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

October 22, 2012

MEMORANDUM FOR: File 151422SWR2009SA00255 (TN 2012/02696) Permit 13791

FROM: for Chris Yates, Assistant Regional Administrator for Protected Resources Division

SUBJECT: National Environmental Policy Act Review for Issuance of Permit 13791 to the United States Fish and Wildlife Service, Stockton Fish and Wildlife Office, under the Provisions of Section 10(a)(1)(A) of the Endangered Species Act

National Oceanic and Atmospheric Administration Environmental Review Procedures Administrative Order (NAO) 216-6, requires all proposed actions to be reviewed with respect to environmental consequences on the human environment. This memorandum summarizes the determination that the issuance of Endangered Species Act (ESA) of 1973 Section 10(a)(1)(A) Permit 13791 qualifies to be categorically excluded from further National Environmental Policy Act (NEPA) review.

Description of the Action

NOAA's National Marine Fisheries Service (NMFS) proposes to issue scientific research Permit 13791 to the U.S. Fish and Wildlife Service (USFWS), under the Provisions of Section 10(a)(1)(A) of the ESA. The permit will authorize take of ESA-listed endangered Sacramento River (SR) winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley (CCV) steelhead (*O. mykiss*), and threatened Southern distinct population segment (SDPS) of North American green sturgeon (*Acipenser medirostris*) associated with scientific research.

Research and monitoring activities will occur in the Sacramento River, Bay-Delta and San Joaquin River in the Central Valley, California. Activities authorized under Permit 13791 will include capture of fish by beach seine, midwater trawl, fyke net, gill net, zooplankton net and electrofishing; the application of anesthesia; activities associated with fish handling (species identification, enumeration by life stage and race, the taking of fork length measurements, and wet weights in grams); and the release of smolt and juvenile salmonids and juvenile green sturgeon back into the Bay-Delta, Sacramento and San Joaquin Rivers.

II. CONSULTATION HISTORY

On April 4, 2008, NMFS was contacted by Paul Cadrett, Deputy Project Leader for the Delta Juvenile Fish Monitoring Program (DJFMP), operating out of the U.S. Fish and Wildlife Service (USFWS) office in Stockton, California. Mr. Cadrett requested a three-year permit for the take associated with research and monitoring studies in the San Francisco Bay-Delta Estuary (Bay-Delta) and the San Joaquin River Basin in California. Mr. Cadrett provided a hard copy of a draft research application for NMFS consideration and comments.

On October 15, 2008, NMFS contacted DJFMP co-investigator Pat Brandes for clarification on a project that she is requesting ESA-coverage under Permit 13791. In response, on October 31, 2008, Ms. Brandes provided a report entitled, "Estimating Juvenile Chinook Salmon Spring and Winter Run Abundance at Chipps Island" which describes the research activities carried out for this project.

On November 21, 2008, NMFS published a notice of receipt in the *Federal Register* outlining the research activities and take of ESA-listed salmonids proposed under Permit 13791 (73 FR 70622). The public comment period for Permit 13791 was closed on December 22, 2008, and no comments were received.

On April 2009, Mr. John Netto was identified by the DJFMP as the primary contact for Permit 13791. Mr. Netto has provided additional details to assist in the analysis of the project description, including validation of requested take, and clarification on the final list of co-investigators for inclusion in the permit. Supplemental changes to the electronic permit application were completed on May 29, 2009, with no revision to the project description.

On November 8, 2011, NMFS was notified that Mr. Netto is no longer working for USFWS and Joseph Kirsch took over as the primary contact.

In February 2012, changes to the project description occurred involving different estimated take to incorporate genetic analysis to be done by the University of California – Davis.

On April 24, 2012, due to substantial changes in the permit application NMFS published a notice of receipt in the *Federal Register* outlining the research activities and take of ESA-listed salmonids proposed under Permit 13791 (77 FR 24470). The public comment period for Permit 13791 was closed on May 24, 2012, and no comments were received.

On May 4, 2012, Amanda Cranford took over as NMFS lead permit analyst.

On June 13, 2012, USFWS submitted proposals for efficiency testing to be incorporated into the project description. USFWS also estimated a change in take.

On July 2, 2012, NMFS assigned Sierra Franks the responsibility of completing the biological opinion and review for Permit 13791.

III. DESCRIPTION OF THE PROPOSED ACTION

NMFS Southwest Region, Protected Resources Division proposes to issue scientific research Permit 13791 under the authority of section 10(a)(1)(A) of the ESA. Permit 13791 will authorize scientific research and monitoring activities in the Sacramento River, Bay-Delta and San Joaquin River during a five-year period, starting from the date of permit issuance through July 3, 2015. The permit will authorize USFWS for non-lethal and unintentional lethal take of juvenile SR winter-run and CV spring-run Chinook salmon, juvenile and adult CCV steelhead, and juvenile sDPS green sturgeon. The permit will also authorize intentional lethal take of adipose fin-clipped, hatchery origin, juvenile SR winter-run Chinook salmon and CV spring-run Chinook salmon for the purpose of coded wire tag (CWT) retrieval and reading. The take activities authorized under Permit 13791 will include capture of fish by beach seine, midwater trawl, fyke net, gill net, zooplankton net and electrofishing; the application of anesthesia; activities associated with fish handling (species identification, enumeration by life stage and race, the taking of fork length measurements, and wet weights in grams); and the release of juvenile salmonids and green sturgeon back into the Bay-Delta, Sacramento and San Joaquin Rivers.

A. Research Project Description

The DJFMP, primarily funded by the U.S. Bureau of Reclamation and the California Department of Water Resources, has monitored juvenile fish populations annually within the San Francisco Bay Estuary since 1976. Currently, the monitoring of juvenile fishes throughout the lower Sacramento and San Joaquin Rivers and San Francisco Estuary is generally conducted weekly throughout the year and is expected to continue indefinitely. The Breach III Project, funded by a CALFED grant, monitors larval and juvenile fishes weekly at Liberty Island during the spring (February – June). The Interagency Ecological Program (IEP) Gear Efficiency Evaluation Study is an interagency study, primarily funded by the IEP and USFWS, which will sample fish to estimate gear efficiency among IEP sampling gears near Suisun Bay. The study will occur annually for 1 to 2 weeks per month.

The Stockton USFWS Office's DJFMP monitors the abundance, temporal and spatial distribution, migration, and survival of juvenile salmonids and other fishes occurring within the lower Sacramento and San Joaquin Rivers and San Francisco Estuary. The Breach III Project documents the occurrence and habitat use of ESA-listed fishes within Liberty Island, which is a tidally influenced freshwater marsh located within the San Francisco Estuary and undergoing passive restoration. The IEP Gear Efficiency Evaluation Study will determine the relative gear efficiency between IEP sampling gears to better estimate the abundance and distribution of fish occurring near Suisun Bay. The fish monitoring data collected by the DJFMP and through the Breach III Project are intended to provide basic biological and fish population information on fishes of management concern, including the ESA listed SR winter-run and CV spring-run Chinook salmon and CCV steelhead, that can be used by natural resource managers to evaluate the effectiveness of water operations, aquatic habitat restoration, and fish management practices within the San Francisco Estuary and its watershed. It will also allow for collection of unidentifiable species, which may in turn lead to the indication of new alien species in the study area.

Research Studies

Research Study #1: Delta Fish Monitoring Program

The DJFMP monitors fishes at over 60 locations within the San Francisco Estuary each year using surface trawls (i.e., Kodiak and mid-water trawls) and beach seines. To better facilitate the understanding of the relative abundance of fishes migrating through the San Francisco Estuary, surface trawling is conducted at three open water locations distributed among the entry (i.e., Sacramento River at Sherwood Harbor and the San Joaquin River at Mossdale) and exit (i.e., Suisun Bay at Chipps Island) points of the Sacramento - San Joaquin Delta. In general, the DJFMP attempts to sample each surface trawl location three days per week, ten times per day throughout the year. To better facilitate the understanding of the spatial distribution of fishes occurring in shallow shoreline habitats, over 55 locations are sampled using beach seines throughout the lower Sacramento and San Joaquin Rivers, the Sacramento - San Joaquin Delta, and the San Pablo and San Francisco Bays. In general, the DJFMP attempts to sample fishes at most beach seine locations one day per week, one time per day throughout the year. A subset of approximately seven beach seine locations near Sacramento, California, also may be sampled up to three days per week, one time per day from October through January in order to better detect ESA listed salmonids entering the Delta. In addition, larval fish and zooplankton within Liberty Island will be monitored bi-weekly during the spring (February – July) each year using larval trawl nets between sunrise and sunset. The DJFMP also may use other sampling gears (e.g., gill nets, electrofishing equipment) at beach seine locations if alternative sampling methods are needed based on changing environmental conditions or to assess the gear efficiency of beach seines within the San Francisco Estuary. If backpack or boat electrofishing is conducted at beach seine locations, the NMFS 2000 Electrofishing Guidelines will be followed. Beach seine efficiency sampling will be conducted seasonally each year at a subset of beach seine monitoring locations. All adipose fin clipped Chinook salmon collected during the Breach III Project are presumed to be hatchery reared and possess a CWT, in which all individuals caught will be sacrificed and brought back to the Stockton USFWS Office for additional processing to extract, read, and record the CWT information to assess the survival and distribution of juvenile Chinook salmon migrating through the San Francisco Estuary.

Surface Trawling

Fish sampling at all surface trawl locations will be conducted using Kodiak trawls (KDTR) and/or mid-water trawls (MWTR). The Suisun Bay at Chipps Island trawl location will be sampled using a MWTR and the San Joaquin River at Mossdale trawl location will be sampled using a KDTR. The Sacramento River at Sherwood Harbor trawl location will be sampled using a KDTR from October to March and a MWTR for the remainder of each year due to boat safety concerns. During each sampling day, a total of ten 20-minute tows will be attempted between sunrise and sunset. The MWTR and KDTR nets will be towed by one and two vessels, respectively, in the top few meters of the water column at a speed necessary and distance apart (for KDTR) to ensure the net mouth remains fully extended and submerged while in tow.

The MWTR net that will be used at the Sacramento River at Sherwood Harbor trawl location is composed of six panels, each decreasing in mesh size towards the cod end. The mesh size for each panel ranges from 20.3-centimeters (cm) stretch at the mouth to 0.6-cm stretch just before the cod end. The cod end is composed of 0.3-cm-weave mesh. The fully extended mouth size is 1.83 x 4.57 meters (m). Two depressors and hydrofoils will enable the net to remain fully extended at the top few meters of the water column while sampling. On each side of the net, the depressor and hydrofoil are connected to the towing vessel using a 30.5-m Amsteel rope bridle (0.64-cm diameter). As a result, the MWTR net that will be used at the Sacramento River at Sherwood Harbor trawl location is fished approximately 30 m behind the towing vessel.

