiency of their downstream emigration.

(2) ***Juvenile Chinook Salmon Behavior.*** Juvenile salmonids that are exposed to the screen will behave in certain generalized patterns. Recent experiments by Swanson, *et al.* (2004) exposed juvenile Chinook salmon to a simulated fish screen in a large annular flume. During daylight experiments, fish generally swam steadily into the current around the channel of the flume. In low- to moderate-sweeping velocity regimes, the fish swam in groups but at higher sweeping velocities the fish tended to disperse. During nighttime experiments, fish did not school but were randomly distributed around the annular flume. As sweeping velocities increased, fish typically increased their swimming velocities in response to the greater velocity. Fish also swam faster during the day than they did at night under identical flow regimes. Increases in approach velocities did not significantly affect swimming velocities.

Juvenile Chinook salmon tended to exhibit positive rheotaxis, swimming against the resultant current at all times, with the exception of larger fish in warmer waters (19 ^{o}C), which showed a tendency to swim with the current "downstream" as the experiment progressed. Positive rheotaxis increased with increases in water velocity, except for the larger fish already mentioned. During daylight experiments, fish moved further away from the screen as sweeping velocities increased. During nighttime experiments, the preferred distance fish held from the screen was not affected by changes in the sweeping velocity. Changes in approach velocity did not significantly affect swimming location relative to the screen face. Smaller fish tended to swim further away from the screen than did larger fish.

The incidence of impingement was very low (< 1 percent) in experimental fish. However, juvenile Chinook salmon experienced frequent temporary contacts with the screen surface, particularly with their tails (80 percent of contacts). The frequency of contact with the screen during the daylight experiments was inversely proportional to the sweeping velocity, with the highest rate of screen contacts made when sweeping velocities were absent. This would tend to indicate that fish had a lower precision of avoidance when the fish could not orient to the flow correctly. Screen contacts were also higher at night than during the daylight, and were unaffected by velocity. The greatest difference between nighttime and daytime contact frequencies occurred when the sweeping velocity was high. Even though fish responded to the flow field around them, they were unable to detect the "porous" screen or even other fish and the rate of incidental contacts increased significantly over the daytime values.

The rate of morbidity was very low following the incidental contacts with the screen in these experiments. However, this could be a reflection of the benign environmental conditions under which the experiments took place. There were no predators, and the post-experiment observation period only lasted 48 hours. In the field, screens may have debris and other anomalies on their surface which could produce abrasions to the skin of the fish. These wounds to the skin of the juvenile salmonid would create an opening for pathogens to colonize, and possibly cause morbidity or mortality in the affected fish later on. In addition, predators may seize the opportunity to mount attacks on juvenile salmonids that are dazed by the contact with the screen, or otherwise concentrated around the surface of the screen while holding position against the current.

(3) ***Juvenile Chinook Salmon and Steelhead Distribution***. The potential for the DWSP fish screen to impact juvenile and adult salmonids is also influenced by the site conditions and the location of fish within the channel itself. The northern bank of the San Joaquin River in the area of the intake site is heavily riprapped with stone and generally denuded of riparian or emergent vegetation. The quality of the aquatic habitat on the northern bank of the river for the rearing of juvenile salmonids is considered poor in this reach. To the south of the dredged ship channel, the margins of the river have several small vegetated islands that are remnants of the original river channel (ESA 2006). Radio-telemetry studies (Vogel 2004, 2005) indicated that approximately 50 percent of the tagged juvenile Chinook salmon (smolt and yearling-sized) that entered the project area from upstream moved through the San Joaquin River channel in the project reach. The other half moved into Turner and Columbia Cuts before reaching the project area. These same studies indicated that these larger juveniles moved downstream in the center of the channel, rather than along the margins of the channel. However, beach seining conducted by the FWS and CDFG routinely captures smaller juvenile Chinook salmon, which would preferentially use the velocity refugia along the banks to hold and rear. Beach seining at Venice Island has recovered fish in the size range appropriate juvenile spring-run Chinook salmon during the months of January and February (Bay Delta and Tributaries Project (BDAT) 2006). Venice Island is slightly more than 2 miles downriver from the intake site and fish from this river location could reasonably be expected to be present in the locale of the intake under different hydrological conditions (*i.e.*, low San Joaquin River flows and spring tides). Similarly, juvenile Central Valley steelhead have been captured in mid-water trawls in the region during most of the winter months and early spring months (January through May). It is estimated that only a few hundred to a few thousand juvenile steelhead emigrate from the San Joaquin River basin and the Calaveras River watershed in any given year. It is not known how these larger steelhead juveniles distribute themselves in the channel, but it is assumed that they behave similarly to larger Chinook salmon smolts and yearlings.

b. *Reservoir Carryover Capacity*

The computer simulation modeling conducted by the applicant has indicated that there are subtle, yet pervasive effects on the water storage and conveyance operations in the Central Valley of California. These effects include reductions in net Delta outflow on the San Joaquin River (QWEST), decreases in water supplied to contractors of the CVP and SWP, and decreases in the volume of water carried over at the end of the hydrologic year in area reservoirs operated by the state and Federal water systems. These changes in water operations are slight, yet are consistent throughout the modeling runs using the comparative study analysis. Effects follow consistent trends based on the projected growth trends of the future level of development forecasts.

The effects on upstream reservoir carryover storage typically are small, yet represent a factor that could have significant impacts to reservoir operations and downstream water temperature compliance for listed salmonids. The modeling indicates that at the 2003 level of development, the changes under the proposed DWSP operations (30 mgd) will affect carryover storage in CVP north of Delta (NOD) reservoirs only slightly, with an average decline of approximately 0.2 percent. However, when broken down by water year type, the impacts in critically dry years become more pronounced: Trinity Reservoir is reduced by 1.2 percent; Folsom reservoir is reduced by 1.8 percent; Shasta Reservoir is reduced by 0.45 percent; and Oroville Reservoir is reduced by 1.5 percent. New Hogan Reservoir shows the largest decline in carryover with an average of 7.5 percent, and up to 10.9 percent in critically dry years. However, the applicant has stated that this is due to the increase in Stockton East Water District's increased diversion of municipal and industrial water to supply the growth of the COSMA region and is not directly related to the DWSP. This trend in decreasing carryover storage continues in the 2015 level of development studies. When the simulation is carried out to the projected full diversion capacity of 160 mgd in 2050, the carryover capacities of the different reservoirs are further diminished. Of note is the decrease in carryover capacity in Trinity and Shasta Reservoirs of nearly 4 percent in critically dry years (MWH 2005).

Reductions in the end of year carryover capacity of these key reservoirs may impact listed salmonids and green sturgeon outside of the localized project area. The key concern NMFS has with changes in the end of year carryover storage is management of tailwater temperatures in the current year and the management of water operations in the ensuing year due to lowered carryover volume. The computer simulations indicate that in critically dry years the carryover capacity of the key reservoirs will be diminished. This decrease in the pool of cold water behind the dams may decrease the ability to manage aquatic habitat for listed salmonids, and, for green sturgeon which also have cool water preferences.

The Sacramento River below Keswick Dam is essential for the survival of the endangered Sacramento River winter-run Chinook salmon ESU. Diminishing the cold-water pool behind Shasta dam may inhibit the ability of resource managers to control the temperature of the Sacramento River in the late summer and early fall when river temperatures begin to rise to levels deleterious to salmonids. At this time of year, juvenile Sacramento River winter-run Chinook salmon and Central Valley steelhead are still rearing in this reach of the river and would be exposed to the elevations in the water temperature. Elevated water temperatures may cause the juvenile fish to move out of the impacted reaches into water conditions more suitable to their physiology. This may create either an upstream migration towards the cooler reaches closer to Keswick Dam or into tributaries where cold water refugia may exist, such as Battle Creek. This migration to cooler waters may lead to increased crowding which can decrease food availability and cause disease outbreaks among the crowded fish already stressed by increased water temperatures. Such ecosystem effects likely would lead to the diminishment of the physiological status of the affected fish, leading to lower survival rates during their later emigration to the Delta and ocean. The simulations indicate that in critically dry years, when cool water resources may already be limiting factors in the survival of the endangered Sacramento River winter-run Chinook salmon and the threatened Central Valley steelhead residing in the Sacramento River, there will be additional reductions to an already limited resource. Similar scenarios are anticipated on the Feather River below Lake Oroville (spring-run Chinook salmon and steelhead) and on the American River below Folsom Dam (steelhead).

The temperature modeling conducted by the applicant indicates that under the different levels of development there will be increased variability in the river temperatures compared to the baseline conditions. The frequency of departures from the baseline temperatures (2003-no project) increased with increased pumping rates, level of development, and with the drier water year types. Although the comparative studies of the computer simulations indicate that these changes are on the order of less than 1 ^{o}F, these are monthly averages and not indicative of short term temperature fluctuations occurring on a daily or weekly basis. Such short-term temperature fluctuations are just as critical as monthly averages to the physiology of the affected salmonid or green sturgeon. The monthly averages tend to smooth out the biologically relevant daily and weekly fluctuations that could lead to mass fish migrations or mortalities.

The applicant has also indicated that these temperature fluctuations and carryover volumes may be artifacts of the mathematical algorithms used in the modeling of the computer simulation.

VI. CUMULATIVE EFFECTS

For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultations pursuant to section 7 of the ESA.

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

The Delta and East Bay regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, are expected to increase in population by nearly 3 million people by the year 2020 (California Commercial, Industrial, and Residential Real Estate Services Directory 2002). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. The General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east and Highway 205/120 in the south and west. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require Federal permits, and thus will not undergo review through the section 7 consultation process.

Increased urbanization also is expected to result in increased wave action and propeller wash in Delta waterways due to increased recreational boating activity in the surrounding Delta. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids. Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta. In addition to recreational boating, commercial vessel traffic is expected to increase with the redevelopment plans of the Port of Stockton. Portions of this redevelopment plan have already been analyzed by NMFS (NMFS 2005b) for the West Complex (formerly Rough and Ready Island) but the redevelopment of the East Complex, which currently does not have a Federal action associated with it, will also increase vessel traffic as the Port becomes more modernized. Commercial vessel traffic is expected to create substantial entrainment of aquatic organisms through ship propellers as the vessels transit the shipping channel from Suisun Bay to the Port and back again. In addition, the hydrodynamics of the vessel traffic in the confines of the channel will create sediment resuspension, and localized zones of high turbulence and shear forces. These physical effects are expected to adversely affect aquatic organisms, including both listed salmonids and North American green sturgeon resulting in death or injury.

VII. INTEGRATION AND SYNTHESIS

A. Effects on Listed Species

The impacts of the short-term construction phase of the DWSP are expected to be avoided or minimized through application of work windows for in-water activities and appropriate construction BMPs. The long-term operation of the project is expected to create the most significant adverse effects to listed salmonids and green sturgeon within the action area. The operation of the fish screen is not expected to cause significant direct mortality of listed salmonids or green sturgeon from its operation. The fish screen will, however, cause some adverse impacts to listed juvenile salmonids and green sturgeon that come within its zone of influence. As described in the effects analysis, fish that are entrained into the flow field in front of the screen will alter their swimming behavior in response to it. Smaller fish and most larger fish will swim against the current while trying to maintain position in front of the screen face. This sustained swimming against the current will be energetically expensive and will diminish the energy reserves of affected fish. The swimming capacity of these fish may diminish with prolonged exposure, increasing the frequency of "touches" to the screen face. Most of these "touches" will involve only the tail or a small proportion of the body, but as described in the fish treadmill studies, a proportion are expected to be full body impingements. These contacts may remove the protective mucous coating of the fish or even lead to abrasions of the fish's skin. This can lead to infections by opportunistic pathogens such as bacteria or fungus that are present in the waters of the Delta. If the fish are already in a compromised physiological state due to poor water quality, warm water temperatures, or the process of smoltification, then infections may lead to increased levels of mortality. Increased contacts with the screen are expected to occur during the night and when sweeping velocities are diminished, as would occur during the slack water periods at the changing of the tides. Larger fish (*i.e.*, smolts and yearlings) would also tend to have higher rates of "touches" due to their preference for swimming closer to the screen than smaller fish as described in the fish treadmill experiments (Swanson, *et al*. 2004).

