Guidance Document for Methods to Assess San Joaquin River Spring-Run Chinook Salmon in Relation to CVP/SWP Delta Facility Operational Triggers and Incidental Take Limits

SAN JOAQUIN RIVER
RESTORATION PROGRAM

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1.0 Introduction and Purpose

1.1 Introduction

A settlement (Settlement) was reached in 2006 in *NRDC, et al., v. Rodgers, et al.*, related to the San Joaquin River below Friant Dam, which is currently being implemented through the San Joaquin River Restoration Program (SJRRP). The Federal Implementing Agencies are authorized and directed to implement the Settlement by the San Joaquin River Restoration Settlement Act (Settlement Act) (Pub. L. 111-11, 123 Stat. 1349 (2009)). The Settlement mandates that spring-run Chinook salmon (*Oncorhynchus tshawytscha*) are to be reintroduced into the San Joaquin River under the SJRRP and the Settlement Act requires that reintroduced SJRRP Central Valley (CV) spring-run Chinook salmon be considered an experimental population pursuant to section 10(j) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1539(j)).

The Settlement Act further requires the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) to prepare a rule pursuant to section 4(d) of the ESA so that reintroduction will not impose more than "*de minimus*: water supply reductions, additional storage releases, or bypass flows on unwilling third parties." The Settlement Act defines "third party" to mean persons or entities diverting or receiving water pursuant to applicable State and Federal laws; this includes CVP contractors outside of the Friant Division of the CVP and the State Water Project (SWP) contractors. This 10(j)/4(d) rule entitled "Designation of a Nonessential Experimental Population of Central Valley Spring-run Chinook Salmon Below Friant Dam in the San Joaquin River California" was published on December 31, 2013 (10(j)/4(d) rule; 78 FR 251, December 31, 2013). This rule requires that a technical memorandum (Tech Memo) is prepared and released annually by NMFS. The annual Tech Memo is produced to calculate and document the proportionate contribution of CV spring-run Chinook salmon originating from the SJRRP and describe how loss of these fish will be deducted or adjusted for when applying the operational triggers and incidental take statements associated with the NMFS 2009 Biological Opinion or future biological opinions for the Long-term Operations of the Central Valley Project (CVP) and State Water Project (SWP)(CVP/SWP BO, NMFS 2009), or ESA Section 10 permits.

A technical work group consisting of fisheries and water management agencies and water users was convened in May 2013 to provide input throughout the preparation of the annual Tech Memo. The San Joaquin River Spring-run Tech Memo Work Group provides an open forum for interested entities to participate collaboratively in this process. The group provided input to NMFS for consideration in the initial 2014 Tech Memo. The 2014 Tech Memo was released on January 15, 2014, by NMFS. Workshops with experts in the field were held in summer 2014 to explore various accounting methods. The information explored during those workshops is the science foundation for this guidance document. The second Tech Memo was developed collaboratively and released by NMFS on January 15, 2015. The Tech Memo Work Group has been meeting bi-monthly in 2015 to explore accounting methods that could be used in the short and long-term and will finalize this guidance document to support San Joaquin River (SJR) CV spring-run Chinook salmon accounting decisions.

1.2 Purpose

The purpose of this guidance document is to provide a framework for identifying methods to assess reintroduced SJR CV spring-run Chinook salmon with regard to CVP/SWP Delta facility operational triggers and incidental take limits and weigh the pros and cons of each identified accounting method. This document and the associated review process also provides a collaborative, transparent process for all of the agencies, water users and others interested in the SJR CV spring-run Chinook salmon reintroduction.

There are a number of complex issues surrounding the task of calculating the proportionate contribution of SJR-produced spring-run Chinook salmon to ensure that the reintroduction does not cause more than a *de minimus* impact on water supply, additional storage releases, and bypass flows associated with the operation of the CVP and SWP. The *de minimus* requirement can be achieved at the CVP/SWP water export facilities either by: 1) confirming that juvenile CV spring-run Chinook salmon from the SJR do not fall within the older juvenile or winter-run size at date; or, 2) accounting for juvenile CV spring-run Chinook salmon that originate from the reintroduction and then adapting the existing or future incidental take allowances or operational triggers at the CVP/SWP Delta facilities. Either of these options would ensure that the reintroduction of CV spring-run Chinook salmon into the San Joaquin River will not impose more than a *de minimus* impact on water supply (NMFS 2013).

