UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion

Issuance of Section 10(a)(1)(A) Permit 18181-4R to the California Department of Fish and Wildlife

NMFS Consultation Number: WCRO-2021-03116

Action Agency: National Marine Fisheries Service

Affected Species and NMFS' Determinations:

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

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

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Date: January 11, 2022

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1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

1.1. Background

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the NMFS California Central Valley Office.

1.2. Consultation History

- March 30, 2020 – The California Department of Fish and Wildlife (CDFW) submitted their renewal application for Section 10(a)(1)(A) Permit 18181-3A. Since the renewal application was submitted prior to the expiration of Permit 18181-3A, CDFW was informed that interim coverage for the permitted activities would be in place until the renewed permit was issued.

- February 19, 2021 – CDFW approached NMFS regarding proposed modifications to one of their existing Section 10(a)(1)(A) Permits to include monitoring required as part of the Incidental Take Permit No. 2081-2019-066-00 (ITP) issued to the California Department of Water Resources (DWR) in March of 2020 for the operation of the State Water Project (SWP). The ITP describes the necessary conditions to minimize impacts of the SWP on Central Valley spring-run Chinook salmon, among other covered species. Condition of Approval 7.5.2 of the ITP requires DWR to convene an interagency team to support development and implementation of an annual spring-run Chinook salmon Juvenile Production Estimate (JPE).

- April 22, 2021 – NMFS and CDFW met to discuss permitting approaches for new monitoring associated with the spring-run JPE effort. It was determined that the preferred approach would be to consolidate two of CDFW's existing Section 10(a)(1)(A) Permits (14808-5R and 18181-3A), which would be addressed through the renewal process for Permit 18181-3A. The research and monitoring efforts previously covered under CDFW's Section 10(a)(1)(A) Permit 14808-5R were carried over to the renewal application for Permit 18181-3A. The newly proposed spring-run JPE monitoring was incorporated as well.

- May 24, 2021 – CDFW made the final revisions to their application for Permit 18181-4R and submitted it to NMFS through the Applications and Permits for Protected Species (APPS) website.

- August 13, 2021 – NMFS published a notice of receipt in the *Federal Register* outlining the research and enhancement activities proposed under Permit 18181-4R (86 FR 154). The public comment period for Permit 21477 closed September 13, 2021. No comments were received regarding the permit application.

- September 15, 2021 – NMFS and CDFW determined that no additional changes to the application were warranted. NMFS informed CDFW that the application was complete and initiated Section 7 consultation on the issuance of Permit 18181-4R.

1.3. Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Under MSA, Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). We considered, under the ESA, whether the proposed action would cause any other activities and determined that it would not.

CDFW proposes to carry out rescues, research, and monitoring activities throughout California's Central Valley. The upper Sacramento River and its tributaries provide essential spawning and rearing grounds for the Central Valley's salmonid populations. With escapement numbers of Sacramento River winter-run Chinook salmon only measured in the thousands and annual spawning runs of Southern Distinct Population Segment (sDPS) green sturgeon averaging less than 500, any loss to these spawning populations is cause for concern. Further, reduced flows and higher water temperatures in the upper Sacramento River associated with extreme drought conditions may lead to substantial losses to both incubating eggs and emergent fry. Monitoring efforts are conducted in order to compile information on timing, composition (species/run), and relative abundance of Central Valley Chinook salmon and steelhead. This information enables the implementation of adaptive management practices, both up and downstream of the Delta, deemed necessary to protect Central Valley salmonids. Data collected over several years will further our understanding and aid in the recovery and protection of the Sacramento River's anadromous fish populations.

1.3.1. Juvenile Emigration Monitoring

The loss of emigrating fish is increased by the many diversions, such as the Delta Cross Channel Gates (DCC), that lie between their natal streams and the Pacific Ocean. Potentially, the most imposing of these diversions are the Southern Sacramento-San Joaquin Delta's Harvey Banks Delta Pumping Plant (State Water Project [SWP]) and the Tracy Pumping Plant (Central Valley Water Project [CVP]). In March 2020, CDFW issued Incidental Take Permit No. 2081-2019-066-00 (ITP) to the DWR for the operation of the SWP, which describes the necessary conditions to minimize impacts of the SWP on Central Valley spring-run Chinook Salmon, among other covered species. Condition of Approval 7.5.2 of the ITP requires DWR to convene an interagency team to support development and implementation of an annual spring-run Juvenile Production Estimate (JPE).

The work put forth for this study is a continuous effort by combined agencies to reduce the detrimental impacts of the SWP and CVP facilities on Central Valley Chinook salmon and steelhead stocks. The ability to accurately measure the abundance and timing of emigrating salmonids would aid in addressing critical water management procedures. Current water management practices throughout the Sacramento-San Joaquin Delta (Delta) and its corresponding tributaries influence the rate of survival of emigrating salmonids. Improved estimates of the timing and relative abundance of these species as they entered the Delta should improve confidence in defining impacts and protective measures to enhance overall protection, and potentially maximize water management flexibility.

The recommended goals of this monitoring are as follows:

1) Monitor the outmigration of juvenile salmonids on a real-time basis.
2) Provide daily summaries of timing, abundance and size distribution of salmonids in the Sacramento River before they enter the Delta.
3) Provide timing information to water agencies for better management decisions regarding operation of the DCC gates and to reduce frequency of entrainment by the SWP and the CVP.
4) Evaluate how environmental conditions (flow, temperature, turbidity) affect the downstream movement of juvenile salmonids.

The Knights Landing monitoring site, located in Yolo County, was chosen due to its favorable channel structure and flow conditions, as well as its position within the Sacramento River system. The monitoring site at Tisdale Weir provides emigration timing, run composition, and abundance above a frequently topped flood relief weir, the Tisdale Weir, which allows Sacramento River flows to inundate the Tisdale Bypass and, subsequently, the Sutter Bypass during storm driven high flow events. Fish entering the bypass system are routed around the Knights Landing monitoring site, muting measures of increased emigration and abundance used to guide Delta water operations. These monitoring sites are unique in that upstream sites cannot adequately measure the timing of Delta entry due to factors, such as rearing behaviors, delaying Delta entry and changes in survival as fish move downstream. Additionally, downstream monitoring programs cannot accurately distinguish upper Sacramento River salmonids from those originating in the Feather or American rivers.

Currently, all juvenile monitoring on the Feather River is limited to the upper regions of the river, which does not provide an accurate picture of juvenile migration through the Feather to the confluence of the Sacramento River. An additional site positioned lower on the Feather River past the confluence of the Yuba River will be chosen to inform the annual development of the spring-run Chinook salmon JPE. To monitor juvenile salmonid migration past the confluences of the Feather and American rivers, an additional monitoring site (Delta Entry site) will be selected between river mile (RM) 62.5 and RM 73 on the lower Sacramento River. The exact location of the site will be determined based on safety for fish, equipment, staff, and accessibility in varying flow conditions.

Sampling will be conducted using paired 8-foot (diameter) rotary screw traps (RSTs). Traps will be placed on the outside of a wide bend in the river, in the deepest part of the river channel. This is in an area of active emigration that will allow for predictions of emigration timing at various sites downstream, including the Delta. Traps will sample continuously 24 hours per day, 7 days per week from August through June. Data collection is once daily, unless conditions warrant more frequent sampling (*i.e.*, large quantities of debris, high catch numbers, or excessive high flows). Environmental measurements to be recorded are as follows: river discharge (to be determined from the California Data Exchange Center's [CDEC] site managed by DWR), water temperature, depth, and turbidity. All fish will be identified to species. Salmonids will be measured to the nearest millimeter (mm), assessed for life stage, assigned a run (determined using Length-at-Date [LAD] criteria), and weighed to the nearest tenth of a gram. A subsample of fish identified as spring-run Chinook salmon will have genetic sampling conducted via swab. Additionally, a subsample (up to 20 fish per run) of adipose fin-clipped Chinook salmon will be held and euthanized for coded wire tag (CWT) retrieval and analysis. Euthanized adipose fin-clipped Chinook salmon and incidental mortalities that occur may be retained by CDFW or transferred to the NMFS Southwest Fisheries Science Center (SWFSC) for otolith extraction (or other tissues/parts) and analysis.

Trap capture efficiency trials are essential to estimate abundance. The monitoring sites on the Sacramento River will use both captured juvenile Chinook and juvenile Chinook obtained from Coleman National Fish Hatchery for efficiency trials. Juveniles used in the efficiency trials will either be marked with a Visible Implanted Elastomer (VIE) tag or stained with a biological stain, such as Bismarck Brown or Methylene Blue. The site on the lower Feather River will use fish from the Feather River Hatchery. Historically, trap capture efficiency estimates were conducted using only trap captured juveniles. Expanding these efforts to include juveniles obtained from Central Valley hatcheries increases the number of trials conducted throughout the year and the range of environmental conditions during which trials are conducted. Reach survival estimates using acoustically tagged hatchery fish will also be conducted; Coleman National Fish Hatchery fall-run Chinook salmon will be used for release sites on the Sacramento River, and Feather River Hatchery fish will be used for sites on the Feather River.

1.3.2. Central Valley Steelhead Monitoring Program

CDFW has developed a comprehensive Steelhead Monitoring Plan that includes several population monitoring programs targeting steelhead throughout the Sacramento River and San Joaquin River basins. The primary goal is to provide recommendations for the development of steelhead monitoring programs that collect the data necessary to help assess progress towards restoration and recovery goals. Information obtained will be used to examine the distribution, abundance, and population trends of California Central Valley (CCV) steelhead. Important components of the comprehensive plan include: 1) the Mainstem Sacramento River Steelhead Mark-Recapture Program, and 2) the Upper Sacramento River Basin Adult Steelhead Video and Dual-Frequency Identification Sonar (DIDSON) Monitoring Program.

Objectives include:

1) Estimate steelhead population abundance in the Central Valley
2) Examine trends in steelhead abundance in the Central Valley

3) Identify the spatial distribution of steelhead in the Central Valley to identify their current range and observe changes over time.

The Mainstem Sacramento River Mark-Recapture component of the Steelhead Monitoring Program will use a temporally stratified mark-recapture survey design in the lower Sacramento River. The survey will utilize wire fyke traps to capture, mark, and recapture upstream migrating adult steelhead in order to estimate adult steelhead escapement from the Sacramento-San Joaquin Delta. A computer simulation was undertaken to estimate the variability of escapement estimates. Simulation results and the potentially low steelhead capture rate in fyke traps in the lower Sacramento River suggest that at least seven traps should be used for sampling to achieve maximum recapture levels. Tagged steelhead will be released below the most downstream trap to maximize the probability of recapture and provide estimates with an acceptable level of error. The number of traps and release methodology will be re-evaluated during initial implementation. Exact placement of the traps will be determined based on evaluation of habitat requirements, historical recommendations, and past trapping efforts. Traps will be set at a depth that provides sufficient flow to the live well at all times and as close to the bank as possible.

Fyke trapping will occur year-round as conditions (*e.g.*, flow, temperature) allow. A DIDSON camera or device of similar capabilities may be placed at the entrance to the fyke traps to monitor salmonid movements and assist in adjusting trap placement to maximize capture rates. Traps will be fished for 24 hours a day, with all traps being inspected, cleaned, and emptied at least once every 24 hours to minimize the period of time that steelhead are detained. Trap holding periods will be reduced, if capture rates are greater than expected or result in high fish stress levels. Steelhead (five at a time) will be transferred directly from traps using dip nets to an aerated holding tank (> 400 liters) on a sampling boat for processing. Removal of larger and "trouble-maker" fish will occur first to minimize stress to other fish in the trap.

All captured steelhead (hatchery and wild) will be enumerated, weighed, measured, sexed (if possible), photographed for body condition, checked for previous tags, and sampled for scales. Scales will be submitted to the CDFW Central Valley Salmonid Tissue Archive for mounting, photographing, aging, and verification of anadromy. Collection of genetic samples from adult steelhead will provide additional samples for current phylogenetic research occurring through NMFS and CDFW single nucleotide polymorphisms (SNP) programs. Steelhead that are unacceptable for marking and transport (*e.g.*, sick, injured) will be released at the capture site immediately upon recovery from handling. Healthy steelhead captured in good condition will receive a passive integrated transponder (PIT) tag. A genetic sample will also be taken from the upper caudal fin with a 1-millimeter diameter hole-punch, which can also be used to investigate the retention rate of tagged individuals by establishing a permanent mark and providing tissue for the CDFW Tissue Archive. Hatchery-origin steelhead will receive a two inch, individually numbered, Floy tag posterior to the dorsal fin. Floy tags will be used to visually identify individuals and determine the PIT tag-shedding rate of recaptured individuals. A randomly selected subset of captured steelhead will receive an acoustic tag in addition to PIT and Floy tags to determine migration and survival behavior. Individuals selected for acoustic tagging will be surgically tagged with a VEMCO acoustic transmitter tag or similarly compatible device in the abdomen posterior to the pelvic fins. All recaptured steelhead that enter the trap will be released at the site of recapture following recovery from handling.

Tributary-specific run timing and escapement abundance estimates will be produced through recaptures of individuals migrating to spawning tributaries from the lower Sacramento River marking site. Angler harvest will be monitored to determine if tagged fish have been encountered. Hatchery- and natural-origin steelhead will be inspected for tags during handling by hatchery broodstock collection programs at Coleman National Fish Hatchery, Nimbus Fish Hatchery, and Feather River Fish Hatchery. Adult steelhead immigration monitoring in Sacramento River tributaries will be performed using passive monitoring techniques, including maintaining in-stream PIT antennas and operating electronic device counters including video-camera systems, VAKI River-Watchers, and DIDSON/ARIS sonar units. In-stream PIT tag antennas are designed to fit the form of the streambed and allow passive capture of tag information from individuals without disruption of natural behavior. Where applicable, PIT tag antennas are also located within fish ladders. Some electronic device counters are located within fish ladders, while others are operated in-stream using partial fencing to funnel fish into the camera area of the PIT tag antennas. PIT tag antennas and electronic device counters are employed within the following areas: Battle Creek, Cow Creek, Bear Creek, Cottonwood Creek, Clear Creek, Antelope Creek, Mill Creek, Deer Creek, Yuba River, and the American River, Feather River, and Mokelumne River fish hatchery ladders.