NMFS does not expect any salmonids or green sturgeon to actually be entrained through the screen under normal operating conditions due to the small openings of the wedge wire screen. The width of juvenile salmonids and green sturgeon life stages that are anticipated to be present in the vicinity of the intake are wider than the 1.75 mm width of the proposed screen, and thus under normal approach velocities the fish could not pass through the wire screen. It may be possible in very wet years for Chinook salmon yolk sac fry or alevins to be present in the Delta due to high runoff, but the origins of these fish are most likely to be from the San Joaquin River or Mokelumne River basins and thus would be fall-run Chinook salmon. During these types of hydrological events, the Delta Cross Channel is closed and Sacramento River basin fry would have to transit through Georgiana Slough or channels further west and then travel back upstream to come into the project area. In order to move upstream against the ambient flow, these weak swimming fry would have to take advantage of flood tides and use them to move upstream into the project locale. NMFS considers this to be an unlikely event.

NMFS anticipates that a proportion of the juvenile salmonids that are drawn into the zone of influence around the fish screen will be lost to predation. As indicated in the fish treadmill studies, fish tend to school together when under the influence of low to moderate sweeping velocities during daytime exposures. This congregation of fish holding station in a limited area likely will attract predators such as striped bass or large mouth bass. As observed at the SWP and CVP fish screens, significant predation can occur in front of the screens as juvenile salmonids hold station in front of the screens before encountering the bypasses. In addition, fish holding station against the current set up by the sweeping and approach currents will reduce their energy reserves and eventually fatigue. This may increase the capture success of attacking predators due to reduced swimming capacity of the small, juvenile salmonids. The dispersion of fish during the nighttime would indicate that predators would have to switch tactics in order to be successful. Attacks likely would be mounted on individual fish rather than on groups. It is unclear, however, whether daytime or nighttime attacks would be more successful.

It is also unclear, due to the lack of appropriate data, what effect the fish screens will have on juvenile green sturgeon. NMFS expects that entrainment and impingement rates for juvenile sturgeon larger than 60 to 80 mm will be similar or less than salmonids of similar size. This is the size of green sturgeon when they undergo metamorphosis from larval fish to juvenile fish at 45 days of age and begin to have active swimming behavior. Prior to this metamorphosis, green sturgeon larvae have axial fin folds and weak swimming capabilities. Sturgeon swimming behavior is more bottom oriented than juvenile salmonids, and thus the fish are expected to remain in the slower currents associated with the bottom boundary layer.

The distribution of fish in the channel will reduce the adverse effects of the screen to a large degree. As previously discussed, it is assumed that the majority of juvenile salmonids that emigrate down the San Joaquin River past the intake location do so along the southern margin of the river opposite the project water intake where small islands and vegetated banks are more common than along the northern bank of the river channel. In addition, according to telemetry studies (Vogel 2004, 2005), a large proportion of the emigrating salmonids follow the channels of Turner and Columbia Cuts into the south Delta and away from the San Joaquin River main channel. Although these fish may not benefit by moving into the South Delta and may become entrained by the CVP and SWP water diversions, they would not suffer adverse effects from the DWSP under review.

The effects of the DWSP upon reservoir operations and water deliveries are difficult to quantify. The comparative studies between the “no project” and “project” computer simulation runs indicate that the DWSP will have subtle yet widespread effects on the water operations of the CVP and SWP. The applicant’s environmental documents have indicated that additional discharges of reservoir water may be needed to ensure water quality criteria in the Delta, namely the X2 position in the western Delta. These releases would be in response to the diversion of water by the DWSP, which has the potential to shift the X2 position upstream. These shifts in the X2 position would require that the SWP and CVP release water to move it back downstream or, alternatively, to reduce diversions at the South Delta pumping facilities to bring the Delta back into “balance”.

In light of the inability of the computer simulations to give empirical predictive values for future effects, NMFS will provide a general narrative concerning the future effects of the DWSP upon listed fish in affected river reaches within the Central Valley. The most pressing concern is the impacts of reservoir carryover storage in the Trinity and Shasta reservoirs. These two reservoirs supply water to the Sacramento River and it is their operation that allows fishery managers to have some control over water temperatures in the tailwater reaches below Keswick Dam. The only spawning habitat that is still accessible and utilized by the endangered Sacramento River winter-run Chinook salmon is the reach of the Sacramento River below Keswick Dam, downstream to about Bend Bridge. As the only extant population left in the wild, it is highly vulnerable to extirpation by natural or anthropogenic factors. Water quality, including water temperature, is one of the key factors affecting the viability of this remaining population. During periods of dry and critically dry hydrology, maintaining the appropriate water temperatures in this reach of the Sacramento River is key to the survival of the winter-run Chinook salmon ESU. Excessive water temperatures in the spawning reach will lead to egg mortality or abnormalities in the development of the embryos themselves. Likewise, yolksac larvae, alevins, and fry need the appropriate cool water for proper growth and survival. Since winter-run Chinook salmon spawn in the late spring and early summer, developing eggs must have appropriate incubation temperatures during the heat of summer when water demands are at their highest. Water temperatures typically can be held during this period through the use of a temperature control structure on Shasta Dam, which draws water from the appropriate depth to supply the desired water temperature. However, as the summer progresses, water levels drop in Lake Shasta and drawing water from a depth with the correct temperature characteristics becomes more difficult as the cold water pool diminishes. During dry and critically dry years, this cold-water pool is already smaller than usual and maintaining the cool water flow necessary for the survival of winter-run Chinook salmon below Shasta becomes more difficult to achieve. The computer simulations indicate that the carryover storage will be diminished during these water year types, by less than 1 percent at the initial operating level (2003) but up to 4 percent in the final operating level of 160 mgd in 2050. It is not indicated in the simulations how much the cold water pool is decreased by these operations, which is of paramount importance to managing downstream water temperatures for winter-run Chinook salmon. Since the data derived from the computer simulation was based on total end of year carry over capacity in the reservoirs, the percentage of reduction in the cold-water pool is expected to be greater due to the smaller volume and accelerated depletion from maintaining cold water flows for fishery management purposes during the hot summer period. Thus, in dry and critically dry years, the cold-water pool in the reservoir is expected to be consumed faster than it is currently, and the ability to maintain cool water flows for fishery needs may be compromised. The likely result of exhausting the cold-water pool would be leaving the juveniles rearing below the dam vulnerable to excessive water temperatures in the early fall.

Similar effects would be seen below other Central Valley reservoirs where end of year storage has been decreased. Central Valley spring-run Chinook salmon and Central Valley steelhead would be exposed to increased warming of the tailwater flows on the Feather River below Lake Oroville. Spring-run Chinook salmon spawn during the late summer and early fall and are particularly susceptible to late season warming of their aquatic habitat. Steelhead which spawn in the winter and spring will have fry and juveniles that will require cool water for survival during the late summer and early fall when cool water pools will be at their lowest volume. The American River's population of Central Valley steelhead also will face tailwater warming based on the reduction in carry over volume in Folsom Lake.

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2 ^{o}C and 7 ^{o}C by 2100 (Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Dettinger *et al.* 2004, Dettinger 2005), with a drier hydrology predominated by precipitation rather than snowfall. This would indicate that reservoirs may not fill as completely as before, and that the crucial cold-water pools necessary for maintaining cool water over the summer and fall will be smaller than previously seen. The impacts of global warming and reduced precipitation have not been included in the applicant's computer simulation, but rather the hydrology has been modeled on the past with the assumption that the past will be reflected in future hydrological events. This assumption may lead to an overly optimistic forecast for future hydrology and the level of water demands in a region with an increasing population.

The applicant has indicated that the initially proposed level of water diversion, 30 mgd, will be maintained until the new City of Stockton General Plan has been developed. This new General Plan will define the expected growth and development for the COSMA beyond the current General Plan which was finished in 1996. New environmental documents (California Environmental Quality Act – CEQA) and permits will need to be developed and implemented before the water diversion can be expanded, which should give NMFS additional opportunities to review the effects of the increased diversion above the current 30 mgd. This is expected to occur sometime around 2015. During the intervening years, real world data will become available to augment the computer simulations and give a clearer picture of the effects of the DWSP.

B. Effects on Species Likelihood of Survival and Recovery

1. Central Valley Steelhead DPS

NMFS does not anticipate that Central Valley steelhead adults and juveniles will occur in any appreciable numbers within the construction area during the proposed work windows (July 1 through November 30). There is a potential for adult steelhead to be present in the construction area very late in the construction window (October - November) following flow increases in area rivers to attract fall-run Chinook salmon. These elevated flows can draw fish into the system. Barring any delays in the initial construction schedule, dredging, pile driving, cofferdam installation, and the placement of riprap should have already occurred by the time these flow increases are implemented. Therefore, construction of the infrastructure of the intake will take place behind the cofferdam, effectively separating the work activities from the river channel and the fish and thus avoiding or minimizing any potential adverse effects of the project's construction phase upon listed fish in the area. However, if construction is delayed and these actions are initiated in late summer or early fall (September through November), the risk of adverse effects to listed Central Valley steelhead increases substantially.

NMFS anticipates that the operation of the proposed project will result in the exposure of a small number of adult and juvenile Central Valley steelhead each year to the direct effects of the fish screen. These effects should occur predominantly to juvenile fish since healthy adult fish should be able to easily avoid the currents present at the screen. The effects related to the operation of the screen will include impingement resulting in elevated stress due to contact with the screen, potential infections from abrasions and loss of protective mucous resulting from contact with the screens, fatigue from holding position in front of the screen while being swept down current in front of the screen, and predation losses from predators congregating around the screens. The Central Valley steelhead that are expected to have direct exposure to the screens are assumed to originate in the San Joaquin River basin or the Calaveras River basin, although a very low number of fish could originate from the Mokelumne River or Sacramento River watersheds and migrate through the Central Delta to the location of the DWSP fish screens.

Estimates of adult escapement of steelhead to the San Joaquin River and Calaveras River watersheds are typically only a few dozen or so fish annually. Therefore the populations of emigrating smolts are projected to be fairly low. This is reflected by the low number of smolts captured by monitoring activities throughout the year in different tributaries (*i.e.*, rotary screw traps on the Stanislaus, Tuolumne, Merced, and Calaveras Rivers, and the Mossdale trawls on the San Joaquin River below the confluence of these tributaries) in which only a few dozen smolts to several hundred smolts are collected each year (Marston 2004, Cramer 2005). These capture numbers have been extrapolated to estimate an annual population of only a few thousand juvenile steelhead smolts basin-wide in the San Joaquin River region. The Stanislaus River weir, which is used to count adult steelhead passing through the counting chamber or dead carcasses floating back onto the weir, has only recorded a few adult fish each year it has been in use. This is indicative of the low escapement numbers for adult steelhead in this watershed (Cramer 2005). The other watersheds are thought to have similar or even lower numbers based on the superiority of the Stanislaus River in terms of habitat and water quality for Central Valley steelhead.

Given the low numbers of emigrating smolts entering the main channel of the San Joaquin River from the San Joaquin and Calaveras Rivers, and the assumption that few of these fish would then occur within the nearshore waters adjacent to the intake location, the number of steelhead smolts that would encounter the screen is believed to be very low. The efficiency of the screen for preventing entrainment of steelhead smolts, which are frequently greater than 150 mm in length, is nearly 100 percent. Thus, there should be no direct mortality due to impingement of fish upon the screen, as healthy steelhead smolts should be able to avoid whole body impingement that would result in immediate mortality or severe injury. Those fish that do have “touches” against the screen may incur sublethal injuries due to abrasions from materials lodged against the screen, which subsequently may become infected by bacterial or fungal pathogens. A small proportion of these fish are expected to die.

