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

JUN 23 2009

In Response Refer To:
2009/00173

Jeffery G. Jensen
Office Chief, Office of Biological Sciences and Permits
Department of Transportation
111 Grand Avenue
P.O. Box 23660
Oakland, California 94623-0660

Dear Mr. Jensen:

Enclosed is NOAA's National Marine Fisheries Service's (NMFS) biological and conference opinion (Enclosure 1) for the proposed Antioch Bridge Seismic Retrofit project (Project) located in Contra Costa and Sacramento Counties, California, and its effects on Sacramento River Winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley (CV) Spring-run Chinook salmon (*O. tshawytscha*), CV steelhead (*O. mykiss*), and Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*) 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 formal section 7 consultation and conferencing on this project was received on January 26, 2009. On February 6, 2009, formal consultation and conferencing was initiated by NMFS' Sacramento Area Office.

This biological and conference opinion is based primarily on the biological assessment (BA) provided on January 14, 2009. The BA incorporated recommendations and addressed NMFS comments as discussed in meetings, correspondence, and emails.

Based on the best available scientific and commercial information, the biological and conference opinion concludes that the Project, as presented by the California Department of Transportation, is not likely to jeopardize the continued existence of the listed species or destroy or adversely modify designated or proposed critical habitat. NMFS anticipates that the proposed project will result in the incidental take of CV steelhead and North American green sturgeon. An incidental take statement that includes reasonable and prudent measures and non-discretionary terms and conditions that are intended to minimize the impact of the anticipated incidental take of CV steelhead and North American green sturgeon is included with the opinion. The section 9 prohibitions against taking of listed species and the terms and conditions in the incidental take statement of this conference and biological opinion will not apply to the Southern DPS of North American green sturgeon until a final section 4(d) ruling under the ESA has been published in the Federal Register. Additionally, the analysis of project effects on proposed critical habitat for the Southern DPS of North American green sturgeon is considered a conference opinion for those effects. This conference opinion does not take the place of a biological opinion under section 7(a)2 of the ESA. The conference opinion may be adopted as a biological opinion when the proposed critical habitat designation for the Southern DPS of North American green sturgeon becomes final if no significant new information is developed, and no significant changes to the project are made that would alter the contents, analyses or conclusions of this opinion.

Also enclosed are NMFS' Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (O. tshawytscha) as required by the Magnuson-Stevens Fishery Conservation and Management Act as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). The document concludes that the Project 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.

Please contact Monica Gutierrez at our Sacramento Area Office at (916) 930-3657, or via e-mail at Monica.Gutierrez@noaa.gov, if you have any questions regarding this response or require additional information.

Sincerely,

Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: Copy to file – ARN# 151422SWR2009SA00060
NMFS-PRD, Long Beach, CA
Bryan Chesney, Long Beach, CA

**Enclosure 1**

# BIOLOGICAL and CONFERENCE OPINION

**ACTION AGENCY:** California Department of Transportation

**ACTION:** Antioch Bridge Seismic Retrofit Project

**CONSULTATION**
**CONDUCTED BY:** Southwest Region, National Marine Fisheries Service – MG 2009/00173

**FILE NUMBER:** 151422SWR2009SA00060

**DATE ISSUED:** June 23, 2009

## I. CONSULTATION HISTORY

The California Department of Transportation (Caltrans) proposes to retrofit the Antioch Bridge on State Route (SR) 160 in Contra Costa and Sacramento Counties, California. The seismic retrofit of Antioch Bridge is a necessary action for the bridge to meet current design standards. The original construction of Antioch Bridge was completed in 1978. The seismic design of the bridge was based on the criteria developed after the San Francisco Earthquake of 1971. The Loma Prieta Earthquake of 1989 prompted Caltrans to implement the Seismic Retrofit Program (Program). After the Northridge Earthquake of 1994, Caltrans implemented Phase two of the Program, which required seven state-owned toll bridges, including the Antioch Bridge, to be retrofitted.

On April 21, 2008, the first of several pre-consultation meetings was held at the Caltrans District 4 office in Oakland, California. Technical assistance was provided to Stuart Kirkham (Caltrans District 4) relating to Incidental Harassment Authorization under the Marine Mammals Protection Act and other pre-consultation discussions.

On September 10, 2008, a meeting was held at the Caltrans headquarters in Sacramento, California, to discuss design changes to the project description. In addition, John Clecker (U.S. Fish and Wildlife [USFW] Biologist) specified an in-water work window (August 1-November 30) for delta smelt (*Hypomesus transpacificus*) for the project region. Doug Hampton (National Marine Fisheries Service [NMFS] Biologist) concurred, stating that a work window of August 1-October 31 would cover both delta smelt and Chinook salmon, but that he would allow up to November 30 as a work window, provided that the project proponent incorporated appropriate minimization measures in constructing the temporary marine trestle (*e.g.* limiting pile size to no greater than 24-inch diameter, vibrating piles). Melissa Escaron (California Department of Fish and Game [CDFG] Biologist) concurred with the work window.

On November 5, 2008, the second interagency meeting for the Antioch Bridge Seismic Retrofit Project was held at Caltrans Headquarters in Sacramento, California. At this meeting, John Clecker, suggested sending copies of the biological assessment (BA) to every party that would need the biological and conference opinion (BO). He also agreed with NMFS on the methodology Caltrans was pursing in the hydro-acoustic analysis.

On December 3, 2008, a teleconference was held between NMFS and Caltrans to confirm the in-water work windows and avoidance and minimization measures. NMFS indicated that the August 1 - November 30 work window would be likely to avoid impacts to all the NMFS species for the project, except for CV steelhead. Avoidance and minimization measures for Green sturgeon were not discussed.

On January 6, 2009, another teleconference was held between NMFS, Stuart Kirkham (Caltrans District 4), and Melissa Escaron, to discuss project effects to CV steelhead and proposed mitigation. NMFS concurred with Caltrans' estimates of take for CV steelhead, and the proposed compensatory mitigation, pending review of Caltrans' analysis report on the estimates of CV steelhead.

On January 14, 2009, a meeting was held at the Caltrans Headquarters in Sacramento to discuss summary of findings, conclusions, and determinations of the draft BA.

On January 26, 2009, NMFS received a letter from Caltrans (District 4) requesting initiation of formal section 7 consultation under ESA.

## II. DESCRIPTION OF THE PROPOSED ACTION

### A. Construction Activities

Caltrans proposes to retrofit the Antioch Bridge to meet current seismic standards due to current insufficient bridge performance during a maximum credible earthquake. Caltrans plans to install steel cross bracing between columns to stiffen the superstructure cross frames (pier 12 to pier 31) and will install bracing to the existing cross frames at the bent caps (pier 2 to pier 40). The existing elastometric bearings will be replaced with isolation bearings (abutment 1 to pier 41). Existing curtain walls will be removed and all columns within the slab span structure (bent 42 to abutment 71) will be retrofitted. A temporary marine trestle, with an approximate length of 910 feet and a width of 25 feet, will be constructed from the south bank of the San Joaquin River to pier 11 to allow construction access to the piers in the shallow water area. The trestle platform is expected to be approximately 5 feet above the Mean Higher-High Water (MHHW). The trestle will be constructed using approximately 160, 24-inch diameter hollow steel shell piles. The piles will be installed with a vibratory hammer, which should take approximately 10 minutes per pile to install. An impact hammer will be used on every other pile to ensure that the piles meet load bearing specifications. This will result in a maximum of 60 strikes per day. Pile installation will be limited to the in-water work window of August 1-November 30. A temporary access road on the south shore will be constructed to allow access to the temporary marine trestle. At the completion of the project, the trestle along with the piles will be removed by the same vibratory hammer used to install the piles. The duration of the vibration for removing the piles will be no longer than 30 sec/pile. Barges will be used to retrofit piers 12 to 21 and no aquatic impacts are anticipated beyond the potential installation of mooring lines.

Another temporary access road will be constructed from the southernmost bridge support on Sherman Island (pier 22) to the last bridge support of Mayberry Slough (pier 38) to provide construction access for retrofit work. There will be construction of another temporary access road that parallels the slab span structure on both sides, north of Mayberry Slough, to facilitate removal of the curtain walls from the slab structure and reinforce existing columns and abutments and to allow work for the permanent widening of an existing access road along Mayberry Slough to access piers north of Mayberry Slough. There is no anticipated aquatic disturbance during the construction of the temporary access roads. The proposed project is scheduled to begin mid-2010 and end in late 2012.

**B. Action Area**

Action area is defined as 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). For purposes of this consultation, the action area consists of two components. The terrestrial component of the action area is defined by: 1) the project footprint, including all cleared areas, and staging areas; and 2) construction noise levels in excess of ambient conditions. The aquatic component of the action area is defined by: 1) the segment of the Feather River upstream and downstream of bridge construction sites where pile driving sound noise levels are expected to exceed ambient conditions; 2) construction-related water quality impacts in excess of ambient conditions; and 3) operational stormwater quality impacts in excess of ambient conditions. A plan view map of the project vicinity showing the action area boundary is presented in Figure 1.

The proposed Antioch Bridge Seismic Retrofit project is located along a two mile (mi) stretch of SR 160, from the southern limit of the project at Post Mile (PM) 0.8 in Contra Costa County to PM 1.3 at the Contra Costa/Sacramento County line, and from PM 0 to PM 1.3 in Sacramento County, on Sherman Island (Figure 1). The bridge currently supports SR 160 and connects the City of Antioch on the south bank of the San Joaquin River to Sherman Island on the north. It spans the 3,600-foot (ft) width of the river and over 4,000 feet of Sherman Island, before touching down just north of Mayberry Slough. The San Joaquin River is relatively shallow on the south side, with depths of less than 10 ft out to pier 11. The main channel extends between piers 12 and 20 with deep water passage between piers 19 and 20 near the northern shore. On the north side of the river, Sherman Island supports irrigated pasture and irrigated crops as well as ruderal vegetation in fallow fields. Mayberry Slough and an irrigation canal cross the project action area in the vicinity of piers 32, 39, and 40, respectively.

The project limits, which include Caltrans right-of-way (ROW) and temporary construction easements, cover approximately 62 acres (ac), including 7.5 ac on the south shore of the San Joaquin River in Contra Costa County, 21 ac of the San Joaquin River, and 33.5 ac on Sherman Island in Sacramento County. The action area consists of the project's footprint including areas for access and staging. No areas of indirect effects are anticipated. The action area also includes the project limit, plus an additional 8577 m zone around the temporary trestle which represents the extent of elevated underwater sound pressure levels that may result in adverse behavioral responses to listed species.

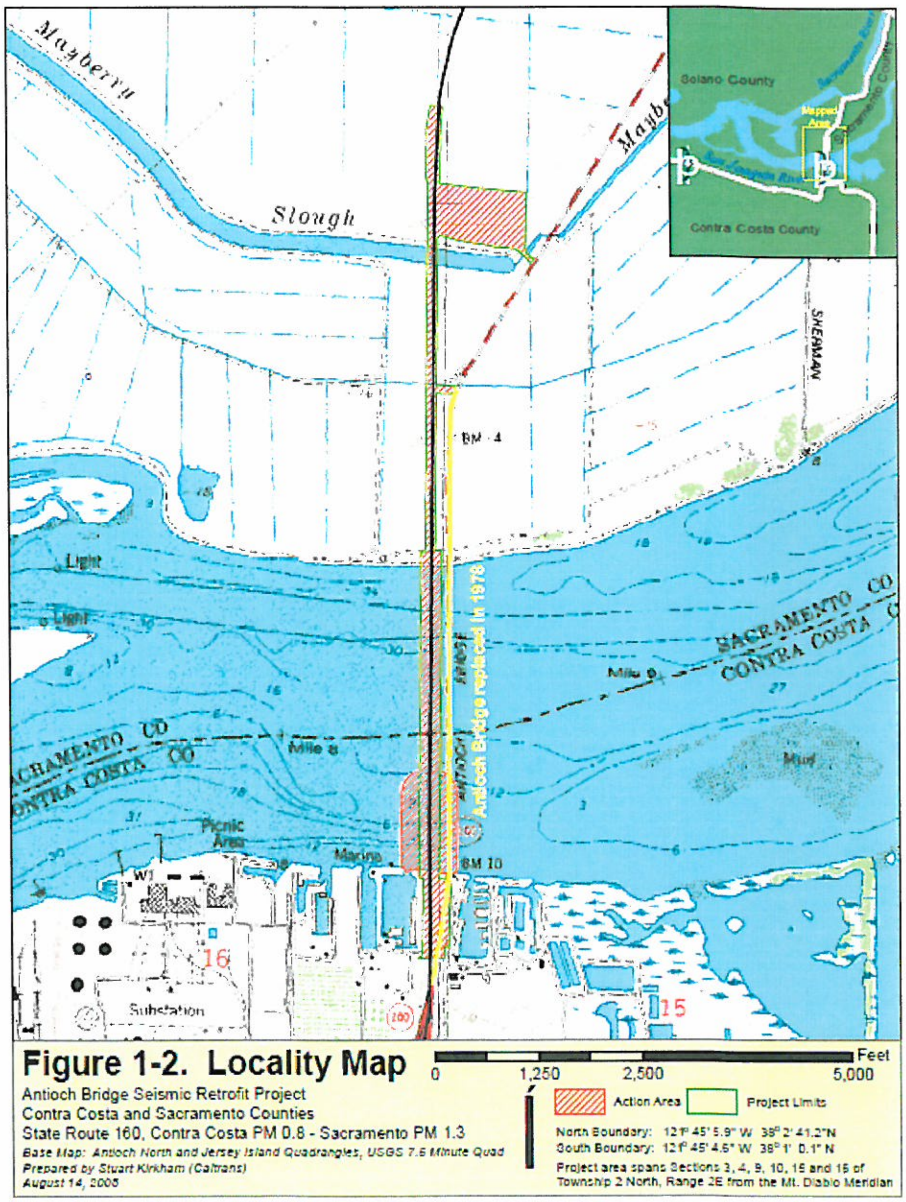


Figure 1. Antioch Bridge Seismic Retrofit project area map (Kirkham 2008)

## C. Proposed Conservation Measures

The following conservation measures have been incorporated into the project design to avoid and/or minimize potential adverse effects of the proposed project on special status fish species and their designated and/or proposed critical habitats.