The MWTR net that will be used at the Suisun Bay at Chipps Island trawl location is composed of six panels, each with decreasing mesh size towards the cod end. The mesh size for each panel ranges from 10.2-cm stretch at the mouth to 1.3-cm stretch just before the cod end. The cod end is composed of 0.8-cm weave mesh. The fully extended mouth size of the MWTR net is 3.05 x 9.14 m. Two depressors and hydrofoils will enable the net to remain fully extended at the top few meters of the water column while sampling. On each side of the net, the depressor and hydrofoil are connected to the towing vessel using a 30.5-m Amsteel rope bridle (0.6-cm diameter) attached to a 15.2-m- tow rope (0.95-cm diameter). As a result, the MWTR net that will be used at the Suisun Bay at Chipps Island trawl location is fished approximately 45 m behind the towing vessel.

The KDTR nets that will be used at the Sacramento River at Sherwood Harbor and the San Joaquin River at Mossdale trawl locations will be composed of five panels, each decreasing in mesh size towards a live box at the cod end. The mesh size for each panel ranges from 5.1-cm stretch at the mouth to 0.3-cm stretch just before the live box. The live box (36 cm wide x 36 cm tall x 49 cm long) is composed of 0.18 cm thick aluminum that was perforated with numerous 0.46 cm diameter holes. The live box contains several internal baffles to minimize the effect of flow pressure on fishes being sampled. The fully extended mouth size of the KDTR nets is 1.83 x 7.62 m. A float line and lead line enables the nets to remain at the top few meters of the water column while sampling. In addition, at the front of each wing of the net is a 1.83 m bar with floats at the top and weights at the bottom to keep depth constant while sampling. The KDTR nets are connected to the two towing vessels using a 2.3-m- rope bridle (2.4-cm diameter) attached to a 30.5-m- tow rope (0.95-cm diameter) on each side of the net. As a result, the KDTR nets are fished approximately 31-m behind the towing vessels.

At the end of each tow, the MWTR nets are retrieved expeditiously by the towing vessel using winches and are brought onto the towing vessel by hand. After retrieval, the cod end of the MWTR nets are placed in a fish holding container filled with water collected onsite prior to or preceding each tow, untied, and all fishes observed within are immediately emptied into the holding container for processing. At the end of each tow using the KDTR nets, the two towing vessels (i.e., net and chase boats) come together and the chase boat transfers its tow rope to the net boat. The crew on the chase boat expeditiously retrieves the live box from the KDTR net, collects all the fishes observed within the live box, and places all collected fishes into a holding container filled on site with river water for processing. The river water within holding containers is replaced between all tows.

After wetting the hands, all collected fishes are immediately identified to species, measured for fork length to the nearest millimeter, assessed for maturation or life stage, and released into or near the location sampled. If greater than 30 individuals of a species or race are collected, a sub sample of at least 30 individuals is randomly measured for fork lengths and the remaining individuals are counted with the total count documented. All efforts are made to process and release salmonids and ESA listed fishes prior to other fishes and before the MWTR or KDTR nets are reset for the next tow. The total holding time for processing Chinook salmon, steelhead, and green sturgeon is typically < 5 minutes depending upon the number of individuals captured.

Beach Seining and Backpack Electro-fishing

Fish sampling at beach seine locations is conducted between sunrise and sunset using a 15.2 x 1.3-m beach seine net with 3-mm delta square mesh, a 1.2-m bag in the center of the net, and a float line and lead line attached to 1.8-m tall wooden poles on each side. Beach seines are deployed along the shoreline by two staff within unobstructed habitats including boat ramps, mud banks, and sandy beaches. When sampling mud banks (i.e., dominated by substrata with particles less than 0.5-mm in diameter), rollers are applied to the lead line of the beach seine to limit the net from sinking into the substrate and impeding net deployment.

The beach seines are generally deployed starting from the downstream portion of each location less than or equal to 15-m from the shoreline, distributed upstream parallel to the shoreline, and pulled towards the shoreline. After the seine is pulled onto the shore, all fishes observed are expeditiously collected from the seine bag and other parts of the seine, and placed in a holding container filled with onsite water for processing.

All collected fishes are handled with wet hands, and are immediately identified to species, measured for fork length to the nearest millimeter, assessed for maturation or life stage, and released into the location sampled. If greater than 30 individuals of a species or race are collected, a sub sample of at least 30 individuals is randomly measured for fork length. All efforts are made to process and release salmonids and ESA listed fishes prior to other fishes. The total holding time for processing Chinook salmon, steelhead, and green sturgeon is typically < 5 minutes depending upon the number of individuals captured.

Beach seine efficiency sampling will be conducted using a standard DJFMP beach seine net inside a gill-net and/or block-net (3-mm square mesh) enclosure. A backpack electro-fisher will then be used to capture any remaining fish within the enclosure. The enclosure will be deployed around the intended sample area of DJFMP beach seines at fixed monitoring locations. Once the enclosure is deployed, a beach seine will be conducted within the enclosure. All fish captured in the beach seine will be identified, measured for fork length, and released outside of the enclosure. Thereafter, backpack electro-fishers and beach seines will be used to collect all remaining fish within the enclosure and the gill-nets, if used, will be checked for entrained fish. All fish collected using secondary gears and gill-nets will be identified to species, measured for fork length, and released into the previously sampled area after the enclosure is removed. All efforts will be made to process and release salmonids and ESA listed fishes prior to other fishes. The total holding time for processing Chinook salmon, steelhead, and green sturgeon is typically < 5 minutes depending upon the number of individuals captured. No backpack electro-fishers will be used in San Pablo Bay and perhaps Suisun Bay based on high salinity concentrations and therefore gear inefficiency. Larval trawl nets will be used to monitor larval fish abundance and distribution throughout the open water habitats within Liberty Island. Larval trawl nets will be composed of a conical plankton net with a 46-cm-diameter mouth, 500 micron nylon mesh, and a detachable one liter screened (500 micron mesh) plastic cod-end jar. A total of two larval trawl nets will be used simultaneously while trawling at approximately 1.2k RPM and will be attached to the sides of the towing vessel using a 1.5-m long steel bar. Approximately ten 10-minute tows will be conducted within Liberty Island one day every other week (i.e., biweekly). After each tow, all contents observed within the nets will be rinsed into a 500-µm- mesh sieve. All identifiable juvenile or adult fishes collected from the sieve and will be immediately identified to species or race, measured for fork length to the nearest millimeter, and released back into the sampled location. All unidentifiable (i.e., larval) fishes will be stored in 10 percent formalin solution with rose bengal dye and brought back to the Stockton USFWS Office for processing. Samples will be sorted in the laboratory and all individuals will be measured to the nearest 0.1 millimeter and identified to species using morphometric and meristic characteristics.

Zooplankton Trawl Net

The sampling of zooplankton will occur in tandem with larval fish sampling within Liberty Island to better understand the spatial and temporal distribution of native and non-native larval fishes in a restoring tidally influenced wetland. The two larval trawl nets are suspended from each side of a boat using a 1.5-m-long steel bar. A zooplankton trawl net, composed of a 1m long conical plankton net with a mouth diameter of 0.127-m, 153-µm mesh, and a detachable 250-ml screened (153-µm mesh) plastic cod-end jar, will be attached to one of the two steel bars between the side of the boat and the larval net. During each tow, the zooplankton trawl net will be deployed and retrieved in tandem with the larval trawl nets. Approximately ten 10-minute tows will be conducted within Liberty Island one day every other week (i.e., biweekly). After the completion of each tow, zooplankton samples will be placed in a sample jar and preserved in 10 percent buffered formalin solution. In the laboratory, the number of zooplankton will be counted and at least 10 percent of the zooplankton will be identified to the lowest taxonomic level for each zooplankton sample. If any larval fish are found within the zooplankton samples, they will be collected, identified to species, and stored for up to one year at the Stockton USFWS Wildlife Office.

Research Study #2: Breach III Project

The Breach III Project will monitor larval, juvenile, and adult fishes at Liberty Island during the spring (February – June) of 2012 using larval trawl nets, beach seines, experimental multi-mesh gill nets, and fyke nets between sunrise and sunset. In general, fishes will be monitored using larval trawl nets and beach seines bi-weekly throughout Liberty Island within open water and shallow shoreline habitats, respectively, during the spring of 2012. Fishes will be monitored using experimental multi-mesh gill nets and fyke nets at approximately six fixed shoreline locations within Liberty Island for a 10-12 consecutive day period during the spring of 2012, which will coincide with either wet, dry, or transitional water/river conditions. In addition, the Breach III Project also will monitor the abundance and distribution of zooplankton throughout Liberty Island on a bi-weekly basis during the spring of 2012 using zooplankton trawl nets, which can inadvertently capture larval or juvenile fishes. All adipose fin clipped Chinook salmon collected during the Breach III Project are presumed to be hatchery reared and possess a

CWT, in which all individuals caught will be sacrificed and brought back to the Stockton USFWS Office for additional processing to extract, read, and record the coded wire tag information to assess the survival and distribution of juvenile Chinook salmon migrating through the San Francisco Estuary.

Larval Fish Trawl Net

Larval trawl nets will be used to monitor larval fish abundance and distribution throughout the open water habitats within Liberty Island. Larval trawl nets will be composed of a conical plankton net with a 46-cm diameter mouth, 500- µm nylon mesh, and a detachable one liter screened (500-µm mesh) plastic cod-end jar. A total of two larval trawl nets will be used simultaneously while trawling at approximately 1.2 k RPM and will be attached to the sides of the towing vessel using a 1.5-m long steel bar. Approximately ten 10-minute tows will be conducted within Liberty Island one day every other week (i.e., biweekly). After each tow, all contents observed within the nets will be rinsed into a 500-µm mesh sieve. All identifiable juvenile or adult fishes collected from the sieve and will be immediately identified to species or race, measured for fork length to the nearest millimeter, and released back into the sampled location. All unidentifiable (i.e., larval) fishes will be stored in 10 percent formalin solution with rose bengal dye and brought back to the Stockton USFWS Office for processing. Samples will be sorted in the laboratory and all individuals will be measured to the nearest 0.1- mm and identified to species using morphometric and meristic characteristics.

Beach Seine

Beach seines will be used to monitor juvenile fishes throughout Liberty Island within unvegetated shoreline habitats including mud banks and sandy beaches. Other beach seine methodologies used within Liberty Island will be the same as described within the description section for DJFMP beach seining.

