UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
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Long Beach, California 90802-4213

October 22, 2012

MEMORANDUM FOR: Permit 16543 (151422SWR2012SA00299) file

FROM: for Rodney R. McInnis
Regional Administrator

SUBJECT: Documentation of Endangered Species Act section 7 consultation (PCTS TN# 2012/02698) for the issuance of section 10(a)(1)(A) scientific research Permit 16543 authorizing take of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha)*, Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*) and Southern DPS green sturgeon (*Acipenser medirostris*).

I. INTRODUCTION

Section 10(a)(1)(A) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1536 *et seq*.), provides NOAA's National Marine Fisheries Service (NMFS) with authority to grant scientific research exemptions to the ESA's section 9 "taking" prohibitions (see regulations at 50 CFR 222.301 through 222.308, and 50 CFR 224.101 through 224.102). Section 10(a)(1)(A) scientific research or enhancement permits may be issued to Federal or non-Federal entities conducting research or enhancement activities that involve intentional take of ESA-listed species. Any permitted research or enhancement activities must: (1) be applied for in good faith; (2) if granted and exercised, not operate to the disadvantage of the threatened or endangered species; and (3) be consistent with the purposes and policy set forth in section 2 of the ESA [50 CFR 222.303(f)]. When granting such permits, NMFS must consult internally under section 7 of the ESA to ensure that permits do not appreciably reduce the likelihood of survival and recovery of ESA-listed species. In compliance with section 7(a)(2) of the ESA, in this biological opinion (BO), NMFS analyzed the effects of the issuance of Permit 16543, authorizing take of ESA-listed species from the Sacramento River (SR) winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*), evolutionarily significant units (ESUs), the California Central Valley (CCV) steelhead (*O. mykiss*) distinct population segment (DPS), and the Southern DPS of North American (sDPS) green sturgeon (*Acipenser medirostris*).

II. CONSULTATION HISTORY

On July 20, 2011, the application for permit 16543 was submitted by the Department of Water

Resources (DWR), Environmental Services to NMFS.

On September 16, 2011, the application for permit 16543 was completed by DWR and submitted to NMFS for review.

On September 16, 2011, NMFS published a notice of receipt in the *Federal Register* outlining the research activities and take of ESA-listed salmonids proposed under Permit 16543 (76 FR 23842). The public comment period for Permit 16543 was closed on October 17, 2011, and no comments were received.

On May 4, 2012, the lead staff, Shirley Witallis, for NMFS permitting applications resigned and Amanda Cranford took over as permit analyst.

On July 2, 2012, NMFS assigned Sierra Franks the responsibility of completing the BO and review for Permit 16543.

III. DESCRIPTION OF THE PROPOSED ACTION

NMFS Southwest Region, Protected Resources Division proposes to issue scientific research Permit 16543 under the authority of section 10(a)(1)(A) of the ESA. Permit 16543 will authorize scientific research and monitoring activities in the Sacramento River above Rio Vista, Georgiana, Steamboat, Miner, and Cache sloughs, Sacramento Deep Water Ship Channel, Liberty Island, and Yolo Bypass, starting from the date of permit issuance through June of 2014. The permit will authorize DWR for non-lethal and unintentional lethal take of adult SR winter-run and CV spring-run Chinook salmon, adult CCV steelhead, and juvenile and adult sDPS green sturgeon. The take activities authorized under Permit 16543 will include capture of fish by trammel net and; activities associated with fish handling (species identification, taking the measurement of fork length (FL); and the release of salmonids and green sturgeon back into the study area if they are incidentally captured.

A. Research Project Description

This project will examine predation by introduced fishes: 1,000 striped bass (*Morone saxatilis)* 300 largemouth bass (*Micropterus salmoides*), 300 smallmouth bass (*Micropterus dolomieu*) and native resident fishes, 400 Sacramento pikeminnow (*Ptychocheilus grandis*) on migrating native fishes (juvenile spring-, winter-, fall-, and late-fall-run Chinook salmon, juvenile steelhead, delta smelt (*Hypomesus transpacificus)* and longfin smelt (*Spirinchus thaleichthys*), white sturgeon (*Acipenser transmontanus*) and green sturgeon, and Sacramento splittail (*Pogonichthys macrolepidotus*)) across a variety of habitats and migration corridors in the northern Sacramento-San Joaquin Delta. Results will provide information on spatial and environmental patterns of predation; critical information for guiding future restoration projects on conditions likely to support or discourage higher predation rates on endangered and native fishes. The sampling will be conducted in December 2012, April, June, and December 2013, and April and June of 2014 in the Sacramento River above Rio Vista, Georgiana, Steamboat, Miner, and Cache sloughs, Sacramento Deep Water Ship Channel (DWSC), Liberty Island, and Yolo Bypass. Sampling months were selected based on likely periods of co-occurrence of predators and prey species of interest. Predators will be sampled with trammel nets, with the goal of genetically analyzing their gut contents for the DNA of various prey items. Trammel netting was determined to be the preferred sampling method due to the target species and sample sizes, water depth, and inherent biases of alternative methods (electrofishing, hook and line, beach seining), and because it is less likely than gill netting to inflict harm on listed species captured incidentally. ESA-listed adult Chinook (winter- and spring-runs), adult CCV steelhead, and sDPS green sturgeon may be incidentally collected in trammel nets, but stress will be minimized by using short net soak times (40 minutes) and by immediate processing and releasing listed species. Listed species are not the target of the sampling program, but incidental take will provide valuable information on their size, habitat use, and migration timing.

Four potential migration corridors for out-migrating Chinook smolts will be sampled, including Steamboat Slough, Miner Slough, Georgiana Slough, and the main-stem Sacramento River. Additionally, predators will be sampled from Liberty Island and the Sacramento (DWSC). Also, samples will be collected from the lower Sacramento River downstream of the confluence of Steamboat Slough but upstream of Rio Vista, California. Sampling will not be conducted within two kilometers (km) of the upstream and downstream extents of each sampling reach to create separation between the different sampling areas.

Within each of seven sampling areas, ten stations will be chosen at random. All stations will be sampled once in December, once in April, and again in June, with sampling to be repeated during winter/spring 2012 - 2013 and 2013 - 2014. All stations will be sampled over the course of 10 days for each sampling period, and over the course of the entire study each station will be sampled six times. Target predator species will include age-1+ striped bass (250 - 600 millimeters (mm)), largemouth bass (250 – 500 mm), smallmouth bass (250 – 400 mm), and Sacramento pikeminnow (250 – 500 mm).