1. The Project Delivery Team (PDT) altered the design strategy such that deep water permanent pile driving to reinforce the foundations of the bridge columns will be unnecessary, a change which will greatly reduce the potential for effects to the listed ESA fish species in the San Joaquin River. Additionally, coordination efforts concerning the temporary marine trestle have refined the design parameters of the temporary structure to use a vibratory hammer for pile driving and to limit the pile size to a maximum diameter of 24 in, which will minimize the hydro-acoustic signature and effects on earlier life stages and smaller individuals of listed anadromous fish. Caltrans will proof one pile per day for every 4 to 6 piles. In other words, one pile per day (thus, either 1 of 4 or 1 of 6) will be tested with an impact hammer to see if the pile will withstand the load that the trestle will have to bear.

2. An in-water work window will be established from August 1 to November 30. This will help avoid any direct impacts to most ESA-listed species covered under this consultation. However, adult and juvenile CV steelhead and green sturgeon may be present in the action area during the proposed in-water construction period.

3. Barges will be used to retrofit piers 12 to 21, and no aquatic impacts are anticipated from this activity.

4. Bridge cross bracings that will be installed between bridge columns will be anchored to the columns using a drill and bond method. This method will reduce the amount of concrete debris that could potentially fall into the San Joaquin River.

5. This project will not require on-site borrow or disposal of excavated material. Gravel and rock will be imported for construction of the temporary access road and road widening. These materials will be removed upon completion of the project, and removal and disposal of this material will be implemented through contractors and subcontractors as part of the Caltrans standard Best Management Practices (BMPs) and Stormwater Pollution Prevention Plan (SWPPP). BMPs and SWPPP measures are a standard part of the plans and specifications for this project and are included in the California Central Valley Regional Water Quality Control Board (CVRWQCB) Section 401 Water Quality Certification.

## III. STATUS OF THE SPECIES AND CRITICAL HABITAT

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

**Sacramento River winter-run Chinook salmon ESU** (*Oncorhynchus tshawytscha*)
endangered (June 28, 2005, 70 FR 37160)
**Sacramento River winter-run Chinook salmon designated critical habitat**
(June 16, 1993, 58 FR 33212)
**Central Valley spring-run Chinook salmon ESU** (*Oncorhynchus tshawytscha*)
threatened (June 28, 2005, 70 FR 37160)
**Central Valley spring-run Chinook salmon designated critical habitat**
(September 2, 2005, 70 FR 52488)
**Central Valley steelhead DPS** (*Oncorhynchus mykiss*)
threatened (January 5, 2006, 71 FR 834)
**Central Valley steelhead designated critical habitat**
(September 2, 2005, 70 FR 52488)
**Southern DPS of North American green sturgeon** (*Acipenser medirostris*)
threatened (April 7, 2006, 70 FR 17757)
**Southern DPS of North American green sturgeon proposed critical habitat** (September 8, 2008, 73 FR 52084)

### A. Species and Critical Habitat Listing Status

In 2005, NMFS completed an updated status review of 16 salmon ESUs, including Sacramento River winter-run Chinook salmon and Central Valley (CV) spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (June 28, 2005, 70 FR 37160). On January 5, 2006, NMFS published a final listing determination for 10 steelhead DPSs, including CV steelhead. The new listing concludes that CV steelhead will remain listed as threatened (71 FR 834).

1. Sacramento River Winter-run Chinook salmon

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. NMFS reaffirmed the listing of Sacramento River winter-run Chinook salmon as endangered on June 28, 2005 (70 FR 37160). The critical habitat designation includes the Sacramento River from Keswick Dam, Shasta County (River Mile 302) to Chipps Island (River Mile 0) at the westward margin of the Sacramento-San Joaquin Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of the San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge (58 FR 33212). Designated critical habitat for Sacramento River winter-run Chinook salmon does not occur within the proposed project's action area.

2. CV spring-run Chinook salmon

NMFS listed the CV spring-run Chinook salmon ESU as threatened on September 16, 1999 (64 FR 50394). In June 2004, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102). This proposal was based on the recognition that although CV spring-run Chinook salmon productivity trends are positive, the ESU continues to face risks from having a limited number of remaining populations (*i.e.*, 3 existing independent populations from an estimated 17 historical populations), a limited geographic distribution, and potential hybridization with Feather River Hatchery (FRH) spring-run Chinook salmon, which until recently were not included in the ESU and are genetically divergent from other populations in Mill, Deer, and Butte creeks. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV spring-run Chinook salmon as threatened (70 FR 37160). This decision also included the FRH spring-run Chinook salmon population as part of the CV spring-run Chinook salmon ESU. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488). Designated critical habitat includes approximately 8,935 net miles (mi) of riverine habitat and 470 $mi^2$ of estuarine habitat (primarily in San Francisco-San Pablo-Suisun Bays) in California (70 FR 52488). Designated critical habitat for CV spring-run Chinook salmon does not occur within the proposed project's action area.

3. CV steelhead

CV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin river basins in California's Central Valley. In June 2004, after a complete status review of the 26 west coast salmon DPSs, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102), while the other Chinook salmon and steelhead were further reviewed. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV steelhead as threatened (70 FR 37160). This decision also included the Coleman National Fish Hatchery and FRH steelhead populations. These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for CV steelhead on September 2, 2005 (70 FR 52488). 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. Designated critical habitat for CV steelhead does occur within the proposed project's action area.

4. Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2006, (70 FR 17386). The Southern DPS presently contains only a single spawning population in the Sacramento River, and adults and juveniles may occur within the action area. NMFS issued proposed critical habitat for the Southern DPS of North American green sturgeon on September 8, 2008 (73 FR 52084). The areas proposed as critical habitat include: coastal U.S. marine waters within 110 meters (m) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, and Yaquina Bay), and Washington (Willapa Bay and Grays Harbor). Proposed critical habitat for Southern DPS of North American green sturgeon does occur within the proposed project's action area.

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

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 stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38 °F to 56 °F (Bell 1991; CDFG 1998). 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. 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.

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

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995a). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. The upper preferred water temperature for spawning Chinook salmon is 55 °F to 57 °F (Chambers 1956; Smith 1973; Bjornn and Reiser 1991; Snider 2001).

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

Rearing fry seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996a). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001).

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). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of maturation (Kjelson *et al.* 1982; Brandes and McLain 2001).

Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. Martin *et al.* (2001) found that the daily migration of juveniles passing Red Bluff Diversion Dam (RBDD) is highest in the four hour period prior to sunrise. Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980; Levy and Northcote 1981).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, CV 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 to 57 °F (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54 °F by February in a typical year. Other portions of the Delta (*i.e.*, South Delta and Central Delta) can reach 70 °F by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

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

b. *Sacramento River Winter-Run Chinook Salmon*

Sacramento River winter-run Chinook salmon adults enter the San Francisco Bay between November and June, with a peak occurring in March (Yoshiyama *et al.* 1998; Moyle 2002). Spawning occurs primarily from mid April to mid August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick dam and Red Bluff Diversion Dam (RBDD) (Vogel and Marine 1991). The majority of Sacramento River winter-run Chinook salmon spawners are 3 years old.

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Post-emergent fry disperse to the margins of the river, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

Emigration of juvenile winter-run past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991; NMFS 1997). From 1995 to 1999, all Sacramento River winter-run Chinook outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Table 1; Martin *et al.* 2001).

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

**(1) Population Dynamics**. Historical Sacramento River winter-run Chinook salmon population estimates were as high as 100,000 fish in the 1960s; however, populations declined below 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,218), 2004 (7,869), 2005 (15,875), and 2006 (17,304) show a recent increase in the population size (CDFG 2009) and a 4-year average of 12,317 (2003 through 2006). The 2006 run was the highest since the listing. However, the population estimate for winter-run Chinook salmon in 2007 was only 2,542 and 2,850 for 2008 (CDFG 2009). The saltwater life history traits and food requirements of winter-run Chinook salmon and fall-run Chinook salmon are similar. Therefore, the unusual and poor ocean conditions that caused the drastic decline in returning fall run Chinook salmon populations coast wide in 2007 and 2008 (Lindley *et al.* 2009) are suspected to have also caused the observed decrease in the winter-run Chinook salmon spawning population during this period (Oppenheim 2008). Two current methods are utilized to estimate the juvenile production of Sacramento River winter-run Chinook salmon: the Juvenile Production Estimate (JPE) method, and the Juvenile Production Index (JPI) method (Gaines and Poytress 2004). Gaines and Poytress (2004) estimated the juvenile population of Sacramento River winter-run Chinook salmon exiting the upper Sacramento River at RBDD to be 3,707,916 juveniles per year using the JPI method between the years 1995 and 2003 (excluding 2000 and 2001). Using the JPE method, they estimated an average of 3,857,036 juveniles exiting the upper Sacramento River at RBDD between the years of 1996 and 2003 (Gaines and Poytress 2004). Averaging these 2 estimates yields an estimated juvenile population size at RBDD of 3,782,476.

Based on the RBDD counts, the population showed steady growth from the 1990s through 2006 with positive short-term trends. However, an age-structured density-independent model of spawning escapement by Botsford and Brittnacker in 1998 (as referenced in Good *et al.* 2005) assessing the viability of Sacramento River winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good *et al.* 2005). Lindley *et al.* (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures and found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the Sacramento River winter-run Chinook salmon population has improved over the last two decades since its listing, the recent severe declines illustrate the volatility of this small, single population ESU. Because there is only one population, and it depends on cold-water releases from Shasta Dam to provide suitable spawning habitat, the ESU is highly vulnerable to a prolonged drought resulting in depletion of the cold-water pool in Shasta Lake (Good *et al.* 2005).

Although NMFS proposed that this ESU be upgraded from endangered to threatened status in 2005, the Final Listing Determination (June 28, 2005, 70 FR 37160) maintained the status of the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the draft recovery goals established for the run (NMFS 1997, 1998) and the naturally spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the draft recovery criteria for Sacramento River winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0. Recent trends in Sacramento River winter-run Chinook salmon abundance and cohort replacement remain positive, indicating some recovery since the listing. However, the population remains well below the recovery goals of the draft recovery plan, and is particularly susceptible to extinction because of the reduction of the genetic pool to one population.

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. The percentage of habitat loss for steelhead is presumably greater, because steelhead were more extensively distributed upstream than Chinook salmon.

As a result of migrational barriers, winter-run populations have been confined to lower elevation mainstems that historically only were used for migration and rearing. Population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Higher temperatures at these lower elevations during late-summer and fall are also a major stressor to adult and juvenile salmonids. According to Lindley *et al.* (2004), of the four independent populations of winter-run that occurred historically, only one mixed stock of winter-run remains below Keswick Dam. Similarly, of the 19 independent populations of spring-run that occurred historically, only three independent populations remain in Deer, Mill, and Butte Creeks (Lindley *et al.* 2007). Dependent populations of spring-run continue to occur in Big Chico, Antelope, Clear, Thomes, and Beegum Creeks and the Yuba River, but rely on the extant independent populations for their continued survival. CV steelhead historically had at least 81 independent populations based on Lindley *et al.*'s (2006) analysis of potential habitat in the Central Valley. However, due to dam construction, access to 38 percent of all spawning habitat has been lost, as well as access to 80 percent of the historically available habitat.

Lindley *et al.* (2007) state that the winter-run Chinook salmon population fails the "representation and redundancy rule" because it has only one population and that population spawn outside of the eco-region in which it evolved. In order to satisfy the "representation and redundancy rule," at least two populations of winter-run Chinook salmon would have to be re-established in the basalt- and porous-lava region of its origin. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction over an extended period of time (Lindley *et al.* 2007).

**(2) Viable Salmonid Population Summary for Sacramento River Winter-Run Chinook Salmon.** McElhany *et al.* (2000) define a viable salmonid population (VSP) as an independent population that has a negligible probability of extinction over a 100-year time frame. The VSP concept provides specific guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as ESU or DPS. Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (*i.e.*, population growth rate); (3) population spatial structure; and (4) diversity (McElhany *et al.* 2000).

*Abundance.* Redd and carcass surveys, and fish counts, suggest that the abundance of winter-run Chinook salmon has been increasing. The depressed 2007 and 2008 abundance estimates are significant exceptions to this trend and may represent a new cycle of poor ocean productivity. Population growth is estimated to be positive in the short-term trend at 0.26; however, the long-term trend is negative, averaging -0.14. Recent winter-run Chinook salmon abundance represents only 3 percent of the maximum post-1967, 5-year geometric mean, and is not yet well established (Good *et al.* 2005).

*Productivity.* Prior to the recent declines, ESU productivity had been positive over the short term, and adult escapement and juvenile production were been increasing annually (Good *et al.* 2005). The long-term trend for the ESU remains negative however, as the cohort replacement rate (CRR) estimate suggests a reduction in productivity for the 1998-2001 cohorts.