Experimental Multi-mesh Gillnet

Experimental ('survey') multi-mesh gillnets will be used to: (1) examine finer-scale fish distributions across more complex habitat gradients (e.g., vegetated habitats); and (2) target larger adult fishes for monitoring efforts. The experimental multi-mesh gill nets will be composed of a 3 x 35-m monofilament net with a 38.5-m sink line. Each gillnet will include five different mesh panels (meshes ranging between 17 and 50 mm knot-to-knot). Gillnets will be arrayed across habitat gradients, such as from a vegetated patch to a mudflat or tidal channel edge. A great advantage of a gill net is that the general orientation and behavior of the fish can be interpreted from the position in the gill net (*e.g.*, depth relative to the bottom, direction of travel, schooling distance, etc.). Gillnets will be set during a high tide and allowed to sample until low tide while monitored continuously and checked by field staff each hour to release ESA listed fishes, except adipose fin clipped Chinook salmon, away from the sampling to prevent mortality and recapture. It is possible to encounter marine mammals while sampling, therefore, based on the CESA MOU, sampling will stop when marine mammals are observed. Fishes collected from the gillnets will be immediately identified to species or race, measured for fork length to the nearest millimeter, and released back into the sampled location. A subsample of numerically dominant non-ESA listed fish species (up to 10 to15 individuals) may be preserved for diet or isotope analyses. Fishes will be preserved by freezing if otolith samples are to be extracted for isotope analysis or by placing individuals in a 10 percent buffered formalin solution. Any fish found to be dead in the nets during or after sampling also will be preserved for diet analyses to reduce the number of live fish needed to be sacrificed. Fishes preserved will be processed, analyzed, and stored in Dr. Steve Bollen's Laboratory at Washington State University.

Fyke Net

The fyke nets that will be used to sample larger tidal channel systems within Liberty Island are composed of 3.1-mm-mesh and will be deployed in a manner that allows fish to be captured while emigrating from the marsh through ebb tide. If required, where tidal channels do not completely dewater, field staff also will sample shallow shoreline areas between the deployed fyke net and the shoreline with a 3.1-mm-mesh pole seine to maximize capture efficiency. Fyke nets will be deployed during a high tide and allowed to sample until low tide. When feasible, fishes and large macroinvertebrates (e.g., shrimp) will be immediately removed from the fyke nets after capture, identified to species or race, and released downstream of the fyke net during the tidal ebb. In addition, the total catch or subsamples of the total catch for each species may be retained for individual fork length and weight measurements and released downstream of the fyke nets during the tidal ebb. A subsample of numerically dominant non-ESA listed fish species (up to 10 to 15 individuals) may be preserved for diet or isotope analyses. Fishes will be preserved by freezing if otolith samples are to be extracted for isotope analysis or by placing individuals in a 10 percent buffered Formalin solution. Preserved fishes will be processed, analyzed, and stored in Dr. Steve Bollen's Laboratory at Washington State University.

Zooplankton Trawl Net

The sampling of zooplankton will occur in tandem with larval fish sampling within Liberty Island to better understand the spatial and temporal distribution of native and non-native larval fishes in a restoring tidally influenced wetland. The two larval trawl nets are suspended from each side of a boat using a 1.5-m-long steel bar. A zooplankton trawl net, composed of a 1m long conical plankton net with a mouth diameter of 0.127-m, 153-µm mesh, and a detachable 250 ml screened (153-µm mesh) plastic cod-end jar, will be attached to one of the two steel bars between the side of the boat and the larval net. During each tow, the zooplankton trawl net will be deployed and retrieved in tandem with the larval trawl nets. Approximately ten 10-minute tows will be conducted within Liberty Island one day every other week (i.e., biweekly). After the completion of each tow, zooplankton samples will be placed in a sample jar and preserved in 10 percent buffered formalin solution. In the laboratory, the number of zooplankton will be counted and at least 10 percent of the zooplankton will be identified to the lowest taxonomic level for each zooplankton sample. If any larval fish are found within the zooplankton samples, they will be collected, identified to species, and stored for up to one year at the Stockton USFWS Office.

Research Study #3: IEP Gear Efficiency Evaluation Study

The DJFMP will cooperatively sample fish near Suisun Bay with the California Department of Fish and Game to calculate the relative gear efficiencies for all Interagency Ecological Program (IEP) fish survey nets and determine the depth and lateral distributions of delta smelt by life stage. The information obtained from this study would allow fish managers within the San Francisco Estuary to use data from multiple IEP monitoring programs and surveys that use a variety of gear types to address questions concerning delta smelt and possibly other fishes of management concern including juvenile salmonids and longfin smelt. Beach seining, midwater trawling, and Kodiak trawling will be used for two days per week, 1 to 2 weeks per month throughout the year.

Surface Trawling

Fish sampling at all surface trawl locations within and near Suisun Bay will be conducted using KDTR and MWTR. During each sampling day, a maximum of fourteen 10-minute tows (6 flood tows, 6 ebb tows and 1 to 2 tows on each slack water) will be attempted between sunrise and sunset. Field work will be planned for two successive (replicate) days when flood and ebb tides occur primarily during daylight hours. Data will be checked, processed and evaluated for sufficiency prior to another set of days being implemented to repeat the sampling within a month. Limited daylight hours in the winter will result in spreading sampling effort across additional days. If needed, the second sampling effort should occur within about 1 to 2 weeks of the first within each sampling month. The MWTR and KDTR nets will have the same configurations and follow the same protocols as specified in the DJFMP monitoring section(s).

Beach Seine

Beach seines will be used to sample fish in shoreline habitats in locations adjacent to surface trawling. Other beach seine methodologies used within the IEP Gear Efficiency Evaluation Study will be the same as described within the description section for DJFMP beach seining.

Justification for the Project

Fishery managers rely on abundance and distribution metrics derived from long term monitoring data to make vital decisions that affect fish population dynamics and assemblage structure. Within the San Francisco Estuary, beach seining has been used since the 1970s by the USFWS's DJFMP to monitor the relative abundance and distribution of juvenile Chinook salmon and other fishes of management concern occurring in near shore habitats. Over 2,000 seine samples are currently being collected throughout the San Francisco Estuary annually. Data from these surveys are used to make various water operation decisions and help inform managers on the status of fish populations within the San Francisco Estuary.

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 (USGS): lower Sacramento River, lower San Joaquin River, Delta, and San Francisco Bay. The sampling area is currently divided into six regions (Figure 1) to facilitate data analyses and our understanding of fish abundance and movement throughout the system: (1) Lower Sacramento River (between Colusa and Elkhorn); (2) North Delta (Discovery Park to Antioch on the Sacramento River); (3) Central Delta (between the San Joaquin River and Sacramento River); (4) South Delta (adjacent to and south of the San Joaquin River); (5) San Joaquin River (between Mossdale and the Tuolumne River); and (6) San Francisco/San Pablo Bays (downstream of Pittsburg to Tiburon in San Francisco Bay). Regions were originally established in 1976 as areas where fish-movement patterns should be similar and are delineated by locations of canals or water bypasses where fish may be diverted from historical migration routes.

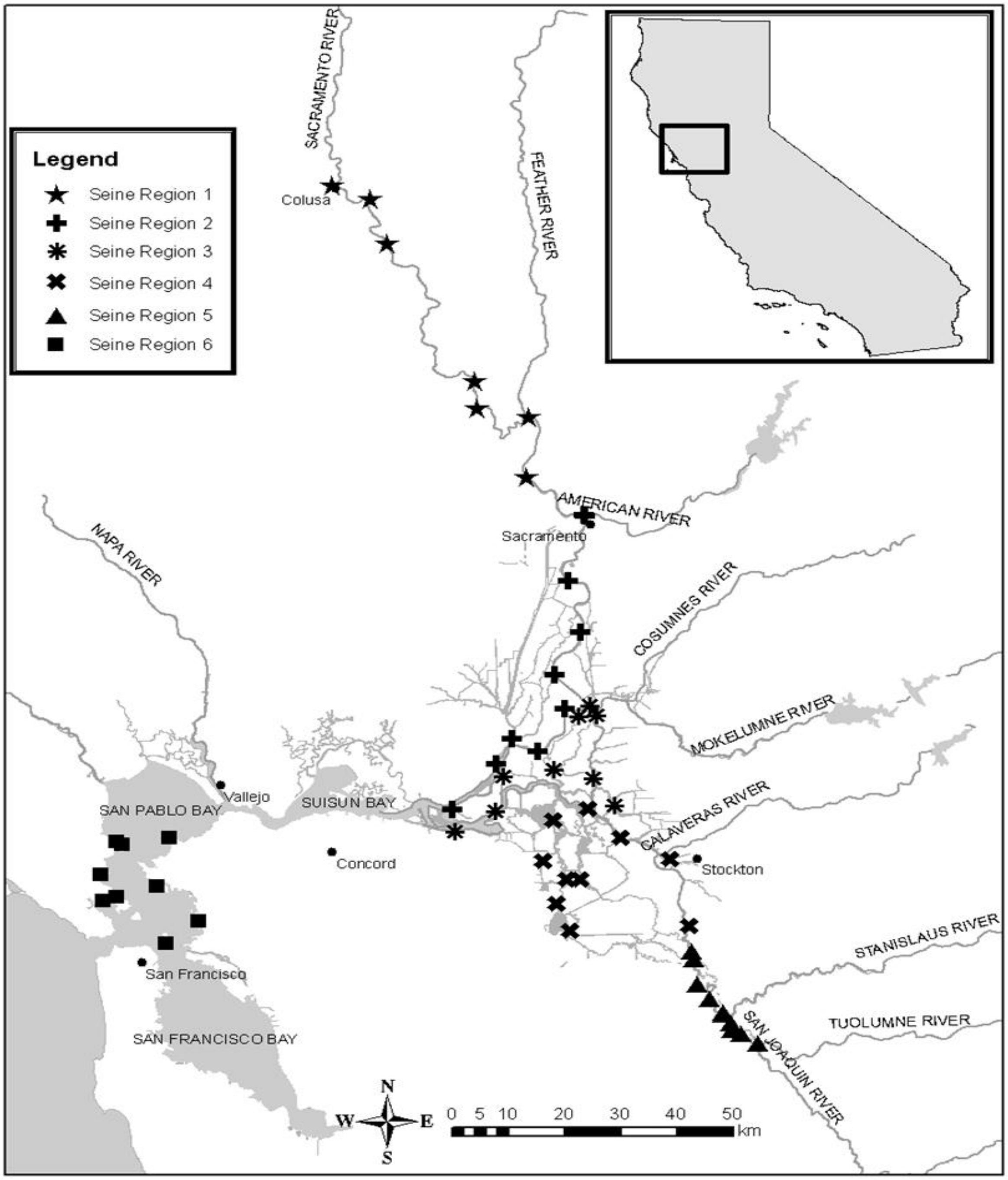

Figure 1. DJFMP Seine Site Locations throughout the Study Area

C. Requested Amount of Take

The requested amount of take, including lethal, non-lethal and unintentional mortality presented below: (1) has been determined jointly by NMFS and USFWS, and; (2) is the minimum amount of take necessary to achieve the goals and objectives of the research programs proposed under Permit 13791. 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.

Take is estimated using data collected from previous years of sampling. Almost all injury and mortality that occurs is due to the capture process (indirect mortality). It is possible that some mortality may occur after release due to scaling or stress incurred while in the net/trap, but this is difficult to quantify. Appendix 1 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 USFWS for Permit 13791. See Appendix 1 for a complete list of take tables.

IV. STATUS OF THE SPECIES AND CRITICAL HABITAT

This BO analyzes the effects of Permit 13791 on the following federally listed ESU's 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 13791 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, bay and estuarine substrates and banks from walking, netting, installing, and operating sampling gear. These minor disturbances are unlikely to adversely affect designated critical habitat for ESA-listed salmonid conservation. Designated critical habitat is not considered further in this BO.