At each station, predators will be sampled using trammel nets. The trammel nets will be comprised of a center panel of 2.5 inch (in.) stretch mesh monofilament gillnet with two outer panels of 18 in. trammel nets. The nets will be 50 meters (m) long and either 2-m deep for slough habitats or 2.5-m deep for the main-stem Sacramento River sampling sites. Trammel nets will be set for 40 minutes with one set per station. The orientation of the net to shore will be randomized between perpendicular (70 percent of sets) and parallel (30 percent of sets) so as to effectively sample all targeted predator species. All fishes collected in the trammel nets will be identified to species and their FL measured to the nearest mm. Samples will be collected between dawn and dusk, across all tidal stages. Water quality parameters (temperature, pH, electrical conductivity, turbidity, and dissolved oxygen), secchi depth, water depth, global positioning system (GPS) coordinates, and tide/current conditions will be recorded at each set. Environmental variables (depth, presence of submerged or floating aquatic vegetation, bank and substrate type) will also be recorded at each of the sampling locations in order to relate predation rates to habitat. All water quality and environmental parameters will be recorded while the nets are soaking.

All potential predators of native fish will have their stomachs and intestines preserved for genetic analysis. Predators will have their guts dissected out immediately after capture using DNA-sterile protocols (bleaching and rinsing of all instruments and work surfaces). Predator guts will then be preserved in 80 percent ethanol and stored on dry ice until transferred to the Genomic Variation Laboratory (GVL) at the University of California (UC) Davis for genetic analysis.

All sampling will be conducted from either an 18 feet (ft) Fish-Rite jetboat or a 24-ft landing craft style vessel. During the fishing of the net, the boat will either anchor or hold station in the immediate vicinity of the net (<25 m) so the net can be constantly observed.

The periods for sampling (December, April, June) were specifically chosen to minimize the potential for interactions with ESA-listed fish species (Quinn 2005; Moyle 2002). These periods minimize the possibility of incidental catch of adult listed species, while still maximizing the local abundance of prey species of interest (ESA-listed juvenile salmonids, delta smelt, splittail, etc.). Other periods were considered but were not chosen because they either had an unacceptably high probability of listed species bycatch or there were no prey species of interest in the target areas (e.g. summer). Additionally, these months were chosen because of the high likelihood of encountering striped bass in the sampling area, as striped bass move upstream in the late fall to spawn and feed.

Aside from trammel net sampling, predators will also be collected out of the Interagency Ecological Program (IEP) Yolo bypass monitoring survey's fyke trap in the toe drain of the Yolo bypass. This method is an alternative source of predators to the main sampling effort, and is meant to supplement the study's sample size and provide a valuable floodplain habitat type to DWR breadth of areas sampled. This trap is operated by the Yolo Bypass Fisheries Monitoring Program at DWR and is permitted separately under the existing IEP section 10(a)1(A) permit (13791). Thus, the take of listed species incurred by the operation of this trap is not included on this permit application.

Justification for the Project

The effect of predation on native fishes in the Sacramento – San Joaquin Delta (Delta) has been identified as a major stressor to declining native fish populations [Bay Delta Conservation Plan, (BDCP) 2010]. While predation is a universal process for biota of nearly all trophic levels, a primary concern for native fishes in the Delta is that predation pressure from introduced, highly effective predators such as striped bass, largemouth bass, and smallmouth bass may limit population recovery or even exacerbate species' declines (Baxter *et al*. 2010). While the original cause of these declines is likely rooted in large-scale changes in habitat conditions (extensive wetland reclamation, channel dredging, dam construction on freshwater inputs to the system, and installation of powerful pumping operations that alter hydrodynamic patterns), these changes have modified conditions to favor abundance of these introduced predators, while decimating suitable habitat for native fishes (Brown and Michniuk 2007; Sommer *et al.* 2007). Emerging conservation plans for the Delta prescribe extensive habitat restoration designed to favor native species while discouraging non-native predators (BDCP 2010; Ecological Restoration Plan (ERP) Conservation Strategy 2010; Delta Vision Strategic Plan 2008), as well as aggressive predator removal programs targeting "predation hot spots" during periods when listed species are present (e.g. section 3.4.4.4, BDCP 2010). While this project is not explicitly evaluating any specific restoration actions, nor is it directly associated with any planned restoration actions, the project will contribute to the understanding of the predator-prey dynamics of native fishes and how they differ from non-native fishes across variable landscapes. The information gathered will thus help to promote more effective conservation strategies to benefit native and ESA-listed fish communities.

B. Description of the Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 404.2). For the purposes of this BO, the action area encompasses the following hydrologic units, as defined by the United States Geological Survey: lower Sacramento River, and the Delta. The sampling area is currently divided into eight regions (Figure 1) to facilitate data analyses and our understanding of fish abundance and movement throughout the system: (1) Sacramento River above Rio Vista; (2) Georgiana Slough; (3) Steamboat Slough; (4) Miner Slough; (5) Cache Slough; (6) Sacramento Deep Water Ship Channel; (7) Liberty Island; and (8) Yolo Bypass.