The indirect effects of the DWSP extend throughout a significant proportion of the Central Valley steelhead DPS home range. The tailwaters below the Federal and State reservoirs in the Sacramento Valley provide most of the remaining habitat for Central Valley steelhead. These reservoirs, which now block access to the original upstream habitats of these fish, provide a source of cool water which is necessary for the survival of salmonids in the lower elevation waterways of the hot Central Valley. Although both adult and juvenile steelhead are found in these waters, the juvenile life stages are believed to be most susceptible to the adverse effects of elevated water temperatures due to their year round occupancy. Juvenile steelhead have been reported to tolerate water temperatures approaching 24 ^{o}C (Nielsen *et al.* 1994, Myrick and Cech 2004, Lindley *et al.* 2006), but air temperatures on the valley floor of the Central Valley commonly exceed 26 ^{o}C during the year. Therefore, reductions in the cold-water pool or increased frequency or extent of excursions of water temperatures above baseline conditions are anticipated to have adverse effects upon Central Valley steelhead residing in those waters. The level of impact may not reach incipient lethal temperatures resulting in mortality, but reductions in the area of suitable habitat downstream of the affected dams, and reductions in physiological fitness resulting from adverse effects to respiration, metabolism, food resources, disease, etc., are likely to occur.

NMSF anticipates that the occurrence of these adverse effects, which are attributable to the downstream operations of the DWSP, will occur in dry or critically dry years when upstream water resources are limited. These effects would be exacerbated in multi-year droughts in which the reduced carry-over volumes in the reservoirs are perpetuated and exacerbated from one dry year to the next. When viewed with the predicted climate changes due to accelerated global warming in mind, the frequency of dry and critically dry years in these watersheds is anticipated to increase.

2. Sacramento River Winter-run Chinook salmon ESU

NMFS does not anticipate that Sacramento River winter-run Chinook salmon adults will occur in any demonstrable numbers within the construction area during the proposed work window (July 1 through November 30). Therefore, impacts from the initial construction phase of the DWSP are not likely to adversely affect adult winter-run Chinook salmon. There is a slight potential for juvenile winter-run Chinook salmon to be present in the construction area very late in the construction window (November) following a high precipitation event. However, as explained above, NMFS expects this exposure to be benign due to the installation of the cofferdam early in the work window (*i.e.,* June or July). The presence of the cofferdam will effectively separate the work activities from the river channel. If the start of construction activities are delayed until early fall (*e.g.*, September), then the dredging, pile driving and riprapping actions may overlap with the presence of early arriving winter-run Chinook salmon in the action area and the probability of adverse effects from construction activities increases substantially.

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile Sacramento River winter-run Chinook salmon to the direct effects of the fish screen. As described previously for Central Valley steelhead, effects due to the screen are expected to impact juvenile fish since healthy adult salmon should be able to avoid the screen with minimal effort due to their larger size and greater swimming capacity. These screen-related effects on juveniles are likely to include impingement resulting in elevated stress due to contact with the screen, potential infections from abrasions and loss of protective mucous resulting from contact with the screens, fatigue from holding position in front of the screen while being swept down current in front of the screen, and predation losses from predators congregating around the screens.

Winter-run juveniles originate from spawning areas in the Sacramento River main-stem between Keswick Dam and Red Bluff. These juveniles enter the Central Delta through several channels, including Georgiana Slough, Three Mile Slough, and the Mokelumne River system via the Delta Cross Channel gates. Juveniles can start arriving in the Delta as early as November based on salvage records at the CVP and SWP pumping facilities. However the main emigration of juveniles occurs between early January and late March and appears to be correlated with higher flow events in the Sacramento River. These higher flow events result in pulses of fish arriving in the Delta system. The frequency of juveniles moving upstream from the confluence of the Mokelumne River with the mainstem San Joaquin River is unknown and likely is influenced by tidal flows, San Joaquin River outflow, and the CVP and SWP pumping rates. NMFS expects that the number of juvenile winter-run Chinook salmon that move upstream as far as the DWSP intake to be a small fraction of the total number entering the San Joaquin River via the Mokelumne River channel. NMFS estimates this number to be on the order of several hundred to several thousand fish. Those fish that actually encounter the screen’s zone of influence will be a significantly smaller subset of this number. At the initial pumping rate of 30 mgd, NMFS estimates the rough extent of the zone of influence to be approximately 35 feet when the sweeping velocity is at 0 fps and the full 30 minutes of slack tide is utilized (0.02 fps approach velocity x 1800 seconds = 36 feet). Therefore, for a channel width of approximately 2,500 feet at the DWSP, from north bank to south bank of the San Joaquin River, including mid-channel islands, the radius of influence at slack tide extends less then 1.5 percent into the channel width. When the pumping rate is at its maximum, 160 mgd, the zone of influence will be approximately 80 feet at slack tide (0.044 fps x 1800 seconds = 80 feet) and the radius of influence form the screens extends out approximately 3 percent of the channel width.

Of the fish encountering the screen, NMFS expects these screens to be greater than 95 percent effective at preventing morbidity and mortality, since the approach velocity is designed for the Delta smelt criteria (0.2 fps) rather than the salmonid criteria (0.4 fps). There should be no direct mortality due to impingement of fish upon the screen, as healthy winter-run Chinook salmon juveniles and smolts should be able to avoid whole body impingement that would result in immediate mortality or severe injury. Those fish that do have "touches" against the screen may incur sublethal injuries due to abrasions from materials lodged against the screen, which subsequently may become infected by bacterial or fungal pathogens. A small proportion of these fish may be expected to die.

The indirect effects of the DWSP's long-term operation will extend throughout the Sacramento River winter-run Chinook salmon's current range in the Central Valley. The tailwaters below Shasta and Keswick dams provide the only remaining habitat for Sacramento River winter-run Chinook salmon in the Central Valley. The reservoirs behind these dams, which block access to the original upstream habitat of these fish in the upper Sacramento, McCloud and Pit River drainages, provide a source of cool water which is essential for the spawning and survival of winter-run Chinook salmon in the lower elevation waterways they now occupy. Reductions in carryover reservoir storage and hence the cold water pool behind the dams, likely will limit the ability of resource managers to provide consistent and reliable cool water discharges to this endangered Chinook salmon population. In dry and critically dry years, when cool water pools are reduced by water demands in the Central Valley, the DWSP operations are expected to put additional demands on this already limited resource. Modeled reductions range from 0.5 percent in carryover capacity at the initial operating rate of 30 mgd, to approximately 4 percent when the full capacity of the DWSP is realized. Unfortunately, the sensitivity of the computer simulations is not sufficient to predict with any degree of precision the actual reductions in cold-water pools behind the dams, or how the reductions will translate into actual operating procedures for the release of this cold water to support the winter-run Chinook salmon population below Keswick Dam. The impacts associated with the initial pumping rate covered under this opinion, 30 mgd, appear to be of sufficient magnitude to alter the range of adequate habitat only in the dry and critically dry years. The increased variability in the average monthly water temperature suggests that the decrease in carryover storage and the associated cold-water pool will move aquatic habitat of suitable temperature upstream. Impacted juveniles in the Sacramento River are anticipated to migrate upriver to follow the upstream shift in suitable water temperatures. The associated cost of this movement is an increase in the density of the juvenile winter-run Chinook salmon in a reduced habitat area which holds suitable water temperatures. Increased fish density would result in behavioral alterations due to intraspecific interactions, increased competition for territory and food, and an increased susceptibility to disease outbreaks due to warmer water and higher fish densities. These associated effects are expected to be exacerbated by the additional impacts brought on by climatic warming trends and changes in precipitation patterns.

3. Central Valley Spring-run Chinook salmon ESU

NMFS does not anticipate that Central Valley Spring-run Chinook salmon adults will occur in any demonstrable numbers within the construction area during the proposed work window. Therefore, impacts from the initial construction phase of the DWSP are not likely to adversely affect adult spring-run Chinook salmon. There is a small likelihood that juvenile spring-run Chinook salmon will be present in the construction area very late in the construction window (October - November) following a high precipitation event that may stimulate yearling fish to emigrate downstream. However, as explained above, NMFS expects this exposure to be benign due to the installation of the cofferdam early in the work window (*i.e.,* June or July). The presence of the cofferdam will effectively separate the work activities from the river channel. If the start of construction activities are delayed until early fall (*e.g.*, September), then the dredging, pile driving and riprapping actions may overlap with the presence of early arriving spring-run Chinook salmon in the action area and the probability of adverse effects from construction activities increases substantially.

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile Central Valley spring-run Chinook salmon to the direct effects of the fish screen. As described previously for Central Valley steelhead, effects due to the screen are expected to impact juvenile fish since healthy adult salmon should be able to avoid the screen with minimal effort due to their larger size and greater swimming capacity. These screen related effects on juveniles are likely to include impingement resulting in elevated stress due to contact with the screen, potential infections from abrasions and loss of protective mucous resulting from contact with the screens, fatigue from holding position in front of the screen while being swept down current in front of the screen, and predation losses from predators congregating around the screens.

Similarly to winter-run Chinook salmon, spring-run Chinook salmon juveniles currently enter the Central Delta through one of the interior channels connecting the Sacramento River with the San Joaquin River. At this time, spring-run Chinook salmon are known to spawn only in the Sacramento River watershed, which includes populations in Mill, Deer, and Butte Creeks as well as a population in the lower Feather River below Oroville Dam. Previous populations in the San Joaquin River were extirpated with the construction of Friant Dam. Spring-run juveniles typically begin to show up in the Delta starting in March and continue to be seen through the end of May. The same hydrological factors that influence the probability of winter-run Chinook salmon moving upriver into the vicinity of the DWSP fish screens or being adversely affected also apply to spring-run Chinook salmon juveniles. NMFS estimates that several hundred to several thousand juvenile spring-run Chinook salmon may enter the San Joaquin River downstream of the DWSP intake, and that a small number may actually encounter the DWSP fish screen's zone of influence. A small proportion of these fish may be expected to die from sublethal injuries or increased likelihood of predation.

The indirect effects created by the reduction of carryover storage on the reservoirs apply to spring-run Chinook salmon habitat on the Feather River below Oroville Dam. Reductions in the pool of cool water behind the dam create situations where the tailwater temperatures become increasingly difficult to maintain within the optimal range for spring-run Chinook salmon physiology. This is particularly important for Feather River spring-run Chinook salmon which have to over-summer in the low flow section of the Feather River between the Thermalito afterbay discharge and Oroville Dam. By the end of summer, when ambient air temperatures are well above 26 ^{o}C, water temperature in the lower Feather River may fluctuate above the preferred water temperatures of Chinook salmon . Elevated water temperatures can reduce gamete viability in exposed adult spring-run Chinook salmon over-summering in these regional watersheds and can lead to increased rates of mortality as seen recently in the Butte, Deer and Mill Creek watersheds. The long-term operations of the DWSP may reduce the flexibility and reliability of temperature control management during dry and critically dry years as already explained for the winter-run Chinook salmon ESU.

4. Southern DPS of North American Green Sturgeon

Little is known about the migratory habits and patterns of either adult or juvenile green sturgeon in the Delta region. The basic pattern described for adult green sturgeon migrations into the Delta region from the San Francisco Bay estuary is that fish enter the Delta region starting in late winter or early spring and migrate upstream towards the stretch of the Sacramento River between Red Bluff and Keswick Dam. After spawning, adults return downstream and re-enter the Delta towards late summer and fall (based on behavior of sturgeon in the Klamath and Rogue River systems). Juvenile and larval green sturgeon begin to show up in rotary screw trap catches along the Sacramento River starting in summer (Beamesderfer *et al.* 2004) and could be expected to reach the Delta by fall. The extent and duration of rearing in the Delta is unclear (*i.e.*, months to years), but NMFS believes that juvenile green sturgeon, including sub-adults, could be found during any month of the year within the waters of the Delta. Therefore, both adult and juvenile green sturgeon have the potential to be adversely affected by increased suspended sediment and turbidity, entrainment within the cofferdam, and noise generated due to the pile driving and sheet wall installation associated with the project. However, because green sturgeon apparently spawn only in the Sacramento River, relatively few green sturgeon are expected to occur in the San Joaquin River drainage and be exposed to the adverse effects of the project during construction, and no larval green sturgeon (< 50 mm) are expected to be present at the fish screen during its operation.

Due to the lack of population abundance information regarding the Southern DPS of North American green sturgeon, a variety of estimates must be utilized to determine the range of effects resulting from the take of a small number of green sturgeon. Compared to the estimated population sizes suggested by the CDFG tagging efforts (CDFG 2002c), juvenile and sub-adult captures passing Red Bluff Diversion Dam, and past IEP sampling efforts, the incidental take associated with the construction phase would only affect a small proportion of the adult and sub-adult North American green sturgeon population in the Sacramento River watershed. Adult and juvenile North American green sturgeon take is expected to represent a relatively small proportion of the standing population and is not expected to jeopardize the continued existence of the Southern DPS of North American green sturgeon.