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

*Diversity.* The second highest risk factor for the Sacramento River winter-run Chinook salmon

ESU has been the detrimental effects on its diversity. The genetics of the present winter-run population has resulted from the introgression of several stocks that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam; there may have been several others within the recent past (Good *et al.* 2005). Concerns of genetic introgression with hatchery populations are also increasing. Although Livingston Stone National Fish Hatchery (LSNFH) is characterized as one of the best examples of a conservation hatchery operated to maximize genetic diversity and minimize domestication of the offspring produced in the hatchery, it still faces some of the same diversity issues as other hatcheries in reducing the diversity of the naturally-spawning population. Therefore, Lindley *et al.* (2007) characterizes hatchery influence as a looming concern with regard to diversity. Even with a small contribution of hatchery fish to the natural spawning population, hatchery contributions could compromise the long term viability and extinction risk of winter-run.

NMFS concludes that the current diversity in this ESU is much reduced compared to historic levels, and that winter-run are at a high risk of extinction based on the spatial structure and diversity VSP parameters.

c. *CV Spring-Run Chinook Salmon*

Historically the spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (CDFG 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 foot elevations) 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 CV spring-run Chinook salmon from these watersheds. Naturally-spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998a) and enter the Sacramento River between March and September, primarily in May and June (Table 2; Yoshiyama *et al.* 1998; Moyle 2002). Lindley *et al.* (2006a) indicate adult CV spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al.* 1998). Spring-run Chinook salmon 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).

Table 1. The temporal occurrence of adult and juvenile Sacramento River winter-run Chinook salmon in the Sacramento River.

| **Adult Location** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sacramento River basin[1] | | | | | | | | | | | | |
| Sacramento River[2] | | | | | | | | | | | | |
| **Juvenile Location** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Sacramento River at Red Bluff[3] | | | | | | | | | | | | |
| Sacramento River at Red Bluff[2] | | | | | | | | | | | | |
| Sacramento River at Knights Landing[4] | | | | | | | | | | | | |
| Lower Sacramento River (seine)[5] | | | | | | | | | | | | |
| West Sacramento River (trawl)[5] | | | | | | | | | | | | |

**Relative Abundance:** =High; =Medium; =Low

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

Table 2. The temporal occurrence of adult and juvenile Central Valley spring-run Chinook salmon in the Sacramento River.

| **Adult Location** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sacramento River basin[1, 2] | | | | | | | | | | | | |
| Sacramento River[3] | | | | | | | | | | | | |
| Mill Creek[4] | | | | | | | | | | | | |
| Deer Creek[4] | | | | | | | | | | | | |
| Butte Creek[4] | | | | | | | | | | | | |
| **Juvenile Location** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Sacramento River Tributaries | | | | | | | | | | | | |
| Upper Butte Creek | | | | | | | | | | | | |
| Mill, Deer, Butte Creeks | | | | | | | | | | | | |
| Sacramento River @ RBDD | | | | | | | | | | | | |
| Sacramento River @ Knights Landing | | | | | | | | | | | | |

**Relative Abundance:** =High; =Medium; =Low

Sources: [1]Yoshiyama *et al.* (1998); [2]Moyle (2002); [3]Meyers *et al.* (1998); [4]Lindley *et al.* (2007); [5]CDFG (1998); [6]McReynolds *et al.* (2005); Ward *et al.* (2002, 2003); [7]Snider and Titus (2000)

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and emigration timing is highly variable, as they may migrate downstream as young-of-the-year

(YOY) or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2006a). Studies in Butte Creek (Ward *et al.* 2002, 2003; McReynolds *et al.* 2005) found the majority of CV spring-run Chinook salmon migrants to be fry occurring primarily during December, January, and February, and that these movements appeared to be influenced by flow. Small numbers of CV spring-run Chinook salmon remained in Butte Creek to rear and migrate as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creeks juveniles typically exhibit a later YOY migration and an earlier yearling migration (Lindley *et al.* 2006a).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing their yolk sac (Moyle 2002). Many will also disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper, faster water as they grow. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles are also observed between November and the end of May (Snider and Titus 2000). Based on the available information, the emigration timing of CV spring-run Chinook salmon appears highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998).

**(1) Population Dynamics**. The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. The average abundance for the ESU was 12,590 for the period of 1969 to 1979, 13,334 for the period of 1980 to 1990, 6,554 from 1991 to 2001, and 16,349 between 2002 and 2005. For the period of 2006 to 2008 the average abundance for the ESU fell to a low of 854 (CDFG 2009). Sacramento River tributary populations in Mill, Deer, and Butte creeks are probably the best trend indicators for the CV spring-run Chinook ESU as a whole because these streams contain the primary independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995 (until 2005). During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remains well below estimates of historic abundance. Additionally, in 2003 high water temperatures, high fish densities, and an outbreak of Columnaris Disease (*Flexibacter Columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) contributed to the pre-spawning mortality of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek. Most recently, returns on Butte, Mill, and Deer creeks have been the lowest since prior to 2000, with the 2008 estimate on Butte Creek at 3,935, 362 on Mill Creek and 140 on Deer Creek.

**(2) Viable Salmonid Population Summary for Central Valley Spring-Run Chinook**

**Salmon.** The following provides the evaluation of the likelihood of viability for the threatened spring-run ESU based on the VSP parameters of abundance, productivity, spatial structure, and diversity.

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

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

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

*Diversity.* The CV spring-run ESU fails to meet the "representation and redundancy rule," since the Northern Sierra Nevada is the only diversity group in the spring-run ESU that contains demonstrably viable populations out of at least 3 diversity groups that historically contained them. Independent populations of spring-run only occur within the Northern Sierra Nevada diversity group. The Northwestern California diversity group contains a few ephemeral populations of spring-run that are likely dependent on the Northern Sierra Nevada populations for their continued existence. The spring-run populations that historically occurred in the Basalt and Porous Lava, and Southern Sierra Nevada, diversity groups have been extirpated. Over the long term, the three remaining independent populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run populations in the Deer, Mill and Butte Creek watersheds due to their close proximity to each other. Feather River spring-run have introgressed with the fall-run, and it appears that the Yuba River population may have been impacted by FRH fish straying into the Yuba River. Additionally, the diversity of the spring-run ESU has been further reduced with the loss of the San Joaquin River basin spring-run populations.

Butte Creek and Deer Creek spring-run are at low risk of extinction, satisfying both population viability analysis and other viability criteria. Mill Creek is at moderate extinction risk according to the PVA, but appear to satisfy the other viability criteria for low risk status (Lindley *et al.* 2007). Spring-run fail the representation and redundancy rule for ESU viability, as their current distribution has been severely constricted. Therefore, spring-run are at moderate risk of extinction over an extended period of time.

2. CV steelhead

*a. General Life History*

Steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Only winter steelhead currently are found in California 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).

CV steelhead generally leave the ocean from August through April (Busby *et al.* 1996) and enter freshwater from August to November and spawn from December to April in small streams and tributaries where cool, well oxygenated water is available year-round (Table 3; Williams 2006; Hallock *et al.* 1961; McEwan and Jackson 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

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

Table 3. The temporal occurrence of adult and juvenile Central Valley steelhead in the Central Valley.

| Adult Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sacramento River basin[1, 2] | | | | | | | | | | | | |
| Sacramento River at Red Bluff[2, 3] | | | | | | | | | | | | |
| Mill, Deer Creeks[4] | | | | | | | | | | | | |
| Sacramento River at Fremont Weir[6] | | | | | | | | | | | | |
| San Joaquin River[7] | | | | | | | | | | | | |
| **Juvenile Location** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Sacramento River[1, 2] | | | | | | | | | | | | |
| Sacramento River at Knights Landing[2, 8] | | | | | | | | | | | | |
| Sacramento River at Knights Landing[9] | | | | | | | | | | | | |
| Chipps Island (wild)[10] | | | | | | | | | | | | |
| Mossdale[8] | | | | | | | | | | | | |
| Woodbridge Dam[11] | | | | | | | | | | | | |
| Stanislaus River at Caswell[12] | | | | | | | | | | | | |
| Sacramento River at Hood[13] | | | | | | | | | | | | |

**Relative Abundance:** =High =Medium =Low

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

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating CV steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile CV steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002). Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring with a much smaller peak in the fall. Nobriga and Cadrett (2003) also have verified these temporal findings based on analysis of captures at Chipps Island.

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

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

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

Until recently, CV steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001).

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread throughout accessible streams and rivers in the Central Valley (Good *et al.* 2005). CDFG staff has prepared juvenile migrant CV steelhead catch summaries on the San Joaquin River near Mossdale representing migrants from the Stanislaus, Tuolumne, and Merced rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River" (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003b). The documented returns on the order of single fish in these tributaries suggest that existing populations of CV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed.

Lindley *et al.* (2006b) indicated that prior population census estimates completed in the 1990s found the CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

**(2) Viable Salmonid Population Summary for Central Valley Steelhead.** In order to determine the current likelihood of viability of the CV steelhead DPS, we used the historical population structure of CV steelhead presented in Lindley *et al.* (2006) and the concept of VSP for evaluating populations described by McElhany *et al.* (2000). While McElhany *et al.* (2000) introduced and described the concept of VSP, Lindley *et al.* (2007) applied the concept to the CV steelhead DPS. The following provides the evaluation of the likelihood of viability for the threatened CV steelhead DPS based on the VSP parameters of abundance, productivity, spatial structure, and diversity.

*Abundance.* All indications are that natural CV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005); the long-term trend remains negative. There has been little steelhead population monitoring despite 100 percent marking of hatchery steelhead since 1998. Hatchery production and returns are far greater than those of natural fish and include significant numbers of non-DPS-origin Eel River steelhead stock.

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

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

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

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

3. <u>Southern DPS of North American Green Sturgeon</u>

*a. General Life History*

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

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

The southern DPS of North American green sturgeon life cycle can be broken into three distinct phases based on developmental stage and habitat use: (1) year-round juveniles, (2) pre-and post-spawning adults, and (3) adult and sub-adult summer residents.

Southern DPS green sturgeon adults begin their upstream spawning migrations into the San Francisco Bay in March, reach Knights Landing during April, and spawn between March and July (Heublein *et al.* 2006). Peak spawning is believed to occur between April and June and thought to occur in deep turbulent pools (Adams *et al.* 2002). Substrate is likely large cobble but can range from clean sand to bedrock (USFWS 2002). Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length. According to Heublein (2006), all adults leave the Sacramento River prior to September 1.

Adult green sturgeon in the San Francisco Estuary make significant long-distance movements with distinct directionality and are not related to salinity, current, or temperature, but resource availability (Kelley *et al.* 2007). The majority of green sturgeon in the Rogue River emigrated from freshwater habitat in December after water temperatures dropped (Erickson *et al.* 2002). Green sturgeon were most often found at depths greater than 5 meters with low or no current during summer and autumn months (Erickson *et al.* 2002). Holding in deep pools is a way to conserve energy and utilize abundant food resources. Based on captures of adult green sturgeon in holding pools on the Sacramento River above the Glenn-Colusa Irrigation District (GCID) diversion (RM 205), the documented presence of adults in the Sacramento River during the spring and summer months, and the presence of larval green sturgeon in late summer in the lower Sacramento River indicating spawning ocurrence, it appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to nine months of the year (Beamesderfer *et al.* 2004; S.P. Cramer & Associates, Inc., pers. comm. 2006).

Based on the distribution of sturgeon eggs, larva, and juveniles in the Sacramento River, CDFG (2002) indicated that southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City possibly to Keswick Dam. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (Table 4; CDFG 2002). Adult female green sturgeon produce between 60,000 and 140,000 eggs each reproductive cycle, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992; Van Eenennaam *et al.* 2001).

After approximately 10 days larvae begin feeding, growing rapidly, and young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging from 24 to 31 mm fork length (CDFG 2002; USFWS 2002). The mean yearly total length of post-larval green sturgeon captured in rotary screw traps

Table 4. The temporal occurrence of adult, larval and post-larval, juvenile, and coastal migrant Southern DPS of North American green sturgeon.

| **Adult Location (≥13 yrs for females, ≥9 yrs for males)** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Sac River[1, 2, 3] | | | | | | | | | | | | |
| SF Bay Estuary[4, 8] | | | | | | | | | | | | |
| **Larval / Post-Larval Location (≤10 mos)** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| RBDD, Sac River[5] | | | | | | | | | | | | |
| GCID, Sac River[5] | | | | | | | | | | | | |
| **Juvenile Location (>10 mos and ≤3 yrs)** | | | | | | | | | | | | |
| South Delta*[6] | | | | | | | | | | | | |
| Sac-SJ Delta[6] | | | | | | | | | | | | |
| Sac-SJ Delta[5] | | | | | | | | | | | | |
| Suisun Bay[5] | | | | | | | | | | | | |
| **Coastal Migrant Location (3-13 yrs for females, 3-9 yrs for males)** | | | | | | | | | | | | |
| Pacific Coast[3, 7] | | | | | | | | | | | | |

**Relative Abundance:** =High =Medium =Low

Sources: [1] USFWS (2002); [2] Moyle *et al.* (1992); [3] Adams *et al.* (2002) and NMFS (NMFS 2005a); [4] Kelley *et al.* (2006); [5] CDFG (2002); [6] IEP Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7] Nakamoto *et al.* (1995); [8] Heublein (2006) *Fish Facility salvage operations at the RBDD ranged from 26 mm to 34 mm between 1995 and 2000 indicating they are approximately 2 weeks old. The mean yearly total length of post-larval green sturgeon captured in the GCID rotary screw trap, approximatley 30 miles downstream of RBDD, ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, unpublished data) indicating they are approximately 3 weeks old (Van Eenennaam *et al.* 2001).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other *Acipenseridae*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions green sturgeon larvae cling to the bottom during the day and move into the water column at night (Van Eenennaam *et al.* 2001). After six days, the larvae exhibit nocturnal swim-up activity (Deng *et al.* 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages. Kynard *et al.*'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first six months of life. When ambient water temperatures reached 46 degrees F, downstream migrational behavior diminished and holding behavior increased. These data suggests that 9-to 10-month-old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Facility (Fish Facilities) in the South Delta, and captured in trawling studies by the CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto *et al.* (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicate juvenile Southern DPS North American green sturgeon likely hold in the mainstem Sacramento River as suggested by Kyndard *et al.* (2005).