Chinook Salmon

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 kilometers (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 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 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 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. 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 kilometers (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 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	Medium, Medium	High, High	Medium, Medium	Medium, Medium	Medium, Medium	Medium, Medium	–, –	–, –	–, –	–, –	Medium, Medium
Sac. River[2]	Medium, Medium	Medium, Medium	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
Sac. River @ Red Bluff[3]	Low, Low	–, –	–, –	–, –	–, –	–, –	Low, Medium	Medium, Medium	Medium, Medium	Medium, Medium	Medium, Medium	Medium, Medium
Sac. River @ Red Bluff[2]	Medium, Medium	Medium, Medium	–, –	–, –	–, –	–, –	Low, Low	High, High	High, High	High, High	Medium, Medium	Medium, Medium
Sac. River @ Knights Landing[4]	Medium, Medium	Medium, Medium	Medium, Medium	Low, Low	–, –	–, –	–, –	Low, Low	Low, Low	Low, Low	Medium, Medium	Medium, Medium
Lower Sac. River (seine)[5]	High, High	High, High	Medium, Medium	Low, –	–, –	–, –	–, –	–, –	Low, Low	Low, Low	Medium, Medium	High, High
West Sac. River (trawl)[5]	Low, Low	High, High	High, High	High, High	–, –	–, –	–, –	–, –	–, –	–, –	Low, Low	Medium, 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 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-year fish 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).

Steelhead

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 CV rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity river systems (McEwan and Jackson 1996).

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-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating 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 1 to 2 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 CV 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 CV are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in Big Chico and Butte creeks and a few wild steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996). Snorkel surveys from 2009 indicate that steelhead are present in Clear Creek (Giovannetti & 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 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 rotary screw trap efforts in all three tributaries, CDFG staff stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River" (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). The documented returns on the order of single fish in these tributaries suggest that existing populations of 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 CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information from Chipps Island trawl data. The future of CV steelhead is uncertain due to limited data concerning their status. CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

<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. 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 9 years of age; (2) larvae and post-larvae less than 10 months of age; (3) juveniles less than or equal to 3 years of age; and (4) coastal migrant females between 3 and 13 years, and males between 3 and 9 years of age, Table 4, (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	Low	Low	Medium	Medium/High	High	High/Medium	Medium	Medium	Medium	Medium	Medium	Low
[4,8]SF Bay Estuary	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low
(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	Low	Low	Low	Low	Medium	High	High	Medium	Low	Low	Low	Low
[5]GCID, Sac River	Low	Low	Low	Low	Medium	High	High	Medium	Light (shaded lighter than Medium)	Light (shaded lighter than Medium)	Low	Low
(c) Juvenile (> 10 months old and ≤3 years old)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[6]South Delta*	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
[6]Sac-SJ Delta	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
[5]Sac-SJ Delta	Low	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low
[5]Suisun Bay	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[3,7]Pacific Coast	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Source: [1]USFWS 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: [dark shade] = High; [medium shade] = Medium; [white] = 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 GCID 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 fork length (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 (*Micropterus dolomieu*) 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°C and 19°C under either full or reduced rations (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed. Ambient water temperature conditions on the Sacramento River system range from 4°C to approximately 24°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 CVP and SWP pumping facilities and consequently prevented from contributing to the productivity of the species.

CV Spring-run Chinook Salmon

Historically, spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (CDFG 1998). The CV drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). 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 two fish in 1978 to 2,908 in 1964.

Beginning in 2002, CDFG and the California Department of Water Resources (CDWR) 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 7,000 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, although Lindley et al. (2004) classified this population as a dependent population, and thus it is not expected to exceed the low-risk population size threshold of 2,500 fish (i.e., annual spawning run size of about 833 fish). 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 (Giovannetti 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 CV (Good *et al*. 2005). CDFG staff have 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.

<u>sDPS Green Sturgeon</u>

Population abundance information concerning the sDPS green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002). 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, 2011. UC Davis, pers. comm.). Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 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, 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.

Habitat Degradation and Destruction

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 (Winterbourne 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), carbon dioxide, water temperature, reversed flows, *etc.*, in the CV 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 CV 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 CV 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 CV 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 CV 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 global positioning system (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, CV 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.* CV 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 DO 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.

<u>Marine Productivity</u>

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 (DWSCs) 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.

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

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

The primary constituent elements (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 biological opinion.

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 Central Valley Project, beginning in 1940, and the State Water Project, beginning in 1960, substantially decreased the outflow of fresh water from the Delta. Water movement patterns have been altered at both local and broad scales (The Bay Institute 1998). The balance between natural sedimentation rates and varying sea levels was altered by sediment deposition associated with placer mining in the Central Valley watershed along much of the western slopes of the Sierra Mountains from the 1860s to the 1880s, and by the direct filling of portions of the San Francisco Bay and estuary to accommodate shoreline development. The combination of these activities significantly reduced the aerial extent of freshwater marshes, once a dominant feature in the Delta habitat mosaic.

The flow of freshwater into the estuary has been greatly reduced by water diversions largely to support irrigated agriculture (Nichols 2007). Many stressors, such as chemical pollution, 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 global positioning system (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 13791 by NMFS.

The adverse effects of Permit 13791 will be primarily associated with the non-lethal take of juvenile and adult ESA-listed salmonids which may result in non-lethal minor stress and injury to a number of fish that are handled. Permit 13791 also authorizes a limited amount of unintentional mortality of juvenile and adult ESA-listed salmonids, as well as a limited amount of intentional mortality of juvenile ESA-listed salmonids. NMFS expects that unintentional mortality to juvenile ESA-listed salmonids will be far less than that authorized based on the procedures and precautions followed by USFWS. The amount of intentional mortality of juvenile ESA-listed salmonids will also likely be far less than that authorized depending on the specific research needs identified by USFWS. Also, a significant amount of the authorized intentional lethal take of juvenile ESA-listed salmonids will be of hatchery origin.

The non-lethal and lethal effects of capture, handling, and sampling on ESA-listed salmonids that will occur under Permit 13791 and the specific measures that USFWS will be performing to reduce stress, injury, and unintentional mortality to ESA-listed salmonids are discussed below.

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

<u>Capture by Siene</u>

USFWS may use beach seines to capture ESA-listed salmonids, primarily in estuarine or lagoon habitats. Beach seines operate by encircling fish with a net, concentrating fish in the net, and then bringing the net to shore where fish are removed and placed in buckets. The top edge of a beach seine has floats, the bottom edge is weighted, and both ends may be attached to ropes or long wood poles (brails). The beach seine may be operated by hand in shallow water or drawn around fish by using a small boat in deeper water.

The potential adverse effects of capture by seine on ESA-listed salmonids include entanglement (gilling), scale and mucus abrasion, suffocation, and crushing. USFWS will utilize seines with knotless nylon mesh to minimize scale and mucus abrasion. Seine tows will be short to prevent suffocation and to ensure that no debris (rocks, logs, *etc.)* are trapped in the seine that may suffocate or crush fish. Researchers will select the smallest mesh-size seine that is appropriate to achieve sampling objectives to reduce the probability that smaller fish will become gilled in the net.

Capture by Fyke-net Trap

USFWS will utilize fyke-net traps to capture ESA-listed salmonid smolts and YOY. A fyke-net trap functions similarly to a pipe-trap but must be placed in deeper water. A soft mesh net spans the majority of the width of the stream and may include mesh net leaders that are set parallel to stream flow. Fish encounter the nets and are directed down a net corridor into a trap box. Fyke-net traps may be used in estuarine or flood plain habitat where flows are low.

Fish caught in fyke-nets can experience adverse effects including stress and injury from overcrowding, debris buildup, and in-trap predation. USFWS will practice measures to minimize injury and mortality to juvenile ESA-listed salmonids that are captured by fyke-net trap. Traps will be monitored at least once daily. Fish will be removed one or more times per day to avoid overcrowding and prevent in-trap predation. Debris, which can kill or injure fish, will be immediately removed from the traps. Also, traps will be removed from the creek or closed during high stream flows (flood conditions) to avoid causing death or injury to fish that are trapped inside the trap box.

Capture by Trawl-nets

Trawl-nets may be used to capture ESA-listed salmonids in the Delta-Bay and Estuary. USFWS will primarily use a midwater trawl towed at 2-3 knots for 15-30 minute intervals and is fished near the surface. Possible adverse effects to ESA-listed salmonids are similar to adverse effects that may occur during seining activities: entanglement (gilling), scale and mucus abrasion, suffocation, and crushing. In the event that USFWS total catch for one trawl-set exceeds the authorized amount of non-intentional lethal take of ESA-listed salmonids surplus individuals that are not harmed or severely affected by the trawl-net shall be released. Individuals that are severely harmed during trawl-net activities shall be sacrificed first and should account for the majority of the requested non-intentional lethal take. If the authorized non-intentional lethal take of ESA-listed salmonids is exceeded by USFWS, then trawl-net activities will be suspended.

Scale-sampling

The primary risk to adult ESA-listed salmonids associated with scale-sampling is from capture and handling to obtain the samples. However, the removal of scales does potentially present a risk to ESA-listed salmonids because scales, along with associated dermal mucus or slime, are an important in protecting the integument of salmonids from abrasion and infection as they make their migrations through fresh and salt water environments. All ESA-listed salmonids that are subject to scale sampling will be thoroughly sedated using MS-222 or Alka-Seltzer® which will expedite the collection of scales and reduce the probability of injury to the fish from the procedure.

NMFS does not believe that scale-sampling, as proposed by USFWS, will present any additional risk to ESA-listed salmonids beyond that associated with capture and handling. USFWS will follow these precautions to prevent injury to ESA-listed salmonids which include: (1) collecting scales from the area above the lateral line just behind the dorsal fin; (2) only collecting scales from ESA-listed salmonids which appear to be in good condition and are not exhibiting injuries or abnormal behavior; and (3) collecting scale-samples from fish that are captured in freshwater only (NMFS anticipates that all ESA-listed salmonids that are captured and handled will be able to remain in freshwater for several days to recover lost scales and dermal mucus).

<u>Fin-Clipping</u>

Fin-clipping is the process of removing part or all of one or more fins to alter the appearance of a fish and thus make it identifiable. When entire fins are removed, it is expected that they will never grow back. Alternatively, a temporary mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, anal, or caudal fins.

The adverse effects of fin-clipping ESA-listed salmonids may include stress and injury from handling and damaged fins resulting in infection and delayed mortality. However, in general, most wounds caused by partial fin-clips heal quickly and do not alter fish growth.

When necessary, fish that are subjected to fin-clipping will be thoroughly sedated using Alka-Seltzer® or MS-222, which will expedite the collection of fin-clips and reduce the probability of injury to the fish. Only ESA-listed salmonids that are in good condition and are at least 60 mm fork length will be fin-clipped. Fin-clipping will entail the removal of a very small amount of fin tissue (not more than three mm^2) from any fin, but primarily the upper lobe of the caudal fin will be used. Fish will be closely observed and allowed to recover fully before being released.