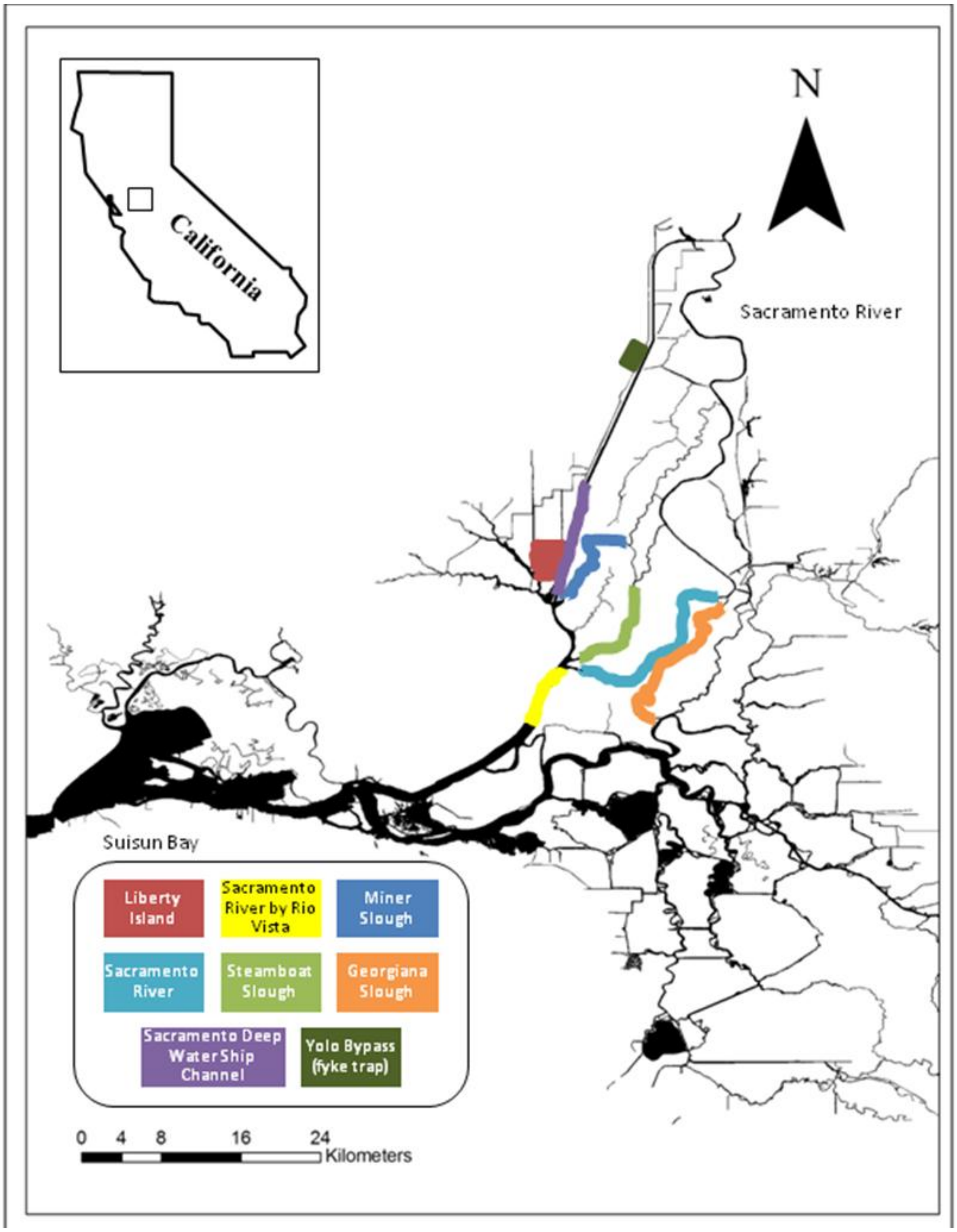

Figure 1. Depicts project locations.

C. Requested Amount of Take

The requested amount of take, including lethal, non-lethal and unintentional mortality presented in the Appendix: (1) has been determined jointly by NMFS and DWR; and (2) is the minimum amount of take necessary to achieve the goals and objectives of the research programs proposed under Permit 16543. The permit holder will not be exempt from the ESA section 9 take prohibition for any additional take above that authorized, including mortalities. In the event that the authorized level of take, including mortalities, is exceeded, the permit holder shall notify

NMFS no later than two calendar days after the unauthorized take. NMFS may evaluate the research project to determine if techniques need to be revised accordingly to prevent additional take. Pending review of these circumstances, NMFS may suspend research activities or amend this permit in order to allow research activities to continue.

See Appendix 1 which documents the amount of requested annual take and potential unintentional mortality of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon by DWR for Permit 16543.

IV. STATUS OF THE SPECIES AND CRITICAL HABITAT

This BO analyzes the effects of Permit 16543 on the following federally listed ESUs and DPS below:

- **SR winter-run Chinook salmon ESU** (*Oncorhynchus tshawytscha*)
  Listed as endangered (70 FR 37160, June 28, 2005)
- **CV spring-run Chinook salmon ESU** (*Oncorhynchus tshawytscha*)
  Listed as threatened (70 FR 37160, June 28, 2005)
- **CCV steelhead DPS** (*Oncorhynchus mykiss*)
  Listed as threatened (71 FR 834, January 5, 2006)
- **sDPS of North American green sturgeon** (*Acipenser medirostris*)
  Listed as threatened (71 FR 17386, April 7, 2006)

The action area for Permit 16543 is within the designated critical habitats listed below:

- **SR winter-run Chinook salmon designated critical habitat**
  (58 FR 33212, June 16, 1993)
- **CV spring-run Chinook salmon designated critical habitat**
  (70 FR 52488, September 2, 2005)
- **CCV steelhead designated critical habitat**
  (70 FR 52488, September 2, 2005)
- **sDPS of North American green sturgeon designated critical habitat**
  (74 FR 52300, October 9, 2009)

The proposed research activities may result in temporary disturbances to river substrate and banks from walking, netting, installing, and operating sampling gear. These minor disturbances are not expected to adversely affect designated critical habitat for ESA-listed salmonid conservation. Designated critical habitat is not considered further in this BO.

<u>Chinook Salmon</u>

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

During their upstream migration, adult Chinook salmon require streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are necessary to allow adult passage to upstream holding habitat. The preferred water temperature range for upstream migration is 38 degrees-Fahrenheit (ºF) to 56ºF (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 65ºF for adult Chinook salmon migration, and Lindley *et al.* (2004) reports that adult migration is blocked and fish can become stressed when water temperatures reach 70ºF.

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

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

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

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

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

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

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries (Maslin *et al.* 1997, Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2002). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54ºF to 57ºF. In Suisun and San Pablo Bays, water temperatures reach 54ºF by February in a typical year. Other portions of the Delta (*i.e*., south Delta and central Delta) can reach 70ºF 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. They tend to follow the rising tide into shallow water habitats from the deeper main channels, returning to the main channels when the tide recedes (Levy and Northcote 1981, 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. In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry will 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 three meters of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon), MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

Sacramento River Winter-run Chinook Salmon

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

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

Table 1. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult

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

b) Juvenile

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

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

Relative Abundance: = High; = Medium; = Low

Emigration of juvenile winter-run Chinook salmon past RBDD may begin as early as mid-July, typically peaking in September, and possibly continuing through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all winter-run Chinook salmon out-migrating as fry passed RBDD by October, and all out-migrating pre-smolts and smolts had passed RBDD by March (Martin *et al.* 2001). Juvenile 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 2001a, 2001b]. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length of approximately 118 mm and are from 5 to 10 months of age. They begin emigrating to the ocean as early as November and continue through May (Fisher 1994, Myers *et al.* 1998).

Central Valley Spring-run Chinook Salmon

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

Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over the summer, spawn in the fall, and the juveniles typically spend a year or more in freshwater before emigrating. Adult spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, peaking in May and June (Table 2, Yoshiyama *et al*. 1998, Moyle 2002). Lindley *et al*. (2004) indicate adult spring-run Chinook salmon enter 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). The U.S. Bureau of Reclamation reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60^{o}F, although salmon can tolerate temperatures up to 65^{o}F before they experience an increased susceptibility to disease. 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 three years of age (Fisher 1994).