**(1) Population Dynamics**. Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately there are many biases and errors associated with these data and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al.* 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicate that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001); however, the portion of the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay. Recent spawning population estimates using sibling based genetics by Israel (2006) indicate a maximum spawning population of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71). Based on the length and estimated age of post-larvae captured at RBDD (approximately two weeks of age) and GCID (downstream, approximately three weeks of age), it appears some of Southern DPS North American green sturgeon are spawning above RBDD. Note, there are many assumptions with this interpretation (*i.e.*, equal sampling efficiency and distribution of post-larvae across channels), and this information should be considered cautiously.

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

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of CV spring-run Chinook salmon and CV steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries (Adams *et al.* 2002; Moyle 2002; Lindley *et al.* 2004).

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

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

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

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

*Diversity.* Green sturgeon genetic analyses shows strong differentiation between northern and southern populations, and therefore, the species was divided into Northern and Southern DPS's. However, the genetic diversity of the Southern DPS is not well understood.

The majority of the NMFS Biological Review Team (BRT) (NMFS 2005) felt that the blockage of green sturgeon spawning from what were certainly their historic spawning areas above Shasta Dam and the accompanying decrease in spawning habitat in the Feather River with the construction of Oroville Dam made the Southern green sturgeon DPS likely to become endangered in the foreseeable future throughout all of its range. Due to substantial habitat loss, and the decline in abundance observed at water pumping facilities, and the occurrence of only one breeding populations, the Southern DPS of North American green sturgeon remains at a moderate to high risk of extinction.

## C. Factors Affecting the Species and Critical Habitat

Water development, water quality, over-harvesting, and disease and predation are some of the many issues affecting the decline of listed anadromous fish species in California. Hydropower, flood control, and water supply dams of the Federal Central Valley Project (CVP), State Water Project (SWP), and other municipal and private entities have permanently blocked or hindered salmonid and green sturgeon access to historical spawning and rearing grounds. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today.

As a result of migrational barriers, spring-run Chinook salmon, and steelhead populations have been confined to lower elevation mainstems that historically only were used for migration. Higher temperatures at these lower elevations during late-summer and fall are a major stressor to adult and juvenile salmonids. Thus, population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Green sturgeon populations were likely also affected by barriers and alterations to the natural hydrology. In particular, the RBDD blocked all access to the primary spawning habitat in the Sacramento River for many years under the old operational procedures, and continues to block a significant portion of the adult spawning run under current operationl procedures.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento and San Joaquin Rivers, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids and green sturgeon. 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).

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

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is one of the primary causes of salmonid habitat degradation (NMFS 1996a). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and dissolved oxygen (DO) levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995). In addition, urban storm water and agricultural runoff may be contaminated with pesticides, oil, grease, heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other organics and nutrients (Regional Board 1998) that can potentially destroy aquatic life necessary for salmonid and green sturgeon survival (NMFS 1996a, b). Point source (PS) and non-point source (NPS) pollution occurs in almost every area where urbanization activity influences the watershed. Impervious surfaces (*i.e.*, concrete, asphalt, and buildings) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996a, b). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. In addition to the PS and NPS inputs from urban runoff, juvenile salmonids and green sturgeon are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges.

These human activities have led to increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids and green sturgeon. Most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in the sediment (Ingersoll 1995). Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids and 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 (Environmental Protection Agency [EPA] 1994). However, the more likely route of exposure to salmonids and sturgeon is through the food chain, when 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 forage base they consume. Response of salmonids and green sturgeon to contaminated sediments is similar to water borne exposures.

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

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

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

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. 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. Overall, this regulation has greatly increased protection of naturally produced adult steelhead; however, the total number of CV steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good *et al.* 2005).

Commercial harvest of white sturgeon results in the incidental bycatch of green sturgeon primarily along the Oregon and Washington coasts and within their coastal estuaries. Oregon, Washington and California have recently prohibited the retention of green sturgeon in their waters for commercial and recreational fisheries. Adams *et al.* (2002, 2007) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River Estuary by commercial means ranged from 240 fish per year to 6,000. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al.* (1991) indicated that averages of 4.7 to 15.9 tons of green sturgeon were landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appeared to be dropping through the years; however, this could be related to changing fishing regulations. Adams *et al.* (2002, 2007) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are captured by sport fisherman targeting white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al.* 1991). However, recent changes to fishing regulations have made it illegal keep green sturgeon for harvest. Based on new research by Israel (2006 and past tagged fish returns reported by CDFG (2002)), a high proportion of green sturgeon present in the Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS North American green sturgeon. This indicates a potential threat to the Southern DPS North American green sturgeon population.

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996a, 1996b, 1998). Specific diseases such as bacterial kidney disease, *Ceratomyxosis shasta* (C-shasta), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996a, 1996b, 1998). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that wild fish tend to be less susceptible to pathogens than are hatchery-reared fish. Nevertheless, wild salmonids may contract diseases that are spread through the water column (*i.e.*, waterborne pathogens) as well as through interbreeding with infected hatchery fish. The stress of being released into the wild from a controlled hatchery environment frequently causes latent infections to convert into a more pathological state, and increases the potential of transmission from hatchery reared fish to wild stocks within the same waters.

Accelerated predation also may be a factor in the decline of listed salmonids and green sturgeon. 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 fish 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 (ACID) diversion dam, GCID's diversion facility, areas where rock revetment has replaced natural river bank vegetation, and at South Delta water diversion structures (*e.g.*, Clifton Court Forebay; CDFG 1998). 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. The Sacramento pikeminnow is a species native to the Sacramento River basin and has co-evolved with the anadromous salmonids in this system. However, rearing conditions in the Sacramento River today (*e.g.* warm water, low-irregular flow, standing water, and water diversions) compared to its natural state and function decades ago in the pre-dam era, are more conducive to warm water species such as Sacramento pikeminnow and striped bass than to native salmonids.

For listed salmonids and green sturgeon, 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 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. This requirement has been difficult to achieve in all water year types and for all life stages of affected species. CV 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.*).

Similar to the listed salmonids, the Southern DPS 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. Anthropogenic manipulations of the aquatic habitat, such as dredging, bank stabilization, and waste water discharges have also degraded the quality of the Central Valley's waterways for green sturgeon.

## IV. ENVIRONEMENTAL BASELINE

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

### A. Status of the Species and Critical Habitat within the Action Area

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

The action area functions primarily as a migratory corridor for adult and juvenile CV steelhead. All adult CV steelhead originating in the San Joaquin River watershed will have to migrate through the action area in order to reach their spawning grounds and to return to the ocean following spawning. Likewise, all CV steelhead smolts originating in the San Joaquin River watershed will also have to pass through the action area during their emigration to the ocean. The waterways in the action area also are expected to provide some rearing benefit to emigrating steelhead smolts as they move through the action area.

The action area also functions as migratory, holding and rearing habitat for adult and juvenile Southern DPS of North American green sturgeon. Green sturgeon presence in the action area could occur in any month as juveniles, and may reside in freshwater habitats throughout their first few years of growth. Adults are likely to be present in the winter and early spring (outside of in-water work window) as they move through the Delta towards their spawning grounds in the upper Sacramento River watershed.

The following are status summaries of these species and their habitat within the San Joaquin River and action area.

*a. Sacramento River Winter-Run Chinook Salmon*

The temporal occurrence of Sacramento River winter-run Chinook salmon smolts and juveniles in the action area are best described by the salvage records of the CVP and SWP fish handling facilities. Based on salvage records covering the last 8 years at the CVP and SWP, Sacramento River winter-run Chinook salmon are typically present in the Western and Central Delta action area starting in December. Their presence peaks in March and then rapidly declines from April through June. Nearly 50 percent of the average annual salvage of Sacramento River winter-run Chinook salmon juveniles occurs in March (48.8 percent). Salvage in April accounts for only 2.8 percent of the average annual salvage and falls to less than 1 percent for May and June combined. The presence of juvenile Sacramento River winter-run Chinook salmon in the Western and Central Delta is a function of river flows on the Sacramento River, where the fish are spawned, and the demands for water diverted by the SWP and CVP facilities. When conditions on the Sacramento River are conducive to stimulating outmigrations of juvenile Sacramento River winter-run Chinook salmon, the draw of the CVP and SWP pumping facilities pulls a portion of these emigrating fish through one of the four access points on the Sacramento River (Georgiana Slough, the Delta Cross Channel, Three Mile Slough, and the San Joaquin River via Broad Slough) into the channels of the Western and Central Delta, including the lower sections of the San Joaquin River. The combination of pumping rates and tidal flows moves these fish into the western delta portion of the action area. When the combination of pumping rates and fish movements are high, significant numbers of juvenile Sacramento River winter-run Chinook salmon are drawn into the action area.

b. *CV spring-Run Chinook salmon*

Like the Sacramento River winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in the action area is under the influence of the CVP and SWP water diversions and the flows on the Sacramento River and its tributary watersheds. Currently, all known populations of CV spring-run Chinook salmon inhabit the Sacramento River watershed. The San Joaquin River watershed populations have been extirpated, with the last known runs on the San Joaquin River being extirpated in the late 1940s and early 1950s by the construction of Friant Dam and the opening of the Kern-Friant irrigation canal.

Juvenile CV spring-run Chinook salmon first begin to appear in the San Joaquin River basin in January. A significant presence of fish does not occur until March (20.1 percent of average annual salvage) and peaks in April (66.8 percent of average annual salvage). By May, the salvage of CV spring-run Chinook salmon juveniles declines sharply (11.5 percent of average annual salvage) and essentially ends by the end of June (1.3 percent of average annual salvage).

c. *CV steelhead*

The CV steelhead DPS occurs in both the Sacramento River and the San Joaquin River watersheds. However the spawning population of fish is much greater in the Sacramento River watershed and accounts for nearly all of the DPS' population. Like Sacramento River Chinook salmon, Sacramento River steelhead can be drawn into the Central and Western Delta by the actions of the CVP and SWP water diversion facilities. Small, remnant populations of CV steelhead are known to occur on the Stanislaus River and the Tuolumne River and their presence is assumed on the Merced River due to proximity, similar habitats, historical presence, and recent otolith chemistry studies verifying at least one steelhead in the limited samples collected from the river. CV steelhead smolts first start to appear in the action area in November based on the records from the CVP and SWP fish salvage facilities. Their presence increases through December and January (22.5 percent of average annual salvage) and peaks in February (34.6 percent) and March (31.6 percent) before rapidly declining in April (7.8 percent). By June, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP.

Steelhead smolt production originating in the San Joaquin River basin (all natural) are monitored by Kodiak trawls conducted by the USFWS and CDFG on the mainstem of the San Joaquin River just above the Head of Old River Barrier during the Vernalis Adaptive Management Program (VAMP) experimental period. These efforts routinely catch low numbers of outmigrating steelhead smolts from the San Joaquin Basin. Monitoring is less frequent prior to the VAMP, therefore emigrating steelhead smolts have a lower probability of being detected. Rotary screw trap (RST) monitoring on the Stanislaus River at Caswell State Park and further upriver near the City of Oakdale indicate that smolt sized fish start emigrating downriver in January and can continue through late May. Fry sized fish (30 to 50 mm) are captured at the Oakdale RST starting as early as April and continuing through June. Adult escapement numbers have been monitored for the past several years with the installation of an Alaskan style weir on the lower Stanislaus River near Riverbank. Typically, very few adult steelhead have been observed moving upstream past the weir. However, in 2006 to 2007, the weir was left in through the winter and spring and seven adult steelhead were counted moving upstream. Natural steelhead production also occurs on the Calaveras River, which empties into the San Joaquin River. Monitoring is conducted by RSTs in the upper reaches of the river below New Hogan Dam. Emigration of smolts from this watershed is highly correlated with stream flow conditions, and passage of smolts through the valley floor section of the watercourse is predicated on the river maintaining connectivity with the Delta. Steelhead smolt migrations are likewise monitored at several sites on the Sacramento River by the USFWS and CDFG. An important monitoring station for tracking smolt numbers is the Chipps Island station in the western Delta. This monitoring site collects steelhead smolts produced within the entire Central Valley basin.

d. *Southern DPS of North American Green Sturgeon*

Juvenile green sturgeon from the Southern DPS are routinely collected at the SWP and CVP salvage facilities throughout the year. However, numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981 through 2007, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August. The sizes of these fish are less than 1 meter and average 330 mm with a range of 136 mm to 774 mm. The size range indicates that these are sub-adult fish rather than adult or larval/juvenile fish. It is believed that these sub-adult fish utilize the Delta for rearing for up to a period of approximately 3 years. The proximity of the CVP and SWP facilities to the action area would indicate that sub-adult green sturgeons have a strong potential to be present within the action area during the installation of the piles in the San Joaquin River. Juvenile green sturgeon have also previously been captured at Santa Clara Shoals during fish monitoring studies (Radtke 1966).