USFWS will follow several precautionary measures to reduce the risk of stress and injury to ESA-listed salmonids from fin-clipping, including: (1) only a very small amount of fin tissue (not more than 3 mm^2) will be collected from any fin, but primarily the upper lobe of the caudal fin; (2) fin-clips will be collected only from ESA-listed salmonids which appear to be in good condition and are not exhibiting injuries or abnormal behavior; and (3) all ESA-listed salmonids will be closely observed and allowed to recover fully before being released.

<u>Capturing and Handling</u>

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 sedative, 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 degrees-Celsius (ºC) 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.

Sedation

MS-222 or Alka-Seltzer® will be administered to fish that are subject to fin-clips or scale sampling. Exact dosage needed varies based on the energy level of the fish upon recovery and water temperature. Precautions should be taken to ensure that the mixture is not too strong, and fish are removed once they are sedated and gilling evenly. Post-sampling, fish should be placed in a recovery bucket of clean, aerated water for three to five minutes, or until they are upright and responsive, and then gently released from the bucket and into the water at or near the capture site.

Electrofishing

Electrofishing is a process by which an electrical current is passed through water in order to stun fish and facilitate capture. It can also be used to guide or block their movements. There are three general systems for electrofishing related to where the generator is maintained: backpack, boat, and shore. Backpack electrofishing is the most common system used for salmonids. Boat and shore electrofishing units often use more current than backpack electrofishing equipment because they are used to cover larger (and deeper) areas and, as a result, potentially have a greater impact on fish. Backpacking electrofishing will be the primary method used if needed, and is the one authorized under the take tables.

The use of electricity to capture fish is potentially one of the most intrusive and risky methods. This method of capture can result in a variety of effects from simple harassment to injury to fish (adults and juveniles) and death. There are two major forms of injuries from electrofishing: hemorrhages in soft tissue and fractures in hard tissue. Only a few recent studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalbey *et al.* 1996, Ainslie *et al.* 1998). Dalbey *et al.* (1996) reports that the growth of rainbow trout was markedly lower when there was moderate to severe electrofisher induced spinal injury. Electrofishing can also result in trauma to fish from stress. The stress caused by electrofishing is usually not recognized because the fish often appear normal upon release. Recovery from this stress can take up to several days, and during this time the fish are more vulnerable to predation, and less able to compete for resources. Stress related deaths can also occur within minutes or hours of release, with respiratory failure usually the cause.

The age or stage of development of the target species affects injury rates. Electrofishing can have severe effects on adult salmonids, particularly spinal injuries from forced muscle contraction. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study. The relatively few studies that have been conducted on juvenile salmonids indicate that spinal injuries are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish (Sharber and Carothers 1988) and may therefore be subject to lower injury rates (e.g., Hollander and Carline 1994, Dalbey *et al.* 1996, Thompson *et al.* 1997). McMichael *et al.* (1998) found a 5.1 percent injury rate for juvenile steelhead captured by electrofishing in the Yakima River sub-basin. Cho *et al.* (2002) showed that electrofishing has a dramatic negative effect on survival of eggs from electroshocked females (up to 93 percent mortality) and eggs electrofished post spawning (up to 34 percent mortality). To minimize harm to fish, NMFS requires researchers to follow NMFS' electrofishing guidelines. For example, NMFS prohibits electrofishing near spawning adults or active redds.

Electrofishing effectiveness and safety have improved over time (Bonar *et al.* 2009). Design specifications to reduce injury to fish and a comprehensive review of electrofishing literature can be found in Snyder (2003 and 2004). Direct current (DC) or low frequency pulsed direct current (PDC; $\geq$30 Hz, the lower the better) should be used over alternating current (AC), as these cause substantially fewer spinal injuries and hemorrhages than higher frequency PCDs and AC (Snyder 2003, 2004; Fredenberg 1992, Dalbey et al. 1996).

C. Measures to Reduce Impacts of Research Activities

The majority of all ESA listed salmonids captured by beach seines, surface trawls, fyke nets, gillnets, and back-pack electrofishing using the methodologies described in previous sections exhibit very little adverse behavior or physical characteristics, except if retained for CWT processing (adipose fin clipped Chinook salmon only). In addition, green sturgeon have been rarely encountered while sampling using these methodologies and are thought to also exhibit very little adverse behavior or physical characteristics after capture. However, fishes can incur physical damage (e.g., descaling, body injury, mortality, bruising) and/or physiological damage (e.g., increase in cortisol levels, internal temperature, and respiratory stress) after being captured and subsequently handled/processed. To date, no salmonids or green sturgeon have been captured in larval trawls at Liberty Island.

To minimize physiological stress all ESA listed fishes captured by the DJFMP, Breach III Project and IEP Gear Efficiency Evaluation Study, except adipose clipped winter- and spring-run Chinook salmon, will be immediately collected from the sampling gears, placed in containers filled with water collected at the location being sampled, processed, held in another container filled with onsite collected water for recovery, and subsequently released in the sampled location. The total handling time to take and record data from a fish out of the water ranges only from 15 to 30 seconds. Large catches may require small concentrations of anesthetic (MS-222) or subsampling to further minimize stress or holding times, respectively. In addition, salmonids and green sturgeon receive processing priority over non ESA listed fishes. No ESA listed fish will be intentionally held, except adipose fin clipped Chinook salmon and any fish captured in the larval trawl sampling that must be returned to the lab for identification. When large numbers of fish are caught, the holding container should be moved into the shade for processing or shade should be provided. Also gentle handling of the fish is important and fish should be placed back into the water or holding tank as so and not be thrown or tossed. The boat should be facing upstream during releases, ideally with the engine off to avoid being caught up in the boats intake or caught in propellers.

To minimize physical injury, all DJFMP, Breach III Project, and IEP Gear Efficiency Evaluation Study sampling will make every effort to avoid collecting mud and other debris within the gear while sampling. The presence of mud, thick aquatic vegetation, and woody debris can suffocate or cause physical damage to fishes captured. In addition, ESA listed fishes are removed from gillnets hourly while sampling or being used in beach seine gear efficiency sampling to prevent injury and mortality, and trawls will not be fished more than 20 minutes to prevent large catches which can cause bodily harm to juvenile fishes. When using back-pack electrofishers, the DJFMP will follow the NMFS June 2000 Guidelines for Electrofishing Waters Containing Salmonids Listed under the ESA to further reduce fish injury. Sunscreen will be applied at least 30 minutes prior to handling fish and will be removed from hands as best as possible to avoid contact with fish.

To minimize negative effects to the habitats of ESA listed fishes and the San Francisco Estuary while sampling, the DJFMP, Breach III Project, and IEP Gear Efficiency Evaluation Study will make all possible efforts to limit the translocation or introduction of aquatic invasive species by having specific sampling gear for particular sampling locations and/or rivers. Sampling will also be done starting upstream while continually working downstream to lessen the possibility of spreading invasive species. All sampling gears also are inspected for the presence of aquatic invasive species pre and post sampling to prevent unwanted introductions and translocation of any species, respectively.

D. Integration and Synthesis of Effects

All races of Chinook salmon in the CV use the Delta as a migration corridor to the ocean and many rear there before emigration. The survival of juvenile salmon through the Delta is considered critical to year class success, as density-dependent mortality after Delta residence is believed to be minimal (Junge 1970). Actions in the Delta to improve survival are considered important in increasing the production of these CV salmon populations. In addition to contributing to the general body of scientific knowledge in support of ESA-listed salmonid conservation and recovery planning, the research activities conducted by USFWS respond directly to the mission of the IEP. Estimating the abundance of "true" juvenile winter and spring-run Chinook salmon leaving the Delta is fundamental to achieving two of the Science Program's priority research topics: 1) identifying trends and patterns of populations and system response to a changing environment and 2) using discretionary environmental water supplies more effectively for at-risk species to develop a better understanding of how water conditions affect juvenile winter- and spring-run Chinook production and survival. Research carried out under Permit 13791 will provide a means for better understanding of race proportions in the Delta and determination if past assumptions need to be modified about the timing and relative abundance of various races of juvenile salmon in the Delta.

Also as described in section IV. C of the Biological Opinion, "Species Population Trends" NMFS utilizes JPE to estimate total annual juvenile production of SR winter-run Chinook salmon. Annual juvenile SR winter-run releases from Livingston Stone National Fish Hatchery (LSNFH) from 2006-2011, ranged from 70,000 to 198,766. USFWS proposes to intentionally sacrifice up to 455 juvenile hatchery SR winter-run Chinook salmon annually for all sampling locations combined for CWT removal and processing. Given the range of juvenile SR winter-run produced at LSNFH over the past five years, the directed intentional mortality proposed by USFWS would equate to 0.007 – 0.002 percent of the total hatchery production, which is less than one percent. Additionally, USFWS proposes to intentionally sacrifice 627 CV spring-run Chinook salmon at all project locations combined. The CV spring-run released from the Feather River Hatchery in 2011 show that there were 2,312,122 fish released. A requested intentional take of 627 from that release equates to 0.0003 percent, a number too insignificant to affect the overall survival of these listed species. The benefits associated with the ability to collect and read CWT's present in hatchery-origin Chinook salmon allow for comparison of race determinations using Fisher's length at date criteria to hatchery release records and estimates of hatchery-origin to juvenile survival.

E. Benefits of Issuing Permit 13791

Permit 13791 will allow the USFWS to gather information on population abundance, distribution, and status information on SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS of green sturgeon. In order to document the progress of growth and downstream juvenile migration, regular monitoring for juvenile salmon and steelhead along the lower Sacramento River and throughout the Delta is required. This information is useful to fishery and water managers in providing estuarine and river conditions compatible with the requirements for the salmon and steelhead life stages present. The research findings will enable NMFS to use the best scientific data available to perform recovery and conservation planning for ESA-listed salmonids, as well as numerous other agencies involved with the recovery ESA-listed salmonids. NMFS believes that this information will be instrumental in making informed management and conservation decisions concerning ESA-listed salmonids. In addition to contributing to the general knowledge of the distribution, abundance, and population structure of ESA-listed salmonids, Permit 13791 will provide further insight to life history strategies of ESA-listed salmonids that will aid in the recovery of the species. All research findings will be directly used by NMFS, as well as numerous Federal, State, local and private agencies or organizations, to benefit ESA-listed salmonid populations through improved resource conservation and management.

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 13791, 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 13791 is for intentional and unintential take of ESA-listed salmonids associated with scientific research and monitoring activities.

X. REINITIATION OF CONSULTATION

This concludes formal consultation on the issuance of Permit No. 13791. 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.

XI. LITERATURE CITED

Adams, P.B., C.B. Grimes, J.E. Hightower, S.T. Lindley, and M.L. Moser. 2002. Status review for North American green sturgeon, Acipenser medirostris. National Marine Fisheries Service. 58 pages.

Alderdice, D.F. and F.P.J. Velsen. 1978. Relation between temperature and incubation time for eggs of Chinook salmon (Oncorhynchus tshawytscha). Journal of the Fisheries Research Board of Canada 35(1):69-75.