Table 2. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult

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

(b) Juvenile

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

Source:[1]Yoshiyama *et al*. 1998; [2]Moyle 2002; [3]Myers *et al*. 1998; [4]Lindley *et al*. 2004; [5]CDFG 1998; [6]McReynolds *et al*. 2005; Ward *et al*. 2002, 2003; [7]Snider and Titus 2000

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

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year or as juveniles or yearlings. The modal size of fry migrants (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*. 2004). Studies in Butte Creek (Ward *et al*. 2002, 2003; McReynolds *et al*. 2005) found the majority of spring-run Chinook salmon migrants to be fry occurring primarily from December through February; and that these movements appeared to be influenced by flow. Small numbers of spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al*. 2004).

Once juveniles emerge from the gravel, they seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many 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 larger. Microhabitat use can be influenced by the presence of predators, which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). The emigration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the young-of-the-yearfish out-migrating through the lower Sacramento River and Delta during this period (CDFG 1998). Spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, Snider 2001). Peak movement of juvenile spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000). Based on the available information, the emigration timing of 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).

<u>Steelhead</u>

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

California Central Valley Steelhead

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

The female selects a site where there is good intergravel flow, then digs a redd and deposits eggs while an attendant male fertilizes them. The eggs are then covered with gravel when the female begins excavation of another redd just upstream. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51°F. Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954).

CCV steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-yearalso 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 CCV steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile CCV 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 CCV steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Nobriga and Cadrett (2003) also have verified these temporal findings based on analysis of captures at Chipps Island, Suisun Bay.

Table 3. The temporal occurrence of adult (a) and juvenile (b) Central Valley steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult

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

(b) Juvenile

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

Source: [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [5]Hallock et al. 1957; [6]Bailey 1954; [7]CDFG Steelhead Report Card Data 2007; [8]CDFG unpublished data 2011; [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.

Relative Abundance: (H) = High (M) = Medium (L) = Low

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

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned CCV 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 CCV 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). Snorkel surveys from 2009 indicate that steelhead are present in Clear Creek (Giovanetti and Brown 2010), as well as monitoring from 2005 through 2009 in Battle Creek (Newton and Stafford 2011). Due to the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not yet been estimated.

Until recently, CCV 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 (RSTs) at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001). Additionally, Zimmerman *et al.* (2008) documented CCV steelhead in the Stanislaus, Tuolumne and Merced rivers based on otolith microchemistry.

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

Good *et al*. (2005) indicated that prior population census estimates completed in the 1990s found the CCV 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 from Chipps Island trawl data. The future of CCV steelhead is uncertain due to limited data concerning their status. CCV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

4. <u>Green sturgeon</u>

Spawning populations of North American green sturgeon are currently found in three river systems: the Sacramento and Klamath rivers in California, and the Rogue River in southern Oregon. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (NMFS 2005a). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Moser and Lindley 2007). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo bays (Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Lindley (2006a) reported that green sturgeon make seasonal migratory movements along the west coast of North America, overwintering north of Vancouver Island and south of Cape Spencer, Alaska. The sDPS green sturgeon have been detected in these seasonal aggregations.

Southern DPS of North American Green Sturgeon

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

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

Table 4. The temporal occurrence of adult (a) larval and post-larval (b) juvenile (c) and coastal migrant (d) Southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult (≥13 years old for females and ≥9 years old for males)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2,3]Upper Sac. River												
[4,8]SF Bay Estuary												
(b) Larval and post-larval (≤10 months old)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]RBDD, Sac River												
[5]GCID, Sac River												
(c) Juvenile (> 10 months old and ≤3 years old)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[6]South Delta*												
[6]Sac-SJ Delta												
[5]Sac-SJ Delta												
[5]Suisun Bay												
(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[3,7]Pacific Coast												

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

Relative Abundance: = High = Medium = Low

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

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River and its tributaries (Stanislaus, Tuolumne, and Merced rivers) occurred early in the European settlement of the region. During the latter half of the 1800s, impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for approximately a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. Both white and green sturgeon likely utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of spring-run Chinook salmon and CCV 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. However, recently eight sDPS green sturgeon were documented in the 2011 Surgeon Report Card (CDFG 2011) report as released catch by anglers fishing from above the Highway Bridge 140 to the city of Stockton, to Sherman Lake, in the San Joaquin River basin.

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

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

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

Green sturgeon larvae hatch after approximately 169 hours at a water temperature of 15^{o}C (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Van Eenennaam *et al.* (2001) indicated that an optimum range of water temperature for egg development is between 14^{o}C and 17^{o}C. Temperatures over 23^{o}C resulted in 100 percent mortality of fertilized eggs before hatching. Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length. After roughly 10 days, the yolk sac becomes greatly reduced in size and the larvae begin feeding and growing rapidly. Young green sturgeon appear to rear for the first one to two months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Juvenile sDPS green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging from 24 to 31 mm FL(CDFG 2002, USFWS 2002). The mean yearly total length of post-larval sDPS green sturgeon captured in rotary screw traps at the RBDD ranged from 26 mm to 34 mm between 1995 and 2000, indicating they are approximately 2 weeks old. The mean yearly total length of post-larval sDPS green sturgeon captured in the GCID RST, approximately 30 miles downstream of RBDD, ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, 2002) indicating they are approximately three 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*. (2005) indicated that juvenile fish continue to migrate downstream at night for the first six months of life. When ambient water temperatures reach 8^{o}C, downstream migrational behavior is reduced and holding behavior increased. These data suggest that 9- to 10-month old fish hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. During these early life stages, larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Smallmouth bass have been recorded on the Rogue River preying on juvenile green sturgeon, and prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005).

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

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

C. Species Population Trends

<u>SR Winter-run Chinook Salmon</u>

Historical winter-run Chinook salmon population estimates, which included males and females, were as high as near 100,000 fish in the 1960s, but declined to under 200 fish in the 1990s (Good *et al.* 2005). In recent years, the carcass survey population estimates of winter-run included a high of 17,334 in 2006, followed by a precipitous decline in 2007 that continues through 2011 (CDFG GrandTab, April 23, 2012).