Coordination and collaboration among resource agencies will be essential to recapture individuals upstream from the lower Sacramento River fyke-trapping site. Selection of watersheds for recapture monitoring was based on streams that support steelhead runs and have consistent and sufficient spawning and rearing habitat. These methods will have limited negative impacts to individuals. Because the abundance of steelhead in the Sacramento River is low, it is unlikely that escapement estimates can be derived from the proportion of the recaptured PIT-tagged steelhead detected at monitoring sites. However, the recapture of individuals provides valuable data on seasonal, temporal, and behavioral characteristics that can be used to evaluate and enhance monitoring, research, and management goals and objectives. Tributary monitoring sites will be located as close to the confluence with the Sacramento River as workable to maximize the number of recaptures.

1.3.3. Upper Sacramento River Restoration Site Monitoring Program

In a free-flowing river, sediment and other materials are continually moving downstream providing diverse habitats for successful salmonid spawning and juvenile rearing. Below large dams, coarse sediment continues to be transported downstream by the flowing water without it being replaced by upstream sources. In addition, channel complexity is reduced downstream of dams when flows are regulated for reservoir storage and high flow events are attenuated for flood control.

Construction and operations of Shasta Dam on the mainstem Sacramento River have altered the river's normal hydrology, interrupted the transportation of sediment (including spawning gravel) from upstream sources, and have resulted channel simplification and loss of complexity. These changes are most prominent from Keswick Dam (RM 302) to the Cow Creek confluence (RM 278). Section 3406(b)(13) of the CVPIA identifies the need for a continuing restoration program that replaces, as needed, spawning gravel blocked by Shasta Dam, along with creation of juvenile rearing habitat through side-channel construction or enhancement. Monitoring the success of construction and enhancement projects is a critical program element, which is used to inform design of future projects.

Objectives of the Restoration Site Monitoring include:

1) Evaluating the outcome of (b)(13) restoration projects through documentation of spawning activity (redds), and relative abundance of juvenile salmonids utilizing restored habitat.
2) Documenting and quantifying habitat attributes and quantities in restoration sites.
3) Document habitat conditions and fish presence in control sites, and pre and post construction within rehabilitated restoration sites

CDFW staff will conduct redd monitoring and presence/absence surveys for juvenile salmonids via direct observation at a variety of control and restoration sites on the upper Sacramento River, upstream of the Red Bluff Diversion Dam (RBDD) (RM 243). Sampling methods will include snorkel surveys, video surveys, and beach seining. Most monitoring activity will be observational, but will also include minimal handling of juvenile salmonids during beach-seining efforts. The monitoring will occur year-round and will establish baseline use at proposed restoration sites to help determine the success once restoration projects are implemented.

1.3.4. Central Valley Fish Rescues

CDFW's rescue and relocation efforts to date have provided an understanding of timing and magnitude of potential fish entrainment and loss, as well as conditions that can exacerbate the potential for fish entrainment. These efforts have also allowed for methods and protocols to be developed and refined that minimize handling stress and lethal take of ESA-listed species during rescue efforts.

During high flow events, a significant proportion of the Sacramento River is diverted into the Sutter and Yolo Bypass through specific flood relief structures. Substantially more water can be passing through the bypasses than is in the river itself during these flood events. This dramatically alters not just the volume of water in the main channel, but the variations in flow over time. Fish in the river downstream of these flood relief structures experience a drastically different flow regime than fish do upstream of these structures. Furthermore, agricultural diversions and drainages take Sacramento River water and send it through a maze of canals, ditches, and natural streams down the heart of California's Central Valley, from as far north as Glenn County, and drain it back into the Sacramento River just a few miles from where it branches off from the confluence of the San Joaquin River. The main structure running the length of the agricultural area is the Colusa Basin Drainage Canal (CBDC). This influence of Sacramento River water can cause migrating salmon to stray into waterways that are not conducive to spawning or have no easy returns to the River.

Significant reductions in flow also have the potential to entrain salmonids and sturgeon. Stable and continuous river flows are important to the early life history (egg incubation to emergence from the gravel) of salmonids. If redds are dewatered or exposed to warm, deoxygenated water, incubating eggs/larval fish may not survive. After emergence from their redd, juvenile salmon can become stranded in shallow isolated water and be exposed to the same poor environmental conditions as well as increased predation. For the eggs and juveniles to survive, they need water, of a suitable temperature, velocity, and water quality, at all times. Juvenile stranding surveys are usually implemented to observe and report on locations that could potentially contain stranded salmonids that are isolated to varying degrees by flow reductions. Attempts will be made to capture and relocate stranded juveniles to more suitable habitat. Further, CDFW will assist with the emergence of stranded fry in redds at risk of being dewatered. This effort will be considered as a last resort to increase the opportunity for juvenile Sacramento River winter-run Chinook salmon to emerge from a redd that is going to be dewatered by flow reductions.

Objectives of CDFW's Fish Rescue efforts are to:

1) Capture, tag, and relocate Sacramento River winter-run Chinook salmon and other species of management concern in the lower reaches of the CBDC at the Wallace Weir within the Yolo Bypass.
2) Construct and place modified fyke traps at key locations within the interior of the CBDC system to capture, tag and relocate stranded fish, if fish passage occurs at the Wallace Weir Trapping Facility.
3) If environmental conditions (such as high flows or flooding) warrant monitoring and rescue of fish entrained behind Fremont and Tisdale weirs, CDFW aims to assess the level of entrainment and evaluate the survival and behavior of entrained adults that are rescued and relocated.
4) Monitor winter-run Chinook salmon redds by identification of redds at risk of being dewatered, marking of redds, and repeated measurements of water levels around redds. This monitoring allows CDFW biologists to predict the flow at which redds will be dewatered on a redd-by-redd basis.
5) If deemed necessary, CDFW may physically modify redds in danger of being dewatered to lessen the impacts to emerging juveniles within each redd.
6) Survey known stranding sites immediately following Keswick Dam flow reductions (as feasible), to determine if a fish rescue is necessary.
7) Conduct fish rescues in Shasta and Tehama counties including, but not limited to, the following locations: Sacramento River, Deer Creek, Mill Creek, Antelope Creek, and various urban streams as needed.
8) Identify conditions resulting in high levels of entrainment specific to each location.

The following monitoring, rescue, and relocation activities may be conducted by CDFW to reduce potential losses of ESA-listed fish species within California's Central Valley.

1.3.4.1. Wallace Weir Trapping and Relocation Operation

CDFW identified Wallace Weir in the Knights Landing Ridge Cut (KLRC) as a location where anadromous fish species could be captured and relocated to the Sacramento River before they enter the CBDC. On June 20, 2016, NMFS completed a Section 7 Consultation with the U.S. Army Corps of Engineers (USACE) for the Wallace Weir Fish Rescue Project (WCR-2016-5014). The project involved construction of a new, permanent weir, installation of a positive fish barrier (*i.e.,* picket weirs), demolition of the existing weir, and construction of a permanent fish rescue facility. Although the biological opinion issued to the USACE authorizes the construction activities outlined above, it does not authorize the rescue and relocation of ESA-listed salmonids and green sturgeon at the new fish trapping facility. Operation of the new fish collection facility for purposes of collecting, handling, and transporting captured fish will be carried out by CDFW.

The new Wallace Weir Fish Collection Facility is located at the terminus of the KLRC and the west levee of the Yolo Bypass, approximately three miles north of Interstate 5 and five miles northeast of the City of Woodland. The new permanent structure improves flow control for agricultural purposes and facilitates efficient salvage and relocation of fish from the KLRC to the Sacramento River. Adult salmonids and sDPS green sturgeon may enter the Yolo Bypass at the Cache Slough Complex and migrate upstream into the KLRC and the CBDC. In the event that the facility is inoperable, CDFW will continue to collect fish below Wallace Weir and relocate the fish to the Sacramento River.

Wallace Weir Fish Rescue Program Objectives:

1) Collect and relocate listed salmonids and sDPS green sturgeon, and other species of concern (*e.g.*, fall-run Chinook salmon, white sturgeon) that become entrained at the fish collection facility at Wallace Weir.
2) Record and report the numbers and species composition of trapped fish to NMFS and other interested agencies (*i.e.*, DWR), and maintain a program database.
3) Mark and/or tag listed salmonids, sDPS green sturgeon, and other species of concern collected at the facility and collect genetic samples.
4) Refine fish rescue methods to minimize handling stress and costs of operations.
5) Document the magnitude of stranding of listed salmonids, sDPS green sturgeon, and other species of concern and to the extent possible document survival and spawning success of fish through mark and recapture methods and biotelemetry.
6) Document any weir over-topping resulting in the potential for fish to move into the CBDC. This will be used to inform the need for potential rescues in other areas of the CBDC watershed.

CDFW will check the fish collection facility at Wallace Weir on a daily basis or more frequently, if necessary. The facility will impound all fish species, so all fish present will be handled and removed from the fish collection facility. Target species and species of management concern will be prioritized for collection, processing, transportation, and release back to the Sacramento River. The Sacramento River release location(s) will be evaluated and may vary with species and time of year, but will only occur in locations where DWR or CDFW have property rights or landowner permission to carry out fish releases. All salmonids and sturgeon will be identified to species, measured and evaluated for condition, and sexed, if possible. To document the magnitude of stranding of ESA-listed fish, genetic samples will be collected from all salmonids. To allow information to be gathered on movement, survival, and spawning success after releases, salmonids and sturgeon that are rescued will be marked and/or tagged. Species other than target species or species of management concern that are found in the facility will be passed through to the upstream or downstream side of the weir using infrastructure incorporated into the facility.

1.3.4.2. Rescue and Salvage Operations in the Upper Colusa Basin Drainage Canal

During Fremont Weir overtopping events, Yolo Bypass flows may also overtop the Wallace Weir Fish Collection Facility resulting in listed fish species continuing upstream in the KLRC to the CBDC. If fish passage is thought to occur, CDFW will initiate a roving survey using DIDSON imagery at known choke points within the CBDC and associated tributaries to look for listed salmonids or sDPS green sturgeon (target species). Once target species presence is determined, in the CBDC, CDFW will focus efforts to capture and then relocate the wayward fish to the Sacramento River.

Semi-permanent barriers and fyke traps may be installed upstream in key areas within the CBDC, such as the CBDC diversion structure at the juncture of Hunter Creek, under the 4 Mile Road Bridge and Dam 3 on Hunters Creek, Dam 1 at North Logan Creek, the confluence of Logan and North Logan Creeks, the confluence of Stone Corral Creek and Funks Creek, and the CBDC near the Delevan National Wildlife Refuge. CDFW observed ESA-listed salmonids during the 2012-2013 water year at these locations after they entered the CBDC via the KLRC. Similar to target species rescued at the Wallace Weir Fish Collection Facility, fish will be measured, sampled for tissues, tagged externally with two individually numbered Floy tags, placed in a fish transport tank, and returned to the Sacramento River.

If and when fish passage is thought to occur (in the unlikely event that the trapping facility experiences operational issues), CDFW will initiate a roving survey using DIDSON imagery at known choke points within the CBDC and associated tributaries to look for focal species. Sonar imagery will help to identify substrate complexity, species presence/absence, and potential capture equipment needed for a rescue. Sonar imagery will also be helpful in identifying underwater hazards that may foul capture gear or be dangerous for CDFW personnel.

Once target species are determined to be present at any one location in the CBDC, CDFW will focus efforts to capture and then relocate fish to the Sacramento River. Semi-permanent barriers and fyke traps may be installed upstream in key areas within the CBDC. These areas may include the CBDC diversion structure at the juncture of Hunter Creek, under the 4 Mile Road Bridge and Dam 3 locations on Hunters Creek, Dam 1 at North Logan Creek, the confluence of Logan and North Logan Creeks, the confluence of Stone Corral Creek and Funks Creek, and the CBDC near the Delevan NWR. CDFW discovered that fish strayed to these locations during 2012-2013. Each rescued fish will be measured, sampled for tissues (genetic testing), externally tagged with two individually numbered Floy tags, placed in a fish transport tank, and returned to the Sacramento River near Tisdale Weir.

1.3.4.3. Tisdale, Sacramento, and Fremont Weirs Rescue and Relocation

Flooding of the Yolo and Sutter bypasses results in up to 80 percent of flows in the Sacramento River basin being diverted from the Sacramento River into the Tisdale, Sutter, Yolo, and Sacramento bypasses to protect populated areas from flooding. Anadromous fish species are attracted to these bypass flows and as a result alter their migration routes. When flood waters recede, both upstream and downstream migrating anadromous fish may become entrained downstream of flood control weirs including the Tisdale, Fremont, and Sacramento weirs. Among these are federal and state anadromous listed species, including Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. Even in years when the Fremont Weir does not spill, west side tributary and drainage canal flows can attract anadromous fish into the Yolo Bypass at the Cache Slough complex, particularly during periods of high tides and low Sacramento River flows. Fish attracted by west side stream and drainage canal flows migrate upstream through the Toe Drain, Tule Canal, KLRC, and CBDC. Fish attracted into the Yolo Bypass by west side tributary and drainage canal flows are unable to return to the Sacramento River when river flows are not overtopping weirs and may become isolated and stranded.

Entrainment and stranding within the bypasses can result in considerable mortality for listed fish species. It is crucial to identify the level of impact that flood relief structures and diversions are having on populations of ESA-listed species and to identify whether rescued fish can successfully contribute to the population. CDFW aims to identify: 1) the level of entrainment and stranding into Sacramento River flood relief structures and bypasses, 2) the survival and behavior of entrained adults that are rescued, and 3) the conditions resulting in high levels of entrainment specific to each location. The Tisdale, Sutter, and Yolo bypasses will be surveyed after weir overtopping events with a specific focus on Tisdale, Sacramento, and Fremont weirs. In the event of stranding of listed fish species, DWR and the U.S. Bureau of Reclamation have contracted with CDFW to conduct fish rescue operations as necessary (DWR 2010, Flood Operations Branch, Fact Sheet Sacramento River Flood Control Project Weirs and Flood Relief Structures).

Any stranded adult sturgeon will be captured, if possible, using block nets and hoop nets, measured and tagged both acoustically (internal VEMCO acoustic tags) and with two colored and individually numbered Floy tags. If any adult or juvenile salmonids are found to be entrained during rescue efforts, they will be captured using beach seines and their presence will be documented. Adult salmonids will be tagged with two colored and individually numbered Floy tags. Steelhead (adults and juveniles) may also receive a PIT tag as part of CDFW's Steelhead Monitoring Program. All rescued fish will be transported to the nearest Sacramento River location and released.