Ainslie, Barbara J.; Post, John R., and Paul, Andrew J. Effects of pulsed and continuous DC electrofishing on juvenile rainbow trout. 1998. North American Journal of Fisheries Management. 18(4):905-918.

Bailey, E. D. 1954. Time pattern of the 1953 to 1954 migration of salmon and steelhead in the upper Sacramento River. Results of fyke net trapping near Fremont Weir on the Sacramento River. Inland Fisheries Division, California Department of Fish and Game, July 26, 4 pp.

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin rivers and tributaries. Prepared for State Water Contractors by S.P. Cramer and Associates, Inc., Gresham, Oregon. 46 pages.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. Third edition. U.S. Army Corps of Engineers, Office of the Chief of Engineers, Fish Passage Development and Evaluation Program, North Pacific Division, Portland, Oregon.

Bilby, R.E., Fransen, B.R., and P.A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Can. J. Fish. Aquat. Sci. 53(1): 164-173. doi:10.1139/cjfas-53-1-164.

Bilby, R.E., and P.A. Bisson. 1998. Function and distribution of large woody debris. Pages 324-346 in R. Naiman and R.E. Bilby, editors. River and Stream Ecology. Springer-Verlag, New York, New York.

Boles, G. 1988. Water temperature effects on Chinook salmon (Oncorhynchus tshawytscha) with emphasis on the Sacramento River: a literature review. Report to the California Department of Water Resources, Northern District. 43 pages.

Bonar, S.A., W.A. Hubert, and D.W. Willis, eds. 2009. Standard method for sampling North American freshwater fishes. American Fisheries Society. Bethesda, Maryland. 335 pages.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of anadromous salmonids. *In* W.R. Meehan (editor), Influences of forest and rangeland management on salmonid fishes and their habitats, pages 83-138. American Fisheries Society Special Publication 19.

American Fisheries Society, Bethesda, Maryland.

Brandes, P. L. and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: R.L. Brown, editor. Contributions to the biology of Central Valley salmonids. Volume 2. California Department of Fish and Game Fish Bulletin 179:39-136.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. August, 1996.

CalFed Bay Delta Program. 2001. Scrutinizing the Delta Cross Channel. in Science in Action: news from the Calfed Bay Delta Science Program. Available at: http://www.science.calwater.ca.gov/pdf/SIA_cross_channel_060101.pdf

California Data Exchange Center. Department of Water Resources. cdec.water.ca.gov

California Department of Fish and Game. 2012. Grand Tab database. Available at www.calfish.org.

California Department of Fish and Game. Unpublished data. 2011. Aerial salmon redd survey excel tables.

California Department of Fish and Game. 2011. Sturgeon Report Card Data.

California Department of Fish and Game. 2007. California Steelhead Fishing Report-Restoration Card. A Report to the Legislature. July.

California Department of Fish and Game. 2003. Letter from Dean Marston, CDFG, to Madelyn Martinez, National Marine Fisheries Service. January 9.

California Department of Fish and Game. 2002. California Department of Fish and Game comments to NMFS regarding green sturgeon listing. 79 pages plus appendices.

California Department of Fish and Game. 1998. A status review of the spring run Chinook salmon in the Sacramento River drainage. Report to the Fish and Game Commission. Candidate species status report 98-1. Sacramento, California. June. 394 pages.

California Department of Fish and Game. 1995. Adult steelhead counts in Mill and Deer Creeks, Tehama County, October 1993-June 1994. Inland Fisheries Administrative Report Number 95-3.

California Regional Water Quality Control Board-Central Valley Region. 1998. Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins, fourth edition. Available: http://www.swrcb.ca.gov/~CRWQCB5/home.html

Cho, G.K., J.W. Heath, and D.D. Heath. 2002. Electroshocking influences Chinook salmon egg survival and juvenile physiology and immunology. Transactions of the American Fisheries Society 131:224-233.

Clark, G. H. 1929. Sacramento-San Joaquin salmon (*Oncorhynchus tshawytscha*) fishery of California. California Fish and Game Bulletin 17:1-73.

Cox. W. 2010. Personal Communication. Senior Fish Pathologist. Fish Health Laboratory, California Department of Fish and Game. Rancho Cordova, California.

Dalbey, S.R., McMahon, T.E., and Fredenberg, W. 1996. Effect of electrofishing pulse shape and electrofishing induced spinal injury on long-term growth and survival of wild rainbow trout: North American Journal of Fisheries Management, vol. 16, p. 560–569.

Deacon, J. E. 1961. A staining method for marking large numbers of small fish. Prog. Fish Cult. 23:41–42.

Deng, X., J.P. Van Eenennaam, and S.I. Doroshov. 2002. Comparison of early life stages and growth of green and white sturgeon. In: W. Van Winkle, P.J. Anders, D.H. Secor, and D.A. Dixon, editors, Biology, management, and protection of North American sturgeon, pages 237-248. American Fisheries Society, Symposium 28, Bethesda, Maryland.

Dunford, W.E. 1975. Space and food utilization by salmonids in marsh habitats in the Fraser River Estuary. M.S. Thesis. University of British Colombia, Vancouver, B.C., 81 pages.

Erickson, D. L., J. A. North, J. E. Hightower, J. Weber, L. Lauck. 2002. Movement and habitat use of green sturgeon Acipenser medirostris in the Rogue River, Oregon, USA. Journal of Applied Ichthyology 18:565-569.

Fisher, F. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8(3):870-873.

Fitzgerald, D.G., Lanno, R.P., and D.G. Dixon. 1999. A comparison of a sentinel species evaluation using creek chub (Semotilus atromaculatus Mitchill) to a fish community evaluation for the initial identification of environmental stressors in small streams: Ecotoxicology, v. 8, p. 33-48.

Fredenberg, W.A. 1992. Evaluation of electrofishing induced spinal injuries resulting from field electrofishing surveys in Montana. Montana Department of Fish, Wildlife and Parks, Helena.

Fry, D.H. 1961. King salmon spawning stocks of the California Central Valley, 1940-1959.

California Fish and Game 47:55-71.

Gadomski, D.M. and M.J. Parsely. 2005. Effects of turbidity, light level, and cover on predation of white sturgeon larvae by prickly sculpins. Transactions of the American Fisheries Society 134:369-374.

Gaines, P.D. and W.R. Poytress. 2004. Brood-year 2003 winter Chinook juvenile production indices with comparisons to adult escapement. U.S. Fish and Wildlife Service report to California Bay-Delta Authority. San Francisco, California.

Giovannetti, S.L. and M.R. Brown. 2010. Adult Steelhead and Late-fall Chinook Salmon Monitoring on Clear Creek, California. 2009 Annual Report. U.S. Fish and Wildlife Service. Red Bluff, California.

Good, T.P., R.S. Waples, and P. Adams, *editors*. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. NOAA Technical Memorandum NMFS-NWFSC-66. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. June, 2005.

Gresh, T., Lichatowich, J., and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific ecosystem: evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. Fisheries, 25(1): 15-21. doi:10.1577!1548-8446(2000)025<0015:AEOHAC>2.0.C0;2.

Hallock, R.J., and F.W. Fisher. 1985. Status of winter-run Chinook salmon, Oncorhynchus tshawytscha, in the Sacramento River. Report to the California Department of Fish and Game, Anadromous Fisheries Branch, Sacramento, California.

Hallock, R. J., Elwell, R. F. and Fry, D. H. 1970. Migrations of Adult King Salmon *Oncorhynchus tshawytscha* in the San Joaquin Delta, as Demonstrated by the Use of Sonic Tags. State of California Department of Fish and Game, Fish Bulletin 151

Hallock, R.J., W.F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery reared steelhead rainbow trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. California Department of Fish and Game 114. 74 pp.

Hallock, R.J. D.H. Fry, and D.A. LaFaunce. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. California Fish and Game 43(4): 271-298

Healey, M. C. 1991. Life history of Chinook salmon (Oncorhynchus tshawytscha). In C. Groot and L. Margolis, editors, Pacific Salmon Life Histories, pages 396-445 [check. Another reference said Pages 313-393]. University of British Columbia Press, Vancouver, British Columbia. 564 pages.

Herren, J.R. and S.S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. In: Brown R.L. editor. Fish Bulletin 179. Sacramento (CA). California Department of Fish and Game.

Herbold, B. and Moyle, P.B. 1989. The ecology of the Sacramento-San Joaquin Delta: a community profile. U.S. Fish and Wildlife Service Biological Report 85(7.22). 106 pp.

Heublein, J.C. 2006. Migration of green sturgeon Acipenser medirostris in the Sacramento River. Master of Science Thesis. California State University, San Francisco. October 2006. 63 pages.

Hollender, B.A., and Carline, R.F., 1994, Injury of wild brook trout by backpack electrofishing: North American Journal of Fisheries Management, vol. 14, p. 643–649.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review Existing Programs, and Assessment Needs. In Comprehensive Assessment, and Research Program Plan, Tech. App. VII. www.iep.water.ca.gov.

Israel, J.A., and A.P. Klimley. 2008. Life History Conceptual Model for North American Green Sturgeon (Acipenser medirostris), prepared for DRERIP. University of California, Davis, California. December 27. 50 pages.

Israel, J. 2006. Determining spawning population estimates for green sturgeon with microsatellite DNA. Presentation at the 2006 CALFED Science Conference. Sacramento, California. October 23, 2006.

Jacobson, R.B., Femmer, S.R., and McKenney, R.A, 2001, Land-use changes and the physical habitat of stream-A review with emphasis on studies within the U.S. Geological Survey Federal-State cooperative program: U.S. Geological Survey Circular 1175, 63 p.

Keefer, M. L., C. A. Perry, M. A. Jepson, and L. C. Stuehrenberg. 2004. Upstream migration rates of radio-tagged adult Chinook salmon in riverine habitats of the Columbia River basin. Journal of Fish Biology 65:1126-1141.

Kelly, J.T., A.P. Klimley, and C.E. Crocker. 2007. Movements of green sturgeon, Acipenser medirostris, in the San Francisco Bay Estuary, CA. Environmental Biology of Fishes 79(3-4): 281-295.

Kelly, J. T., A. P. Klimley, and C. E. Crocker. 2006. Movements of green sturgeon, Acipenser medirostris, in the San Francisco Bay Estuary, California. Editorial manuscript for Environmental Biology of Fishes.

Kelsch, S. W., and B. Shields. 1996. Care and Handling of Sampled Organisms. Fisheries Techniques, 2nd edition. American Fisheries Society 121-155.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile chinook salmon, Oncorhynchus tshawytscha, in the Sacramento-San Joaquin estuary, California. In V.S. Kennedy (editor), Estuarine comparisons, pages 393-411. Academic Press, New York, New York.

Klein, R.D. 1979. Urbanization and stream quality impairment: Water Resources Bulletin, v. 15, p. 948-963.

Kynard, B., E. Parker, and T. Parker. 2005. Behavior of early life intervals of Klamath River green sturgeon, Acipenser medirostris, with note on body color. Environmental Biology of Fishes 72:85-97.