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

The recent 5-year status review on SR winter-run Chinook salmon has concluded that the “endangered” status of the species remains (NMFS 2011a, 76 FR 50447). Survival of hatchery-origin fish is greater than that of the naturally-produced population, lending to concerns of ESU viability due to increasing hatchery contribution to natural productivity (greater than 18 percent in the 2005 redd survey) (Lindley *et al.* 2007). Beginning in 2010, the Livingston Stone National Fish Hatchery follows a no-hatchery broodstock spawning protocol so that the hatchery-origin contribution to the natural-origin population will not go beyond the F1 generation, *i.e.,* the first filial generation, comprised of offspring resulting from a cross between wild-origin broodstock. The 2012 JPE for winter-run Chinook salmon calculated by NMFS includes 512,192 out-migrating smolts from the upper Sacramento River, of which 162,051 juvenile winter-run Chinook salmon are expected to enter the Delta. Of the released 194,734 hatchery-origin SR winter-run juvenile Chinook salmon, NMFS expects 96,525 will enter the Delta during the 2012 season (B. Oppenheim, 2012, NMFS, pers. comm.). There is a risk to the Delta-bound winter-run Chinook salmon of being taken at the Central Valley Project (CVP) and State Water Project (SWP) pumping facilities and consequently prevented from contributing to the productivity of the species.

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

Historically, spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (CDFG 1998). The Central Valley drainage as a whole is estimated to have supported spring-run 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 spring-run Chinook salmon from these watersheds. Naturally-spawning populations of spring-run are currently restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the Feather River Hatchery (FRH). In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is below the 10-year average of 4,727 fish. However, CWT information from these hatchery returns indicates substantial introgression has occurred between spring-run and fall-run populations within the Feather River system due to hatchery practices. Because spring-run and fall-run Chinook salmon have not always been temporally separated in the hatchery, the two runs have likely been spawned together, thus compromising the genetic integrity of spring-run Chinook salmon. The number of naturally spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964.

Beginning in 2002, CDFG and the DWR began efforts to restore the integrity of the FRH spring-run Chinook salmon stock. Management focuses on identifying expression of spring-run Chinook salmon life history in early-returning fish (April through June) entering the hatchery, marking these fish with a hallprint tag, and releasing them back to the river to hold over summer. The fish ladder is closed at the end of June and is reopened in mid-September. Fish (adipose fin-clipped and non-clipped) entering the facility and having a hallprint tag are used exclusively as FRH spring-run Chinook salmon broodstock for the program. To protect what remains of spring-run Chinook salmon life history in the Feather River system (a distinctive Feather River spring-run Chinook salmon genome has not yet been recognized), the FRH spring-run Chinook salmon stock was included in the CV spring-run Chinook salmon ESU (NMFS 2005b). Although carcass surveys for Feather River fall-run Chinook salmon are typically inclusive of spring-run Chinook salmon, annual returns to the FRH have averaged 3,210 adults over a 10-year period (2001 through 2010).

The spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. Sacramento River tributary populations in Mill, Deer, and Butte creeks are probably the best trend indicators for the spring-run Chinook salmon ESU as a whole because these streams contain the primary independent populations within the ESU. Escapement estimates from 1995 through 2005 showed an average of over 7000 spring-run Chinook salmon returning to Butte Creek (CDFG GrandTab, April 23, 2012). Although trends previous to 2006 were positive, annual abundance estimates displayed a high level of fluctuation, and the overall number of spring-run Chinook salmon remained well below estimates of historic abundance. Further, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21^{o}C for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of columnaris disease (*Flexibacter columnaris*) and ichthyophthiriasis (*Ichthyophthirius multifiis*) in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to the pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek.

With a few exceptions, escapements have declined over the past 10 years, in particular since 2006. The recent declines in abundance place the Mill and Deer creek populations in the high extinction risk category due to their rate of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011b). Butte Creek continues to satisfy the criteria for low extinction risk, although the rate of decline is close to triggering the population decline criterion for high risk. Overall, the recent declines have been significant but not severe enough to qualify as a catastrophe under the criteria of Lindley et al. (2007). On the positive side, spring-run Chinook salmon appear to be repopulating Battle Creek, home to a historical independent population in the Basalt and Porous Lava diversity group that was extirpated for many decades. This population has increased in abundance to levels that would qualify it for a moderate extinction risk score. Similarly, the spring-run Chinook salmon population in Clear Creek has been increasing, and although Lindley et al. (2004) classified this population as dependent on other populations for its continued existence, the draft Central Valley Salmon and Steelhead Recovery Plan considers Clear Creek to be a core 1 population, that will be capable of reaching viable status (NMFS 2009). Over the long term, the remaining independent populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run populations in the Deer, Mill, and Butte creek watersheds due to their close proximity to each other. One large event could eliminate all three populations.

CCV Steelhead

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

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

Existing natural-origin CCV 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 natural-origin CCV steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996). Snorkel surveys from 2009 indicate that CCV steelhead are present in Clear Creek (Giovanetti and Brown 2010), as well as monitoring from 2005 through 2009 in Battle Creek (Newton and Stafford 2011).

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 CCV steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001). Zimmerman *et al.* (2008) has documented CCV steelhead in the Stanislaus, Tuolumne and Merced rivers based on otolith microchemistry.

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

4. sDPS Green Sturgeon

Population abundance information concerning the sDPS green sturgeon is described in the NMFS status reviews (Good *et al*. 2005). Limited population abundance information comes from incidental captures of North American green sturgeon during the CDFG sturgeon tagging program which aims to monitor white sturgeon (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. A more recent estimate of 75 to 200 mature green sturgeon, was made based on the use of DIDSON equipment in the upper Sacramento River (E. Mora, 2010. UC Davis, pers. comm.). Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between zero and 2,068 juvenile sDPS green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the sDPS green sturgeon includes changes in abundance at the John E. Skinner Fish Collection Facility between 1968 and 2006. The average number of sDPS green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47. For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32. In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of sDPS green sturgeon is declining. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (April 5, 2005). Catches of sub-adult and adult Northern and sDPS green sturgeon, primarily in San Pablo Bay, by the IEP ranged from 1 to 212 green sturgeon per year between 1996 and 2004 (212 occurred in 2001). However, the portion of sDPS green sturgeon is unknown. Recent spawning population estimates using sibling-based genetics by Israel (2006) indicate spawning populations of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 upstream of RBDD (with an average of 71).

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

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

D. Factors Responsible for Salmon, Steelhead and Green Sturgeon Declines

NMFS cites many reasons for the decline of Chinook salmon (Myers *et al.* 1998) and steelhead (Busby *et al.* 1996). The foremost reason for the decline in these anadromous populations is the degradation and/or destruction of freshwater and estuarine habitat. Additional factors contributing to the decline of these populations include: commercial and recreational harvest, artificial propagation, natural stochastic events, and reduced marine-derived nutrient transport. A principal factor in the decline of the sDPS of green sturgeon is the reduction of the currently known spawning area to a limited section of the Sacramento River (71 FR 17757). This remains a threat due to increased risk of extirpation from catastrophic events. Insufficient freshwater flow rates in spawning areas, contaminants (*e.g.*, pesticides), bycatch of green sturgeon in fisheries, potential poaching (*e.g.*, for caviar), entrainment by water projects, influence of exotic species, small population size, impassable barriers, and elevated water temperatures likely pose a threat to this species (71 FR 17757).