1.3.4.4. Upper Sacramento River Basin Redd Dewatering and Stranding Surveys

Stable and continuous river flows are important to the early life history stages of salmonids, including egg incubation and pre-gravel emergence. Flow reductions during these developmental periods have the potential to cause mortality through dewatering and poor water quality. Beginning in 2013, CDFW agreed to annually monitor winter-run Chinook salmon redds that may be dewatered as a result of flow reductions from Keswick Reservoir. Redds in shallow water will be identified and monitored by boat crews to determine formation date and subsequent emergence date of each redd. If dewatering of redds appears likely, CDFW may take action to reduce the impacts of dewatering.

CDFW understands that the ideal situation is not to disturb Chinook salmon redds at all. However, in case of dewatered redds, the disturbance is justified as an attempt to provide as much opportunity for survival as possible, while minimizing disturbance. As redds become dewatered, the top of the redd emerges from the water preventing emergent fry from exiting through the top of the redd. Further, the water velocity around the remaining redd area is typically reduced, resulting in less flow through the redd. This can trap emerging fry, preventing them from departing through the underwater sides of the redd. It may also reduce available dissolved oxygen and raise water temperatures. Removing substrate from the top of dewatered redds produces more flow over and through the redd, and theoretically, allows for increased alevin emergence.

Just prior to a Keswick flow reduction (1-2 days), if deemed necessary, a field crew will gently remove substrate from the tops of redds that are likely to become dewatered (*e.g.*, redds in water 2-3 inches or less before a 250 cubic feet per second [cfs] reduction). Crews can attempt to remove by hand the rocks from the tops of redds to a sufficient depth that will allow water to remain freely flowing over the redd top after the forecasted flow reduction. Redd tops will be removed using a slow and gentle manner to minimize abrasion impacts to fry in the uppermost area removed. Water velocity will be measured at the redd before and after the substrate removal process. Water depth measured from the redd top to the water surface will also be recorded pre and post rock removal. Photographs will document the substrate removal process. Numbers of fry observed during the redd removal will be noted. Crews will revisit and repeat if necessary on the monitored redds until after the emergence date of each redd in the effort has passed. If any redds become entirely dewatered, CDFW staff may remove rocks and dig up redd to determine the level of mortality that occurred as a result of dewatering the redd. It is important to document whether there is significant mortality occurring due to flow reductions and changes in water operations in the upper Sacramento River.

CDFW staff will also survey known stranding sites immediately following Keswick flow reductions (as feasible), to determine if a fish rescue is necessary. Juvenile salmonids can become stranded when reduced result in hydrological isolation of aquatic habitat, such as naturally occurring and man-made side channels that become disconnected from the main Sacramento River channel. Stranding can lead to direct mortality from desiccation, poor water quality, and increased predation (Jarret and Killam 2014). If a fish rescue is determined to be necessary, CDFW staff will use beach seines, dip nets or, as a last resort, backpack electrofishing gear to capture stranded juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and CCV steelhead. Fish will be enumerated by species and Evolutionarily Significant Unit (ESU), as determined by visual estimation using LAD criteria. Fish are then immediately transported by bucket to an adjacent river section that is not isolated and released (see Jarret and Killam 2014 for data collection protocols). Side channel sites (both natural and restored) may also be surveyed in order to get lengths and weights on captured Chinook salmon to calculate condition factor of fish using various restored habitats.

Fish rescues may also be conducted in Shasta and Tehama counties, including the following locations: Deer Creek, Mill Creek, Antelope Creek, and various urban streams. Fish rescues may also occur on other Sacramento River tributaries, but are not anticipated on a regular basis as those mentioned above. Water diversion structures along various creeks and tributaries to the upper Sacramento River have the potential to entrain ESA-listed salmonids. Although screened, these diversions have not been equipped with fish bypass return structures. When these diversions are operated in the spring, out-migrating juvenile Chinook salmon, juvenile steelhead, adult steelhead kelts, and other fish are drawn into the ditches and are trapped between the diversion head gates and the fish screens. Once entrained, these fish must be manually captured and released downstream of the diversion or they will succumb to predation or lethal summer water temperatures.

In the Sacramento River tributaries, the primary capture method will be beach seining. When seining is not feasible, other methods, such as fyke netting, backpack electroshocking or hook and line, may be used as a last resort. If necessary, a one-ton flatbed truck fitted with a 200-gallon oxygenated water tank will be used to transport rescued salmonids. If staff identify a suitable release location nearby, fish may be relocated by hand (aerated buckets) to avoid transportation by truck.

1.4. Measures to Minimize Impacts Applied to all Research Permits

Research permits lay out the conditions to be followed before, during, and after the research activities are conducted. These conditions are intended to (a) manage the interaction between scientists and listed salmonids by requiring that research activities be coordinated among permit holders and between permit holders and NMFS, (b) minimize impacts on listed species, and (c) ensure that NMFS receives information about the effects the permitted activities have on the species concerned. All research permits the NMFS' WCR issues have the following conditions:

1. The permit holder must ensure that listed species are taken only at the levels, by the means, in the areas and for the purposes stated in the permit application, and according to the terms and conditions in the permit.
2. The permit holder must not intentionally kill or cause to be killed any listed species unless the permit specifically allows intentional lethal take.
3. The permit holder must handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided (*e.g.*, the holding units must contain adequate amounts of well-circulated water). When using gear that captures a mix of species, the permit holder must process listed fish first to minimize handling stress.
4. The permit holder must stop handling listed juvenile fish if the water temperature exceeds 72 degrees Fahrenheit (°F) at the capture site[1]. Under these conditions, listed fish may only be visually identified, counted, and released. In addition, electrofishing is not permitted if water temperature exceeds 64°F to minimize the potential for increased stress and incidental mortality associated with higher water temperatures.
5. If the permit holder anesthetizes listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

[1] This measure deviates from the standard permit language, which states, "The permit holder must stop handling listed juvenile fish if the water temperature exceeds 70 degrees Fahrenheit (°F) at the capture site. Under these conditions, listed fish may only be visually identified and counted." These temperature limits have been increased for Permit 18181-4R to account for the frequent occurrence of elevated water temperatures in the mainstem Sacramento River and the suboptimal conditions that are typically present when rescue activities are conducted.

6. The permit holder must use a sterilized needle for each individual injection when PIT tags are inserted into listed fish.
7. If the permit holder unintentionally captures any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported to NMFS as soon as possible, but no later than two business days.
8. The permit holder must exercise care during spawning ground surveys to avoid disturbing listed adult salmonids when they are spawning. Researchers must avoid walking in salmon streams whenever possible, especially where ESA-listed salmonids are likely to spawn. Visual observation must be used instead of intrusive sampling methods, especially when the only activity is determining fish presence.
9. The permit holder using backpack electrofishing equipment must comply with the June 2020 NMFS' Backpack Electrofishing Guidelines (NMFS 2000). Link: https://media.fisheries.noaa.gov/dam-migration/electro2000.pdf
10. The permit holder must obtain approval from NMFS before changing sampling locations or research protocols.
11. The permit holder must notify NMFS as soon as possible, but no later than two business days, after any authorized level of take is exceeded or if such an event is likely. The permit holder must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.
12. The permit holder is responsible for any biological samples collected from ESA-listed species as long as they are used for research purposes. The permit holder may not transfer biological samples to any person or entity not listed in the application without prior written approval from NMFS.
13. The person(s) actually doing the research must carry a copy of this permit while conducting the authorized activities.
14. The permit holder must allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.
15. The permit holder must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.
16. The permit holder may not transfer or assign this permit to any other person as defined in Section 3(12) of the ESA. This permit ceases to be in effect if transferred or assigned to any other person without NMFS' written authorization.
17. NMFS may amend the provisions of this permit after giving the permit holder reasonable notice of the amendment.
18. The permit holder must obtain all other Federal, state, and local permits/authorizations needed for the research activities.
19. On or before January 31 of every year, the permit holder must submit to NMFS a post-season report in the prescribed form describing the research activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the research results. The report must be submitted electronically on the Applications and Permits for Protected

Species (APPS) website where downloadable forms can also be found. Falsifying annual reports or permit records is a violation of this permit.

20. If the permit holder violates any permit condition, they will be subject to any and all penalties provided by the ESA. NMFS may revoke this permit, if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA Section 10(d) findings are no longer valid.

"Permit holder" means the permit holder or any employee, contractor, or agent of the permit holder. In addition, NMFS may include conditions specific to the proposed research in the individual permits.

Finally, NMFS will use the annual reports to monitor the actual number of listed fish that are taken every year by scientific research activities and will adjust permitted take levels if they are deemed to be excessive or if cumulative take levels rise to the point where they are detrimental to the listed species.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

2.1. Analytical Approach

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

This opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

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

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.2. Rangewide Status of the Species and Critical Habitat

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

Table 1. Description of Covered Species, Current ESA Listing Classifications, and Summary of Species Status

Species	Listing Classification and Federal Register Notice	Status Summary
Sacramento River winter-run Chinook salmon ESU	Endangered, 70 FR 37160; June 28, 2005	According to the NMFS 5-year species status review (NMFS 2016c), the extinction risk of the Sacramento River winter-run Chinook salmon ESU has increased from moderate risk to high risk of extinction since the 2007 and 2010 assessments. Based on the Lindley *et al.* (2007) criteria, the population is at high extinction risk in 2019. High extinction risk for the population was triggered by the hatchery influence criterion, with a mean of 66 percent hatchery origin spawners from 2016 through 2018. Several listing factors have contributed to the recent decline, including drought, poor ocean conditions, and hatchery influence. Thus, large-scale fish passage and habitat restoration actions are necessary for improving the winter-run Chinook salmon ESU viability.
Central Valley spring-run Chinook salmon ESU	Threatened, 70 FR 37160; June 28, 2005	According to the NMFS 5-year species status review (NMFS 2016b), the status of the Central Valley spring-run Chinook salmon ESU, until 2015, has improved since the 2010 5-year species status review. The improved status is due to extensive restoration, and increases in spatial structure with historically extirpated populations (Battle and Clear creeks) trending in the positive direction. However, recent declines of many of the dependent populations, high pre-spawn and egg mortality during the 2012 to 2016 drought, uncertain juvenile survival during the drought are likely increasing the ESU's extinction risk. Monitoring data showed sharp declines in adult returns from 2014 through 2018 (CDFW 2018).

Species	Listing Classification and Federal Register Notice	Status Summary
California Central Valley steelhead Distinct Population Segment (DPS)	Threatened, 71 FR 834; January 5, 2006	According to the NMFS 5-year species status review (NMFS 2016a), the status of CCV steelhead appears to have remained unchanged since the 2011 status review that concluded that the DPS was in danger of extinction. Most natural-origin CCV populations are very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to natural-origin fish. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.
Southern DPS of North American green sturgeon	Threatened, 71 FR 17757; April 7, 2006	According to the NMFS 5-year species status review (NMFS 2015) and the 2018 final recovery plan (NMFS 2018b), some threats to the species have recently been eliminated, such as take from commercial fisheries and removal of some passage barriers. Also, several habitat restoration actions have occurred in the Sacramento River Basin, and spawning was documented on the Feather River. However, the species viability continues to face a moderate risk of extinction because many threats have not been addressed, and the majority of spawning occurs in a single reach of the main stem Sacramento River. Current threats include poaching and habitat degradation. A recent method has been developed to estimate the annual spawning run and population size in the upper Sacramento River so species can be evaluated relative to recovery criteria (Mora *et al.* 2018).

Table 2. Description of Critical Habitat, Listing, and Status Summary

Critical Habitat	Designation Date and Federal Register Notice	Description
Sacramento River winter-run Chinook salmon ESU	June 16, 1993; 58 FR 33212	Designated critical habitat includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge. The designation includes the river water, river bottom and adjacent riparian zones used by fry and juveniles for rearing. PBFs considered essential to the conservation of the species include: Access from the Pacific Ocean to spawning areas; availability of clean gravel for spawning substrate; adequate river flows for successful spawning, Incubation of eggs, fry development and emergence, and downstream transport of juveniles; water temperatures at 5.8–14.1 degrees Celsius (°C) (42.5–57.5°F) for successful spawning, egg incubation, and fry development; riparian and floodplain habitat that provides for successful juvenile development and survival; and access to downstream areas so that juveniles can migrate from spawning grounds to the San Francisco Bay and the Pacific Ocean. Although the current conditions of PBFs for winter-run critical habitat in the Sacramento River are significantly limited and degraded, the habitat remaining is considered highly valuable.

Critical Habitat	Designation Date and Federal Register Notice	Description
Central Valley spring-run Chinook salmon ESU	September 2, 2005; 70 FR 52488	Critical habitat for Central Valley spring-run Chinook salmon includes stream reaches of the Feather, Yuba and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. PBFs considered essential to the conservation of the species include: spawning habitat; freshwater rearing habitat; freshwater migration corridors; and estuarine areas. Although the current conditions of PBFs for spring-run Chinook salmon critical habitat in the Central Valley are significantly limited and degraded, the habitat remaining is considered highly valuable.
California Central Valley steelhead DPS	September 2, 2005; 70 FR 52488	Critical habitat for CCV steelhead includes stream reaches of the Feather, Yuba and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. PBFs considered essential to the conservation of the species include spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine areas. Although the current conditions of PBFs for CCV steelhead critical habitat are significantly limited and degraded, the habitat remaining is considered highly valuable.

Critical Habitat	Designation Date and Federal Register Notice	Description
Southern DPS of North American green sturgeon	October 9, 2009; 74 FR 52300	Critical habitat includes the stream channels and waterways in the Delta to the ordinary high water line. Critical habitat also includes the main stem Sacramento River upstream from the I Street Bridge to Keswick Dam, the Feather River upstream to the fish barrier dam adjacent to the Feather River Fish Hatchery, and the Yuba River upstream to Daguerre Dam. Critical habitat in coastal marine areas include waters out to a depth of 60 fathoms, from Monterey Bay in California, to the Strait of Juan de Fuca in Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are included as critical habitat for sDPS green sturgeon. PBFs considered essential to the conservation of the species for freshwater and estuarine habitats include: food resources, substrate type or size, water flow, water quality, migration corridor; water depth, sediment quality. In addition, PBFs include migratory corridor, water quality, and food resources in nearshore coastal marine areas. Although the current conditions of PBFs for sDPS green sturgeon critical habitat in the Central Valley are significantly limited and degraded, the habitat remaining is considered highly valuable.