The indirect effects of the DWSP operations are assumed to affect green sturgeon in a similar fashion to Chinook salmon and steelhead. Green sturgeon prefer cooler waters, 15 to 19 ^{o}C, based on their bioenergetic profiles (Mayfield and Cech 2004) and require water temperatures between 14 and 17 ^{o}C for optimal hatching success based on hatchery experiments (Van Eenennaam *et al.* 2005). During dry and critically dry years, end of summer storage in the region's reservoirs may not be of sufficent volume to hold river temperatures in the reach around Red Bluff Diversion Dam in the preferred temperature range for green sturgeon juveniles. Hatching success should not be adversely affected since river temperatures in early summer are still dominated by snow pack runoff, and should remain cool enough for green sturgeon eggs to hatch.

C. Effects of the Proposed Action on Critical Habitat

1. <u>Direct Effects of the Action</u>

The construction and operation of the City of Stockton DWSP will have minimal direct effects on the critical habitat of the Central Valley steelhead. Approximately 0.44 acres of aquatic habitat will be permanently removed from the area of Central Valley steelhead critical habitat. A small additional amount of critical habitat will be temporarily disturbed by the installation of the rock riprap along the wing walls leading up to the DWSP diversion inlet and fish screen. The habitat that is to be removed from use by Central Valley steelhead is currently comprised of rock riprapped levee banks that is spradically vegetated with tules, cattails, and bulrushes.

In July, 2005, NMFS' critical habitat analytical review teams (CHARTs) issued their final assessments of critical habitat for 7 listed salmon and steelhead ESUs in California (NMFS 2005c). This included critical habitat descriptions for the Central Valley spring-run Chinook salmon ESU and the Central Valley steelhead DPS. Section 3 of the ESA (16 U.S.C. 1532(5)) defines critical habitat as "(i) the specific areas within the geographic area occupied by the species, at the time of the listing * * * on which are found those physical and biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection". These features include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, and rearing of offspring; and habitats that are protected from disturbance or are representative of the historical geographical and ecological distribution of the species. After considering the above features, the CHARTs considered the principal biological and physical constituent elements that are essential to the conservation of the species, known as PCEs. The specific PCEs considered in determining the critical habitat for listed salmonids in California include (NMFS 2005c):

(1) **Freshwater spawning sites** with sufficient water quantity and quality and adequate substrate to support spawning, incubation and larval development.

(2) **Freshwater rearing sites** with sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions and allow salmonid development and mobility; sufficient water quality to support growth and development; food and nutrient

resources such as terrestrial and aquatic invertebrates and forage fish; and natural cover such as shade, submerged and overhanging large woody debris, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

(3) **Freshwater migration corridors** free of obstruction and excessive predation with adequate water quantity to allow for juvenile and adult mobility; cover, shelter, and holding areas for juveniles and adults; and adequate water quality to allow for survival.

(4) **Estuarine areas** that provide uncontaminated water and substrates; food and nutrient sources to support growth and development; and connected shallow water areas and wetlands to cover juveniles.

(5) **Marine areas** with sufficient water quality to support salmonid growth, development, and mobility; food and nutrient resources such as marine invertebrates and forage fish; and nearshore marine habitats with adequate depth, cover, and marine vegetation to provide cover and shelter.

The CHART indicated in their review (NMFS 2005c) that the San Joaquin Delta sub-basin encompasses an area of approximately 628 square miles with 455 miles of stream channels. Of this, fish distribution and habitat use occur in approximately 276 miles of occupied riverine/estuarine habitat for Central Valley steelhead and 142 miles for the Central Valley spring-run Chinook salmon. The CHART concluded that these occupied areas contained one or more PCEs (*i.e.*, freshwater rearing sites, freshwater migratory corridors, and estuarine areas) and described the San Joaquin Delta as having a high conservation value, primarily due to its use as a rearing and migratory corridor for listed steelhead and spring-run Chinook salmon in the Central Valley.

The river channel within the action area is primarily used as a migratory corridor by the small number of Central Valley steelhead moving downstream out of the San Joaquin and Calaveras River watersheds. These fish move through the channels of the San Joaquin Delta to the lower reaches of the Delta and the marine waters beyond. Due to the loss of riparian habitat and tidal flats resulting from decades of dredging and riprapping, the ecological value of the San Joaquin River channel as a rearing habitat has been greatly diminished from historical conditions, although rearing is still considered to occur in the main channel and its associated side channels. The CHART has determined that the waterways of the San Joaquin Delta are necessary for connecting the freshwater spawning habitats located upstream in the San Joaquin and Calaveras River watersheds with the downstream waterways leading to the ocean and thus have a high conservation value. The project itself will not significantly diminish the value of the waterway as a migratory corridor compared to its current condition.

2. Indirect Effects of the Action

The operation of the DWSP under current climatic conditions and the permitted diversion volume of 30 mgd is likely to have only minimal impacts to critical habitat affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead in the waters of the Sacramento River downstream of Shasta Dam, the Feather

River downstream of Oroville Dam and the American River downstream of Folsom Dam. The modeling of the reservoir operations predicted only a slight decrease in carryover reservoir capacity in dry and critically dry water years. However, the modeling also predicted increases in the depletions of the carryover capacity with increasing diversion rates at the DWSP, as anticipated by the applicant. Furthermore, none of the modeling runs for the different diversion rates at the DWSP incorporated climatic change and NMFS anticipates that the frequency and level of reservoir depletions will increase under the influence of global warming.

Under the currently proposed project, the operation of the DWSP is likely to result in changes to water quality criteria in the Delta (*e.g.,* X2 position and EC levels), which would then trigger the response of State and Federal agencies to ameliorate the adverse water quality conditions in the Delta as mandated by public law. These responses typically take the form of additional releases of water from upstream reservoirs to reposition the X2 location in the western Delta and "freshen" the Delta. Depletion of reservoir carryover storage volume is expected to change the functioning of the identified critical habitat below that reservoir by altering the temperature profile of the tailwater reaches downstream of the operated dam. The occurrences of these actions are anticipated to occur infrequently (during dry or critically dry periods or during extended drought conditions). They are not considered long-term alterations or permanent impacts under current conditions. However, the frequency of dry and critically dry years, coupled with warmer summer air temperatures on the valley floor, are expected to increase in the future due to the effects of global warming and this may alter the validity of this previous statement.

The mainstem section of the Sacramento River from immediately below Keswick Dam (RM 302) to approximately the Red Bluff Diversion Dam (RM 243) is considered to support critical life stages of the Sacramento River winter-run Chinook salmon (*i.e.*, spawning, juvenile rearing, and adult and juvenile migrations) (NMFS 1997a). Those occupied areas, therefore, would contain one or more PCEs (*i.e.*, freshwater spawning, freshwater rearing, and freshwater migration corridors) and under current methodologies by a CHART, this reach would have a high conservation value for the Sacramento River winter-run Chinook salmon. Early on in the management of the Sacramento River winter-run Chinook salmon ESU, a temperature compliance point of ≤56 ^{o}F at Bend Bridge (40 miles below Keswick Dam) was instituted for normal, above normal, and wet water years from April 15 to September 30 and ≤60 ^{o}F during October to protect postemergent fry. In dry and critical water years, the temperature compliance point was allowed to move upstream to Jellys Ferry Bridge (35 river miles below Keswick Dam). Historically, the incidences of maximum monthly temperatures exceeding the thermal criteria occurred primarily in late summer and early fall when juvenile winter-run Chinook salmon were rearing in the affected reach. Water temperatures during spawning and egg incubation typically remained within the optimal temperature range. In addition to the temperature compliance criteria, NMFS required that the end of year carryover storage in the Shasta reservoir be 1.9 million acre feet (MAF) in all but the driest 10 percent of water years. This was anticipated to protect approximately 90 percent of the winter-run Chinook salmon spawning population in 90 percent of the water years based upon spawning distributions in the river system (NMFS 1997a).

The additional drawdown of the reservoir has the potential to exacerbate the frequency of excursions of the water temperatures in this lower section of the Sacramento River (RBDD to

Jellys Ferry Bridge) to levels above the thermal optimum for rearing juvenile winter-run Chinook salmon, particularly in hot, dry summers. This reduction in the quality of the water (thermal compliance) reaching these downstream segments affects not only the physiology of the juvenile winter-run Chinook salmon rearing there, but also adversely affects the type and quantity of the available macrobenthic invertebrates that serve as a forage base for the juvenile salmon. Furthermore, elevations in water temperature decrease ambient water column DO, enhance the susceptibility of fish to pathogens and predation, induce movement of fish to either colder reaches farther upstream, or to emigrate downstream towards the Delta earlier than normal.

Central Valley steelhead also spawn and rear in this segment of the Sacramento River and will face similar effects related to the potential temperature increases. Unlike the winter-run Chinook salmon, juvenile steelhead may spend up to several years rearing in this freshwater habitat. Therefore, several separate cohorts of juvenile steelhead may be affected by temperature related declines in habitat quality should the previously described events occur. Similar situations will also occur in the tailwaters below Oroville Dam on the Feather River and Folsom/Nimbus Dams on the American River due to altered operations of the dams to meet Delta water quality objectives.

Central Valley spring-run Chinook salmon on the Feather River face an additional impact related to elevated water temperatures. Spring-run Chinook salmon enter the Feather River starting in spring and continue to do so throughout the summer. Due to the presence of the Oroville Dam, they are blocked from moving upstream into the higher elevations of the Feather River watershed in the northern Sierras. Forced to hold over in the low flow section of the Feather River below the Oroville dam, these fish are highly susceptible to adverse changes in the ambient water temperature. Elevated temperatures decrease the fertility of gametes (primarily eggs), as well as increasing the susceptibility of the fish to disease outbreaks. It is expected that any additional excursions above the optimal water temperature levels will increase the occurrences of these negative events.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the southern population DPS of the North American green sturgeon, the environmental baseline, the effects of the proposed City of Stockton DWSP, and the cumulative effects, it is NMFS' biological opinion that the City of Stockton DWSP, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, the southern DPS of North American green sturgeon, or result in the destruction or adverse modification of the designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead.

IX. INCIDENTAL TAKE STATEMENT

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

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

While some measures described below are expected and intended to avoid, minimize, or monitor the take of North American green sturgeon, the prohibitions against taking of listed species in section 9 of the ESA do not apply to recently listed North American green sturgeon until the publication of section 4(d) rules in the Federal Register. However, NMFS advises the Corps to consider implementing the following reasonable and prudent measures for North American green sturgeon proactively.

A. Amount or Extent of Take

NMFS anticipates that the proposed operation of the City of Stockton DWSP and the associated long term indirect impacts will result in the incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon.

The incidental take is expected to be in the form of death, injury, harassment, and harm from sources such as impingement on the fish screens, secondary infections arising from impingement on the fish screens, predation associated with the screen structures, and the temperature related effects of reduced reservoir carryover storage upon listed salmonids and green sturgeon. Direct take of salmonids from the applicant's water intake and fish screen construction activities (*e.g.*, entrainment in the dredge, exposure to resuspended contaminants, acoustic noise from the pile driving actions) is not expected to occur if construction actions are implemented early in the construction window (*i.e.*, July 1 through August 30) so that construction actions are completed prior to November 30. Should constructions actions be initiated later in the construction window (September 1 through November 30), the exposure risk to listed salmonids increases due to the increased likelihood of early emigrating Sacramento River winter-run Chinook salmon juveniles or early arriving adult Central Valley steelhead occurring in the action area. Take from the long-term operation of the water intake and its associated fish screen is expected to affect listed salmonids from approximately November 1 through June 30, which includes the entire period when individuals from one or more of the listed ESUs or DPSs may be expected to occur in the action area. Indirect take from the operation of the water intake facilities of the DWSP and the interrelated reservoir re-operations and changes in the carryover storage volumes are expected to affect listed salmonids from late August through late October when ambient air temperatures interact with reduced reservoir storage to the greatest extent.