The following section details the general factors affecting anadromous ESUs and DPSs in California. The extent to which there are species- specific differences in population limiting factors is not clear; however, the freshwater ecosystem characteristics necessary for the maintenance of self-sustaining populations of anadromous species are similar.

<u>Habitat Degradation and Destruction</u>

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of West Coast salmonids by reducing and degrading habitat by adversely affecting essential habitat features. Most of this habitat loss and degradation has resulted from anthropogenic watershed disturbances caused by urban development, reduced water quality, water development and dams, levee embankment projects, gravel mining, and agriculture.

Urban Development

Urbanization has degraded anadromous fish habitat through stream channelization, flood plain drainage, riparian damage, and both point- and non-point source pollution. When watersheds are urbanized, problems can result simply because structures are placed in the path of natural run-off processes, or because the urbanization itself has induced changes in the hydrologic regime. Parking lots, rooftops, and paved roads can prevent rainfall from infiltrating into soil and ground water, leading to increased runoff to streams. With rainfall moving to streams more quickly and in greater amounts, streamflow conditions can change more rapidly, the peak streamflows may be higher, and flooding may occur more frequently in urban areas (U.S. Environmental Protection Agency 1998). Increased runoff to streams often leads to changes in water quality as well. Runoff can transport contaminants to streams from a variety of urban sources, including automobiles (hydrocarbons and metals); rooftops (metals); wood treated with preservatives (hydrocarbons); construction sites (sediment and any adsorbed contaminants); and golf courses, parks, and residential areas (pesticides, nutrients, bacteria) (Pitt *et al.* 1995). In addition, stream channels in urban areas can be straightened, deepened, and widened from their natural states to promote drainage and prevent flooding (Klein 1979). Commercial, residential, and industrial development commonly involves soil disturbance, which can lead to increased movement of sediment to the stream, and the removal of vegetation on the streambank, which can lead to loss of sheltered areas and stream canopy cover (Jacobson *et al.* 2001). The loss of stream canopy cover in turn can lead to greater daily changes in stream temperature (Sinokrot and Stefan 1993).

Changes in stream hydrology, water quality, physical habitat, and stream temperature in urbanizing areas can have profound effects on aquatic communities of algae, invertebrates, and fish. Periods of high streamflow can eliminate some aquatic organisms, particularly in channelized streams where refuge (seclusion and rest) areas such as boulders and woody debris are lacking (Winterbourn and Townsend 1991). In addition, higher streamflows are associated with increased movement of sediment to streams, which can affect aquatic communities by decreasing light penetration and photosynthesis and degrading stream-bottom habitat (Waters 1995). Higher contaminant concentrations and stream temperatures can adversely affect growth, reproduction, species competition, and disease progression within aquatic communities (Fitzgerald *et al.* 1999; LeBlanc *et al.* 1997).

Water Quality

Increased urban and commercial land use along the mainstem of the Sacramento River has resulted in additional water withdrawals and increased effluent containing pesticides, heavy metals, and organics in high levels (Central Valley Regional Water Quality Control Board 1998). Water diversions and water exports are a significant cause of the loss and decline of many resident and migratory fish species. Many stressors, such as chemical pollution, dissolved oxygen (DO), water temperature, reversed flows, *etc.*, in the Central Valley have resulted in the detriment of salmonids and sturgeon. Many waterways fail to meet the Federal Clean Water Act and Federal Safe Drinking Water Act water quality standards due to the presence of pesticides, suspended sediments, heavy metals, dioxins, and other pollutants. Salmon require clean water and gravel for successful spawning, egg incubation, and fry emergence. Fine sediments clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs. Pollutants, excess nutrients, low levels of DO, heavy metals, and changes in pH also decrease the water quality for salmon and steelhead. CDFG (1992) found significant correlations between mean daily flow during the spring and white sturgeon year class strength, as well as spring outflow and annual production of white sturgeon indicating the importance of outflow for sturgeon production (the effects on Southern DPS of the North American green sturgeon are thought to be similar). Sturgeon may accumulate polychlorinated biphenyls and selenium, substances known to be detrimental to embryonic development. Increased water temperature as a result of decreased outflow, reduced riparian shading, and thermal inputs from municipal, industrial, and agricultural return water in the Sacramento River also are a threat.

Water Development and Dams

Water withdrawals have reduced summer flows in many streams and have thereby decreased the amount and quality of rearing habitat. Water quantity problems are a significant cause of habitat degradation and reduced fish production. Dams have eliminated spawning and rearing habitat and altered the natural hydrograph of most of the major river systems. Depletion and storage of natural flows have altered natural hydrological cycles in many California rivers and streams, directly in conflict with evolved salmonid life histories.

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

Leveed Embankments

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 that have diminished conditions for adult and juvenile migration and survival. Many of these levees use angular rock (riprap) to armor the bank from erosive forces. The effects of channelization and riprapping include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000; Schmetterling *et al.* 2001). 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 (USFWS 2000).

Agricultural Practices

Modern agricultural practices have contributed to degradation of salmonid habitat on the West Coast through irrigation diversions, elimination or conversion of riparian and estuarine habitats, subsequent sedimentation and decline in water quality, over-grazing in riparian areas, and compaction of soils on stream banks and in upland areas from livestock. Agricultural application of herbicides and pesticides may lead to long-term soil contamination and areas of depleted oxygen in-river due to runoff contamination, effectively decreasing fish habitat and creating a possible barrier to fish migration.

The flow of freshwater into the Central Valley has been greatly reduced by water diversions largely to support irrigated agriculture (Nichols 1986). As of April 1997, 3,356 diversions have been located and mapped in the Central Valley, using the satellite GPS (Herren and Kawasaki 2001). 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-run Chinook salmon formerly existed in the major river tributaries and upper watersheds, and there also may have been a late fall-run Chinook salmon presence in the mainstem (Yoshiyama *et al.* 2001).

Commercial and Recreational Harvest

Ocean salmon fisheries off California are managed to meet the conservation objectives for certain stocks of salmon listed in the Pacific Coast Salmon Fishery Management Plan, including any stock that is listed as threatened or endangered under the ESA. Early records did not contain quantitative data by species until the early 1950's. In addition, the confounding effects of habitat deterioration, drought, and poor ocean conditions on Chinook salmon and steelhead make it difficult to assess the degree to which recreational and commercial harvest have contributed to the overall decline of salmonids in West Coast rivers.