Species-specific status information, including abundance estimates by life stage and hatchery or naturally produced fish, is discussed in more detail below. For most of the listed species, we estimate abundance for adult returning fish and outmigrating smolts. Estimates of adult abundance often come from annual spawning surveys or counts at dams, weirs, or fish ladders, and may or may not differentiate natural-origin from hatchery-origin fish. For some ESUs and DPSs, long-term adult abundance data are available for all or most populations, while others are lacking complete or continuous monitoring data. For hatchery-origin juvenile salmonids, we use hatchery production goals. In many cases, estimates of naturally produced outmigrating juveniles are not available from monitoring data, and are instead estimated from adult spawner abundance, any known estimate of spawner fecundity, and average egg-to-smolt survival rates.

These estimates should be viewed with caution, as they only address one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including:

- The available data often do not include all populations;
- Spawner counts and associated sex ratios and fecundity estimates can vary widely between years;
- Multiple juvenile age classes (fry, parr, smolt) are present, yet comparable data sets may not exist for all of them;
- Survival rates between life stages are often poorly understood and subject to a multitude of natural and human-induced variables (*e.g.*, predation, floods, fishing, *etc*.); and
- In the case of steelhead, it can be very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead (both *O. mykiss*) during surveys.

2.2.1. Sacramento River winter-run Chinook salmon

To estimate annual abundance of adult spawners (natural- and hatchery-origin), we calculate the average of the most recent three years of adult spawner counts (2017 through 2019) from surveys conducted by CDFW (GrandTab 2021). The average total abundance for Sacramento River winter-run Chinook salmon is 3,702 adult spawners. Adult hatchery broodstock numbers during these years have averaged 180 adults. Therefore, the total average adult escapement for winter-run Chinook salmon is 3,882 (Table 3).

It is important to note that the natural-origin adult escapement estimate is based on adult returns that were produced during the recent severe drought in California's Central Valley. Juvenile winter-run Chinook salmon production during 2015-2017 was low as a result of poor conditions affecting survival during outmigration through the Delta (averaging 130,809 juveniles). Early estimates of adult winter-run Chinook salmon escapement during 2020 and 2021 appear to be much higher than those from 2017-2019 (CDFW GrandTab 2021). Therefore, the average adult escapement used in our analysis likely represents a conservative estimate of the natural-origin adult abundance.

Annually, NMFS calculates a winter-run Chinook salmon JPE, pursuant to the biological opinion on the long-term operations of the CVP and SWP (NMFS 2009, NMFS 2019). The JPE is the estimated number of juvenile Sacramento River winter-run Chinook salmon expected to enter the Sacramento-San Joaquin Delta. The estimate is used to determine the authorized level of incidental take, under Section 7 of the ESA, for Sacramento River winter-run Chinook salmon while operating the CVP and SWP Delta Pumping Facilities. Therefore, the expected number of outmigrating natural-origin juvenile winter-run Chinook salmon is the average JPE from the last three brood years (2017-2019). These brood years were produced during 2017-2019 and emigrated as juveniles during the following water years (*i.e*., 2018-2020).

Like the discussion for adults above, the juvenile winter-run Chinook salmon produced during 2017-2019 come from a limited number of adult returns, due to poor survival during prior drought years (2015-2017). The JPE for brood year 2019 shows an increase in juvenile production as the population began to rebound from the effects of prolonged drought (854,941 juveniles estimated to enter the Delta). However, similar to the discussion for adult abundance above, the average juvenile abundance used for this analysis should be viewed as a conservative estimate.

Livingston Stone National Fish Hatchery is the only hatchery that produces Sacramento River winter-run Chinook salmon. Therefore, the annual number of hatchery-origin winter-run Chinook salmon produced is calculated by averaging the releases from Livingston Stone National Fish Hatchery during 2017-2019 (USFWS unpublished data)

Table 3. Sacramento River winter-run Chinook salmon Abundance Estimates

Life Stage	Average Annual Abundance Estimates
Adult Escapement (2017-2019)	3,882
Juvenile Production Estimate Average for natural-origin winter-run Chinook salmon (brood years 2017-2019)	496,509
Hatchery Releases from Livingston Stone NFH (2017-2019)[1]	327,669

[1]2018-2019 also include hatchery-origin winter-run Chinook salmon releases into Battle Creek as part of the Reintroduction Jumpstart Project.

2.2.2. Central Valley spring-run Chinook salmon

To estimate annual abundance of adult spawners (natural- and hatchery-origin), we calculate the average of the most recent five years of adult spawner counts (2017 through 2019) from surveys conducted by CDFW (GrandTab 2021). The average total abundance for Central Valley spring-run Chinook salmon is 6,672 adult spawners. This estimate does not include adult spring-run Chinook salmon spawners from the Feather River, due to the temporal and spatial overlap of spring- and fall-run Chinook salmon spawning that occurs. However, the Feather River Hatchery implements a tagging program for early-arriving (phenotypic spring-run) Chinook salmon, which allows them to identify spring-run Chinook salmon broodstock when they return to spawn in the fall. Fish ascending the fish ladder between April 1 and June 30 are tagged and released back to the Feather River. The number of phenotypic spring-run Chinook salmon tagged at the Feather River Hatchery provides an annual estimate of spring-run Chinook salmon adult spawners in the Feather River. This estimate also includes adults that are used as hatchery broodstock, since only tagged individuals will be used during spawning in the fall. The average number of adult spring-run Chinook salmon tagged at the Feather River Hatchery from 2017-2019 is 3,304. Therefore, the total average adult escapement (including Feather River adults) for spring-run Chinook salmon is 9,976 (Table 4).

The expected natural-origin juvenile production estimate was developed by applying the average fecundity of 4,161 eggs per female (CDFG 1998) to the estimated 4,988 females returning (half of the most recent three-year average of spawners), and applying an estimated survival rate from egg to smolt of 10 percent. Using this approach, an average of 2,075,507 natural-origin juvenile spring-run Chinook salmon are expected to be produced annually.

The Feather River Hatchery is the only hatchery that produces Central Valley spring-run Chinook salmon (with the exception of the San Joaquin Salmon Conservation and Research Facility). Therefore, the annual number of hatchery-origin spring-run Chinook salmon produced is calculated by averaging the releases from the Feather River Hatchery during recent years (CDFW and DWR 2018).

Table 4. Central Valley spring-run Chinook salmon Abundance Estimates

Life Stage	Average Annual Abundance Estimates
Average Adult Escapement (2017-2019)	9,976
Expected Natural-origin Juvenile Production	2,075,507
Average Annual Hatchery Releases from Feather River Hatchery (2006-2017)	2,025,571

2.2.3. California Central Valley steelhead

To estimate annual abundance for adult spawners (natural- and hatchery-origin) we use the average of the estimated run sizes for the most recent three years (2017-2019) from populations with available survey data (Scriven *et al.* 2018, additional unpublished data provided by the NMFS SWFSC; Table 5). It should be noted that these estimates do not include data from a number of watersheds where steelhead are known to be present, and therefore likely represent an underestimate of adult abundance for the DPS.

Both adult and juvenile abundance data are limited for this DPS. While we currently lack data on naturally produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data for adults (Table 5). However, the sum of the annual hatchery adult broodstock goals (1,820 adults; CDFW unpublished data, USFWS 2011) have been subtracted from the total to account for the separate juvenile hatchery production estimate.

For the species, fecundity estimates range from 3,500 to 12,000, and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females, 16.9 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 1,100,418 natural-origin outmigrants annually (Table 5).

The sum of expected annual releases from all of the hatchery programs is used to estimate the abundance of outmigrating hatchery-origin juvenile CCV steelhead (CDFW unpublished data, USFWS 2011; Table 5).

Table 5. California Central Valley steelhead Abundance Estimates

Life Stage	Average Annual Abundance Estimates
Average Adult Escapement (2017-2019)	11,494
Natural-origin Juveniles	1,100,418
Hatchery-origin Juveniles	1,730,000

2.2.4. Southern DPS green sturgeon

A Southern DPS green sturgeon population estimate was developed by Mora *et al.* (2018) through DIDSON surveys of aggregation sites conducted from 2010-2015 in the upper Sacramento River. Mora *et al.* (2018) estimated the total population size to be 17,548 individuals (95 percent confidence interval [CI] = 12,614-22,482). These surveys estimate the abundance of sDPS green sturgeon adults at 2,106 individuals (95 percent CI = 1,246-2,966) (Mora 2016, Mora *et al.* 2018). A conceptual demographic structure applied to the adult population estimate resulted in the sDPS subadult population estimate of 11,055 (95 percent CI = 6,540-15,571) and juvenile population estimate of 4,387 (95 percent CI = 2,595-6,179) (Mora *et al.* 2018). These estimates do not include the number of spawning adults in the lower Feather or Yuba rivers, where green sturgeon spawning was recently confirmed (Seesholtz *et al.* 2014).

Table 6. Southern DPS green sturgeon Abundance Estimates

Life Stage	Estimate	95% Confidence Interval (Low)	95% Confidence Interval (High)
Adult	2,106	1,246	2,966
Sub-Adult	11,055	6,540	15,571
Juvenile	4,387	2,595	6,179
DPS Abundance	17,548	12,614	22,482

2.2.5. Recovery Plans

In July 2014, NMFS released a final Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and CCV steelhead (NMFS 2014). The Recovery Plan outlines actions to restore habitat and access, and improve water quality and quantity conditions in the Sacramento River to promote the recovery of listed salmonids. Key recovery actions in the Recovery Plan include conducting landscape-scale restoration throughout the Delta, incorporating ecosystem restoration into Central Valley flood control plans that includes breaching and setting back levees, and restoring flows throughout the Sacramento and San Joaquin River basins and the Delta. In August 2018, NMFS released a final Recovery Plan for the sDPS green sturgeon (NMFS 2018), which focuses on fish screening and passage projects, floodplain and river restoration, and riparian habitat protection in the Sacramento River Basin, the Delta, San Francisco Estuary, and nearshore coastal marine environment as strategies for recovery.

2.2.6. Global Climate Change

One major factor affecting threatened and endangered anadromous fish in the Central Valley and aquatic habitat at large is climate change.

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen *et al*. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991, Dettinger *et al*. 2004). Specifically, the Sacramento River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1987, Roos 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. The large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (VanRheenen *et al*. 2004). Factors modeled by VanRheenen *et al*. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100 percent in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (VanRheenen *et al*. 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where the snowpack is shallower than in the San Joaquin River watersheds to the south.

Projected warming is expected to affect Central Valley Chinook salmon. Because the runs are restricted to low elevations as a result of impassable rim dams, if temperatures rise by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon populations can persist (Williams 2006). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951- 1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the Central Valley are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats used by naturally produced fall-run Chinook salmon are thermally acceptable. This would particularly affect fish that emigrate as fingerlings, mainly in May and June, and especially those in the San Joaquin River and its tributaries.

For Sacramento River winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. The only remaining population of Sacramento River winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates *et al*. 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008, Beechie *et al*. 2012, and Dimacali 2013). These factors will compromise the quantity and/or quality of SR winter-run Chinook salmon habitat available downstream of Keswick Dam. It is imperative for additional populations of winter-run Chinook salmon to be reestablished into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (NMFS 2014).

Central Valley spring-run Chinook salmon adults are vulnerable to climate change, because they over-summer in freshwater streams before spawning in autumn (Thompson *et al*. 2011). Central Valley spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia, usually provided by springs, will be more susceptible to impacts of climate change. In years of extended drought and warming water temperatures, unsuitable conditions may occur even in tributaries with cool water springs. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating and would be susceptible to warming water temperatures. In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser *et al*. 2013).

Although steelhead will experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile steelhead, which range from 14°C to 19°C (57°F to 66°F). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough *et al*. 2001). In fact, McCullough *et al*. (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F). Successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F), as reported in Richter and Kolmes (2005). As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support wild CCV steelhead populations.

The sDPS green sturgeon spawn primarily in the Sacramento River in the spring and summer. ACID is considered the upriver extent of green sturgeon passage in the Sacramento River. The upriver extent of green sturgeon spawning, however, is approximately 30 kilometers downriver of ACID where water temperatures are higher than at ACID during late spring and summer. Thus, if water temperatures increase with climate change, temperatures adjacent to ACID may remain within tolerable levels for the embryonic and larval life stages of green sturgeon, but temperatures at spawning locations lower in the river may be more affected. It is uncertain, however, if green sturgeon spawning habitat exists closer to ACID, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of green sturgeon in other accessible habitats in the Central Valley (*i.e*., the Feather River) is limited, in part, by late spring and summer water temperatures. Similar to salmonids in the Central Valley, green sturgeon spawning in the major lower river tributaries to the Sacramento River are likely to be further limited if water temperatures increase and suitable spawning habitat remains inaccessible.

In summary, observed and predicted climate change effects are generally detrimental to the species (McClure 2011, Wade *et al*. 2013), so unless offset by improvements in other factors, the status of the species and critical habitat is likely to decline over time. The climate change projections referenced above cover the time period between the present and approximately 2100. While there is uncertainty associated with projections, which increases over time, the direction of change is relatively certain (McClure *et al*. 2013).

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). CDFW's monitoring and rescue activities will take place in the Sacramento River Basin, including its tributaries, and the Sacramento-San Joaquin Delta. Because the proposed activities are so wide-ranging, the action area for this opinion encompasses all anadromous streams of the Sacramento River Basin in California's Central Valley.

In all cases, the proposed research activities would take place in individually very small sites. For example, the researchers might electrofish a few hundred feet of river, deploy a beach seine covering only a few hundred square feet of stream, or operate a screw trap in a few tens of square feet of habitat. All of the actions would take place in designated critical habitat, with the exception of some rescue and relocation activities, such as those occurring in the Colusa Basin Drain.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

Since settlement of the Central Valley in the mid-1800s, populations of native Chinook salmon, steelhead, and green sturgeon have declined dramatically, largely due to factors that completely reshaped the aquatic ecosystem such as dam construction, water management, hydropower facilities, levee construction, and before those, gold mining. These land use changes eliminated important habitats, or blocked access to them, and reduced the abundance, productivity, and distribution of Central Valley salmonids and sturgeon. Habitat simplification, fishing, hatchery impacts, and other stressors led to the loss of genetic and phenotypic (life history, morphological, behavioral, and physiological) diversity in Central Valley salmonids, which has reduced their capacity to cope with a variable and changing climate (Herbold *et al.* 2018). Land use changes to support and protect California's rapidly increasing human population combined with substantial and widespread water development, including the construction and operation of the CVP and SWP, have been accompanied by significant declines in nearly all species of native fish (State Water Resources Control Board 2017b). Recent evidence from a study that used a novel combination of tagging technologies suggests that the freshwater and estuarine environment has been so dramatically altered by habitat loss and water management that the anadromous life history strategy may no longer be sustainable for Central Valley salmon (Michel 2018).