LeBlanc, R.T., Brown, R.D., and J.E. Fitzgibbon. 1997. Modeling the effects of land use change on the water temperature in unregulated urban streams: Journal of Environmental Management, v. 49, p. 445-469.

Levy, D.A. and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River Estuary. Westwater Research Centre, University of British Columbia, Technical Report no. 25. Vancouver, British Columbia, Canada.

Lindley, S.T., C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, D. L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope, P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council. March 18. 57 pages plus a 61-page appendix.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5: Article 4.

Lindley, S.T. 2006a. Large-scale migrations of green sturgeon. Presentation at Interagency Ecological Program 2006 Annual Workshop, Pacific Grove, California. March 3.

Lindley, S. T., R. Schick, A. Agrawal, M. Goslin, T. Pearson, E. Mora, J.J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R.B. MacFarlane, C. Swanson, and J. G. Williams. 2006b. Historical population structure of Central Valley steelhead and its alteration by dams. San Francisco Estuary and Watershed Science 4(1)(3):1-19. http://repositories.cdlib.org/jmie/sfews/vol4/iss1/art3

Lindley, S.T., R. Schick, B.P. May, J.J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2004. Population structure of threatened and endangered Chinook salmon ESU in California's Central Valley basin.

NMFS Southwest Science Center NOAA-TM-NMFS-SWFSC-360. Santa Cruz, CA.

MacFarlane, B.R. and E.C. Norton. 2002. Physiological ecology of juvenile Chinook salmon (Oncorhynchus tshawytscha) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallones, California. Fisheries Bulletin 100:244-257.

Matter, A.L. and B.P. Sandford. 2003. A comparison of migration rates of radio and PIT-tagged adult Snake River Chinook salmon through the Columbia River hydropower system. North American Journal of Fisheries Management 23:967-973.

Martin, C.D., P.D. Gaines, and R.R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter Chinook salmon with comparisons to adult escapement. Red Bluff.

Maslin, P., M Lennox, and W. McKinney. 1997. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (Oncorhynchus tshawytscha). California State University, Chico, Department of Biological Sciences. 89 pages.

Mayfield, R.B. and J.J. Cech, Jr. 2004. Temperature Effects on green sturgeon bioenergetics. Transactions of the American Fisheries Society 133:961-970.

McEwan, D. 2001. Central Valley steelhead, In Contributions to the biology of Central Valley salmonids, R. L. Brown, editor, CDFG, Sacramento, CA, Fish Bulletin, Vol. 179, pp. 1-44.

McEwan, D. and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game. Sacramento, California. 234 pages.

McMichael, G.A., Fritis, A.L., and T.N. Pearsons. 1998. Electrofishing injury to stream salmonids: injury assessment at the sample, reach, and stream scale. North American Journal of Fisheries Management 18: 894-904.

McReynolds, T.R., C.E. Garman, P.D. Ward, and M.C. Schommer. 2005. Butte and Big Chico Creeks spring-run Chinook salmon, Oncorhynchus tshawytscha life history investigation, 2003-2004. California Department of Fish and Game, Inland Fisheries Administrative Report No. 2005-1.

Meehan, W. R. and T. C. Bjornn. 1991. Salmonid distributions and life histories. In W. R. Meehan, editor, Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats, pages 47-82. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, Maryland. 751 pages.

Mora, E.A. 2011. Personal Communication. Graduate Student Researcher. Department of Wildlife, Fish and Conservation Biology, University of California, Davis.

Moser, M.L. and S.T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes. 79:243-253.

Moyle, P.B. 2002. Inland Fishes of California. University of California Press, Berkeley, California.

Moyle, P.B., P.J. Foley, and R.M. Yoshiyama. 1992. Status of green sturgeon, Acipenser medirostris, in California. Final report sent to NMFS, Terminal Island, California by UC Davis Department of Wildlife and Fisheries Biology. 12 pages.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Wildlife and Fisheries Biology Department, University of California, Davis. Prepared for The Resources Agency, California Department of Fish and Game, Rancho Cordova.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L .J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. Technical Memorandum NMFS-NWFSC-35. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 443 pages.

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. Age and growth of Klamath River green sturgeon (Acipenser medirostris). U.S. Fish and Wildlife Service. Project # 93-FP-13. 20 pages.

National Marine Fisheries Service. 2011a. Central Valley Recovery Domain 5-Year Review: Summary and Evaluation of Sacramento River Winter-run Chinook Salmon ESU. NMFS, Southwest Region. August 15, 2011.

National Marine Fisheries Service. 2011b. Central Valley Recovery Domain 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon ESU. NMFS, Southwest Region. August 15, 2011.

National Marine Fisheries Service. 2005a. Green sturgeon (Acipenser medirostris) status review update. Biological review team, Santa Cruz Laboratory, Southwest Fisheries Science Center, California. February. 31 pages

National Marine Fisheries Service. 2005b. Initial Assessment of NMFS' Critical Habitat Analytical Review Teams (CHARTs) for 13 Evolutionarily Significant Units of Pacific Salmon and 0. mykiss. NOAA's National Marine Fisheries Service, Northwest and Southwest Regions.

National Marine Fisheries Service. 1997. Status review update for West Coast steelhead from Washington, Idaho, Oregon, and California. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Newton, J. M., and L.A. Stafford. 2011. Monitoring adult Chinook salmon, rainbow trout, and steelhead in Battle Creek, California, from March through November 2009. USFWS

Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

Nichols, F.H., J.E. Cloern, S.N. Louma, and D.H. Peterson. 1986. The modification of an estuary. Science 231: 567-573.

Nobriga, M. and P. Cadrett. 2003. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. Interagency Ecological Program for the San Francisco Estuary Newsletter 14:3:30-38.

Oppenheim, B. 2012. Personal Communication. Biologist. Protected Resources Division, National Marine Fisheries Service. Sacramento, California.

Pitt, R.E., Field, R., Lalor, M., and M. Brown. 1995. Urban stormwater toxic pollutants-Assessment, sources, and treatability: Water Environment Research, v. 67, p. 260-275.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon, in Ecological studies of the Sacramento-San Joaquin Delta, Part II. (J. L. Turner and D. W. Kelley, comp.). California Department of Fish and Game Fish Bulletin 136:115-129.

S.P. Cramer and Associates. 2000. Effects of pulse flows on juvenile Chinook migration in the Stanislaus River. Annual Report. Prepared for South San Joaquin Irrigation District, Manteca, CA and Oakdale Irrigation District, Oakdale, CA. Prepared by D. B. Demko and S.P. Cramer, S.P. Cramer & Associates, Inc.

S.P. Cramer and Associates. 2001. Effects of pulse flows on juvenile Chinook migration in the Stanislaus River. Annual Report. Prepared for South San Joaquin Irrigation District, Manteca, CA and Oakdale Irrigation District, Oakdale, CA. Prepared by D. B. Demko and S.P. Cramer, S.P. Cramer & Associates, Inc.

Schmetterling, D. A., C. G. Clancy, and T. M. Brandt. 2001. Effects of riprap bank reinforcement on stream salmonids in the western United States. Fisheries 26:6-13.

Schaffter, R. 1980. Fish occurrence, size, and distribution in the Sacramento River near Hood, California during 1973 and 1974. California Department of Fish and Game.

SEC (Steiner Environmental Consulting). 1996. A history of the salmonid decline in the Russian River. Steiner Environmental Consulting, Potter Valley, California.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fish Bulletin 98:1-375.

Sharber, N.G., and Carothers, S.W., 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout: North American Journal of Fisheries Management, vol. 8, p. 117–122.

Shelton, J. M. 1995. The hatching of Chinook salmon eggs under simulated stream conditions. Progressive Fish-Culturist 17:20-35.

Sinokrot, B.A., and H.G. Stefan. 1993. Stream temperature dynamics-Measurements and modeling: Water Resources Research, v. 29, p. 2,299-2,312.

Slater, D.W. 1963. Winter-run Chinook salmon in the Sacramento River, California, with notes on water temperature requirements at spawning. U.S. Fish and Wildlife Service, Special Science Report Fisheries 461:9.

Snider, B., and R.G. Titus. 2000. Timing, composition, and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1996-September 1997. California Department of Fish and Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 00-04.

Snider, B. 2001. Evaluation of effects of flow fluctuations on the anadromous fish populations in the lower American River. California Department of Fish and Game, Habitat Conservation Division. Stream Evaluation Program. Tech. Reports No. 1 and 2 with appendices 1-3. Sacramento, California.

Snyder, D.E. 2003. Electrofishing and its harmful effects on fish. US Geological Survey, Information and Technology Report USGS/BRD/IRT-2003-0002, Denver, Colorado.

Snyder, D.E. 2004. Invited overview: conclusions from a review of electrofishing and its harmful effects on fish.

Sommer, T. R., M. L. Nobriga, W. C. Harrel, W. Batham, and W. J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325-333.

Spence, B., G. Lomnicky, R., Hughes, and R. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. Technical Environmental Research Services Corp., Corvallis, Oregon.

Stillwater Sciences. 2006. Standard Assessment Methodology (SAM) evaluation for five critical erosion sites, River miles 26.9 left, 34.5 right, 72.2 right, 99.3 right, and 123.5 left, Sacramento River Bank Protection Project. Contract W91238-05-D-0009. Prepared by Stillwater Sciences, Berkeley, California.

Stillwater Sciences. 2004. Appendix H: conceptual models of focus fish species response to selected habitat variables. In: Sacramento River Bank Protection final Standard Assessment Methodology. July.

Stone, L. 1874. Report of operations during 1872 at the U.S. salmon-hatching establishment on the McCloud River, and on the California Salmonidae generally; with a list of specimens collected. Report to U.S. Commissioner of Fisheries for 1872-1873, 2:168-215.

Thompson, K.G., Bergersen, E.P., Nehring, R.G., and Bowden, D.C. 1997. Long-term effects of electrofishing on growth and body condition of brown trout and rainbow trout: North American Journal of Fisheries Management, vol. 17, p. 154–159.

U.S. Environmental Protection Agency. 1998. 1997 Contaminated Sediment Report to Congress. Vol. I, II, III. EPA 823-R-97-006; 007; 008.

U.S. Fish and Wildlife Service. 2002. Spawning areas of green sturgeon Acipenser medirostris in the upper Sacramento River California. U.S. Fish and Wildlife Service, Red Bluff, California.

U.S. Fish and Wildlife Service. 2001a. Abundance and seasonal, spatial, and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Draft Progress Report for Red Bluff Research Pumping Plant, Vol.14. Prepared by Philip Gaines and Craig Martin for the U.S. Bureau of Reclamation. Red Bluff, California.

U.S. Fish and Wildlife Service. 2001b. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary: 1997 and 1998. Annual progress report Sacramento-San Joaquin Estuary. 131 pages.

U.S. Fish and Wildlife Service. 2000. Impacts of Riprapping to Ecosystem Functioning, Lower Sacramento River, California. Sacramento Office, prepared for: Sacramento District, U. S. Army Corps of Engineers, for the FWS's Fish and Wildlife Coordination Act Report, and Biological Opinion for proposed bank protection work.