North American green sturgeon are known to spawn only in the Sacramento River drainage, Therefore, NMFS assumes that like Chinook salmon and steelhead originating from the Sacramento River basin, green sturgeon are most likely to occur in the central and western Delta but their presence in the project area is assumed. The presence of green sturgeon in the action area is expected to occur year-round, although the likelihood is greater from April through October when sturgeon are moving through the system.

The numbers of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon taken will be difficult to quantify because dead, injured, or impaired individuals will be difficult to detect and recover. The ITS will describe the current take estimates for the listed Sacramento River winter-run and Central Valley spring-run Chinook salmon and the Central Valley steelhead, and for future reference, the take of North American green sturgeon from the southern DPS. Currently, the incidental take of green sturgeon is not prohibited under section 9 of the ESA until the section 4(d) rules for green sturgeon under the ESA have been finalized and published in the Federal Register. Take of listed fish is expected to include:

1. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon juveniles and adults harmed, harassed, or killed due to impingement upon the fish screen during operation of the DWSP. Incidental take is calculated for the initially proposed water diversion level of 30 mgd. NMFS understands that increases in the diversion rate beyond 30 mgd will trigger new consultations with the Corps and the City of Stockton. Estimates of impingement rates were calculated from the density of Chinook salmon captured in the FWS mid-water trawls at Prisoners Point in 1999, the number of winter-run Chinook salmon and spring-run Chinook salmon entrained at the CVP and SWP facilities from water years 1999 through 2005, and the total number of Chinook salmon entrained at the CVP and SWP facilities since 1957 (CVP) and 1967 (SWP). Monthly ratios of winter-run Chinook salmon to total Chinook salmon entrainment and spring-run Chinook salmon to total Chinook salmon entrainment were calculated. These monthly ratios were then applied to the calculated entrainment rates of the DWSP based on Chinook salmon densities from the Prisoners Point data and a pumping rate of 30 mgd. NMFS predicts that over the course of one year, 1,631 juvenile Chinook salmon will encounter the screen based on diverted water volumes at the DWSP. Of these fish, 30 will be winter-run

Chinook salmon and 84 will be spring-run Chinook salmon. Based on estimates of steelhead density from mid-water trawl data, 1 steelhead is caught for every 1,000 Chinook salmon, therefore approximately 2 steelhead will encounter the fish screen. Based on the studies by Swanson *et al.* (2004) none of these fish should suffer acute mortality from contacting the screen and full body impingement occurred in less than 0.3 percent of fish tested.

2. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon juveniles and adults harmed, harassed, or killed due to declines in the carryover capacity of the SWP and CVP reservoirs due to operation of the DWSP. During critically dry hydrology years, carryover capacity is reduced by approximately 0.5 percent when water diversion levels are 30 mgd. Incidental take is expected to occur during the life history phase when fry rear to smolts in the tailwater portions of the riverine habitat. Due to insufficient data to quantify the exact temperature changes downstream of the reservoir and the reduction in useable habitat, NMFS assumes that the reduction in carryover capacity is proportional to the loss of habitat and the subsequent reduction in the affected fish populations. This is equivalent to 0.5 percent of the lifestage between egg hatching and downstream migration to the Delta.

The total incidental take associated with the direct actions of this project is expected to be as follows:

	Juveniles		Adult	
ESU/DPS	Number	Percentage of Population	Number	Percentage of Population
Sacramento River winter-run Chinook salmon	30	0.009	0	0
Central Valley spring-run Chinook salmon	84	0.006	0	0
Central Valley steelhead	2	0.001	0	0
North American green sturgeon	2 green sturgeon incidentally taken by project			

Anticipated incidental take may be exceeded if the project activities exceed the criteria described above or if the project is not implemented as described in the biological assessment for the DWSP, including the full implementation of the proposed conservation measures listed in the *Description of the Proposed Action* section of this biological opinion.

B. Effect of the Take

In the accompanying biological opinion, NMFS determined that the level of anticipated take will not result in jeopardy to the species or destruction or permanent adverse modification of designated critical habitat.

C. Reasonable and Prudent Measures

NMFS believes that the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead and North American green sturgeon:

1. The Corps and the City of Stockton shall take measures to avoid, minimize, and monitor the impacts of the construction and operation of the DWSP fish screen upon listed salmonids, North American green sturgeon, and their habitat.

2. The Corps and the City of Stockton shall take measures to avoid, minimize, and monitor the impacts of the diversion of water by the DWSP upon listed salmonids, North American green sturgeon, and their habitat in the tailwater sections of the reservoirs affected by the operation of the DWSP.

D. Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the action must be implemented in compliance with the following terms and conditions, which implement the reasonable and prudent measures described above for each category of activity. These terms and conditions are non-discretionary.

1. **The Corps and the City of Stockton shall take measures to avoid, minimize, and monitor the impacts of the construction and operation of the DWSP fish screen upon listed salmonids, North American green sturgeon, and their habitat.**

    a. A draft hydraulic evaluation plan shall be submitted to NMFS 90 days prior to the completion of the DWSP by the City of Stockton. The plan shall outline in detail the proposed methodology for measuring near-screen velocities under ambient conditions in the San Joaquin River under all extremes of tidal flow (*i.e.* flood, ebb, and slack phases of the tides under neap and spring tidal conditions). This plan shall conform to the guidance given in the *Guidelines for Developing Post-Construction Evaluation & Assessment Plans, and Operations and Maintenance Plans* (Appendix C).

    b. A draft operations and maintenance plan shall be developed and submitted to NMFS 90 days prior to initiating operations of the new fish screen by the City of Stockton. The plan shall act as a manual for operating and maintaining the intake structure and fish screen. The plan shall comport with the guidelines in Appendix C.

    c. An operations and maintenance log shall be maintained on a daily basis by the City of Stockton or its designated representatives if the DWSP is not operated by employees of the City of Stockton. This maintenance log shall be made available to NMFS personnel within 24 hours upon request by NMFS staff.

    d. Prior to the intake structure becoming operational, inspections of the intake structure and fish screen must be conducted by NMFS engineers. Review of the final screen design, 60 percent buildout, and final buildout of the screen will be done in cooperation with NMFS engineers.

e. NMFS staff, including diving personnel, shall be granted access to the site for inspection and measurements of fish screen performance with a minimum of 48 hours advance notice to the Corps and the City of Stockton.

f. The fish screen shall be operated in accordance with NMFS operating criteria for as long as the diversion is in use. When and if the City of Stockton chooses to increase the design intake of the diversion over the initial nominal capacity of 30 mgd, the Corps and the City of Stockton shall enter into formal reinitiation of this consultation with NMFS.

g. The fish screen shall be maintained in operating order at all times. Should the fish screen be damaged or portions of the screen taken off-line for maintenance or repair, such that the protection of juvenile fish is compromised or the screen specifications cannot be met, the City of Stockton shall curtail or cease pumping through that damaged or removed screen section to the greatest extent possible and notify NMFS within 48 hours.

h. Fish surveys shall be conducted to assess which species are using the area in the vicinity of the intake site on the San Joaquin River, both prior to and after one year of operation. Specific goals of the survey should include characterization of the predator population surrounding the intake structure. Two electrofishing surveys or an alternative survey methodology acceptable to NMFS shall suffice. The monitoring plan shall be received by NMFS prior to the start of construction.

i. No incidental take of listed fish species is anticipated with the in-water construction phase of this project due to the application of in-water work windows. NMFS will be notified immediately by fax within 48 hours if one or more adult or juvenile listed fish species are found dead or injured. If take of juvenile or adult salmon, steelhead, or green sturgeon occurs, the following information is to be reported at a minimum: date, time, and location of the carcass or injured fish, cause of injury or death, and the name and affiliation of the person finding the injured or dead fish.

j. The Corps and the City of Stockton will be responsible for reporting any violations of the construction BMPs during construction to NMFS that impinge upon the aquatic habitat. Such violations will include frac-outs from the crossings under Honker or Bishop Cuts, fluid or material spills that enter the channels of adjacent waterways or any spills of toxic fluids or materials over 50 gallons.

k. A final written report will be provided to NMFS regarding water quality, fisheries, and other habitat impacts associated with the construction activities of the DWSP within 60 days of completion of the in-channel construction activities of the project.

l. All reports and correspondence will be sent to the following address:

Sacramento Area Office Supervisor

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

2. **The Corps and the City of Stockton shall take measures to avoid, minimize, and monitor the impacts of the diversion of water by the DWSP upon listed salmonids, North American green sturgeon, and their habitat in the tailwater sections of the reservoirs affected by the operation of the DWSP.**

   a. The operations of the DWSP shall be coordinated with the Bureau (CVP) and DWR (SWP) to avoid or minimize upstream effects of the diversion of water by the DWSP. The DWSP operations shall be conducted so as to avoid reductions of the end of year storage that could adversely affect the ability of the Bureau or DWR to maintain mandated in-stream temperature and flow compliance for listed fish species.

   b. NMFS shall be informed of any coordination between the City of Stockton, and the Bureau or DWR concerning the operation of the DWSP. Notification shall be sent to the address in 1(l) above.

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of pertinent information.

1. The Corps should support and promote aquatic and riparian habitat restoration within the Delta region, and encourage its contractors to modify operation and maintenance procedures through the Corps' authorities so that those actions avoid or minimize negative impacts to salmon, steelhead and North American green sturgeon.

2. The Corps should support anadromous salmonid monitoring programs throughout the Delta and Suisun Bay to improve the understanding of migration and habitat utilization by salmonids and North American green sturgeon in this region.

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

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the actions outlined in the February 28, 2006, final biological assessment for the DWSP. This biological opinion is valid for the City of Stockton DWSP described in the February 28, 2006, BA and covers diversions up to 30 mgd. As provided for in 50 CFR '402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in any 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 previously considered, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion, or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

XII. REFERENCES

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Appendix A: Tables

Table 3:

Monthly Occurrences of Dissolved Oxygen Depressions below the 5mg/L Criteria in the Stockton Deepwater Ship Channel (Rough and Ready Island DO monitoring site) Water Years 2000 to 2004

			Water Year			
Month	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Monthly Sum**
September	0	26**	30**	16**	30**	102
October	0	0	7	0	4	11
November	0	0	12	0	3	15
December	6	4*	13	2	13	38
January	3	4	19	7	0	33
February	0	25	28	13	0	66
March	0	7	9	0	0	16
April	0	4	4	0	0	8
May	2*	0	2	4	0	8
Yearly Sum	11	70	124	42	50	**Total=297**

* = Suspect Data – potentially faulty DO meter readings

** = Wind driven and photosynthetic daily variations in DO level; very low night-time DO levels, high late afternoon levels