Dams, levees, land conversion, urbanization, water management, and gold mining are the main landscape-scale factors that have shaped the Central Valley environment to what it is today, with climate change providing additional impacts. These landscape-scale factors and their impact on Central Valley listed species and critical habitat are discussed below, followed by a section on more localized, but also important factors affecting listed species in the Central Valley.

2.4.1. Dams and Other Passage Impediments

The construction of dams and other structures around the Central Valley has blocked anadromous salmonids and sturgeon from most of their historic spawning and initial rearing habitat, eradicating most historic populations of winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon. Between 72-90 percent of the original Chinook salmon spawning and holding habitat in the Central Valley drainage is no longer accessible due to dam construction (Cummins *et al.* 2008; Yoshiyama *et al.* 2001). Winter-run Chinook salmon lost three of its four historical spawning populations with the construction of Keswick and Shasta dams. Perhaps 15 of the 18 or 19 historical populations of Central Valley spring-run Chinook salmon are extirpated, with their entire historical spawning habitats upstream from impassable dams (Lindley *et al.* 2007). Currently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of the historical populations of steelhead (Lindley *et al.* 2006). Modeling by Mora *et al.* (2009) indicates about nine percent of historic sDPS green sturgeon habitat has been blocked by dams. Impassable barriers are considered to be the main threat to sDPS green sturgeon as migration corridors are blocked and migration cues (water flow) are altered (NMFS 2018b). The existence of these impassable barriers has significant adverse effects on species in the past, present and future.

Prior to 2012, seasonal closure of RBDD limited sDPS green sturgeon spawning to habitats that were likely unsuitable for egg incubation in some years. With permanent decommissioning of RBDD, sDPS green sturgeon presumably have access to suitable spawning and incubation areas on the Sacramento River under all conditions (*e.g.*, droughts). The Anderson-Cottonwood Irrigation District (ACID) Dam, approximately five miles below Keswick Dam (RM 302), remains a potential passage barrier to spawning green sturgeon on the Sacramento River. The percentage of the sDPS green sturgeon spawning run that would utilize the uppermost five miles of the Sacramento River between ACID Dam and Keswick Dam is unknown, but is currently estimated to be small based on the lack of acoustic tag detections in this reach. However, the proportion of sDPS green sturgeon spawning impeded by the ACID Dam may increase with potential spawning habitat expansion, or warmer water releases at Keswick Dam.

The flood control weirs of the Yolo and Sutter bypasses can serve as barriers to salmon, steelhead and green sturgeon migration during high water events (Thomas *et al.* 2013). During some high flow events, fish enter the Yolo and Sutter bypasses and become stranded when the water recedes. In some cases, adult sturgeon remain stranded in small isolated bypass ponds through the summer or fall, making them vulnerable to poaching and other sources of mortality. In 2011, 24 sDPS green sturgeon were rescued from the Yolo and Sutter bypasses (Thomas *et al.* 2013). Since relocation efforts cannot prevent all mortality associated with stranding, and the loss of even a few adult fish periodically should be avoided, it is important to construct structures at these weirs that allow for volitional passage of migrating green sturgeon.

2.4.2. Water Management

Operations of dams across the Central Valley have resulted in major alteration of temperatures and flows through the year. Large amounts of water have historically been and currently are exported from throughout the Central Valley watershed to support agricultural, industrial, and urban demands. Upstream water diversions combined with water exports in the Delta have reduced January to June outflows by an estimated 56 percent (average), and annual outflow by an estimated 52 percent (average). In the driest condition, in certain months outflows are reduced by more than 80 percent, January to June flows are reduced by more than 70 percent and annual flows are reduced by more than 65 percent (State Water Resources Control Board 2017a).

To help put the Central Valley outflow reductions in context it is helpful to look at how other aquatic ecosystems have responded to water extractions. Richter *et al.* (2012) concluded that flow modifications greater than 20 percent likely result in moderate to major changes in natural structure and ecosystem function, with greater risk associated with greater levels of alteration. Based on published studies of European and Asian rivers, Rozengurt *et al.* (1987) concluded that when successive spring and annual water withdrawals exceeded 30 percent and more than 40-50 percent of the normal unimpaired flow respectively, water quality and fishery resources in the river and estuary ecosystems deteriorated to levels which overrode the ability of the system to restore itself. In the context of Richter *et al.* (2012) and Rozengurt *et al.* (1987), it is not surprising that native fish and wildlife in the Bay-Delta watershed have been significantly impacted by removing over half of the water. Water diversions and the corresponding reduction in flows are not the only factor contributing to Central Valley anadromous fish species declines, but they are a significant one (State Water Resources Control Board 2017a).

The CVP and SWP is one of the world's largest water storage and conveyance systems with both the federal and the state portions of the projects capable of storing, diverting upstream, and exporting millions of acre-feet of water away from the Delta each year. The large volumes being exported through the South Delta combined with the location of the pumps in the south Delta result in significantly modified hydrologic and biological systems (Cummins *et al.* 2008). The Public Policy Institute of California summarized the changes and resultant impact on native fish as follows:

"*After the SWP began operations in the late 1960s, the combined effects of CVP and SWP impoundments and diversions—along with those of hundreds of other water users—became clearly apparent. River flows and water quality declined, threatening both economic and environmental uses; and the ecological balance of the Delta became disastrous to native fish species (Lund et al. 2010; Lund et al. 2007; Moyle and Bennett 2008). The conversion of the 700,000-acre tidal freshwater marsh to a network of rock-lined channels had severely limited available habitat for fish, and dramatic reductions in the quantity and quality of Delta inflows further degraded that habitat. As the SWP increased its exports in the 1980s—almost doubling direct extractions from the Delta—conditions reached a crisis point (Figure 1.4)"* (Hanak *et al.* 2011).

Operations of the CVP and SWP prior to the 2009 NMFS biological opinion reduced survival of juvenile salmonids outmigrating through the Delta. Prior to the protections established by the NMFS 2009 biological opinion (NMFS 2009), mortality of winter-run juveniles entering the interior of the Delta (through the DCC or Georgiana Slough) was estimated to be approximately 66 percent, with a range of 35-90 percent mortality (Burau *et al.* 2007; Perry and Skalski 2008; Vogel 2008). Studies indicate overall mortality through the Delta for late fall-run Chinook salmon releases near Sacramento from 2006 through 2010 ranged from 46-83 percent (Perry *et al.* 2016). The available studies are consistent in that mortality is considerably higher through the central and south Delta than if the juveniles stayed within the mainstem Sacramento River.

The operation of the DCC gates can negatively affect migration of sDPS green sturgeon as well by providing false migration cues for juvenile and adult sturgeon to move from the lower Sacramento River to the central Delta, rather than their intended destination of the western Delta and San Francisco Bay (NMFS 2018). Green sturgeon are also vulnerable to entrainment at the unscreened diversions of the Sacramento River and Delta; flow and pipe configuration affects entrainment rates (Mussen *et al.* 2014; Poletto *et al.* 2014). Efforts to salvage green sturgeon at the CVP and SWP have been conducted for decades; the number of green sturgeon observed in these facilities is typically low with a few individuals per year (NMFS 2018b).

Flow fluctuations from past and current Sacramento River operations management of the CVP have resulted in stranding of juvenile salmonids, Chinook salmon redd dewatering and redd scour in the Sacramento River.

2.4.3. Physical Habitat Alteration

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (NMFS 2014), physical habitat alteration was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the spawning life stage of these species, in the upper reaches of their watershed of origin.

Physical habitat alteration includes loss of natural river morphology and function. Flood control measures, regulated flow regimes, and riverbank protection measures have all had a profound effect on riparian and instream habitat in the lower Sacramento River. Levees constructed in this reach are built close to the river in order to increase streamflow, channelize the river to prevent natural meandering, and maximize the sediment carrying capacity of the river (NMFS 1997). Additionally, nearshore aquatic areas have been deepened and sloped to a uniform gradient, such that variations in water depth, velocity, and direction of flow are replaced by consistent moderate to high velocities. Gravel sources from the banks of the river and floodplain have also been substantially reduced by levee and bank protection measures. Levee and bank protection measures restrict the meandering of the river, which would normally release gravel into the river through natural erosion and deposition processes.

Chinook salmon spawn in clean, loose gravel, in swift, relatively shallow riffles, or along the margins of deeper river reaches where suitable water temperatures, depths, and velocities favor redd construction and oxygenation of incubating eggs. The construction of dams and resultant controlled flows and extensive gravel mining affect spawning habitat. Chinook salmon require clean, loose gravel from 0.75 to 4.0 inches in diameter for successful spawning (NMFS 1997). Juvenile Chinook salmon prefer slow and slack water velocities for rearing and the channelization of the river has removed most of this habitat type. The construction of dams in the upper Sacramento River has eliminated the major source of suitable gravel recruitment to reaches of the river below Keswick Dam.

The threat of altered sediments to sDPS green sturgeon due to impoundments is high. The creation of upstream dams and impoundments can reduce sediment delivery to bays and estuaries. This can affect sDPS green sturgeon feeding habitat quality and quantity through changes in sediment deposition and composition and subsequent changes in prey resources or through changes in turbidity that could affect habitat use and predation by sight-predators.

2.4.4. Ongoing Habitat Restoration and Monitoring Actions

There are a number of habitat restoration actions in the action area, many of which are expected to continue to benefit listed fish. Some of the restoration actions are ongoing and require repeated annual implementation at a specific site or watershed (*e.g.*, gravel augmentation below Keswick Dam). Others include program level commitments with detailed restoration actions to be determined at a later date (*e.g.*, side channel restoration). One such program is the NOAA Restoration Center's Program to Facilitate Restoration Projects in the Central Valley (NMFS 2018a), which is expected to continue making improvements to aquatic and/or riparian habitat for listed fish.

Some of the restoration actions in the Central Valley have been consulted on previously such that their past and future beneficial effects to increase spawning and rearing habitat for listed salmonids are factored into the environmental baseline. Examples of previously consulted restoration actions include the Lower Clear Creek Habitat Restoration, Upper Sacramento River Restoration, and Lower American River Restoration that are carried out under CVPIA (NMFS 2019).

There are a number of other ongoing monitoring efforts in the action area, which provide important information on ESA-listed anadromous fish. These include monitoring environmental conditions during action implementation (*e.g.*, turbidity or temperature), monitoring fish presence, tagging fish for tracking distribution and survival, monitoring levels of impacts to fish and/or habitat, as examples. The effects of these other monitoring and research activities are part of the environmental baseline because they previously have undergone ESA Section 7 consultation either through individual or programmatic actions, ESA Section 4(d) authorizations, or issuance of other Section 10(a)(1)(A) permits.

2.4.5. Research Effects

Although not identified as a factor for decline or a threat preventing recovery for any species, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids, whether intentionally or not. For the year 2021, NMFS has issued numerous research section 10(a)(1)(A) scientific research permits allowing listed species to be taken and sometimes killed. NMFS has also issued numerous authorizations for state and tribal scientific research programs under ESA Section 4(d). Table 7 displays the total take for the ongoing research authorized under ESA Sections 4(d) and 10(a)(1)(A).

Table 7. Total Expected Take of ESA-listed Species for Research Already Approved for 2021

Species	Life Stage	Origin	Authorized Handling Take	Authorized Lethal Take	Percent of ESU/ DPS Taken[2]	Percent of ESU/ DPS Killed
Sacramento River winter-run Chinook salmon	Adult	Natural and Listed Hatchery Adipose Clip	3,760	111	96.857	2.859
Sacramento River winter-run Chinook salmon	Juvenile	Natural	443,966	11,577	89.418	2.332
Sacramento River winter-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	205,959	7,568	62.856	2.310
Central Valley spring-run Chinook salmon	Adult	Natural and Listed Hatchery Adipose Clip	3,382	170	33.895	1.704
Central Valley spring-run Chinook salmon	Juvenile	Natural	895,002	17,482	43.122	0.842

[2] While the percent of each ESU or DPS that may be taken is high in some instances, our analysis considers the following: 1) The average abundance estimates for the ESA-listed salmonids considered in this opinion are from a recent 3-year period (2017-2019) following the severe drought that affected California's Central Valley. The abundance estimates reflect the poor survival and reduced productivity that occurred as a result of the drought and are therefore considered conservative estimates of abundance. 2) As described in further detail below, researchers do not handle the full number of adults or juveniles that are authorized and generally take far fewer ESA-listed species than the number allotted every year. Thus, the percentage of fish actually handled by researchers is expected to be significantly lower that the amount authorized.

Species	Life Stage	Origin	Authorized Handling Take	Authorized Lethal Take	Percent of ESU/ DPS Taken[2]	Percent of ESU/ DPS Killed
Central Valley spring-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	29,980	3,741	1.480	0.185
California Central Valley steelhead	Adult	Natural and Listed Hatchery Adipose Clip	6,705	348	58.331	3.027
California Central Valley steelhead	Juvenile	Natural	72,025	2,048	6.545	0.186
California Central Valley steelhead	Juvenile	Listed Hatchery Adipose Clip	28,123	1,846	1.626	0.107
Southern DPS green sturgeon	Adult	Natural	411	11	19.501	0.541
Southern DPS green sturgeon	Subadult	Natural	265	10	2.401	0.093
Southern DPS green sturgeon	Juvenile	Natural	1,845	75	42.056	1.716
Southern DPS green sturgeon	Larvae	Natural	11,208	1,038	-	-
Southern DPS green sturgeon	Egg	Natural	1,866	1,866	-	-

Actual take levels associated with these activities are almost certain to be a substantially lower than the permitted levels. There are three reasons for this. First, most researchers do not handle the full number of adults or juveniles that are authorized. That is, for the vast majority of scientific research permits, history has shown that researchers generally take far fewer ESA-listed species than the number allotted every year. Over the past five years (2014-2019) all Section 10(a)(1)(A) and 4(d) permits reporting take for ESA-listed species in the West Coast Region resulted in researchers using only 16 percent of the requested handling take and 12 percent of the requested mortalities. Second, we purposefully inflate our take and mortality estimates for each proposed study to account for the effects of potential accidental deaths. Therefore, it is very likely that far fewer fish would be killed under any given research project than the researchers are permitted. Third, for juvenile salmonids, many of the young fish that may be affected would not actually be in the smolt stage. As a result, all non-adult fish are simply be described as “juveniles,” which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage, perhaps as much as an order of magnitude more. Therefore, the estimates of percentages of ESUs/DPSs taken were derived by: 1) conservatively estimating the actual number of fish to be taken, 2) overestimating the number of fish likely to be killed, and 3) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of ESA-listed species the research is likely to kill are undoubtedly smaller than the stated figures.