U.S. Fish and Wildlife Service. 1997. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin Estuary. 1994 Annual Progress Report. Stockton, California.

U.S. Fish and Wildlife Service. 1996. Escapement of hatchery-origin winter Chinook salmon (Oncorhynchus tshawytscha) to the Sacramento River, California in 1995, with notes on spring chinook salmon in Battle Creek. USFWS Report. USFWS, Northern Central Valley Office . Red Bluff, CA. 23 pp.

U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volumes 1-3. Prepared by the Anadromous Fish Restoration Program Core Group for the U.S. Fish and Wildlife Service, Stockton, California.

U.S. Fish and Wildlife. 1994-2011. Unpublished data. Stockton Fish and Wildlife Office Mossdale trawls monitoring data. http://www.fws.gov/stockton/jfmp/datamanagement.asp

Van Eenennaam, J.P., M.A.H. Webb, X. Deng, S.I. Doroshov, R.B. Mayfield, J.J. Cech, D.C. Hillemeier, and T.E. Willson. 2001. Artificial spawning and larval rearing of Klamath River green sturgeon. Transactions of the American Fisheries Society 130:159-165.

Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook salmon life history. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. 55 pages.

Waples, R.S. 1991. Pacific Salmon, *Oncorhynchus* spp., and the definition of a species under the Endangered Species Act. Marine Fisheries Review 53:11-21.

Ward, P.D., T.R. McReynolds, and C.E. Garman. 2002. Butte and Big Chico Creeks spring-run Chinook salmon, Oncorhynchus tshawytscha life history investigation, 2000-2001. California Department of Fish and Game, Inland Fisheries Administrative Report.

Ward, P.D., T.R. McReynolds, and C.E. Garman. 2003. Butte and Big Chico Creeks spring-run Chinook salmon, Oncorhynchus tshawytscha life history investigation, 2001-2002. California Department of Fish and Game, Inland Fisheries Administrative Report.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

Williams, T. H., S. T. Lindley, B.C. Spence, and D.A. Boughton. In Preparation. Using viability criteria to assess status of Pacific salmon and steelhead in California. National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, CA.

Williams, J.G. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3): Article 2. 416 pages.

Winterbourne, M.J ., and C.R. Townsend. 1991. Streams and rivers-One-way flow systems, in Barnes, R.S.K, and Mann, K.H., eds. Fundamentals of aquatic ecology: Oxford, England, Blackwell Science Ltd., p. 230-242.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. Sierra Nevada Ecosystem Project: Final report to Congress, vol.III. Centers for Water and Wildland Resources, Univ. Cal. Davis.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18:487-521.

Yoshiyama, R.M, E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. In: Brown, R.L., editor. Contributions to the biology of Central Valley salmonids. Volume 1.

California Department of Fish and Game Fish Bulletin 179:71-177.

Zimmerman, C.E., G.W. Edwards, and K. Perry. 2008. Maternal Origin and Migratory History of *Oncorhynchus mykiss* captured in rivers of the Central Valley, California. Final Report Prepared for California Department of Fish and Game. Contract P0385300. 6 March 2008.

Federal Register Notices Cited

Volume 77 FR 24470 - 24471. April 24, 2012. Endangered and Threatened Species; Take of Anadromous Fish. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Volume 76 FR 50447-50448. August 15, 2011. Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California.

Volume 74 pages 52300-52350. October 9, 2009. Endangered and Threatened Wildlife and Plants: Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon; Final Rule.

Volume 73 FR 70622. November 21, 2008. Endangered and Threatened Species; Take of Anadromous Fish. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Volume 71 pages 17757-17766. April 7, 2006. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon.

Volume 71 pages 834-862. January 5, 2006. Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead; Final Rule.

Volume 70 pages 52488-52627. September 2, 2005. Endangered and Threatened Species; Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule.

Volume 70 pages 37160-37204. June 28, 2005. National Marine Fisheries Service. Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs.

Volume 58 pages 33212-33219. June 16, 1993. National Marine Fisheries Service. Final Rule: Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon.

Appendix 1. Annual Estimated Take for Permit 13791

DJFMP – San Joaquin Delta Seine

SPECIES	LISTING UNIT/ STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/ COLLECT METHOD	PROCEDURES
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Seine, Beach	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	40	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	40	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	

Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Electrofishing, Backpack	

DJFMP – Lower Sacramento Surface Trawl and Seine

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	Juvenile	Male and Female	845	25	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	75	0	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	895	25	Capture/ Handle/ Release Fish	Trawl, Midwater	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	225	0	Intentional (Directed) Mortality	Trawl, Midwater	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	180	5	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Trawl, Midwater	Tissue Sample Scale

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	180	5	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Seine, Beach	Tissue Sample Scale
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	95	2	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Trawl, Midwater	Tissue Sample Scale
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	95	2	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Seine, Beach	Tissue Sample Scale
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	425	12	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	60	0	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	75	3	Capture/ Handle/ Release Fish	Trawl, Midwater	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	60	0	Intentional (Directed) Mortality	Trawl, Midwater	

Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	25	1	Capture/ Handle/ Release Fish	Trawl, Midwater	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	150	5	Capture/ Handle/ Release Fish	Trawl, Midwater	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	25	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	50	2	Capture/ Handle/ Release Fish	Seine, Beach	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Trawl, Midwater	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	10	0	Intentional (Directed) Mortality	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	10	0	Intentional (Directed) Mortality	Net, Gill	

Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	15	1	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	10	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	40	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	0	Intentional (Directed) Mortality	Electrofishing, Backpack	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	70	2	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	0	Intentional (Directed) Mortality	Electrofishing, Backpack	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	

DJFMP – San Pablo/San Francisco Bay Seine

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	Smolt	Male and Female	30	1	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Smolt	Male and Female	30	0	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Smolt	Male and Female	10	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Smolt	Male and Female	10	0	Intentional (Directed) Mortality	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Smolt	Male and Female	30	1	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Smolt	Male and Female	30	0	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Smolt	Male and Female	10	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Smolt	Male and Female	10	0	Intentional (Directed) Mortality	Net, Gill	

Steelhead	California Central Valley (NMFS Threatened)	Natural	Smolt	Male and Female	10	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Smolt	Male and Female	10	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Smolt	Male and Female	10	1	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Smolt	Male and Female	10	1	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Seine, Beach	

DJFMP – Middle/Lower San Joaquin River Surface Trawl and Seine

SPECIES	LISTING UNIT/ STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY	TAKE ACTION	OBSERVE/ COLLECT METHOD	PROCEDURES
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	50	2	Capture/ Handle/ Release Fish	Trawl, Midwater	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	50	2	Capture/ Handle/ Release Fish	Trawl, Midwater	

Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Seine, Beach	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Trawl, Midwater	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	

Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Electrofishing, Backpack	

DJFMP - Suisun Bay at Chipps Island Surface Trawl

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	Juvenile	Male and Female	2050	60	Capture/ Handle/ Release Fish	Trawl, Midwater	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	600	0	Intentional (Directed) Mortality	Trawl, Midwater	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	400	12	Capture/ Handle/ Release Fish	Trawl, Midwater	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	100	0	Intentional (Directed) Mortality	Trawl, Midwater	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	50	2	Capture/ Handle/ Release Fish	Trawl, Midwater	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	200	6	Capture/ Handle/ Release Fish	Trawl, Midwater	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Trawl, Midwater	

DJFMP - Sacramento River Seine

SPECIES	LISTING UNIT/ STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY[6]	TAKE ACTION	OBSERVE/ COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	110	3	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	1	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	0	Intentional (Directed) Mortality	Net, Gill	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	50	2	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	0	Intentional (Directed) Mortality	Electrofishing, Backpack	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	365	10	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	45	0	Intentional (Directed) Mortality	Seine, Beach	

Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	0	Intentional (Directed) Mortality	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	50	2	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	0	Intentional (Directed) Mortality	Electrofishing, Backpack	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Net, Gill	

Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Electrofishing, Backpack	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Seine, Beach	

Breach III Project - Liberty Island

SPECIES	LISTING UNIT/ STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY[7]	TAKE ACTION	OBSERVE/ COLLECT METHOD	PROCEDURES
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	0	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Zooplankton	

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	3	0	Intentional (Directed) Mortality	Net, Zooplankton	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	8	1	Capture/ Handle/ Release Fish	Net, Fyke	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	7	0	Intentional (Directed) Mortality	Net, Fyke	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	8	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	7	0	Intentional (Directed) Mortality	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	8	1	Capture/ Handle/ Release Fish	Net, Fyke	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	7	0	Intentional (Directed) Mortality	Net, Fyke	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	8	1	Capture/ Handle/ Release Fish	Net, Gill	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	7	0	Intentional (Directed) Mortality	Net, Gill	

Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	30	1	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	30	0	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Zooplankton	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	3	0	Intentional (Directed) Mortality	Net, Zooplankton	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Seine, Beach	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	10	1	Capture/ Handle/ Release Fish	Net, Fyke	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	10	1	Capture/ Handle/ Release Fish	Net, Fyke	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Zooplankton	

Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	2	0	Capture/ Handle/ Release Fish	Net, Zooplankton	
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	5	0	Capture/ Handle/ Release Fish	Net, Gill	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	5	0	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Gill	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Larvae	Male and Female	10	0	Capture/ Handle/ Release Fish	Net, Zooplankton	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Net, Fyke	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	3	0	Capture/ Handle/ Release Fish	Seine, Beach	

IEP Gear Efficiency Evaluation Study - Suisun Bay

SPECIES	LISTING UNIT/ STOCK	PRODUCTION/ ORIGIN	LIFESTAGE	SEX	EXPECTED TAKE	INDIRECT MORTALITY[8]	TAKE ACTION	OBSERVE/ COLLECT METHOD	PROCEDURES
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	40	1	Capture/ Handle/ Release Fish	Trawl, Midwater	
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	40	1	Capture/ Handle/ Release Fish	Trawl, Midwater	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	100	3	Capture/ Handle/ Release Fish	Trawl, Midwater	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	40	0	Intentional (Directed) Mortality	Trawl, Midwater	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	40	1	Capture/ Handle/ Release Fish	Trawl, Midwater	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	15	0	Intentional (Directed) Mortality	Trawl, Midwater	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Trawl, Midwater	
Steelhead	Central California Coast (NMFS Threatened)	Natural	Juvenile	Male and Female	10	1	Capture/ Handle/ Release Fish	Seine, Beach	

Steelhead	Central California Coast (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	10	1	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	20	1	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	10	0	Intentional (Directed) Mortality	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Natural	Juvenile	Male and Female	10	1	Capture/ Handle/ Release Fish	Seine, Beach	
Salmon, Chinook	Sacramento River winter-run (NMFS Endangered)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	5	0	Intentional (Directed) Mortality	Seine, Beach	
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Juvenile	Male and Female	1	0	Capture/ Handle/ Release Fish	Seine, Beach	