Appendix B: Figures

Figure 1:
Regional Location of the City of Stockton DWSP

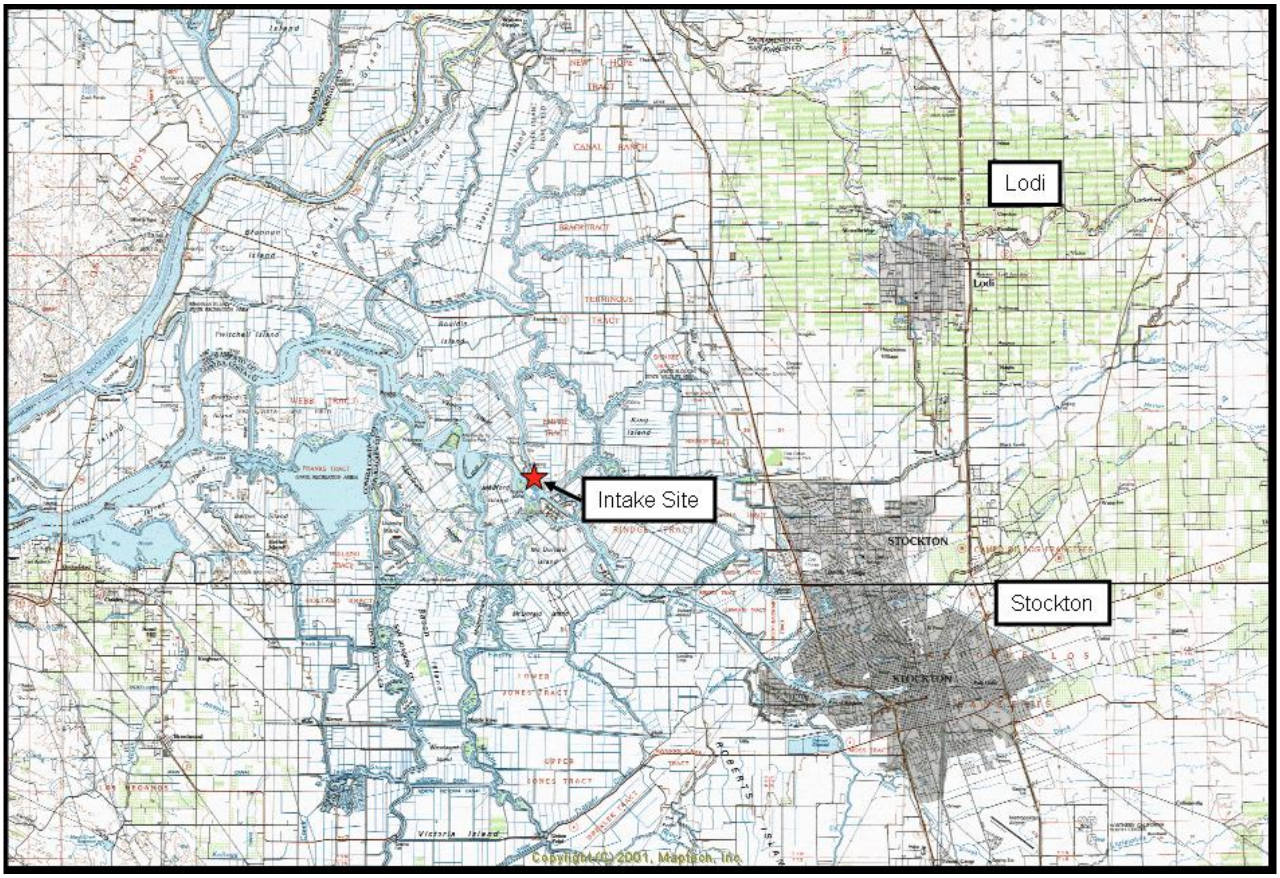


Figure 2:

Intake Site Location on Empire Tract

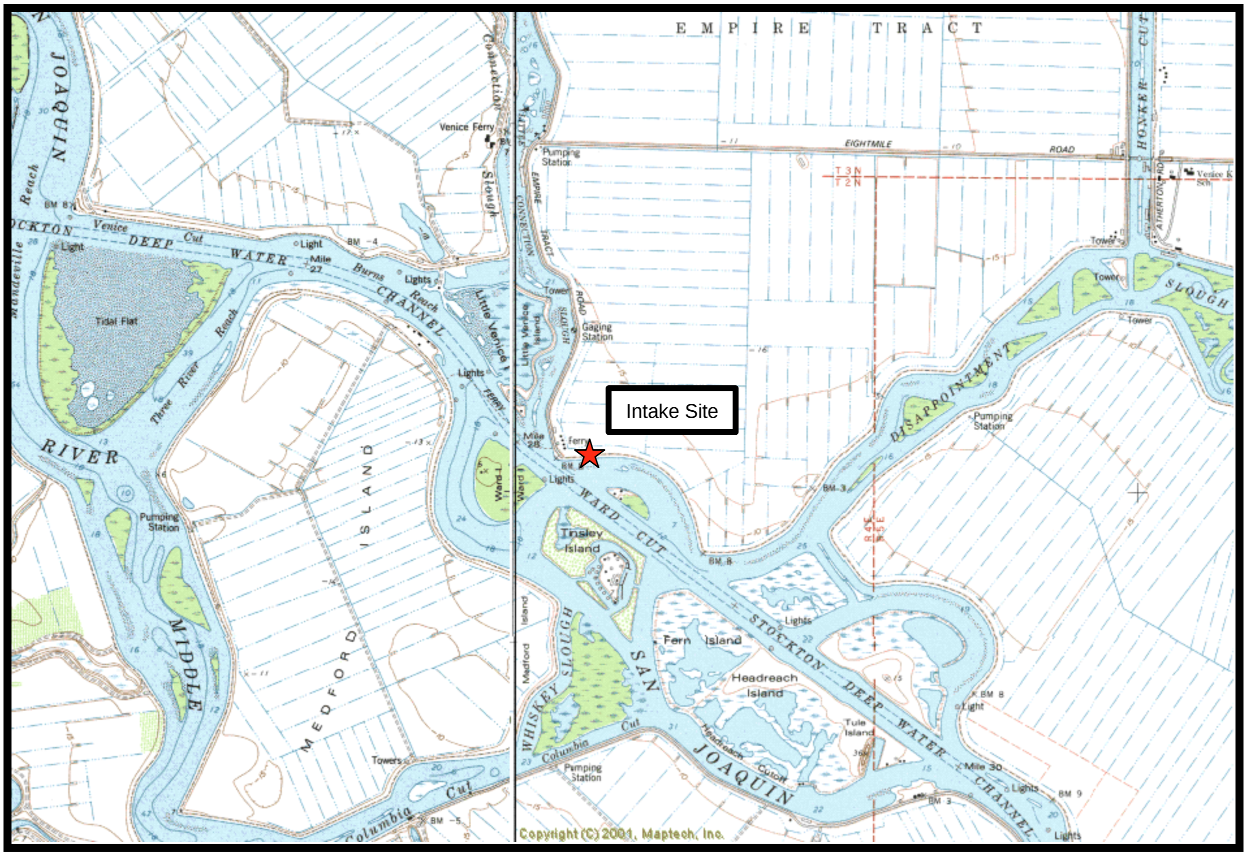


Figure 3: Intake Design

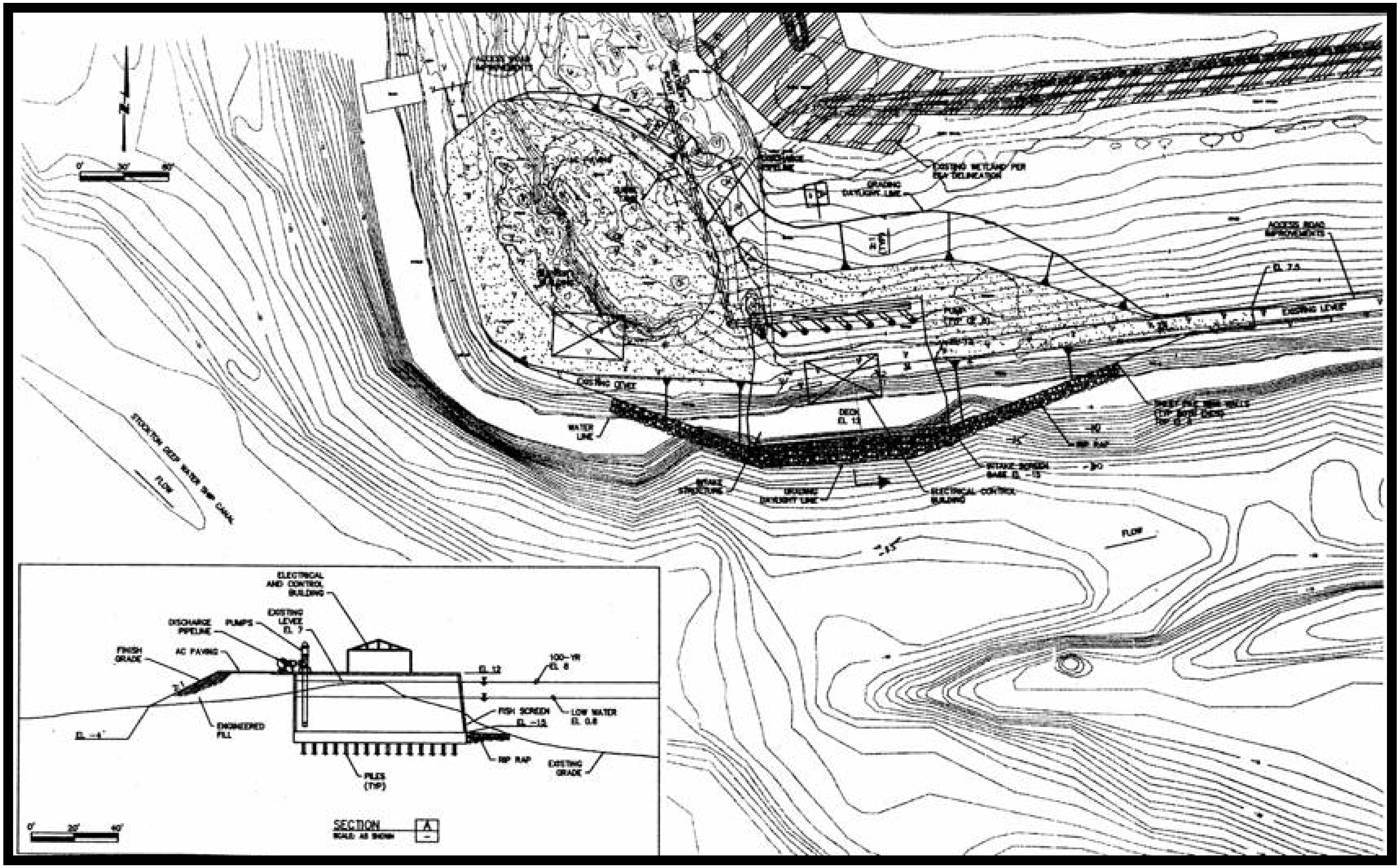
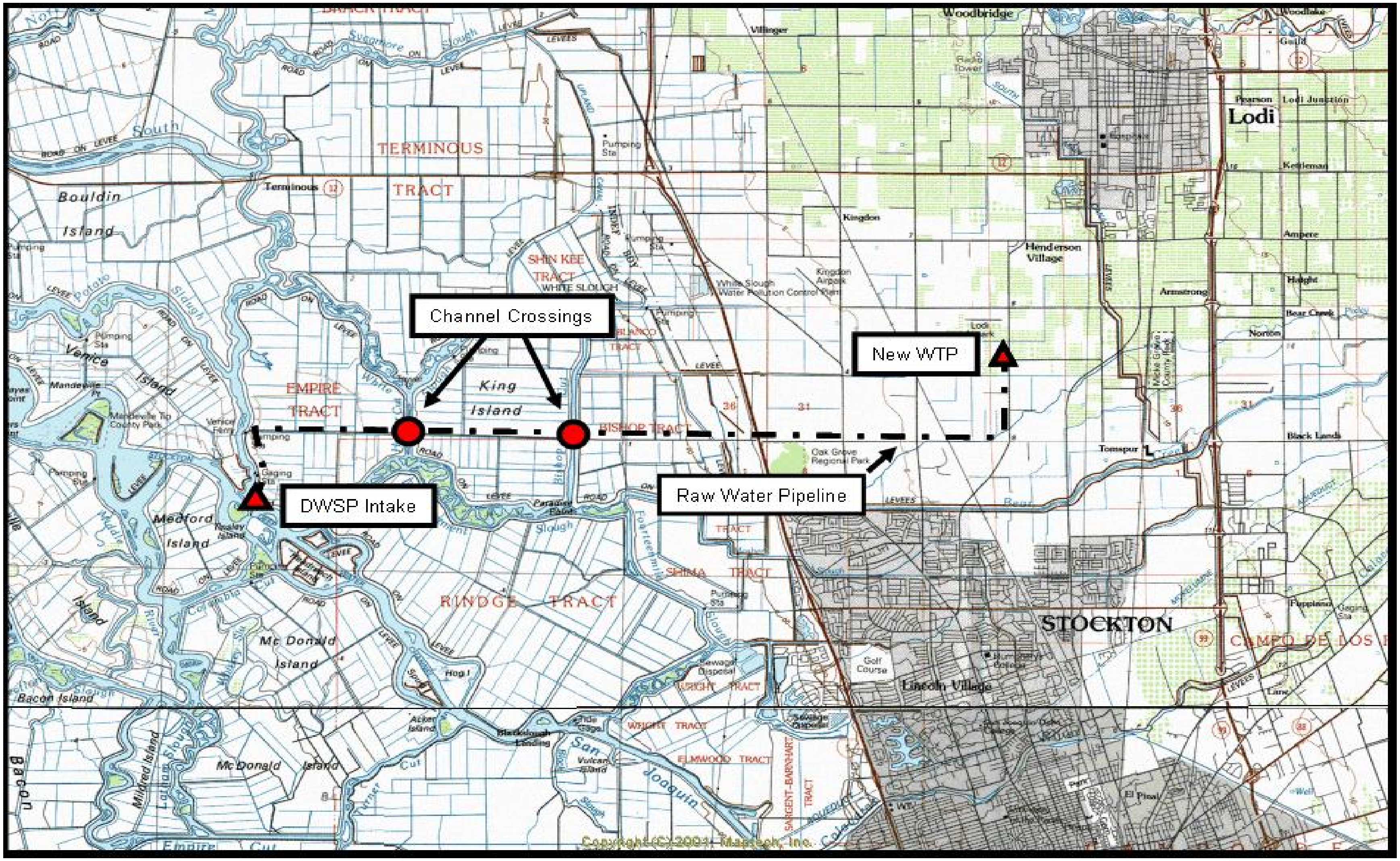