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

2.5.1. Effects on Listed Species

The primary effect of the proposed research and rescue efforts will be on the listed species in the form of capturing and handling the fish. Capturing, handling, and releasing fish, which are detailed in the following subsections, generally lead to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, let alone entire species. To conservatively analyze the potential effects of this kind of take we use what we consider to be modest over estimates of mortalities (*i.e.,* maximum mortality that could occur using non-lethal sampling methods). By doing that, we can be more certain we are capturing the full range of potential effects.

The following subsections describe the types of activities being proposed. The activities would be carried out by trained professionals using established protocols. The effects of the activities are well documented and discussed in detail below. No researcher would receive a permit unless the activities (*e.g.*, electrofishing) incorporate NMFS' uniform, pre-established set of mitigation measures. These measures are described in Section 1.4 of this opinion. They are incorporated (where relevant) into every permit as part of the conditions to which a researcher must adhere.

2.5.1.1. Capture and Handling

The primary effect of the proposed research on the listed species would be in the form of capturing and handling fish. We discuss effects from handling and anesthetizing fish, and the general effects of capture using beach seines and traps here. We discuss effects from other capture methods in more detail in the subsections below.

Harassment caused by capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, populations, and species (Sharpe *et al.* 1998). Handling of fish may cause stress, injury, or death, which typically are due to overdoses of anesthetic, differences in water temperatures between the river and holding buckets, depleted dissolved oxygen in holding buckets, holding fish out of the water, and physical trauma. Stress on salmonids increases rapidly from handling, if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish transferred to holding buckets can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps, nets, and buckets. Decreased survival of fish can result when stress levels are high because stress can be immediately debilitating and may increase the potential for vulnerability to subsequent challenges (Sharpe *et al.* 1998). The permit conditions identified in Section 1.4 contain measures that mitigate factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover rapidly from handling; however, some take is anticipated to occur.

2.5.1.2. Rotary Screw Trapping

Smolt traps, RSTs, and other out-migration traps, are generally used to obtain information on natural population abundance and productivity. On average, they achieve a sample efficiency of four to 20 percent of the emigrating population from a river or stream, depending on river size. Although under some conditions, traps may achieve a higher efficiency for a relatively short period of time. Based on years of sampling at hundreds of locations under hundreds of scientific research authorizations, we would expect the mortality rates for fish captured using RSTs to be one percent or less.

The trapping, capturing, or collecting and handling of juvenile fish using traps are likely to cause some stress on listed fish. However, fish typically recover rapidly from handling procedures. The primary factors that contribute to stress and mortality from handling are excessive doses of anesthetic, differences in water temperature, dissolved oxygen conditions, the amount of time that fish are held out of water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4°F (18°C) or if dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank.

The potential for unexpected injuries or mortalities among listed fish is reduced in a number of ways. These can be found in the individual study protocols and in the permit conditions stated earlier. In general, screw traps are checked at least daily and usually fish are handled in the morning. This ensures that the water temperature is at its daily minimum when fish are handled. In addition, fish may not be handled if the water temperature exceeds 72°F. Furthermore, trapping is expected to cease if water temperatures exceed 74°F. Great care must be taken when transferring fish from the trap to holding areas and the most benign methods available are used - often this means using sanctuary nets when transferring fish to holding containers to avoid potential injuries. The investigators' hands must be wet before and during fish handling. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas. In addition, several other stringent criteria are often applied on a case-by-case basis. These include safety protocols that vary by river velocity and trap placement, frequency of trap checks based on water and air temperatures, number of staff present at the site to account for the number of outmigrants expected, *etc*. All of these protocols and more are used to make sure the mortality rates stay at one percent or lower, but there is some expected to occur.

2.5.1.3. Beach Seining

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 species include entanglement (gilling), scale and mucus abrasion, suffocation, and crushing. Seine tows will be short to prevent suffocation and to ensure that no debris (rocks, logs, *etc*.) is 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.

2.5.1.4. Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them, which makes them easy to capture. It can cause a suite of effects ranging from disturbing the fish to killing them. The percentage of fish that are unintentionally killed by electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician (Sharber and Carothers 1988, McMichael 1993, Dalbey *et al.* 1996, Dwyer and White 1997). Research indicates that using continuous direct current (DC) or low frequency (30 Hz) pulsed DC waveforms produce lower spinal injury rates, particularly for salmonids (Fredenberg 1992, McMichael 1993, Sharber *et al.* 1994, Snyder 1995).

Most studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey *et al.* 1996). Electrofishing can have severe effects on adult salmonids. Adult salmonids can be injured or killed due to spinal injuries that can result from forced muscle contractions. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study.

Spinal injury rates are substantially lower for juvenile fish than for adults. Smaller fish are subjected to a lower voltage gradient than larger fish (Sharber and Carothers 1988) and may, therefore, be subject to lower injury rates (*e.g.*, Hollender and Carline 1994, Dalbey *et al.* 1996, Thompson *et al.* 1997). McMichael *et al.* (1998) reported a 5.1 percent injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin.

When using appropriate electrofishing protocols and equipment settings, shocked fish normally revive quickly. Studies on the long-term effects of electrofishing indicate that even with spinal injuries, salmonids can survive long-term; however, severely injured fish may have stunted growth (Dalbey *et al.* 1996, Ainslie *et al.* 1998).

Permit conditions would require that all researchers follow NMFS’ electrofishing guidelines (NMFS 2000). The guidelines require that field crews:

- Use electrofishing only when other survey methods are not feasible.

- Be trained by qualified personnel in equipment handling, settings, maintenance to ensure proper operating condition, and safety.
- Conduct visual searches prior to electrofishing on each date and avoid electrofishing near adults or redds. If an adult or a redd is detected, researchers must stop electrofishing at the research site and move to a site where adults or redds are no longer visible. Researchers must conduct careful reconnaissance surveys prior to electrofishing at additional sites.
- Test water conductivity and keep voltage, pulse width, and rate at minimal effective levels. Use only DC waveforms.
- Work in teams of two or more technicians to increase both the number of fish seen at one time and the ability to identify larger fish without having to net them. Working in teams allows netter(s) to remove fish quickly from the electrical field and to net fish farther from the anode, where the risk of injury is lower.
- Observe fish for signs of stress and adjust electrofishing equipment to minimize stress.
- Provide immediate and adequate care to any fish that does not revive immediately upon removal from the electrical current.

The preceding discussion focused on the effects backpack electrofishing and the ways those effects would be minimized. In larger streams and rivers, electrofishing units are sometimes mounted on boats or rafts. These units often use more current than backpack electrofishing equipment because they need to cover larger and deeper areas. The environmental conditions in larger, more turbid streams can limit researchers' ability to minimize impacts on fish. As a result, boat electrofishing can have a greater impact on fish. Researchers conducting boat electrofishing must follow NMFS' electrofishing guidelines.

2.5.1.5. Weirs

Capture of adult salmonids near weirs is common practice in order to collect the following information:

- Enumerate adult salmon and steelhead entering the watershed;
- Determine the run timing of adult salmon and steelhead entering the watershed;
- Estimate the age, sex and length composition of the salmon escapement into the watershed; and/or
- Determine the genetic composition of fish passing through the weir (*i.e.,* hatchery versus natural).

Information pertaining to the run size, timing, age, sex and genetic composition of salmon and steelhead returning to the respective watershed will provide managers valuable information to refine existing management strategies. Some weirs have a trap to capture fish, while other weirs have a video or DIDSON unit to record fish migrating through the weir. Weirs, with or without a trap, have the potential to delay migration. All projects involving the use of weirs will adhere to the draft NMFS West Coast Region Weir Guidelines (https://media.fisheries.noaa.gov/dam-migration/electro2000.pdf). The Weir Guidelines require the following:

1. Traps must be checked and emptied daily;

2. All weirs including those equipped with video and DIDSON units must be inspected and cleaned of any debris daily;
3. The development and implementation of monitoring plans to assess passage delay; and
4. The development and implementation of a Weir Operating Plan.

These guidelines are intended to help improve fish weir design and operation in ways that will limit fish passage delays and increase weir efficiency.

2.5.1.6. Fyke Trapping

Fyke traps entrap fish and restrict freedom of movement; they generally do not constrain respiration, but they may confine several species in a small area. The traps are essentially large cylinders, 10 feet in diameter and 19 feet in length. They are open at one end and contain two funnels, which act as a one-way passage for fish to enter a pot or impounding area. The traps are always fished with the back or open end downstream. The two funnels face the same way, with the small openings upstream, and a fish must swim through both to enter the pot. The funnels and the exterior of the trap are covered with wire mesh netting. Captured fish are removed with a dip net through a door that opens into the pot.

To process fish, the trap should be rolled up the bank very slowly. If it is apparent that there is a large catch, overcrowding of the fish is avoided by stopping the trap while it is fairly deep in the water. Fish can then be removed using dip nets and tagged until numbers in the trap are reduced. The trap can then be rolled a little farther up the bank or out of the water and the process repeated. If the trap is rolled too far or too fast, there is likely to be a panic during which even medium-sized fish may injure themselves by swimming into the mesh at great speed. If the trap is moved slowly, the fish remain relatively quiet. Adverse effects resulting from the operation of large fyke traps may include crowding, predation within the trap, and impacts from debris. Daily trap checks and frequent cleaning will ensure that overall impacts associated with fyke trapping are minimized.

The ability of fyke traps to capture large numbers of adult steelhead with nominal bycatch and minimal negative impacts make them an ideal choice for the Central Valley Steelhead Monitoring Program. The Mainstem Sacramento River Mark-Recapture effort will use wire fyke traps set on the streambed with catch openings facing downstream. Previous studies using fyke traps have found fish to be in excellent condition when detained for up to 72 hours without substantial occurrence of escape or mortality (Hallock *et al.* 1957, 1961; Staley 1976; USFWS 2004). While the methods described by Hallock *et al.* (1957) require virtually no alteration, CDFW will ensure that the interior wire mesh is coated with or replaced by a soft rubber or plastic mesh to reduce abrasion to captured fish. Additionally, door dimensions will be altered to allow large quantities of fish to be removed without handling. Traps may be fitted with debris and predator exclusion frames as necessary to protect captured fish. They will also include excluder bars for aquatic mammals such as sea lions and river otters.

2.5.1.7. Observation

For some parts of the proposed studies, listed fish would be observed, but not captured (*e.g.*, by snorkel surveys or from the banks). Observation without handling is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting the fishes' behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind or under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish - which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but per NMFS' pre-established mitigation measures (included in state fisheries agency submittals), would not be walked on. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur, particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish time to reach cover.

2.5.1.8. Marking and/or Tagging

Techniques, such as PIT tagging, coded wire tagging, fin clipping, and the use of radio transmitters, are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

A PIT tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (*e.g.*, any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore, any researchers engaged in such activities will follow the conditions listed previously in this opinion (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies on the use of PIT tags have shown no effect on growth or survival (Prentice *et al.* 1987; Jenkins and Smith 1990; Prentice *et al.* 1990). For example, in a study between the tailraces of Lower Granite and McNary dams (225 km), Hockersmith *et al.* (2000) concluded that the performance of yearling Chinook salmon was not adversely affected by gastrically or surgically implanted sham radio tags or PIT tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall Chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Conner *et al.* 2001). Prentice and Park (1984) found that PIT-tagging did not substantially affect survival in juvenile salmonids.

CWTs are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman *et al.* 1968; Bordner *et al.* 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon; however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher *et al.* 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon, because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to identify which fish possess CWTs, it is necessary to mark the fish externally (usually by clipping the adipose fin) when the CWT is implanted. One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem, because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest or during carcass surveys (and are, therefore, already dead).

The other primary method for tagging fish is to implant them with acoustic tags, radio tags, or archival loggers. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting tags is to place them within the body cavities of (usually juvenile) salmonids. This method of tagging is also typically used for sturgeon. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985; Mellas and Haynes 1985).

Fish with internal tags often die at higher rates than fish tagged by other means, because tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance. As with the other forms of tagging and marking, researchers will keep the harm caused by tagging to a minimum by following the conditions in the permits as well as any other permit-specific requirements.

2.5.1.9. Tissue Sampling

Tissue sampling techniques, such as fin clipping, are common to many scientific research efforts using listed species. All sampling, handling, and clipping procedures have an inherent potential to stress, injure, or even kill the fish. This section discusses tissue sampling processes and its associated risks.

Fin clipping is the process of removing part or all of one or more fins to obtain non-lethal tissue samples and alter a fish's appearance (and thus make it identifiable). When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be applied when only a part of the fin or the end of a fin is removed, 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, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, severing individual fin rays (Welch and Mills 1981), or removing single prominent fin rays (Kohlhorst 1979). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (*e.g.*, Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly, especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (*e.g.*, stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it and Coble (1967) suggested that fish shorter than 90 mm are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100 percent recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are clipped. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality, but other studies have been less conclusive.

2.5.1.10. Intentional (Directed) Mortality

In some instances, it is necessary to kill a captured fish in order to gather the specific data that a study is designed to produce. In such cases, determining the effect of the intentional directed mortality is a very straightforward process: the sacrificed fish, if they are juveniles, are permanently removed from the gene pool and the effect of their deaths is weighed in the context that the effect on their listed unit and, where possible, their local population. If the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed from the population, but so are all their potential progeny. Thus, killing pre-spawned adults has the greatest potential to affect a listed species. Because of this, NMFS only very rarely allows pre-spawned adults to be sacrificed. Moreover, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment, such as a hatchery, thereby greatly decreasing the potential harm posed by sacrificing the adults. Generally, adults are not sacrificed for scientific purposes and no such activity is considered in this opinion.

2.5.2. Species-specific Effects of Permit 18181-4R

In previous sections, we estimated the annual abundance of adult and juvenile listed salmonids and green sturgeon. Since there are no measurable habitat effects, the analysis will consist primarily of examining directly measurable impacts of proposed activities on abundance. Abundance effects are themselves relevant to extinction risk, are directly related to productivity effects, and are somewhat but less directly related to spatial structure and diversity effects. Examining the magnitude of these effects at the individual and, where possible, the population levels is the best way to determine effects at the species level.