Artificial Propagation

Releasing large numbers of hatchery fish may pose a threat to natural-origin salmon and steelhead stocks through genetic impacts (*e.g.*, introgression/homogenization), hatchery-origin fish competition with natural-origin fish for habitat, food and other resources, predation of hatchery fish on wild fish, increased fishing pressure on wild stocks as a result of hatchery production, and displacement of natural-origin fish with hatchery-origin fish, resulting in lower population productivity (Waples 1991).

Anthropogenic Events

Natural events such as droughts, landslides, floods, and other catastrophes have adversely affected salmon and steelhead populations throughout their evolutionary history. The effects of these events are exacerbated by anthropogenic changes to watersheds such as urban development, road and bridge construction, and water irrigation and chemical-based agriculture. Over-harvesting of gravel can lead to river incision, bank erosion, habitat simplification, and tributary down-cutting (SEC 1996). Loss of spawning gravels has a direct impact on salmonids. The lack of suitable gravel often limits successful spawning of anadromous salmonids in many streams. Turbidity as a result of increased erosion and sedimentation caused by gravel mining can also be a limiting factor for anadromous salmonid populations. These anthropogenic changes have limited the ability of salmon, steelhead and green sturgeon to rebound from natural stochastic events and depressed populations to critically low levels.

Reduced Marine-Derived Nutrient Transport

Marine-derived nutrients from adult salmon carcasses has been shown to be vital for the growth of juvenile salmonids and the surrounding terrestrial and riverine ecosystems (Bilby *et al.* 1996, Bilby *et al.* 1998, Gresh *et al.* 2000). Declining salmon and steelhead populations have resulted in decreased marine-derived nutrient transport to many watersheds, contributing to the further decline of ESA-listed salmonid populations (Gresh *et al.* 2000). Also, Central Valley salmonid hatcheries do not as standard practice, plant post-spawned program broodstock carcasses into the riverine system (W. Cox, CDFG Senior Fish Pathologist, personal communication).

Climate Change

Long-term climate change is an additional consideration regarding the viability of the CV spring-run Chinook salmon ESU and specific populations in the long-term. Global and localized climate changes, such as El Nino ocean conditions and prolonged drought conditions, may play an important role in the suitability of spring-run Chinook salmon habitat and, hence, viability. The CV spring-run Chinook salmon ESU is highly vulnerable to drought conditions (NMFS 2009). 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.* CCV steelhead) that must hold below the dam over the summer and fall periods. 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.

<u>Delta Ecosystem Impacts</u>

Only three to four percent of the Delta's historic wetlands remain intact today. Threats to the Delta ecosystem (USFWS 1996) include: (1) loss of fish habitat due to freshwater exports that cause salinity; (2) loss of shallow-water habitat due to dredging, diking, and filling; (3) introduced aquatic species that have disrupted the food chain; and (4) entrainment in federal, state, and private water diversions (USFWS 1996). Changed pattern and timing of flows through the Delta, sport and commercial harvest, and interactions with hatchery stocks have affected listed salmonid runs entering the Delta (USFWS 1996). Discharge from industrial and agricultural sources tend to increase water temperatures and contaminant levels, and decrease dissolved oxygen levels, creating areas of unsuitable habitat. Attempts to control non-native invasive species may adversely impact salmonids and sturgeon within chemically-affected waterways, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

Marine Productivity

Ocean conditions play a significant role in the number of Chinook salmon returning to the Sacramento River. Lindley *et al*. (2009) found that unusual ocean conditions in the spring of 2005 and 2006 led to poor growth and survival of juvenile salmon entering the ocean in those years. This likely affected the overall survival of all West Coast salmonid populations including SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead, which were already in low abundance in most watersheds (Good *et al.* 2005). More recently, environmental parameters such as the increase in levels of marine phytoplankton, indicate an upward trend in ocean productivity that may explain the fairly robust fall-run Chinook salmon adult return in 2010.

V. ENVIRONMENTAL BASELINE

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

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

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

The PCEs of freshwater salmonid habitat within the action area include: 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. These features have been affected by human activities such as water management, flood control, agriculture, and urban development throughout the action area. Habitat within the action area is primarily utilized for freshwater rearing and downstream migration by SR winter-run and CV spring-run Chinook salmon, CV steelhead, and sDPS green sturgeon juveniles and smolts, and for adult salmonid and sturgeon upstream migration. The general condition and function of freshwater rearing and migration habitats is described in the *Status of the Species and Critical Habitat* section of this BO.

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

Water conveyance structures such as canals, cross channels, and interties significantly alter 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. 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. Many stressors, such as chemical pollution, DO, water temperature, reversed flows, *etc*., in the Central Valley 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 in the Central Valley, using the satellite GPS (Herren and Kawasaki 2001). 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-run Chinook salmon formerly existed in the major river tributaries and upper watersheds, and there also may have been a late fall-run presence in the mainstem (Yoshiyama *et al.* 2001).

VI. EFFECTS OF THE ACTION

The purpose of this section is to identify effects to ESA-listed salmonids associated with the issuance of Permit 16543 by NMFS.

The adverse effects of Permit 16543 will be primarily associated with the non-lethal take of adult ESA-listed salmonids and juvenile and adult green sturgeon which may result in non-lethal minor stress and injury to a number of fish that are handled.

A. Adverse effects to ESA-listed salmonids and sDPS green sturgeon

Capture by Trammel Net

Studies have indicated that capture and release of Chinook salmon from trammel nets had high survival from initial capture (> 99 %) and had high long term survival (Vander Haegen et al., 2004). Vander Haegen et al. (2004) conducted a study comparing survival of Chinook salmon captured in various gill nets and trammel nets, and they concluded that trammel nets such as the type DWR are proposing to deploy are the safest for salmon capture. Long term effects of trammel net capture on Chinook salmon and steelhead are not well known, mainly due to the difficulty in separating the effects of capture by trammel nets and the effects of the requisite tagging operation on the long term behavior of the fish. Some studies do exist which examine the long term impacts of gill net capture, which is a similar method but with a higher risk of injury to captured fish. Makinen et al. (2000) used radio telemetry to monitor 16 Atlantic salmon and found that all moved downstream after capture in a gill net.

With respect to sturgeon, DWR study's short net soak times (40 min; far less than the 2 to 4 hours recommended by Kahn and Mohead, 2010) and the water temperatures of the study area (< 20°C), sturgeon caught in the nets are unlikely to have significant negative behavioral or physiological effects in either the short or long term (Kahn and Mohead, 2010). Dissolved oxygen will be monitored in the area of the net to ensure that the local oxygen levels do not drop below the 5 mg/L recommended for safe netting of green sturgeon (Kahn and Mohead, 2010). Existing trammel netting operations in the Sacramento-San Joaquin Delta that collect sturgeon (i.e. DFG's annual sturgeon survey) have captured many green sturgeon in recent years with no mortality and little evidence of capture stress (DFG, pers comm.).