Figure 4:
Raw Water Pipeline and Channel Crossings



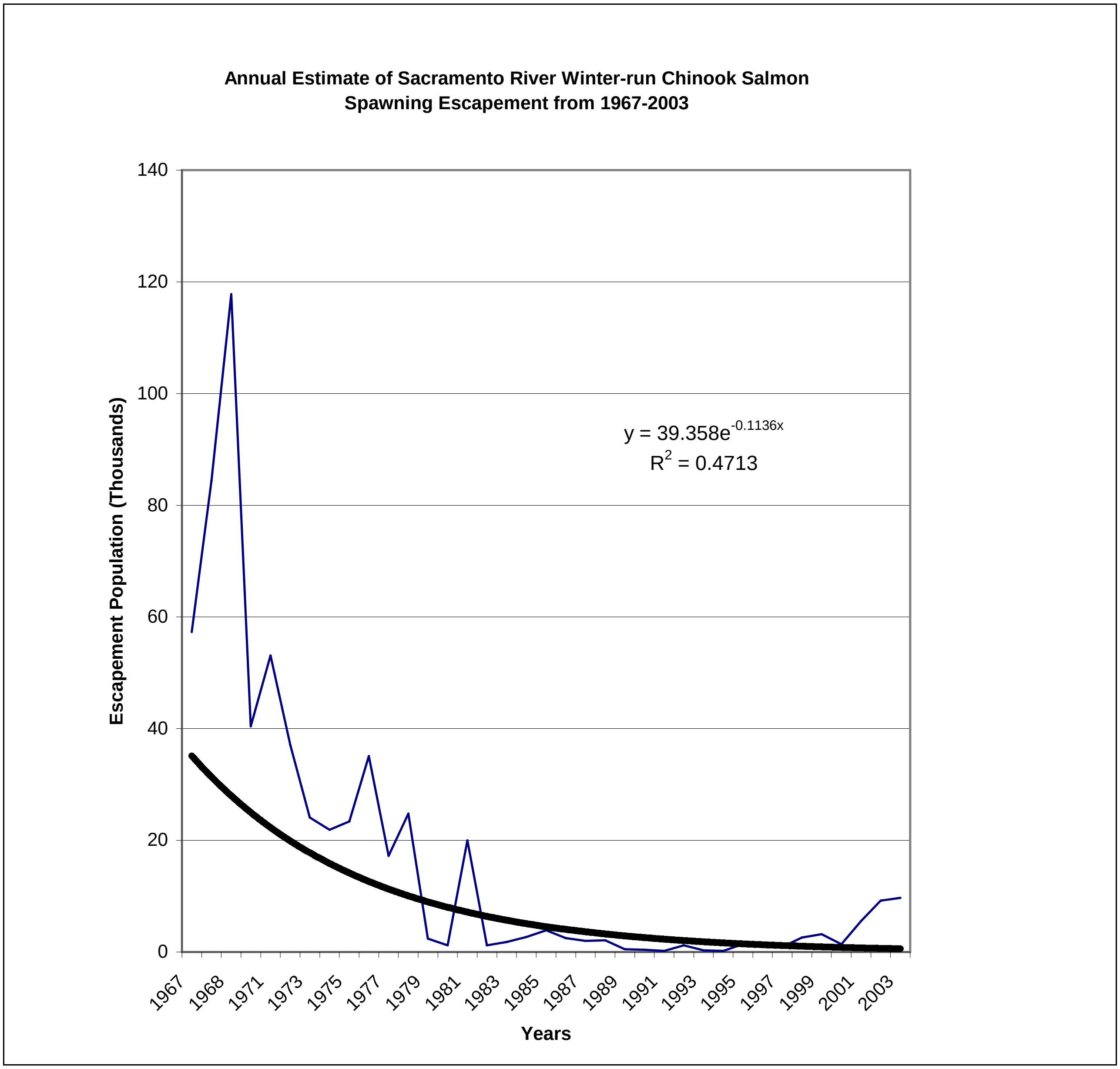


Figure 5:

Annual estimated Sacramento River winter-run Chinook salmon escapement population.
Sources: PFMC 2002, 2004, DFG 2004a, NMFS 1997
Trendline for figure 5 is an exponential function: $Y=39.358\ e^{-0.1136x}$, $R^2=0.4713$.

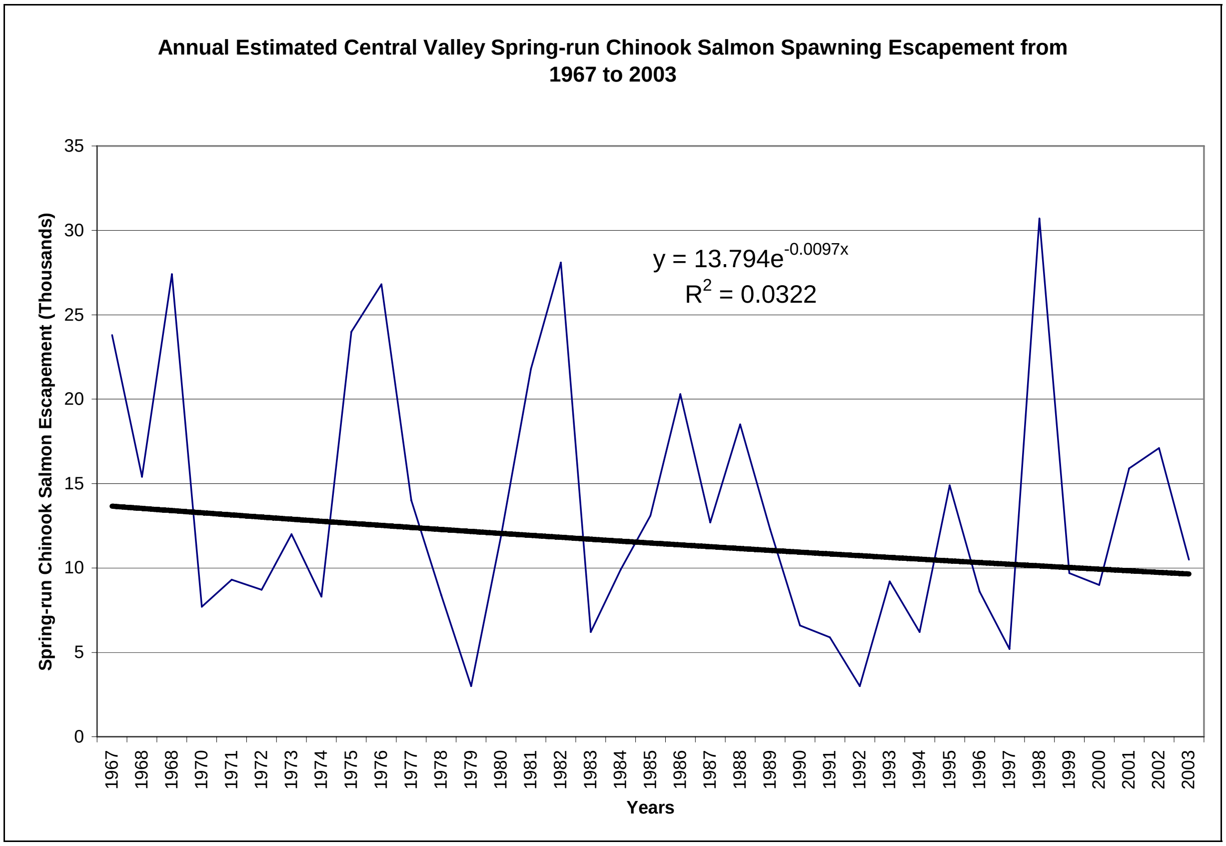
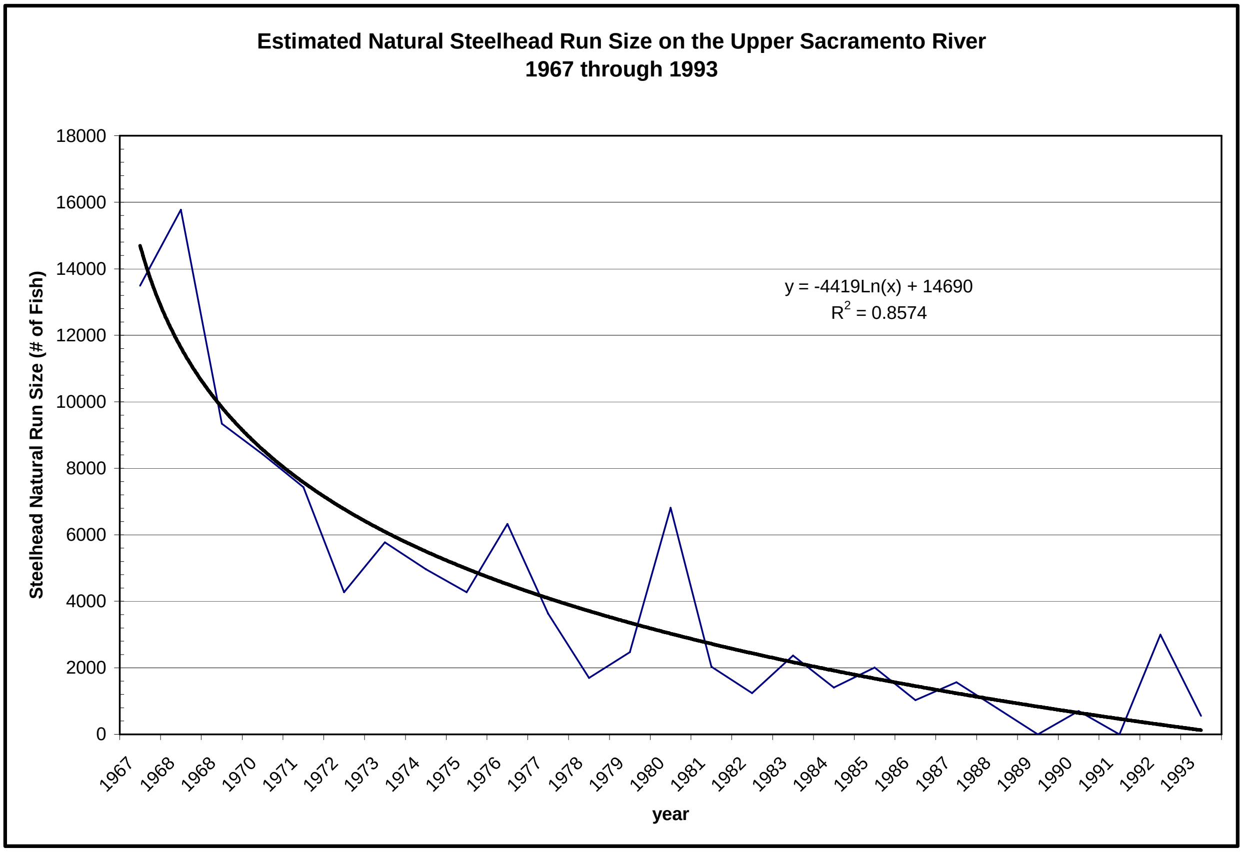


Figure 6:
Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1967 through 2003.
Sources: PFMC 2002, DFG 2004b, Yoshiyama 1998.
Trendline for figure 6 is an exponential function: $Y=13.794\ e^{-0.0097}$, $R^2 = 0.0322$.