In conducting the following analyses, we have tied the effects of the proposed action to its impacts on individual populations wherever it was possible to do so. In those instances, the status of the local population will be discussed and taken into account. In other instances, the nature of the project (*i.e.*, it is broadly distributed or situated in mainstem habitat) is such that the take cannot reliably be assigned to any population or group of populations. In those cases, the effects of the action are measured in terms of how they are expected to affect each listed unit's total abundance by origin (natural or hatchery) and life stage (adult, juvenile, *etc*.), rather than at the population scale.

The analysis process relies on multiple sources of data. In Section 2.2 (Status of the Species), we estimated the average annual abundance for the species considered in this document. For most of the listed species, we estimated abundance for adult returning fish and outmigrating smolts. These data come from estimates compiled by our SWFSC for the species status reviews, which are updated every five years. Additional data sources include state agencies (*i.e.*, CDFW), county and local agencies, and educational and non-profit institutions. These sources are vetted for scientific accuracy before their use. For hatchery-origin juvenile salmonids, we use hatchery production goals and release estimates. Table 8 displays the estimated annual abundance of the listed species.

Table 8. Estimated Annual Abundances of ESA-listed Species

Species	Life Stage	Abundance
Sacramento River winter-run Chinook salmon	Natural- and Hatchery-origin Adult	3,882
Sacramento River winter-run Chinook salmon	Natural-origin Juvenile	496,509
Sacramento River winter-run Chinook salmon	Hatchery-origin juvenile	327,669

Species	Life Stage	Abundance
Central Valley spring-run Chinook salmon	Natural- and Hatchery-origin Adult	9,976
Central Valley spring-run Chinook salmon	Natural-origin Juvenile	2,075,507
Central Valley spring-run Chinook salmon	Hatchery-origin juvenile	2,025,571
California Central Valley steelhead	Natural- and Hatchery-origin Adult	11,494
California Central Valley steelhead	Natural-origin Juvenile	1,100,418
California Central Valley steelhead	Hatchery-origin juvenile	1,730,000
Southern DPS green sturgeon	Adult	2,106
Southern DPS green sturgeon	Sub-adult	11,055
Southern DPS green sturgeon	Juvenile	4,387

CDFW is renewing Permit 18181-3A, which currently allows them to annually take adult and juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon while conducting rescue activities in the Sacramento River Basin. Once Permit 18181-3A has been renewed (the renewed permit will be Permit 18181-4R) it will cover the previously permitted activities in addition to the research activities described in Permit 14808-5R. These research activities are being transferred over as part of the permit renewal process for Permit 18181-3A. As a result, Permit 14808-5R will be withdrawn upon the issuance of Permit 18181-4R.

Fish would be captured (using RSTs, fyke traps, and beach seines), handled (weighed, measured, and checked for marks or tags), and released. Most of the fish that are captured and handled would be sampled for biological tissues, and a subsample would be anesthetized and tagged (PIT, Floy, VIE, or acoustic tag). A subsample of hatchery-origin juvenile winter-run Chinook salmon would be intentionally lethally taken for CWT recovery. Adult and juvenile Chinook salmon and steelhead would also be observed through snorkel, video, or DIDSON surveys. The amount of take requested by CDFW is summarized in the following table.

Table 9. Total Requested Take by Species, Life Stage, Origin, and Action for Permit 18181-4R

Species	Life Stage	Origin	Take Action	Requested Total Take	Requested Lethal Take
Sacramento River winter-run Chinook salmon	Adult	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	125	3
Sacramento River winter-run Chinook salmon	Adult	Natural	Collect, Sample, and Transport Live Animal	450	22
Sacramento River winter-run Chinook salmon	Adult	Natural	Observe/Harass	50	0
Sacramento River winter-run Chinook salmon	Adult	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	125	3
Sacramento River winter-run Chinook salmon	Adult	Listed Hatchery Adipose Clip	Collect, Sample, and Transport Live Animal	225	12
Sacramento River winter-run Chinook salmon	Adult	Listed Hatchery Adipose Clip	Observe/Harass	25	0
Sacramento River winter-run Chinook salmon	Spawned Adult/ Carcass	Natural	Observe/Sample Tissue Dead Animal	20	0
Sacramento River winter-run Chinook salmon	Spawned Adult/ Carcass	Listed Hatchery Adipose Clip	Observe/Sample Tissue Dead Animal	20	0
Sacramento River winter-run Chinook salmon	Juvenile	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	21,405	938
Sacramento River winter-run Chinook salmon	Juvenile	Natural	Observe/Harass	100,000	0
Sacramento River winter-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	4,905	123

Species	Life Stage	Origin	Take Action	Requested Total Take	Requested Lethal Take
Sacramento River winter-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	Intentional (Directed) Mortality	440	440
Sacramento River winter-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	Observe/Harass	200,000	0
Central Valley spring-run Chinook salmon	Adult	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	225	6
Central Valley spring-run Chinook salmon	Adult	Natural	Collect, Sample, and Transport Live Animal	700	45
Central Valley spring-run Chinook salmon	Adult	Natural	Observe/Harass	50	0
Central Valley spring-run Chinook salmon	Adult	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	200	5
Central Valley spring-run Chinook salmon	Adult	Listed Hatchery Adipose Clip	Collect, Sample, and Transport Live Animal	250	15
Central Valley spring-run Chinook salmon	Adult	Listed Hatchery Adipose Clip	Observe/Harass	100	0
Central Valley spring-run Chinook salmon	Spawned Adult/ Carcass	Natural	Observe/Sample Tissue Dead Animal	15	0
Central Valley spring-run Chinook salmon	Juvenile	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	16,300	525
Central Valley spring-run Chinook salmon	Juvenile	Natural	Collect, Sample, and Transport Live Animal	2,200	110
Central Valley spring-run Chinook salmon	Juvenile	Natural	Observe/Harass	75,000	0
Central Valley spring-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	3,400	157

Species	Life Stage	Origin	Take Action	Requested Total Take	Requested Lethal Take
Central Valley spring-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	Intentional (Directed) Mortality	220	220
California Central Valley steelhead	Adult	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	390	17
California Central Valley steelhead	Adult	Natural	Collect, Sample, and Transport Live Animal	300	15
California Central Valley steelhead	Adult	Natural	Observe/Harass	100	0
California Central Valley steelhead	Adult	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	1,535	35
California Central Valley steelhead	Adult	Listed Hatchery Adipose Clip	Collect, Sample, and Transport Live Animal	200	10
California Central Valley steelhead	Adult	Listed Hatchery Adipose Clip	Observe/Harass	100	0
California Central Valley steelhead	Juvenile	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	2,100	79
California Central Valley steelhead	Juvenile	Natural	Collect, Sample, and Transport Live Animal	2,200	110
California Central Valley steelhead	Juvenile	Natural	Observe/Harass	150,000	0
California Central Valley steelhead	Juvenile	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	2,100	58
California Central Valley steelhead	Juvenile	Listed Hatchery Adipose Clip	Observe/Harass	200	0
Southern DPS green sturgeon	Adult	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	55	2

Species	Life Stage	Origin	Take Action	Requested Total Take	Requested Lethal Take
Southern DPS green sturgeon	Adult	Natural	Collect, Sample, and Transport Live Animal	25	1
Southern DPS green sturgeon	Subadult	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	30	2
Southern DPS green sturgeon	Juvenile	Natural	Capture/Handle/Release Animal	20	4
Southern DPS green sturgeon	Juvenile	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	15	2

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are represented in that last column of the table above.

As Table 9 illustrates, the majority of the take that would be authorized represents a small number when compared to the estimated abundance for any listed unit, and for all ESUs and DPSs, this take would kill small fractions of those units. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

In many cases, these abundance estimates are known to be underestimates, because they omit populations for which we do not have data, or assume the lowest conservative figures determined to be reliable, and this permitted research is intended in part to provide estimates that are more accurate. However, it is likely that the impacts would be even smaller than those laid out above. Reporting from the previously issued permits for these projects indicates that, over the past five years (2016-2020), the total handling take reported was between 3.47 percent (Permit 14808-5R) and 8.73 percent (Permit 18181-3A) of the total amount authorized across all species for the previously issued permits. The actual lethal take was also low compared to what was authorized for this permit; total lethal take reported was between 0.39 percent (Permit 18181-3A) and 17.47 percent (Permit 14808-5R) of the lethal take authorized over the past five years. Even if the losses were to be as large as those displayed in Table 9 above, the effects would to some extent be offset by the information generated from the research, which would be used to improve water operations and monitor habitat conditions and thereby improve the species' ability to survive and recover.

Furthermore, although some ESA-listed species may die as a result of capture and handling during rescue activities, it is assumed that these fish will have otherwise perished without intervention. Rescues are typically required when flows and dissolved oxygen are low and water temperatures are high. These conditions lead to increases in stress levels and may result in higher incidental mortality levels. This was taken into account while developing take estimates for the proposed rescue activities.

2.5.3. Effects to Critical Habitat

Full descriptions of effects of the proposed research activities are given in the previous sections. In general, the permitted activities would be (1) rescue activities, (2) capturing fish with traps and nets of various types, (3) collecting biological samples from live fish and applying tags, either externally or surgically, and (4) collecting fish lethally for tag extraction and analysis. All of these techniques are minimally intrusive in terms of their effect on habitat, because they would involve very little, if any, disturbance of streambeds or adjacent riparian zones. Such sampling activities also affect small spatial areas, and are brief in duration, so any effects are expected to be ephemeral and attenuate rapidly. Therefore, none of the activities analyzed in this opinion will measurably affect any habitat PBF function or value described earlier (see Section 2.2.2).

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Because the action area falls almost entirely within designated critical habitat, the vast majority of future actions in the region will undergo Section 7 consultation with one or more of the Federal entities with regulatory jurisdiction over water quality, habitat management, flood management, navigation, or hydroelectric generation. In almost all instances, proponents of future actions will need government funding or authorization to carry out a project that may affect salmonids, sturgeon, or their habitat and, therefore, the effects such a project may have on listed species will be analyzed when the need arises.

In developing this opinion, we considered several efforts being made at the local, state, and national levels to conserve listed species, primarily final recovery plans and efforts laid out in the Status Review updates for Pacific salmon and steelhead listed under the Endangered Species Act. The recovery plans, status summaries, and limiting factors that are part of the analysis of this opinion are discussed in detail in Section 2.2. The result of that review was that take of ESA-listed species, particularly take associated with monitoring and habitat restoration is likely to continue to increase in the region for the foreseeable future. However, as noted above, all actions falling in those categories would also have to undergo consultation (like that in this opinion) before they are allowed to proceed.

Future state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could affect listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities, make any analysis of cumulative effects difficult and speculative. For more information on the various efforts being made at the local, state, and national levels to conserve listed salmonids, see any of the recent status reviews, listing Federal Register notices, and recovery planning documents, as well as recent consultations on issuance of Section 10(a)(1)(A) and 4(d) research permits.

Thus, non-Federal activities are likely to continue affecting listed species and habitat within the action area. These cumulative effects in the action area are difficult to analyze because of this opinion's large geographic scope, the different resource authorities in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, it seems likely that they will continue to increase as a general pattern over time. The primary cumulative effects will arise from those water quality and quantity impacts that occur as human population growth and development shift patterns of water and land use, thereby creating more intense pressure on streams and rivers within this geography in terms of volume, velocities, pollutants, base flows, and peak flows. However, the specifics of these effects, too, are impossible to predict at this time. In addition, there are the aforementioned effects of climate change, many of those will arise from or be exacerbated by actions taking place in the California's Central Valley and elsewhere that will not undergo ESA consultation. Although many state and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects.

According to the U.S. Census Bureau, the State of California's population increased 6.1 percent from 2010 to 2019 (source: Census Bureau California Quick Facts). If this trend in population growth continues, there will be an increase in competing demands for water resources. Water withdrawals, diversions, and other hydrological modifications to regulate water bodies are likely to continue. Urbanization and rural development are limiting factors for many of the ESA-listed species within California's Central Valley and these factors are likely to increase with continued population growth. Therefore, the most likely cumulative effect is that the habitat in the action area is likely to continue to be degraded with respect to its ability to support ESA-listed species.

One final thing to take into account when considering cumulative effects is the time period over which the activity would operate. The permit considered here would be good for a maximum of five years and the effects on listed species abundance they generate could continue for up to four years after that, though they would decrease in each succeeding year. We are unaware of any major non-Federal activity that could affect listed species, and is certain to occur in the action area during that timeframe

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the Effects of the Action (Section 2.5) to the Environmental Baseline (Section 2.4) and the Cumulative Effects (Section 2.6), taking into account the Status of the Species and Critical Habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

Aside from the considerations listed above, these assessments are also made in consideration of the other research that has been authorized and that may affect the various listed species. The reasons we integrate the proposed take in the permit considered here with the take from previous (but ongoing) research authorizations are that they are similar in nature and we have good information on what the effects are, and thus it is possible to determine the overall effect of all research in the region on the species considered here. Therefore, the following two tables: 1) combine the proposed take for each species and life stage associated with all projects proposed under Permit 18181-4R (Table 10), 2) add that take to the take that has already been authorized in the region, and 3) compare those totals to the estimated annual abundance of each species under consideration (Table 11).