Capturing and Handling

Capturing and handling fish causes them stress, though they typically recover rapidly from the process. Therefore, the overall effects of the handling are generally short-lived. The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the original habitat and the container in which the fish are held), DO levels, length of time that fish are held out of water, and physical trauma (Kelsch and Shields 1996). Stress on salmonids increases rapidly from handling if the water temperature exceeds 18°C or DO is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process. In addition, when fish are handled by samplers to obtain measurements and other data, it is not uncommon for fish to be dropped or mishandled due to improper sedation or restraint of fish. This can result in internal injuries, especially in females with developing ovaries. An injured fish is also more susceptible to developing diseases, which can lead to delayed mortality. Some common injuries which can lead to disease include the loss of mucus, loss of scales, damage to integument and internal damage (Kelsch and Shields 1996). In addition to the risks associated with handling, fish will be exposed to additional risks specific to the various methods of capture described in the following subsection.

C. Measures to Reduce Impacts of Research Activities

The steps that will be taken when an ESA-listed species are incidentally caught in DWR nets is as follows:

1) All other sample processing and data collection activities for that site will be suspended until the listed fish is safely released back into the water.

2) As soon as an ESA-listed fish is observed in the net, the crew will immediately retrieve the net and bring the listed fish onboard by carefully supporting the fish's body with the net.

3) The crew will then immediately remove the fish from the net by cutting the mesh entangling the fish.

4) Once freed from the net, the fish will be immediately identified and measured.

5) After measurement, the fish will be immediately released off the stern of the vessel, away from the net. DWR anticipates that no listed fish will be out of the water more than 1 to 2 minutes.

6) An oxygenated tub of sufficient size will be available onboard the vessel. If the fish shows signs of severe stress or trauma (listing or not gilling properly), then it will be given time to resuscitate in the tub before being released (Buchanan et al, 2002). No listed fish will be kept more than 5 minutes before being released.

7) At no point will any ESA-listed fish be anesthetized or marked. No samples of any kind will be taken from any listed fish. No procedures of any kind will be conducted on any listed fish. Any listed fish caught in our nets will be given immediate priority, and they will be handled by experienced crew members in a safe and careful manner. No MS-222 will be used on any ESA-listed species.

8) The entire sampling area (*e.g*. Steamboat Slough, etc.) where the listed fish was captured will then be immediately vacated for a period of at least two days to avoid capture of additional listed fish that may be in the vicinity. The sampling schedule is based on when ESA-listed salmonids are least likely to be in the sampling area. The sampling months of December, April, and June were chosen based on adult salmonid run timings and the likelihood of juvenile salmonids being in the Delta (Quinn, 2005; Moyle, 2002). Additional information from the Yolo Bypass fish monitoring survey (DWR, pers. comm.) provided insight into the prevalence and timing of adult and juvenile salmonids in the north Delta.

D. Integration and Synthesis of Effects

The risks to ESA-listed salmonids and green sturgeon from adverse effects from scientific research are reasonably small and acceptable. As recently highlighted in the IEP Pelagic Organism Decline Work Team's Synthesis of Results (Baxter et al., 2010), quantitative estimates of the impact of predation on native fish populations are largely non-existent. Knowledge of the spatial variability in predation in key areas still inhabited by native fish is extremely limited (see Nobriga and Feyrer 2007, 2008); let alone an understanding of how predation pressure varies with habitat conditions. An understanding of environmental factors that promote or discourage predation, as well as specific locations to target for predator removal, will be critical to guide successful habitat restoration actions. NMFS believes that information derived from the DWR predator research studies will make a significant contribution to the body of science on Central Valley salmonid and sturgeon biology and assist in management decisions that may lead to the conservation and recovery of the various CV salmonid and green sturgeon populations.

E. Benefits of Issuing Permit 16543

This study will provide essential, quantitative information for future restoration and predator removal efforts by examining the incidence of predation on Chinook salmon, steelhead trout, Delta and longfin smelt, white and green sturgeon, and Sacramento splittail by striped bass and largemouth bass as well as the native piscivore, Sacramento pikeminnow, across migration corridors and habitats of the north Delta. This region of the Delta is considered a refuge for many native fish species, contains key migration corridors for Chinook salmon, steelhead, Delta smelt, longfin smelt, splittail, white sturgeon, and green sturgeon, and is also a major target for future tidal marsh restoration (BDCP 2010). In addition, there is concern that planned installation of new pumping operations on the Sacramento River in the north Delta will attract predators to this region, potentially counter-acting benefits of habitat restoration (DRERIP Evaluation of BDCP Conservation Measures, Appendix F, 2009). However, no baseline data is available on current predation levels for this region of the Delta. This study will fill this critical gap and thus facilitate evaluation of the effects of proposed restoration actions.

VII. CUMULATIVE EFFECTS

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

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the BO of NMFS that the issuance of Permit 16543, as proposed, is not likely to jeopardize the continued existence of the aforementioned listed species and is not likely to destroy or adversely modify designated critical habitat. Critical habitat as described above has been designated, however, this action does not affect it and no destruction or adverse modification of that critical habitat is anticipated.

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.

Permit 16543 is for incidental take of ESA-listed salmonids associated with scientific research and monitoring activities. Intentional take of endangered or threatened species is not anticipated, therefore, none is authorized by this BO.

X. REINITIATION OF CONSULTATION

This concludes formal consultation on the issuance of Permit No. 16543. 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 identified 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.

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Appendix

Cortland to Rio Vista (Lower Sacramento)

SPECIES	LISTING UNIT/ STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/ COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	10	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	7	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Adult	Male and Female	5	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Adult	Male and Female	8	0	Capture/ Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	4	0	Capture/ Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	8	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Sub-adult	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Trammel	

Cache Slough

SPECIES	LISTING UNIT/STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/ COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture /Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Sub-adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	

Sacramento Deep Water Ship Channel

SPECIES	LISTING UNIT/STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture /Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Sub-adult	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Trammel	

Georgianna Slough

SPECIES	LISTING UNIT/STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Adult	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Adult	Male and Female	3	0	Capture /Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Trammel	

Steamboat Slough

SPECIES	LISTING UNIT/STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Adult	Male and Female	2	0	Capture /Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	

Miner/Sutter Slough

SPECIES	LISTING UNIT/STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture /Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Trammel	