2. <u>Status of Critical Habitat Within the Action Area</u>

The action area is predominately within the San Joaquin Delta sub-basin (Hydrologic Unit [HU] # 18040003) and is included in the critical habitat designated for CV steelhead and proposed critical habitat for North American green sturgeon. A small portion of the western Delta around the confluence of the Sacramento and San Joaquin Rivers and waters westwards towards Chipps Island as well as the mainstem Sacramento River are also designated critical habitat for winter-run and spring-run Chinook salmon. This opinion will focus on the mainstem San Joaquin River at Sherman Island, outside of the designated critical habitat for winter-run and spring-run Chinook salmon.

The San Joaquin Delta HU is in the southwestern portion of the CV steelhead DPS range and includes portions of the south, central and western Delta channel complex. The San Joaquin Delta HU encompasses approximately 628 square miles, with 455 miles of stream channels (at 1:100,000 hydrography). The critical habitat analytical review team (CHART) identified approximately 276 miles of occupied riverine/estuarine habitat in this hydrologic subunit area (HSA) that contained one or more PCEs for the CV steelhead DPS (NMFS 2005). The PCEs of steelhead habitat within the action area also apply to green sturgeon, and include freshwater rearing habitat, freshwater migration corridors, and estuarine areas. The essential features of these PCEs included the following: sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions necessary for salmonid development and mobility, sufficient water quality, food and nutrients sources, natural cover and shelter, migration routes free from obstructions, natural levels of predation, holding areas for juveniles and adults, and shallow water areas and wetlands. Habitat within the action area is primarily utilized for freshwater rearing and migration by CV steelhead and North American green sturgeon juveniles and smolts and for adult upstream migration. No spawning of CV steelhead and North American green sturgeon occur within the action area.

The general condition and function of freshwater rearing and migration habitats has already been described in the *Status of the Species and Critical Habitat* section of this biological opinion. The substantial degradation over time of several of the essential features of these PCEs has diminished the function and condition of the habitats in the action area. This area currently provides only rudimentary functions compared to its historical status. The natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been cleared for farming. Little riparian vegetation remains in the Delta, limited mainly to tules growing along the foot of artificial levee banks. Numerous artificial channels also have been created to bring water to irrigated lands that historically did not have access to the river channels (*i.e.*, Victoria Canal, Grant Line Canal, Fabian and Bell Canal, Woodward Cut, *etc.*). These artificial channels have disturbed the natural flow of water through the Delta. As a byproduct of this intensive engineering of the Delta's hydrology, numerous irrigation diversions have been placed along the banks of the flood control levees to divert water from the area's waterways to the agricultural lands of the Delta's numerous "reclaimed" islands. Most of these diversions are not screened adequately to protect migrating fish from entrainment. Sections of the Delta have been routinely dredged by DWR to provide adequate intake depth for these agricultural water diversions, particularly in the South Delta. Likewise, the main channels of the San Joaquin River and the Sacramento River have been routinely dredged by the Corps to create an artificially deep channel to provide passage for ocean going commercial shipping to the Port of Stockton and the Port of Sacramento.

Water flow through the Delta is highly manipulated to serve human purposes. Rainfall and snowmelt is captured by reservoirs in the upper watersheds, from which its release is dictated primarily by downstream human needs. The SWP and CVP pumps draw water towards the southwest corner of the Delta which creates a net upstream flow of water towards their intake points. Fish, and the forage base they depend upon for food, are drawn along with the current towards these diversion points. In addition to the altered flow patterns in the Delta, numerous discharges of treated wastewater from sanitation wastewater treatment plants (*e.g.*, Cities of Pittsburg and Antioch) and the untreated discharge of numerous agricultural waste ways are emptied into the waters of the San Joaquin River and the channels of the Delta. This leads to cumulative additions to the system of thermal effluent loads as well as cumulative loads of potential contaminants (*i.e.*, selenium, boron, endocrine disruptors, pesticides, biostimulatory compounds, *etc.*).

Those members of the CV steelhead DPS that spawn in the San Joaquin system must pass through the San Joaquin Delta HSA to reach their upstream spawning and freshwater rearing areas on the tributary watersheds, in addition, also providing rearing and migratory habitat for North American green sturgeon. Therefore, it is of critical importance to the long-term viability of the San Joaquin River basin portion of the CV steelhead DPS and North American green sturgeon to maintain a functional migratory corridor and freshwater rearing habitat through the action area and the San Joaquin Delta HSA.

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

The Project study area is located in the Sacramento-San Joaquin Delta subsection of the Great Valley ecological sub-region (Miles and Goudey 1997). This region is characterized by a low, level plain at the confluence of the Sacramento and San Joaquin Rivers. Numerous artificial levees have been constructed throughout the region to reclaim lands for agricultural production.

Historically, the interplay between deposited sediments, plant growth, daily tidal flooding, and seasonal flooding resulted in a complex distribution of elevated waterways, vegetated islands, and nearshore tidal and subtidal habitats. This interplay continues today, but has been dramatically altered by human activities over the last two centuries.

Early Delta modifications were designed to enable navigation, control flooding of settled areas, and allow farming on the rich islands laced throughout the tidal Delta. Later, freshwater from the tidal Delta was exported to other communities and agricultural lands throughout the Central Valley and beyond to southern California. Water conveyance structures such as canals, cross channels, and interties significantly altered natural features. The pumping facilities at the Federal CVP, beginning in 1940, and the SWP, beginning in 1960, substantially decreased the outflow of fresh water from the Delta. Water movement patterns have been altered at both local and broad scales (The Bay Institute 1998). The balance between natural sedimentation rates and varying sea levels was altered by sediment deposition associated with placer mining in the Central Valley watershed along much of the western slopes of the Sierra Mountains from the 1860s to the 1880s, and by the direct filling of portions of the San Francisco Bay and estuary to accommodate shoreline development. The combination of these activities significantly reduced the aerial extent of freshwater marshes, once a dominant feature in the Delta habitat mosaic.

The flow of freshwater into the estuary has been greatly reduced by water diversions largely to support irrigated agriculture (Nichols 2007). Many stressors, such as chemical pollution, dissolved oxygen, water temperature, reversed flows, etc., in the Delta have resulted in the detriment of salmonids and sturgeon. Water diversions and water exports are a big part of the modified Delta and are a significant cause of the loss and decline of many resident and migratory fish species. As of April 1997, 3,356 diversions have been located and mapped using GPS in the Central Valley (Herren and Kawasaki 2001). Of these, 298 diversions were found within the San Joaquin River Basin. The Federal and State pumping plants draw off much of the inflowing freshwater of the San Joaquin River (Herbold and Moyle 1989). Spring- and fall-runs of salmon formerly existed in the major San Joaquin River tributaries and in the upper San Joaquin River, and there also may have been a late-fall-run present in the mainstem (Yoshiyama *et al.* 2001). However, all salmon runs in the San Joaquin River above the confluence of the Merced River were extirpated by the late-1940s (Yoshiyama *et al.* 2001).

Sources of selenium input to the Delta include: oil refinery effluents from five refineries in the Delta; agricultural drainage discharged through the San Joaquin River; direct discharge of agricultural drainage through a proposed extension of the San Luis Drain; and effluents from municipal wastewater treatment plants (Presser *et al.* 2008). The greatest increase in selenium uptake seems to occur along the pathway from water to algae and zooplankton where selenium is bioaccumulated several hundredfold. Fish consume organisms at lower trophic levels and, in general, seem to accumulate selenium to whole-body concentrations found in their food. Low waterborne concentrations of selenium that are readily bioaccumulated in plankton and detrital food pathways are, therefore, a threat to organisms, such as fish at the top of the trophic structure (Hamilton *et al.* 1990). For example, the introduction of the overbite clam (*Corbula amurensis*) has caused harm to green and white sturgeon. Overbite clams accumulate high levels of selenium and other toxic material and pass it on to sturgeon that consume overbite clams (Moyle 2002). Reproductive failure in fish exposed to elevated concentrations of selenium in the environment is probably due to bioaccumulation in the ovaries and their progeny, which causes lethal edema in larvae (Hamilton *et al.* 1990). Early life stages of salmonids and sturgeon are generally more sensitive to toxicant stresses because of the lack or underdevelopment of metabolic mechanisms essential for handling toxicant stresses, or interference with metabolic processes that are vital to developing organisms (Hamilton *et al.* 1990) (green sturgeon are four times more sensitive than white sturgeon(Woodbury 2009)). Juvenile chinook salmon are exposed to selenium while they undergo parr-smolt transformations in the Sacramento-San Joaquin Delta. According to a study done by Hamilton *et al.* (1990), selenium reduced survival and growth in salmonids in freshwater and only reduced growth in fish that were in brackish water.

Invasive organisms, from plants to fish, are prevalent in the Delta. Introduced exotic species continue to change the area's biota by altering its food webs (Nichols 2007). California has the highest number of fish introductions of any state in the United States. Species invasion is a complex process with multiple steps: transport, release, establishment, spread, and integration. The movements of invaders between watersheds in California are primarily related to water transfers (*i.e.*, aqueducts, canals, and diversions) and salinity gradient in the Delta. Invasive and/or exotic species that become widely established are typically spread by humans (as opposed to natural dispersal from a center of origin). On a watershed basis, there have been relatively few extinctions of native fishes in California, although declining abundances of many native species suggests that the full impact of alien fishes has not yet occurred (Marchetti *et al.* 2004). Invasive species that affect ecosystem processes may indirectly impact populations of native species (see Figure 2). Invasive species can replace native species in their trophic level and can alter properties of an ecosystem.

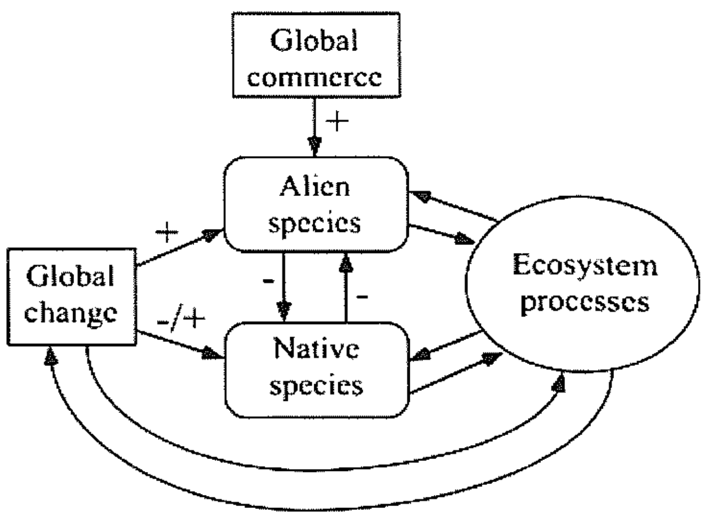


Figure 2 shows how alien species can indirectly and directly impact native species (Dukes and Mooney 2004)

In an uninvaded ecosystem, the value of the ecosystem function may vary over time due to shifts in species dominance. As an invasion progresses, the invader makes up an increasing proportion of biomass at its trophic level. Thus, the decline of listed anadromous fish can be directly attributed to competition with or predation by fish species that were introduced for sport fishing (Dukes and Mooney 2004). Introduced fish and invertebrates change the availability of food and cover, which results in the detriment of listed juvenile salmonids and sturgeon. Introduced fish species (*e.g.* striped bass) tend to be more abundant and thus can out-compete native salmon, sturgeon, and steelhead by limiting their benthic food source (Moyle 2002).

## 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 Antioch Bridge Seismic Retrofit project on CV steelhead, their designated critical habitat, the Southern DPS of North America green sturgeon, and their proposed critical habitat. The proposed Project is likely to adversely affect listed species and critical habitat through vibration of the piles for the temporary marine trestle. 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 NMFS to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of both 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 NMFS to determine if Federal actions would appreciably diminish the value of critical habitat for the conservation of listed species (16 U.S.C. §1536). This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

### A. Approach to the Assessment

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 actions (these effects include direct impacts to a species habitat; 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 disruptive noises). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' likelihood and extent of exposure to any adverse effects caused by the action (*i.e.* the extent of spatial and temporal overlap between the species and the effects of the action). Once NMFS has identified the level of exposure that a species will have to the effects of the action, the available evidence is evaluated to identify the species' probable response, including physical and behavioral reactions, to these effects. These responses then will be assessed to determine if they can 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.

1. Information Available for the Assessment

To conduct the assessment, NMFS examined an extensive amount of 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, the biological assessment for this project, and project meeting notes. Additional information investigating the effects of the project's actions on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was obtained from the aforementioned resources. For information that has been taken directly from published, citable documents, those citations have been referenced in the text and listed at the end of this document.

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 potential adverse effects to listed species resulting from the proposed construction of the Antioch Bridge and the implementation of the minimization measures are primarily associated with elevated underwater sound pressure levels generated during pile driving. However, other potential impacts to listed salmonids and green sturgeon and designated critical habitat include turbidity resulting from ground disturbance for areas associated with bridge construction and mitigation.

The information used in this assessment includes *Status of the Species* and *Environmental Baseline* sections of this biological opinion, studies and accounts of the impacts of construction and pile driving activities on anadromous fish.

## B. Assessment

The proposed project includes actions that may adversely affect several life stages of listed fish species. Adverse effects to these species and their habitat may result from changes in water quality from construction activities, loss of riparian vegetation from construction activities, and physical injury and harassment of juveniles and adults from exposure to elevated levels of underwater sound produced during pile driving. The project includes integrated design features to avoid and minimize many of these potential impacts.