Table 10. Total Requested Take for Permit 18181-4R and Percentages of each ESU or DPS

Species	Life Stage	Origin	Requested Total Take	Requested Lethal Take	Percent of ESU/ DPS Taken	Percent of ESU/ DPS Killed
Sacramento River winter-run Chinook salmon	Adult	Natural and Listed Hatchery Adipose Clip	925	40	23.828	1.030
Sacramento River winter-run Chinook salmon	Juvenile	Natural	21,405	938	4.311	0.189
Sacramento River winter-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	5,345	563	1.631	0.172
Central Valley spring-run Chinook salmon	Adult	Natural and Listed Hatchery Adipose Clip	1,375	71	13.783	0.712

Species	Life Stage	Origin	Requested Total Take	Requested Lethal Take	Percent of ESU/ DPS Taken	Percent of ESU/ DPS Killed
Central Valley spring-run Chinook salmon	Juvenile	Natural	18,500	635	0.891	0.031
Central Valley spring-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	3,620	377	0.179	0.019
California Central Valley steelhead	Adult	Natural and Listed Hatchery Adipose Clip	2,425	77	21.098	0.670
California Central Valley steelhead	Juvenile	Natural	4,300	189	0.391	0.017
California Central Valley steelhead	Juvenile	Listed Hatchery Adipose Clip	2,100	58	0.121	0.003
Southern DPS green sturgeon	Adult	Natural	80	3	3.799	0.142
Southern DPS green sturgeon	Subadult	Natural	30	2	0.271	0.018
Southern DPS green sturgeon	Juvenile	Natural	35	6	0.798	0.137

Thus, the activities contemplated in this opinion may kill, in combination and at most, as much as one percent of the fish from any component of any listed species; that component is adult Sacramento River winter-run Chinook salmon. It should be noted, however, that this percentage represents the death of only 40 individuals. In this case, the level of incidental mortality requested by CDFW is primarily to account for adult fish that are stranded and exposed to poor environmental conditions, resulting in the need to conduct rescue activities. Because these fish are stressed upon capture, the potential for incidental mortality to occur during rescue activities increases. In all other instances, the effect is less than one percent and, in many cases, the effect is several orders of magnitude smaller. It is also important to note that these figures are probably much lower in actuality; as discussed in further detail below, the actual take that occurs is often much less than the level of take that is requested. However, before engaging in that discussion further, it is necessary to add all of the take considered in this opinion to the rest of the research take that has been authorized in the West Coast Region.

As Table 11 below illustrates, in many cases the level of mortality from all of the permits in this opinion and all the previously authorized research would amount to a less than 0.5 percent of each species' total abundance. In these instances, the total mortalities are so small and spread out across each listed unit, such that they are unlikely to have any lasting detrimental effect on the species' numbers, reproduction, or distribution. However, in a few cases, the total potential mortality could amount to a more substantial percentage of an ESU or DPS component (*i.e.*, life stage and origin). These instances are discussed in further detail for each of the ESA-listed species below.

Table 11. Total Expected Take of ESA-listed Species for Permit 18181-4R in addition to Research Already Approved for 2021

Species	Life Stage	Origin	Requested Take plus the Baseline	Requested Mortality plus the Baseline	Percent of ESU/ DPS Taken	Percent of ESU/ DPS Killed
Sacramento River winter-run Chinook salmon	Adult	Natural and Listed Hatchery Adipose Clip	3,760	111	96.857	2.859
Sacramento River winter-run Chinook salmon	Juvenile	Natural	446,061	12,340	89.839	2.485
Sacramento River winter-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	208,164	7,608	63.529	2.322
Central Valley spring-run Chinook salmon	Adult	Natural and Listed Hatchery Adipose Clip	3,482	178	34.898	1.784
Central Valley spring-run Chinook salmon	Juvenile	Natural	905,582	17,961	43.632	0.865
Central Valley spring-run Chinook salmon	Juvenile	Listed Hatchery Adipose Clip	33,600	4,118	1.659	0.203
California Central Valley steelhead	Adult	Natural and Listed Hatchery Adipose Clip	6,725	362	58.505	3.149
California Central Valley steelhead	Juvenile	Natural	72,605	2,179	6.598	0.198
California Central Valley steelhead	Juvenile	Listed Hatchery Adipose Clip	28,723	1,864	1.660	0.108
Southern DPS green sturgeon	Adult	Natural	411	11	19.501	0.541

Species	Life Stage	Origin	Requested Take plus the Baseline	Requested Mortality plus the Baseline	Percent of ESU/ DPS Taken	Percent of ESU/ DPS Killed
Southern DPS green sturgeon	Subadult	Natural	265	10	2.401	0.093
Southern DPS green sturgeon	Juvenile	Natural	1,850	77	42.170	1.762
Southern DPS green sturgeon	Larvae	Natural	11,208	1,038	-	-
Southern DPS green sturgeon	Egg	Natural	1,866	1,866	-	-

2.7.1. ESA-listed Species

A few considerations apply generally to our analyses of the total mortalities that would be permitted for each of these species. First, we do not expect the potential mortality of hatchery-origin fish contemplated in this opinion to have any genuine effect on the species' survival and recovery in the wild because, while they are listed, they are generally considered surplus to recovery needs (with the exception of endangered winter-run Chinook salmon). We therefore focus primarily on the naturally produced ESU or DPS components for the remainder of this discussion.

Second, the true numbers of fish that would actually be taken are expected to be smaller than the amounts authorized. We develop conservative estimates of abundance, as described in Section 2.2. As noted in the Effects Section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the tables above.

Lastly, the research being conducted in the region adds critical knowledge about the species' status, knowledge that we are required to have every five years to perform status reviews for all listed species. So in evaluating the impacts of the proposed research and rescue activities, any effects on abundance and productivity are weighed in light of the potential value of the information collected. Regardless of its relative magnitude, the negative effects associated with the proposed research and rescue activities on these species would to some extent, be offset by the information gained that would be used to help the species survive and recover.

As described in further detail below, we found for each ESU and DPS that:

1. The research activities' expected detrimental effects on the species' abundance and productivity would be small, even in combination with all the rest of the research authorized in the basin; and
2. That slight impact would be distributed throughout the species' entire range and would therefore be so attenuated as to have no appreciable effect on spatial structure or diversity.

As a result, we determined that the impact of the proposed research and rescues would be restricted to a small effect on abundance and productivity, and that the activities analyzed here would add only a small increment to that impact. In addition, as previously described, those small effects on abundance and productivity are offset to some degree, by the beneficial effects that the proposed research and rescue activities, as a whole, generate in fulfilling a critical role in promoting the species' health by producing information that managers need to help listed species recover.

2.7.1.1. Sacramento River Winter Run Chinook salmon

The effect of issuing Permit 18181-4R combined with the scientific research and monitoring permits already approved could result in potential mortality for Sacramento River winter-run Chinook salmon that ranges from 2.3 percent for hatchery-origin juveniles to 2.5 percent for natural-origin juveniles. The potential mortality for adults is estimated to be 2.9 percent. Thus, the projected total lethal take for all research and monitoring activities represents a small yet significant portion of the species' total abundance. However, absolute numbers of mortalities authorized are relatively low when compared to the expected level of adult returns and juveniles produced annually (Table 8). Further, the activities contemplated in this opinion associated with the issuance of Permit 18181-4R represent only fractions of those already small numbers.

The majority of the requested lethal take for adults under Permit 18181-4R is associated with the proposed rescue activities conducted by CDFW and only represents one percent of the expected adult abundance (Table 10). It is assumed that without intervention, these adult winter-run Chinook salmon otherwise perish due to stranding in unsuitable habitat and exposure to unfavorable environmental conditions. Therefore, despite the potential for incidental mortality to occur, the outcome is expected to be far better with the proposed rescues than with no intervention.

The potential mortality for juvenile winter-run Chinook salmon due to activities contemplated in this opinion represents only 0.19 percent of the abundance of naturally produced juveniles and only 0.18 percent of the abundance of hatchery-origin juveniles. The total mortalities considered in this opinion are only 938 of the combined total 21,405 mortalities (4.4 percent) that would be authorized in the region (Tables 10 and 11). Therefore, nearly all of the potential research-related juvenile mortality for natural-origin winter-run Chinook salmon has been previously analyzed and found not to jeopardize the species, and the work contemplated here would add very little to that effect.

It is also very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated in the tables above. Our research tracking system reveals that over the past five years (2015-2019), researchers ended up taking on average 21 percent of the naturally produced winter-run Chinook salmon juveniles they were authorized for the year, and the actual lethal take of natural-origin juveniles averaged only 12 percent of the mortalities authorized. For adults, researchers ended up taking 9 percent of the naturally produced adults they requested, and the actual mortality was only 3.7 percent of the total authorized. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small, even in combination with the rest of the research authorized in the basin. In addition, because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. Once again, the impact of the authorized and proposed research, even in its entirety, is expected to result in minimal effects on abundance and productivity. Furthermore, the activities analyzed here would add only a small increment to that impact, and the information gained from the proposed research and rescue activities would generate lasting benefits for the listed fish.

2.7.1.2. Central Valley Spring Run Chinook salmon

When combined with the scientific research and monitoring permits already approved, the proposed issuance of Permit 18181-4R may result in mortality for Central Valley spring-run Chinook salmon that would range from 0.2 percent for hatchery-origin juveniles to 0.9 percent for natural-origin juveniles. Adult mortalities are estimated to be 1.8 percent. Thus, the projected total lethal take for all research and monitoring activities in the region represents a small percentage of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of that already small number. The potential mortality of spring-run Chinook salmon resulting from activities contemplated in this opinion would equate to only 0.03 percent of the abundance of natural-origin juveniles (Table 10). These 635 juvenile mortalities would account for only 3.5 percent of the total permitted lethal take for the region (17,961 authorized mortalities). Therefore, nearly all of the potential mortality for natural-origin juvenile spring-run Chinook salmon has been previously analyzed and we determined it would not jeopardize the species. Moreover, the work contemplated here would add very little to that already small effect.

It is also very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated in Tables 10 and 11 above. For naturally produced spring-run Chinook, our research tracking system reveals that for the past five years (2015-2019), researchers ended up taking on average only 5.7 percent of the juveniles they requested, and the actual mortality averaged only 5.9 percent. In addition, researchers ended up taking 4.5 percent of the adult spring-run Chinook salmon that were permitted, and the actual mortality was less than 1 percent of the total authorized. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small, even in combination with all the rest of the research authorized in the basin. Additionally, because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find that the impact of the program, even in its entirety, is a small effect on abundance and productivity. Moreover, the activities analyzed here would add only a small increment to that impact, and the information gained from the proposed research and rescue activities would generate lasting benefits for the listed fish.

2.7.1.3. California Central Valley steelhead

When combined with the scientific research and monitoring permits already approved in the region, the issuance of Permit 18181-4R may result in potential mortality for CCV steelhead that ranges from 0.1 percent for hatchery-origin juveniles to 0.2 percent for natural-origin juveniles. Adult mortalities are estimated to be 3.1 percent. Thus, the projected total lethal take for all research and monitoring activities represents a very small fraction of the species' total abundance. The activities contemplated in this opinion constitute about 21 percent of the authorized take in the region (77 of 362 mortalities), which represents 0.7 percent of the estimated abundance adults (Tables 10 and 11). This percentage is much smaller for juveniles (189 of 2,179 for natural-origin and 58 of 1,864 for hatchery-origin), representing only 0.02 percent and 0.003 percent of the estimated abundance of natural-origin and hatchery-origin steelhead, respectively. Therefore, the great majority of the displayed potential mortality of concern has been previously analyzed and found not to jeopardize the species.

In addition, it is very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the tables above. For naturally produced CCV steelhead, our research tracking system reveals that for the past five years (2015-2019) researchers only ended up taking 4.5 percent of the adults they were authorized, and the actual mortality was only 0.98 percent of the total mortalities authorized for adults. This would mean that the actual effect of mortalities is likely to be approximately one-hundredth of the effect displayed in the table above.

Consequently, the effects of these small losses are expected to result in minor reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. Moreover, because that small impact would be distributed throughout the majority of the DPS' range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. However, even when considering the worst-case scenario, the effects are minimal and restricted to reductions in abundance and productivity. Furthermore, to some degree, the negative effects would be offset by the information to be gained, information that in all cases would be used to protect listed fish or promote their recovery.

2.7.1.4. Southern DPS green sturgeon

For sDPS green sturgeon, the effect of the scientific research and monitoring permits already approved in the region combined with the issuance of Permit 18181-4R may result in lethal take levels of 0.5 percent for adults and 1.8 percent for juveniles. However, as with the salmonid species discussed above, the majority of take has already been analyzed in previous opinions and been found not to jeopardize this DPS. The potential mortality of sDPS green sturgeon resulting from activities contemplated in this opinion would equate to only 0.11 percent of the juvenile abundance and 0.14 percent of the adult abundance (Table 10). The adult and juvenile mortalities would account for only 27 percent of the total permitted adult lethal take and 7.8 percent of the total permitted juvenile take for the region (3 of 11 and 6 of 77 authorized adult and juvenile mortalities, respectively; Table 11).

It is also very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated in the tables above. For sDPS green sturgeon, our research tracking system reveals that for the past five years (2015-2019), researchers ended up lethally taking only 4.3 percent of the juvenile mortalities they were authorized (24 of 557 individuals), and have not killed a single adult (0 of 33). Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small, even in combination with all the rest of the research authorized in the basin. However, even if the worst-case scenario were to occur and all the fish authorized as mortalities were killed in actuality, this would represent only a small reduction in overall abundance and productivity for the DPS. Moreover, that slight impact would be distributed throughout the species' range and would be so attenuated as to have no appreciable effect on spatial structure or diversity. Finally, regardless of its relative magnitude, all the negative effect associated with the research program on this species would to some extent be offset by gaining information that would be used to help the species survive and recover.

2.7.2. Critical Habitat

As previously discussed, we do not expect the individual actions to have any appreciable effect on any listed species' critical habitat. The proposed research and rescue activities' short durations, minimal intrusion, and overall lack of measurable effect signify that even when taken together they would have no discernible impact on critical habitat.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon or destroy or adversely modify their designated critical habitat.

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

In this instance, and for the actions considered in this opinion, there is no incidental take at all. The reason for this is that all the take contemplated in this document would be carried out under permits that allow the permit holders to directly take the animals in question. The actions are considered to be direct take rather than incidental take because in every case their actual purpose is to take the animals while carrying out a lawfully permitted activity. Thus, the take cannot be considered "incidental" under the definition given above. Nonetheless, one of the purposes of an incidental take statement is to lay out the amount or extent of take beyond which individuals carrying out an action cannot go without being in possible violation of Section 9 of the ESA. That purpose is fulfilled here by the amounts of direct take laid out in the Effects Section above (2.5). Those amounts constitute hard limits on both the amount and extent of take the permit holder would be allowed in a given year. This concept is also reflected in the reinitiation clause below.

2.10. Reinitiation of Consultation

This concludes formal consultation for the issuance of ESA Section 10(a)(1)(A) Permit 18181-4R to CDFW.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

In the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in § 402.16(a)(1) is not applicable. If any of the direct take amounts specified in this opinion's effects analysis (Section 2.5) are exceeded, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in § 402.16(a)(2) and/or (a)(3) will have been met.

3. Data Quality Act Documentation and Pre-Dissemination Review

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

3.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are NMFS and CDFW. Other interested users could include residents of affected areas and others interested in the conservation of the affected ESUs/DPS. A copy of this biological opinion was preserved on file at the California Central Valley Office and is available to any applicants, intended users, or interested parties upon request. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

3.2. Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

3.3. Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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