Note: Steelhead escapement surveys at RBDD ended in 1993

Figure 7:
Estimated Central Valley natural steelhead escapement population in the upper Sacramento River based on RBDD counts.
Source: McEwan and Jackson 1996.
Trendline for Figure 7 is a logarithmic function: Y= -4419 Ln(x) + 14690 R^2= 0.8574

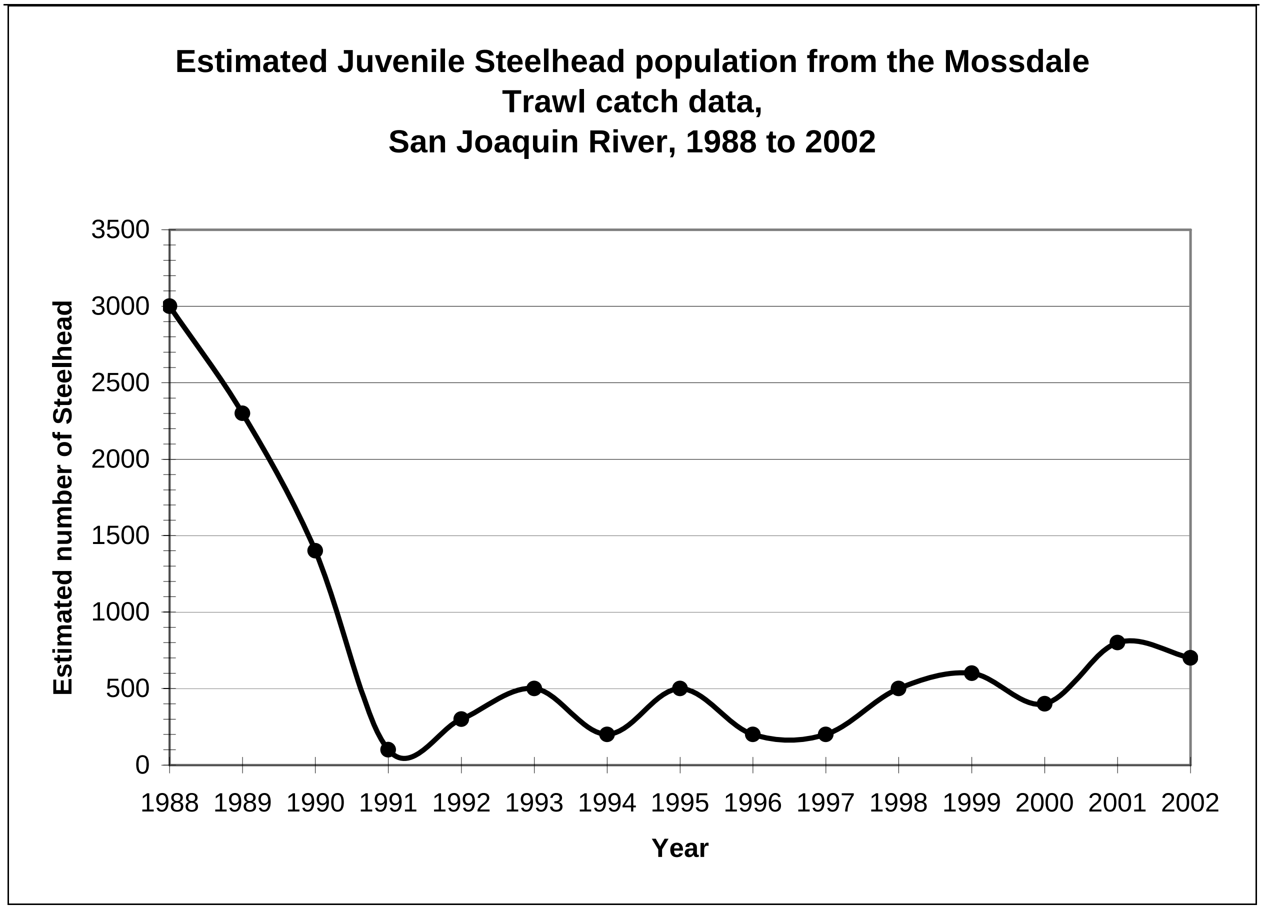


Figure 8:
Estimated number of juvenile Central Valley steelhead derived from the Mossdale trawl surveys on the San Joaquin River from 1988 to 2002.
Source: Marston (DFG), 2003.

Appendix C:

Guidelines for Developing Post-Construction Evaluation & Assessment Plans, and Operations and Maintenance Plans

Enclosure 2

Magnuson-Stevens Fishery Conservation and Management Act

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

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

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, Awaters@ includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; Asubstrate@ includes sediment, hard bottom, structures underlying the waters, and associated biological communities; Anecessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and, Aspawning, breeding, feeding, or growth to maturity@ covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMP and for starry flounder (*Platichthys stellatus*) and English sole (*Parophrys vetulus*) in Amendment 11 to the Pacific Coast Groundfish FMP.

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999). Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes not only the watersheds of the Sacramento and San Joaquin River basins but also the San Joaquin Delta (Delta) hydrologic unit (*i.e.*, number 18040003), Suisun Bay hydrologic unit (18050001) and the Lower Sacramento hydrologic unit (18020109). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the theses basins as well as the Delta, Suisun Bay, and Lower Sacramento units.

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

A. Life History and Habitat Requirements

1. Pacific Salmon

General life history information for Central Valley Chinook salmon is summarized below. Information on Sacramento River winter-run and Central Valley spring-run Chinook salmon life histories is summarized in the preceding biological opinion for the proposed project (Enclosure 1). Further detailed information on Chinook salmon Evolutionarily Significant Units (ESU) are available in the NMFS status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NMFS proposed rule for listing several ESU of Chinook salmon (63 FR 11482).

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

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

2. Starry Flounder

The starry flounder is a flatfish found throughout the eastern Pacific Ocean, from the Santa Ynez River in California to the Bering and Chukchi Seas in Alaska, and eastwards to Bathurst inlet in Arctic Canada. Adults are found in marine waters to a depth of 375 meters. Spawning takes place during the fall and winter months in marine to polyhaline waters. The adults spawn in shallow coastal waters near river mouths and sloughs, and the juveniles are found almost exclusively in estuaries. The juveniles often migrate up freshwater rivers, but are estuarine dependent. Eggs are broadcast spawned and the buoyant eggs drift with wind and tidal currents. Juveniles gradually settle to the bottom after undergoing metamorphosis from a pelagic larva to a demersal juvenile by the end of April. Juveniles feed mainly on small crustaceans, barnacle larvae, cladocerans, clams and dipteran larvae. Juveniles are extremely dependent on the condition of the estuary for their health. Polluted estuaries and wetlands decrease the survival rate for juvenile starry flounder. Juvenile starry flounder also have a tendency to accumulate many of the anthropogenic contaminants found in the environment.

3. English Sole

The English sole is a flatfish found from Mexico to Alaska. It is the most abundant flatfish in Puget Sound, Washington and is abundant in the San Francisco Bay estuary system. Adults are found in nearshore environments. English sole generally spawn during late fall to early spring at depths of 50 to 70 meters over soft mud bottoms. Eggs are initially buoyant, then begin to sink just prior to hatching. Incubation may last only a couple of days to a week depending on temperature. Newly hatched larvae are bilaterally symmetrical and float near the surface. Wind and tidal currents carry the larvae into bays and estuaries where the larvae undergo metamorphosis into the demersal juvenile. The young depend heavily on the intertidal areas, estuaries, and shallow near-shore waters for food and shelter. Juvenile English sole primarily feed on small crustaceans (*i.e.* copepods and amphipods) and on polychaete worms in these rearing areas. Polluted estuaries and wetlands decrease the survival rate for juvenile English soles. The juveniles also have a tendency to accumulate many of the contaminants found in their environment and this exposure manifests itself as tumors, sores, and reproductive failures.

II. PROPOSED ACTION

The proposed action, the Delta Water Supply Project (DWSP), is described in section II (*Description of the Proposed Action*) of the preceding biological opinion for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, and Central Valley steelhead (*O. mykiss*), the proposed threatened southern population of North American green sturgeon, and critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, and Central Valley steelhead (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on salmonid habitat (*i.e.,* for winter, spring and fall/late fall-run Chinook salmon) are described at length in section V (*Effects of the Action*) of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH. The general effects on the quality of EFH for the two species of flatfish are expected to be similar to those for green sturgeon due to their similar benthic life history in the Delta. Benthic dwelling flatfish will have prolonged exposure to habitat changes in the western Delta due to the effects of water diversions by the DWSP. Both the starry flounder and the English sole will spend more time as juveniles rearing in the action area than the Chinook salmon smolts. Therefore, these fish species will have a greater duration of exposure to the changes in water quality and the resulting habitat alterations than the juvenile Chinook salmon, leading to greater levels of adverse effects to the individual organisms.

IV. CONCLUSION

Based on the best available information, NMFS believes that the proposed City of Stockton Delta Water Supply Project may adversely affect EFH for Pacific salmon and groundfish during its normal long-term operations due to impingement, entrainment of food organisms, and alterations in the hydrology of the Delta and upstream tributaries.

V. EFH CONSERVATION RECOMMENDATIONS

NMFS recommends that the reasonable and prudent measures 1(f), 1(g) and 2(a) from the biological opinion, with their associated terms and conditions, be adopted as EFH Conservation Recommendations for EFH in the action area. In addition, certain other conservation measures need to be implemented in the project area, as addressed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999). NMFS anticipates that implementing those conservation measures intended to minimize disturbance and sediment and pollutant inputs to waterways would benefit groundfish as well.

Riparian Habitat ManagementBIn order to prevent adverse effects to riparian corridors, the U.S. Army Corps of Engineers (Corps) should:

- Maintain riparian management zones of appropriate width in the San Joaquin River, Sacramento River and eastside tributary watersheds that influence EFH;

- Reduce erosion and runoff into waterways within the project area; and

- Minimize the use of chemical treatments within the riparian management zone to manage nuisance vegetation along the levee banks and reclamation district=s irrigation drains.

Bank StabilizationBThe installation of riprap or other streambank stabilization devices can reduce or eliminate the development of side channels, functioning riparian and floodplain areas and off channel sloughs. In order to minimize these impacts, the Corps should:

- Use vegetative methods of bank erosion control whenever feasible. Hard bank protection should be a last resort when all other options have been explored and deemed unacceptable;

- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including prey species before planning new bank stabilization projects; and

$ Develop plans that minimize alterations or disturbance of the bank and existing riparian vegetation.

Conservation Measures for Construction/UrbanizationBActivities associated with urbanization (*e.g.*, building construction, utility installation, road and bridge building, and storm water discharge) can significantly alter the land surface, soil, vegetation, and hydrology and subsequently adversely impact salmon EFH through habitat loss or modification. In order to minimize these impacts, the Corps and the applicant should:

$ Plan development sites to minimize clearing and grading;

$ Use Best Management Practices in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoid building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water runoff and trap sediment and nutrients; and

$ Where feasible, reduce impervious surfaces.

Wastewater/Pollutant DischargesBWater quality essential to salmon and their habitat can be altered when pollutants are introduced through surface runoff, through direct discharges of pollutants into the water, when deposited pollutants are resuspended (*e.g.*, from dredging or ship traffic), and when flow is altered. Indirect sources of water pollution in salmon habitat includes run-off from streets, yards, and construction sites. In order to minimize these impacts, the Corps and the applicant should:

$ Monitor water quality discharge following National Pollution Discharge Elimination System requirements from all discharge points;

$ For those waters that are listed under Clean Water Act section 303 (d) criteria (*e.g.*, the Delta), work with State and Federal agencies to establish total maximum daily loads and develop appropriate management plans to attain management goals; and

$ Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling and transport of toxic substances in salmon EFH (*e.g.*, oil and fuel, organic solvents, raw cement residue, sanitary wastes, *etc*.). Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.

VI. STATUTORY REQUIREMENTS

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

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