There will not be any long term changes to the footprint of the bridge or other habitat features within the action area, thus, there will only be short term exposure to construction related impacts to listed fish. During the period of August-October, adult CV steelhead enter freshwater to spawn, with a peak migration period of September-October (Moyle 2002). The steelhead migration period overlaps the pile driving in-water work window (August-November), and thus some of the adult fish moving into the San Joaquin watershed are likely to be exposed to the effects of the in-water work activities. Adult green sturgeon upstream migration occurs from March through July (Moyle *et al.* 1995). Although some of these fish migrate through the action area, they will likely not be present when in-water construction activities are proposed to occur. However, there is a possibility that some of these fish may occur within the action area and be exposed to the effects of the in-water work activities as they migrate back downstream in the fall months following spawning. There is also the potential for juveniles to be rearing and feeding in the Delta and around the action area year round, so a small proportion of the juvenile population may be exposed to the effects of the in-water work activities.

The action area also functions as a migratory corridor and rearing habitat for juvenile Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon ESUs, green sturgeon, and CV steelhead from the Sacramento River watershed that are drawn into the Central and South Delta by the actions of the CVP and SWP water diversion facilities and must therefore emigrate towards the ocean through the lower San Joaquin River system. Winter- and spring-run Chinook salmon, like green sturgeon, only spawn in the upper Sacramento River watershed. Construction of low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne, and Merced Rivers extirpated CV spring-run Chinook salmon from these watersheds. Naturally-spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River. Therefore, adult Chinook salmon are unlikely to migrate through the action area or be exposed to the effects of the in-water work activities. Their designated critical habitat does not extend east of Suisun Bay (towards San Joaquin River). In addition, their migration timing (January through April for winter-run and March through May for spring-run) do not coincide with the proposed in-water work window.

The temporal occurrence of Sacramento River winter-run Chinook salmon smolts and juveniles in the action area are best described by the salvage records of the CVP and SWP fish handling facilities. Based on salvage records covering the last 8 years at the CVP and SWP, Sacramento River winter-run Chinook salmon are typically present in the Western and Central Delta action area starting in December. Their presence peaks in March and then rapidly declines from April through June. Nearly 50 percent of the average annual salvage of Sacramento River winter-run Chinook salmon juveniles occurs in March (48.8 percent). Salvage in April accounts for only 2.8 percent of the average annual salvage and falls to less than 1 percent for May and June combined.

The presence of juvenile Sacramento River winter-run Chinook salmon in the Western and Central Delta is a function of river flows on the Sacramento River, where the fish are spawned, and the demands for water diverted by the SWP and CVP facilities. When conditions on the Sacramento River are conducive to stimulating outmigrations of juvenile Sacramento River winter-run Chinook salmon, the draw of the CVP and SWP pumping facilities pulls a portion of these emigrating fish through one of the four access points on the Sacramento River (Georgiana Slough, the Delta Cross Channel, Three Mile Slough, and the San Joaquin River via Broad Slough) into the channels of the Western and Central Delta, including the lower sections of the San Joaquin River. The combination of pumping rates and tidal flows moves these fish into the western delta portion of the action area. When the combination of pumping rates and fish movements are high, significant numbers of juvenile Sacramento River winter-run Chinook salmon are drawn into the action area. Like the Sacramento River winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in the action area are under the influence of the CVP and SWP water diversions and the flows on the Sacramento River and its tributary watersheds. Currently, all known populations of CV spring-run Chinook salmon inhabit the Sacramento River watershed. The San Joaquin River watershed populations have been extirpated, with the last known runs on the San Joaquin River being extirpated in the late 1940s and early 1950s by the construction of Friant Dam and the opening of the Kern-Friant irrigation canal.

Juvenile CV spring-run Chinook salmon would first begin to appear in the action area in January. A significant presence of fish do not occur until March (20.1 percent of average annual salvage) and peak in April (66.8 percent of average annual salvage). By May, the salvage of CV spring-run Chinook salmon juveniles decline sharply (11.5 percent of average annual salvage) and essentially end by the end of June (1.3 percent of average annual salvage).

1. Pile Driving and Bridge Construction

The proposed project includes installation of a temporary trestle (approximately 910 ft long) that will be constructed from the south end of the bridge. The proposed project will require two 24-inch diameter steel shell piles for every 25 feet of trestle and around the piers. The driving of steel piles for the temporary trestle will occur in water less than 10 feet in depth. There will be approximately 160 piles driven to a depth of 50 feet to support the temporary trestle. Four to six piles supporting between two to three sections of the trestle will be installed per day. Water depths would range from the shore or mud during lower tides to about 10 feet (3 meters). These piles would be vibrated in for approximately ten minutes per pile and one pile per each section (approximately 36 sections in total) will be driven with an impact hammer for approximately 20 blows per pile to verify the bearing capacity of the pile. This would equate to a maximum of 3,600 seconds of vibratory pile installation and 60 hammer strikes per day. The impact radius for 4 piles/day around a single pile for 187 dB SEL would be at a distance of 190 ft. The impact radius for 6 piles/day around a single pile for 187 dB SEL would be at a distance of 235 ft. The impact radius for a single strike of 206 $dB_{peak}$ would be 45 ft.

NMFS uses a single strike peak sound pressure level (SPL) of 206 dB and an accumulated sound exposure level (SEL) of 187 dB to correlate underwater sound with potential injury to fish. These are the thresholds that indicate the onset of physical injury. The SPL is an expression of the sound pressure using the decibel scale and the standard reference pressures of micro-Pascal (1 µPa) for water and biological tissues. SEL is the exposure of fish to a total amount of energy (*i.e.*, dose) that can be used to determine a physical injury response. In other words, it is the time-integrated, sound-pressure-squared level. Because sound is a form of energy, the damage potential of a given sound environment will depend not only on its level, but also its duration. The root-mean-square (RMS) is 150 dB for a behavioral response in a fish. The level is determined by analyzing the waveform and computing the square root of the average of the squared pressures over the time period that comprises that portion of the waveform containing 90% of the sound (pressure squared) energy (Hastings and Popper 2005). This calculated RMS SPL is described as "RMS (impulse)" and is used to report an overall average SPL for a single pile driving pulse (Hastings and Popper 2005). Because all SEL measurements are normalized to a one second time interval, it may be used to compare the energy content of different exposures to sound. SEL is calculated by summing the cumulative pressure squared ($p2$) over time and is often used as an indication of the energy dose.

The installation of steel piles with a vibratory hammer in the San Joaquin River is expected to result in adverse effects to exposed fish due to high levels of underwater sound that will be produced. Adverse effects can range from physical injury to the exposed fish, sometimes resulting in death, to lesser impacts, such as behavioral modifications or increased susceptibility to predation, which do not necessarily result in death or long term adverse impacts by themselves. The degree to which an individual fish exposed to underwater sound will respond (from a startle response to immediate mortality) is dependent on a number of variables such as the species of fish, size of the fish, presence of a swimbladder, sound pressure intensity and frequency, shape of the sound wave (rise time), depth of the water around the pile and the bottom substrate composition and texture. Injury is expected if either: 1) the peak pressure of any strike exceeds 206 dB (re: 1 µPa); or 2) SEL, accumulated over all pile strikes, exceeds 187 dB (re: 1 $\mu Pa_2$*sec) for fishes 2 grams or larger and 183 dB (re: 1 $\mu Pa_2$*sec) for fishes smaller than 2 grams. Because all ESA-listed fish in the action area during pile driving are expected to be larger than 2 grams, the threshold for accumulated SEL used in this analysis is 187 dB.

*a. Immediate Mortality of Fish from Pile Driving*

The effect of pile driving on free swimming fish depends on the duration, frequency (Hz), and pressure (dB) of the compression wave. Rassmusen (1967) found that the immediate mortality of juvenile fish may occur at sound pressure levels exceeding 206 dB. Due to their size, adult CV steelhead and green sturgeon can tolerate higher pressure levels and immediate mortality rates for adults are expected to be less than those experienced by juveniles. As sound pressure levels are not expected to exceed 187 dB, no immediate mortality of juvenile or adult fish is expected.

*b. Injury of Fish from Pile Driving*

High levels of underwater acoustic noises have been shown to have adverse impacts upon the auditory sensory organs of fish within close proximity of the noise source. The loss of hearing sensitivity may adversely affect a salmonids' ability to orient itself (*i.e.*, due to vestibular damage), detect predators, locate prey, or sense their acoustic environment. Chronic noise exposure can reduce a fish's ability to detect piscine predators either by reducing the sensitivity of the auditory response or by masking the noise of an approaching predator. Disruption of the exposed fish'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. Swimbladders, which are inflated with gas, can expand rapidly as the pressure waves pass through the fish and can press against, and strain, adjacent organs, such as the liver and kidney (Keevin and Hempen 1997). In addition, this pneumatic compression causes demonstrable injury, in the form of ruptured capillaries, internal bleeding, and maceration of highly vascular organs (Caltrans 2002). Hastings and Popper (2005) also noted that sound waves can cause different types of tissues to vibrate at different frequencies, and that this differential vibration can cause tearing of mesenteries and other sensitive connective tissues. Exposure to high noise levels can also lead to injury through "rectified diffusion," the formation and growth of bubbles in tissues. These bubbles can cause inflammation, cellular damage, and blockage or rupture of capillaries, arteries, and veins (Crum and Mao 1996; Stroetz *et al.* 2001; Vlahakis and Hubmayr 2000). Death from barotrauma and rectified diffusion injuries can be instantaneous, or delayed for minutes, hours or even days after exposure.

*c. Behavioral Responses of Fish from Pile Driving*

Behavioral responses to high noise levels can be in the form of a startled response, avoidance, agitation, etc. These behavioral responses can also lead to increased susceptibility to predation. In addition, elevated SPLs from impact and vibratory pile driving could conceivably delay the migration of fish and affect their foraging and migratory behavior.

*d. Summary of Effects from Pile Driving*

The activities related to pile driving are temporary and will only last the duration of the in-water work activities. Sublethal and/or subinjurious effects to juvenile CV steelhead and green sturgeon, including altered behavior, auditory masking, and temporary hearing threshold shifts can affect vulnerability to predation, foraging success, and other factors that influence survival and fitness. Pile driving will take place during each in-water work window during the bridge construction period (*i.e.*, concurrently with pile driving during temporary trestle installation and during removal of the temporary piles as elements of bridge construction are completed). Because daily pile driving activities will be separated by overnight rest periods when migration can proceed uninhibited, upstream and downstream migration of listed fish are not expected to be significantly delayed. The populations of these fish in the San Joaquin River represent a small number of the entire population in the Central Valley, and the action is expected to have little impact upon the entire DPS. There is potential for adult CV steelhead and green sturgeon to be adversely effected from pile driving activities, however, it is expected to be relatively low due to their larger bodies (above two grams) and pile driving activities occurring only in the daytime which would avoid corpuscular and nocturnal periods when steelhead and sturgeon migratory activity is highest.

3. Water Quality

NMFS anticipates that some local increases in turbidity will result as a consequence of these actions. The increases in local turbidity levels are associated with the re-suspension of bottom sediments during the piling removal and installation phase of the construction process. The proposed in-water construction activities are not expected to lead to significant impacts to water quality in the action area. There are expected to be minor, short term increases in turbidity and sedimentation in localized areas due to the driving and removal of temporary piles. The expected increases in turbidity and suspended sediment may disrupt feeding and migratory behavior of listed fish over a small area for a short period of time. The turbidity associated with installation and removal of piles could result in localized displacement and likely behavioral modifications to individual salmonids and green sturgeon if they do not readily move away from the areas directly affected by the project. Turbidity and sedimentation events are not expected to affect feeding success of green sturgeon as they are not known to rely heavily on visual cues for feeding (Sillman *et al.* 2005). These temporary behavioral changes are not expected to result in injury or death of listed salmonids and green sturgeon. NMFS does not anticipate that turbidity levels associated with the pile driving will increase to deleterious levels. Furthermore, turbidity conditions are expected to return to ambient levels within hours to days of the termination of pile driving actions. Moreover, based on the timing of the pile driving actions, NMFS does not expect listed salmonids to be adversely effected by sedimentation and turbidity in the San Joaquin River. Green sturgeon, which can occupy waters containing variable levels of suspended sediment and thus turbidity, are not expected to be impacted by the slight increase in the turbidity levels anticipated from the pile driving action as explained above.

Unanticipated spills into the San Joaquin River, such as toxic substances used at construction sites (gasoline and lubricants) can lead to adverse effects and mortality in juvenile and adult salmonids and green sturgeon. If these toxins seep into the water, these substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. However, NMFS expects that Caltrans will adhere to the standard BMP's and SWPPP during construction activities to prevent these kinds of effects on listed salmonids and green sturgeon. Therefore, NMFS does not expect the Project will result in water contamination that will injure or kill listed anadromous fish.

3. Effects on Designated or Proposed Critical Habitat Primary Constituent Elements (PCEs)

The basic premise to the conservation value of an overall critical habitat designation is the sum of the values of the components that comprise the habitat. For example, the conservation value of listed salmonid critical habitat is determined by the conservation value of the watersheds that make up the designated area. In turn, the conservation value of the specific watershed is comprised of the sum of the value of the PCEs that make up the area. PCEs are specific areas or functions, such as spawning or rearing habitat, that support different life history stages or requirements of the species. The conservation value of the PCE is the sum of the quantity, quality, and availability of the essential features of that PCE. Essential features are the specific processes, variables or elements that comprise a PCE. Thus, an example of a PCE would be spawning habitat and the essential features of that PCE are conditions such as clean spawning gravels, appropriate timing and duration of certain water temperatures, and water quality free of pollutants.

Therefore, reductions in the quantity, quality, or availability of one or more essential feature reduce the value of the PCE, which in turn reduces the function of the sub-area (*e.g.*, watersheds), which in turn reduces the function of the overall designation. In the strictest interpretation, reductions to any one essential feature or PCE would equate to a reduction in the value of the whole. However there are other considerations. We look to various factors to determine if the reduction in the value of an essential feature or PCE would affect higher levels of organization. For example:

- The timing, duration and magnitude of the reduction
- The permanent or temporary nature of the reduction
- Whether the essential feature or PCE is limiting (in the action area or across the designation) to the recovery of the species or supports a critical life stage in the recovery needs of the species (for example, juvenile survival is a limiting factor in recovery of the species and the habitat element supports juvenile survival).

In our assessment, we combine information about the contribution of constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) to the conservation value of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area. We use the conservation value of those areas of designated critical habitat that occur in the action area as our point of reference for this comparison. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species, that limited value is our point of reference for our assessment of the consequences of the added effects of the proposed action on that conservation value.

*a. Estuarine Migratory Corridors*

Ideal estuarine areas are free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels, are necessary for juvenile and adult foraging. Current estuarine areas are degraded as a result of human activities such as levee construction, urbanization and water exports.

The trestle for the Antioch Bridge is only temporary and will not obstruct the migratory pathway for exposed fish. Fish that use the action area as a migratory corridor will be able to continue using the channel during and after construction of the Antioch Bridge.

*b. Estuarine Feeding and Rearing Habitat*

Presence of the temporary piles will effect 0.011 ac (estimated as the cross-sectional area of 160 piles of 24-inch diameter) of foraging habitat. Estuarine rearing habitats support juvenile rearing and feeding, and function as migratory corridors for adult fish. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids. Salmonids such as CV steelhead rely more heavily on freshwater rearing habitat and green sturgeon rely more on the condition of the benthos which will not be affected. Prey species for juvenile and adult CV steelhead and green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of these fish within the bays and estuaries. Currently, the estuary provides these food resources, although annual fluctuations in the population levels of these food resources may diminish the contribution of one group to the diet of green sturgeon relative to another food source. The recent spread of the Asian overbite clam has shifted the diet profile of white sturgeon to this invasive species. The overbite clam now makes up a substantial proportion of the white sturgeon's diet in the estuary. NMFS assumes that green sturgeon have also altered their diet to include this new food source based on its increased prevalence in the benthic invertebrate community.

Impacts to foraging habitat associated with the proposed action are minimal and temporary, and will not appreciably diminish the conservation value of the critical habitat, thus will have little impact to the exposed fish

*c. Summary of PCEs in the Action Area*

The PCEs of critical habitat that will be adversely affected include estuarine rearing and feeding sites for juveniles and estuarine migration corridors for both juveniles and adults. The temporary trestle piles will be removed upon completion of the proposed action. Therefore, NMFS expects that nearly all of the adverse effects to critical habitat from this project will be minimal and short-term and will not affect future generations of listed fish beyond the construction period of the project.

## VI. CUMULATIVE EFFECTS

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

Land surrounding the Caltrans ROW in the action area belongs to the California Department of Water Resources. They lease the land to tenants for grazing cattle. The southern part of this action area is located in the East Bay Regional Park District's Oakley Regional Park and includes a small portion of a developed marina.

Non-Federal actions that may affect the action area include ongoing agricultural activities and increased urbanization. Agricultural practices in and upstream of the San Joaquin River may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the San Joaquin River. Unscreened agricultural diversions throughout the Delta entrain fish including juvenile salmonids and green sturgeon. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the San Joaquin River. 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).

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

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

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

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

Anticipated climate change may affect spatial and temporal precipitation patterns along with the intensity and duration of precipitation within the San Joaquin River watershed. Ambient air temperatures in California are projected to increase several degrees centigrade (°C) by the end of this century. As a result, it is possible that less precipitation will occur as snowfall and more will occur as rain in future years. The effect of climate change is anticipated to be more winter and less spring and summer run-off within the watershed. In addition, expected run-off is anticipated to be warmer, possibly affecting the ability to meet downstream water temperature objectives to protect salmon, steelhead and green sturgeon. A reduction in snowpack combined with increased ambient air temperatures is expected to result in earlier melting of snow and less run-off from the snowpack than that which occurs today. A change in the run-off pattern within the San Joaquin River watershed will likely affect reservoir storage and downstream river flows due to more frequent spillway releases. Currently, summer water temperatures often are close to the upper tolerance limits for salmon and steelhead and any increase in ambient air temperatures as a result of climate change is anticipated to make it more difficult at the very least, if not impossible, to meet established water temperature objectives on the San Joaquin River. Reduced reservoir storage as a result of the anticipated change in run-off pattern may also affect the availability of a cold water supply necessary to maintain river temperatures downstream.

There are no specific plans for development within the action area of the proposed project. Therefore, further cumulative effects beyond those described above are not expected.

## VII. INTEGRATION AND SYNTHESIS

This section integrates the current conditions described in the status of the species and the environmental baseline for the action area with the effects of the proposed action and the cumulative effects of future actions. The purpose of this synthesis is to develop an understanding of the likely short-term and long-term responses of listed species and critical habitat to the proposed project.

## A. Summary of Status of the Species and Environmental Baseline

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

Presently, CV spring-run Chinook salmon have been functionally extirpated from the San Joaquin River basin. Populations of CV steelhead in the San Joaquin River basin have been substantially diminished to only a few remnant populations in the lower reaches of the Stanislaus, Tuolumne, and Merced Rivers below the first foothill dams. The Southern DPS of North American green sturgeon have not been documented spawning in the San Joaquin River, but human alterations, which have been ongoing for over 100 years in the watershed, may have extirpated local populations before accurate records were maintained. Since the viability of small remnant populations of CV steelhead in the San Joaquin River basin is especially tenuous and such populations are susceptible to temporally rapid decreases in abundance and possess a greater risk of extinction relative to larger populations (Pimm *et al.* 1988; Berger 1990; Primack 2004), activities that reduce the quality and quantity of habitats, or that preclude the formation of independent population units (representation and redundancy rule cited by Lindley *et al.* 2007), are expected to drive the species towards extinction as individual populations within the larger DPS become extinct (McElhany *et al.* 2000). Therefore, activities having severe impacts on steelhead populations or destroying designated critical habitat, within these smaller population units have significant implications for the DPS as a whole.

*a. CV Steelhead*

Estimates of adult escapement of steelhead to these watersheds are typically only a few dozen or so. 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 three east side 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 San Joaquin tributaries are thought to have similar or even lower numbers based on the superiority of the Stanislaus River in terms of habitat and water quality for CV steelhead.

Under these low adult escapement conditions, the loss of one individual female's reproductive capacity through mortality can have a relatively high impact on a given watershed's potential population if the number of adults returning to each stream is low. Loss of one female with an expected egg capacity of 5,000 eggs represents approximately 50 to 100 smolts returning to the ocean (Good *et al.* 2005) a significant proportion of the total production from the San Joaquin basin.

*b. Southern DPS of North American Green Sturgeon*

Southern DPS green sturgeon were also present in these watersheds prior to anthropogenic changes. The suitability of these watersheds to support these runs of fish changed with the onset of human activities in the region. Southern DPS green sturgeon have not been documented utilizing the San Joaquin River as a spawning river in recorded history but human alterations, which have been ongoing for over 100 years in the watershed, may have extirpated these populations before accurate records were maintained. However, fish survey records indicate that juvenile and sub-adult green sturgeon make use of the lower San Joaquin River for rearing purposes during the first several years of their life.

The basic pattern described for adult green sturgeon migrations into the Delta region from the San Francisco Bay estuary is that adult 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 in the fall and winter months. 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 these fish entering and remaining in the San Joaquin River within the action area is unclear, but because of the habitat similarities and lack of barriers between the action area and documented sturgeon habitat in the Delta, NMFS believes that green sturgeon could be found during any month of the year within the action area. Southern DPS green sturgeon have not been documented utilizing the San Joaquin River as a spawning river in recorded history but human alterations, which have been ongoing for over 100 years in the watershed, may have extirpated these populations before accurate records were maintained. However, fish survey records indicate that juvenile and sub-adult green sturgeon make use of the lower San Joaquin River for rearing purposes during the first several years of their life. Juvenile and adult green sturgeon are likely to be present in the Delta during the construction phase of the project, as juveniles and adults utilize the Delta for rearing on a year-round basis prior to migrating to the ocean.

*c. Designated and Proposed Critical Habitat*

The evidence presented in the Status of Species and Environmental Baseline sections indicate that past and present activities within the San Joaquin River basin have caused significant habitat loss, degradation and fragmentation. This has significantly reduced the quality and quantity of the remaining freshwater rearing sites and the migratory corridors within the lower valley floor reaches of the San Joaquin River for the CV steelhead population. Alterations in the geometry of the San Joaquin River Basin, removal of riparian vegetation and shallow water habitat, construction of armored levees for flood protection, changes in river flow created by demands of water diverters, and the influx of contaminants from agricultural and urban dischargers have also substantially reduced the functionality of the region's waterways. Additional losses of freshwater spawning sites, rearing sites, and migratory corridors have occurred upstream of the action area in the tributaries of the San Joaquin and Sacramento River basins, further reducing the overall conservation value of the critical habitat designation.

The current condition of proposed critical habitat for the Southern DPS of green sturgeon is degraded over its historical conditions. In particular, passage and water flow PCEs have been impacted by human actions, substantially altering the historical river characteristics in which the Southern DPS of green sturgeon evolved. The conservation value of green sturgeon proposed critical habitat has suffered similar types of degradation as already described for CV steelhead critical habitat. In addition, the alterations to the Sacramento-San Joaquin River Delta, as part of proposed critical habitat, may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon due to their protracted rearing time in the delta and estuary. Loss of individuals during this phase of the life history of green sturgeon represents losses to multiple year classes rearing in the Delta, which can ultimately impact the potential population structure for decades to come.

## B. Summary of the Effects of the Proposed Action on Listed Species Likelihood of Survival and Recovery

Under the proposed Antioch Bridge Seismic Retrofit project, adverse impacts to listed species stemming from increased sedimentation and acoustic impacts from pile driving are expected to occur. These impacts may cause physiological stress to the extent that the normal behavior patterns (*e.g.*, feeding, sheltering and migration) of affected individuals may be disrupted. Overall, the changes in turbidity and suspended sediment associated with this project are expected to adversely affect listed species primarily by low-level, short-term alteration of habitat conditions, which may reduce feeding or increase predation rates for juveniles. The potential for the increase in suspended sediment to adversely affect adult green sturgeon is unclear. However, because sturgeon are demersal fish closely associated with the bottom substrate, feed by taste and feel with their barbels, and even shovel up sediment with their snouts when searching for food, it is expected that they would be unaffected by the levels and duration of turbidity expected to be produced by the proposed project. Potential impacts are expected to be minimized by meeting

CVRWQCB water quality objectives, Caltrans water pollution specifications, implementing "best management practices" for erosion control, staging equipment outside of the riparian corridor, limiting the amount of riparian vegetation removal, and restoring disturbed riparian habitat values at the project site.

Pile driving activities are scheduled to occur August 1-November 30. Elevated levels of underwater sound around the pile driving activities may cause mortality, injury, or temporary behavioral changes to exposed fish These impacts will be substantially minimized by the pile driving work window restrictions. Loss of hearing sensitivities in juvenile fish will expose them to higher risks of predation. Fish with impacted hearing capacities will have a lower ability to detect predators and may be unable to maintain position in the water column (due to inner ear equilibrium factors). Underwater noise from pile driving may cause startling and/or avoidance of preferred habitat by fish in the immediate vicinity of the project site. The startling of fish can cause harm by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. Disruption of these behaviors would occur for specific periods during daylight operation hours of the pile driving hammer. Construction lapses, including daily breaks and nighttime non-working periods, as well as long periods when no pile driving is scheduled to occur, will allow fish to migrate through the action area and minimize the extent of impacts to populations. NMFS believes that the limited exposure to underwater sound levels associated with the proposed project is unlikely to significantly affect growth or survival of exposed adult and juvenile salmonids and green sturgeon.

*a. CV Steelhead*

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile CV steelhead to temporary increased levels of turbidity and suspended sediment, as well as noise from pile driving activities. The exposure to noise in particular is expected to adversely affect a small number of individuals. Noise may delay or impede fish migration causing increased energy expenditure by affected individuals, but as sound pressure levels are not expected to exceed a peak of 206 dB, no direct and/or immediate mortality of juvenile or adult fish is expected. However, fish exposed to an SEL exceeding 187 dB can be physically injured, and potentially lead to indirect mortality.

The elevated stress levels may degrade the fish's health and the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Individuals that appear different in their behavior attract predators, and thus experience higher mortality due to predator attacks. Even so, given the low level of exposure expected to result from adherence to the limited seasonal and diurnal in-water work windows, the limited adverse response expected from the few individuals that are exposed to these adverse effects, and the relatively small contribution to juvenile production that the San Joaquin River Basin provides to the overall population numbers for the CV steelhead DPS, it is expected that the effects of the proposed project, when considered in the context of the current baseline and likely future cumulative effects, would not appreciably reduce the likelihood of survival and recovery of the CV steelhead DPS throughout its range.

*b. Southern DPS of North American Green Sturgeon*

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile North American green sturgeon to increased levels of turbidity and suspended sediment, as well as noise from pile driving activities. Given the previous analysis showing that green sturgeon are relatively tolerant of turbid/low light environments, the turbidity effects associated with the proposed project are not expected to result in measurable impacts to green sturgeon. The exposure to noise in particular is expected to adversely affect a small number of individuals. Noise may displace or impede fish that are rearing or holding in the action area causing disruptions in feeding and sheltering behavior of individuals. Prolonged exposure to high sound levels may also result in temporary impacts to the hearing ability of exposed fish, but sound pressure levels are not expected to exceed 206 dB, so no direct and/or immediate mortality of juvenile or adult fish is expected. However, fish exposed to an accumulated SEL exceeding 187 dB can be physically injured, and potentially lead to indirect mortality.

The elevated stress levels associated with sound exposure may degrade the fish's health and the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Individuals that appear different in their behavior attract predators, and thus experience higher mortality due to predator attacks. Due to the lack of general abundance information regarding the Southern DPS of North American green sturgeon in the San Joaquin River, a variety of estimates must be utilized to determine the range of potential effects resulting from the take of a small number of green sturgeon due to the proposed action. Compared to the estimated population sizes suggested by the CDFG tagging efforts (CDFG 2002b), juvenile and sub-adult captures passing Red Bluff Diversion Dam, and past Interagency Ecological Program (IEP) sampling efforts, the low level of take estimated from the proposed project would impact a very small proportion of the adult and sub-adult North American green sturgeon DPS. Ratios of tagged white to green sturgeon in San Pablo Bay have generated population estimates averaging 12,499 sub-adult and adult green sturgeon. Captures of juvenile green sturgeon passing Red Bluff Diversion Dam have exceeded 2,000 individuals in some years. Utilizing trap efficiency estimates generated for salmonids at this sampling site (Marten *et al.* 2001) the total estimate of juvenile green sturgeon passing RBDD would be in excess of 20,000 fish during that sampling period. Given these juvenile population estimates, the low level of incidental take of North American green sturgeon that is expected to result from the proposed project would represent a very small proportion of the standing population and is not expected to appreciably reduce the likelihood of survival and recovery of the Southern DPS of North American green sturgeon.

**C. Summary of Effects of the Proposed Action on Critical Habitat**

The effects of the proposed Antioch Bridge Seismic Retrofit project is expected to have minimal adverse effects upon the functionality and conservation value of the freshwater rearing and migratory corridors designated or proposed as critical habitat in the San Joaquin River. Impacts to the designated and proposed critical habitat within the action area that are related to the construction actions are expected to be temporary, lasting only as long as the pile driving and mooring lines installation/removal activities. The construction actions should never impede or prevent migratory potential in the channel of the San Joaquin River due to numerous factors, including: timing of work, location of the action (large open migratory habitat still accessible to fish), and protective measures implemented to minimize impacts to the river during construction (*i.e.*, BMPs and SWPPP). Temporary loss of foraging habitat is minimal, given the small footprint of the pile driving compared to the available habitat.

NMFS expects that nearly all of the adverse effects to critical habitat from this project will be of a short-term nature and will not affect future generations of listed fish beyond the construction period of the project.

## VIII. CONCLUSION

After reviewing the best scientific and commercial data available, including the environmental baseline, the effects of the proposed project, and the cumulative effects, it is NMFS biological opinion that the Antioch Bridge Seismic Retrofit project is not likely to jeopardize the continued existence of endangered Sacramento River Winter-run Chinook salmon, threatened CV Spring-run Chinook salmon, threatened CV steelhead, or threatened Southern DPS of North American green sturgeon, and is not likely to destroy or adversely modify designated or proposed critical habitat for these species.

## IX. INCIDENTAL TAKE STATEMENT

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

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

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

**A. Amount or Extent of Take**

NMFS anticipates incidental take of CV steelhead and the Southern DPS of North American green sturgeon from impacts directly related to pile driving activities and impairment of essential behavior patterns as a result of these activities. The incidental take is expected to be in the form of harm, harassment, or mortality of CV steelhead and green sturgeon, resulting from the installation and removal of temporary piles. Incidental take is expected to occur from August 1 through November 30, when CV steelhead and green sturgeon could potentially be in the action area. Moreover, it is not possible to monitor the resulting take given the site conditions present (high natural turbidity), and the likelihood that the full extent of these effects may be delayed for hours or days after initial exposure, perhaps longer. Therefore, NMFS cannot predict what proportion of the migrating fish will be exposed to elevated noise levels and what proportion will move through the action area at night or during other periods when pile driving is not occurring. Therefore, NMFS has designated specific project elements and effects to act as ecological surrogates for the extent of take anticipated to result from the Antioch Bridge Seismic Retrofit project.

1. <u>Ecological Surrogates</u>

The most appropriate ecological surrogates for the extent of take caused by the Project are: the amount, duration and timing of pile driving and pile removal associated with the construction and removal of the temporary trestle, and the amount, duration and timing of increased turbidity caused by these pile driving and removal activities.

- The analysis of the effects of the proposed project anticipates the installation and subsequent removal of up to 160, 24-inch diameter hallow steel shell piles during the in-water work window between August 1 and November 30, during daylight hours, for one season.

  Specifically, the areas in which take is expected to occur from pile driving within the San Joaquin River are:

  a. within 12 meters of the unattenuated impact pile driving necessary to establish the baseline SPLs for the monitoring, assuming that the peak underwater noise levels experienced by ESA listed fish within this area will exceed the 206 $dB_{peak}$ injury threshold for a single pile strike (equivalent to no more than 207 $dB_{peak}$ measured 10 meters from the pile);

b. within 6,600 feet of vibratory pile driving, where NMFS expects significant behavioral effects on ESA-listed fish due to SPLs in excess of 150 $dB_{rms}$ (equivalent to 191 $dB_{peak}$ measured at 10 meters from each pile).

NMFS expects that noise levels outside of these areas will not exceed the above described thresholds.

- The analysis of the effects of the proposed project anticipates that the turbidity levels produced by installation/removal of piles will not exceed those permitted under the project SWPPP and that if turbidity levels approach or exceed the acceptable criteria established by the Regional Water Quality Control Board (RWQCB), construction activities will be halted until turbidity levels return to within acceptable levels.

If these ecological surrogates are not met and maintained, the proposed Antioch Bridge Seismic Retrofit project will be considered to have exceeded anticipated take levels, triggering the need to reinitiate consultation on the Project.

**B. Effect of Take**

NMFS has determined that the level of take resulting from the construction of the proposed project is not likely to jeopardize the continued existence of CV steelhead or the Southern DPS of North American green sturgeon, and is not likely to destroy or adversely modify designated critical habitat for CV steelhead or proposed critical habitat for the Southern DPS of North American green sturgeon.

**C. Reasonable and Prudent Measures**

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

1. Real time monitoring shall be conducted to ensure that underwater sound levels analyzed in this biological opinion (150 db RMS, 187 dB accumulated SEL, and 206 peak SPL) are not exceeded.

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

## D. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, Caltrans must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary:

1. Real time monitoring shall be conducted to ensure that underwater sound levels analyzed in this biological opinion (150 db RMS, 187 dB accumulated SEL, and 206 peak SPL) are not exceeded.

   a. Caltrans shall monitor underwater sound during all impact hammer pile driving activities on land or in water whenever there is a possibility the activity may exceed the 206 dB peak sound level. If underwater sound produced during five or more strikes on a single day exceeds the maximum allowable level of 206 $dB_{peak}$ at 14 meters from the pile being installed, then NMFS must be contacted within 24 hours.

   b. Caltrans shall submit to NMFS daily hydroacoustic monitoring reports (by noon of the day following pile driving) that provide data regarding the actual (or estimated using propagation models) distance to the NMFS thresholds (150 db RMS, 187 dB accumulated SEL, and 206 peak SPL) used in this biological opinion to determine adverse effects to listed species. Specifically, the reports shall:

      - Describe the locations of hydroacoustic monitoring stations that were used to document the extent of the underwater sound footprint during pile-driving activities, including the number, location, distances, and depths of hydrophones and associated monitoring equipment;

      - Include the total number of pile strikes per pile, the interval between strikes, the peak/RMS SPL and SEL per strike, and accumulated SEL per day for each hydroacoustic monitor deployed.

      - Include a monitoring and reporting program that will include provisions to provide daily summaries of the hydroacoustic monitoring results to NMFS, as well as more comprehensive summary reports on a monthly basis during the pile-driving season.

   c. Caltrans shall submit to NMFS a hydroacoustic monitoring summary due 30 days following pile driving that provides a review of the monitoring data and process, as well as any problems that were encountered.

   d. Pile driving shall occur only during daylight hours from one hour after sunrise to one hour before sunset. This is to ensure that pile driving does not occur at dawn or dusk, during peak salmonid migration and feeding times.

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

   a. Caltrans shall monitor and maintain all riparian plantings for 5 years, and provide irrigation, fertilization and replacement plantings as necessary to insure full and rapid recovery of disturbed riparian habitat features

   b. If a listed species is observed injured or killed by project activities, Caltrans shall contact NMFS within 48 hours at 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814. Notification shall include species identification, the number of fish, and a description of the action that resulted in take. If possible, dead individuals shall be collected, placed in an airtight bag, and refrigerated with the aforementioned information until further direction is received from NMFS.

Annual updates and reports required by these terms and conditions shall be submitted by December 31 of each year during the construction period to:

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

## XI. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act 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 listed species or critical habitat, to help implement recovery plans, or to develop information.

1. Caltrans should support and promote aquatic and riparian habitat restoration within the Delta region, and implement practices that avoid or minimize negative impacts to salmon, steelhead, and sturgeon on all of their project sites within critical habitat.

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

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

## XII. REINITIATION NOTICE

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

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**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, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and,
"spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon 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 the San Joaquin Delta (Delta) hydrologic unit (*i.e.*, number 18040003). 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 San Joaquin Delta hydrologic unit. The enclosed biological opinion (Enclosure 1) thoroughly addresses the species of Chinook salmon listed both under the Endangered Species Act (ESA) and the MSA which potentially will be affected by the proposed action. These include Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon. Therefore, this EFH consultation will concentrate primarily on the Central Valley fall/late fall-run Chinook salmon which is covered under the MSA, although not listed under the ESA.

Factors limiting Chinook salmon populations in the San Joaquin River 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, rip-rapping, *etc.* (Dettman *et al.* 1987; California Advisory Committee on Salmon and Steelhead Trout 1988, Kondolf *et al.* 1996a, 1996b).

### A. Life History and Habitat Requirements

1. Pacific Salmon

General life history information for Central Valley fall-run Chinook salmon is summarized below. Further detailed information on the other Central Valley Chinook salmon Evolutionarily Significant Units (ESUs) are available in the enclosed biological opinion, the NMFS status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NMFS proposed rule for listing several ESUs of Chinook salmon (63 FR 11482).

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 March and spawn from January to March (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 1997).

Egg incubation occurs from October through April (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 larger juveniles, Central Valley Chinook salmon depend on passage through the Delta for access to the ocean.

## II. PROPOSED ACTION

The proposed action is described in detail in section II (*Description of the Proposed Action*) of the enclosed biological opinion (Enclosure 1).

## III. EFFECTS OF THE PROPOSED ACTION

The effects of the proposed action on salmonid habitat (*i.e.*, Central Valley steelhead) are described at length in *Effects of the Action* of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH.

Effects to EFH stemming from construction activities that may contribute sediment and increase turbidity will be avoided or minimized by meeting Regional Water Quality Board objectives, Caltrans water pollution specifications, implementing applicable BMPs, staging equipment outside of the riparian corridor, limiting the amount of riparian vegetation removal, and replacing (if any) lost riparian vegetation at the project site.

EFH will be adversely affected by the disturbance of up to 0.06 acres of riparian vegetation as a result of construction activities as well as the occupation of the riverbed and water column by temporary work trestles and the columns of the new bridge's substructure. The majority of these impacts are expected to be temporary, as all disturbed areas outside the actual footprint of the new bridge would be restored to preconstruction conditions and any areas of disturbed vegetation would be replanted with native riparian vegetation. Additionally, implementation of the proposed project would result in a permanent net increase of riverine habitat since this project would result in fewer piers being located within the channel.

These effects to EFH may result in a temporary redistribution of some individuals, primarily migrating adult and rearing juvenile salmonids, but, due to the temporary nature of these disturbances, the adverse effects that are anticipated to result from the proposed project are not of the type, duration, or magnitude that would be expected to adversely modify EFH to the extent that it could lead to an appreciable reduction in the function and conservation role of the affected habitat. NMFS expects that nearly all of the adverse effects to EFH from this project will be of a short term nature and will not affect future generations of Pacific salmon beyond the construction period of the project.

## IV. CONCLUSION

Based on the best available information, and upon review of the effects of the proposed Antioch Bridge Seismic Retrofit project, NMFS believes that the construction and operation of the project features will have temporary adverse effects on EFH of Pacific salmon protected under MSA.

## V. EFH CONSERVATION RECOMMENDATIONS

As the habitat requirements of Central Valley fall-run Chinook salmon within the action area are similar to those of the federally listed species addressed in the enclosed biological opinion, NMFS recommends that reasonable and prudent measures numbers 1 and 2 and their respective implementing terms and conditions listed in the incidental take statement prepared for Central Valley steelhead and the Southern DPS of North American green sturgeon in the associated biological opinion, be adopted as EFH conservation recommendations. Those terms and conditions which require the submittal of reports and status updates can be disregarded for the purposes of this EFH consultation as there is no need to duplicate those submittals.

## 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 lead agency 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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