In addition, the potential for straying of SJR origin CV spring-run Chinook salmon adults into other tributaries within the San Joaquin and Sacramento rivers was identified as a concern during the development of the 10(j)/4(d) rule. NMFS' analysis of straying potential conducted as part of an internal Section 7 ESA consultation, concluded that straying of SJR CV spring-run Chinook salmon is unlikely to occur at a higher rate than natural Chinook salmon straying rates. However, NMFS agreed to track this issue as it potentially relates to meeting the *de minimus* requirements. Straying which results in successful spawning and juvenile survival, could lead to salvage of juveniles of SJR heritage. This straying could increase juvenile losses at the Delta facilities and result in exceeding operational triggers. This issue will be considered during the evaluation of SJR CV spring-run Chinook salmon accounting methods.

2.0 Salmon Monitoring in the San Joaquin River

There will be ongoing, long-term monitoring of salmon populations in the SJR within and outside of the SJRRP area, conducted by various agencies and organizations. This monitoring is separate from the Tech Memo process but it may provide some of the data required for future implementation of one or more of the SJR CV spring-run Chinook salmon accounting methods under consideration. The SJRRP is in the process of preparing a Fisheries Implementation Plan, which, among other things, will identify what monitoring should be performed by the SJRRP and the frequency of that monitoring. The SJRRP monitoring described below is monitoring that is anticipated as part of the SJRRP. However, as the SJRRP's monitoring actions are further defined, specific monitoring actions and/or methods may change in the future. Some of the monitoring performed by other agencies and organizations outside of the SJRRP may be reduced in scope or eliminated based on funding, data needs, and management decisions outside of SJRRP control. This is an important factor to consider when selecting an accounting method for implementation.

2.1 Adult Salmon Monitoring

2.1.1 SJRRP Monitoring

Chinook salmon redd and carcass surveys are anticipated to be conducted weekly between the late summer and early winter in the SJRRP area, primarily within Reach 1. The surveys would be conducted to determine the number of fall- and spring-run Chinook salmon that successfully return to spawn in the SJR (Table 1). Genetic tissue samples would be collected from all Chinook salmon carcasses encountered during the carcass survey for genetic analyses (Table 1). At locations in the SJRRP area where fish passage will be constructed around barriers, such as Sack Dam, a fish counting station may be included. The fish counting station(s) would be used to examine fish passage, abundance, and run timing. In addition, it may be possible to construct a live cage at the passage structure(s) that adult salmon are diverted into so that a genetic sample could be taken and a tag [(passive integrated transponder (PIT), acoustic, disc, etc.)] implanted for tracking. These fish passage structures and associated salmon tagging would augment redd and carcass surveys to enhance the knowledge of migration timing and movement through the SJRRP area, as well as limiting factors related to potential pre-spawn mortality.

Until full connectivity is restored to the SJR and barriers to migration are addressed within the SJRRP area, adult Chinook salmon are anticipated to be trapped and hauled around the section of river that does not have connectivity or has unpassable barriers. Trapping and hauling provides the SJRRP an accurate count of how many adult Chinook salmon are released to spawn within the SJRRP area. Trap and haul also allows for data collection (*i.e.*, tissue samples) from the captured salmon and an opportunity to tag these fish to facilitate tracking of their post-release movement.

Currently, fall-run Chinook salmon are trapped above Hills Ferry Barrier from October to mid-December and then hauled for release in Reach 1, typically at Camp Pashayan (near Highway 99). In 2014, fall-run Chinook salmon were trapped using fyke nets directly upstream of the Hills Ferry Barrier, 0.6 miles upstream of the Hills Ferry Barrier, in Mud and Salt sloughs (dead end sloughs), and near the SJR confluence with the Eastside Bypass (SJRRP 2013a). In addition, fall-run Chinook salmon were captured using dip nets in the terminal ends of irrigation canals upstream of the Hills Ferry Barrier (SJRRP 2013a). All fall-run Chinook salmon were tagged with a uniquely numbered Peterson disc tag that was colored differently based on month of capture (*i.e.*, yellow in October, green in November, and orange in December; SJRRP 2013a). In addition, a subsample of the captured fall-run Chinook salmon were implanted with an acoustic tag for tracking of location within Reach 1 (SJRRP 2013a). The following data was collected from the trapped salmon: a fin clip for genetic analysis, length (fork and total), sex, presence or absence of an adipose fin, and overall condition. Similar actions are anticipated to occur in Fall 2015. Scale samples could also be collected from the captured Chinook salmon to study the population age structure.

A monitoring element is currently under development to detect and capture adult CV spring-run Chinook salmon returning to the SJR in the spring, likely from March through June.

2.1.2 Non-SJRRP Monitoring

No non-SJRRP Chinook salmon monitoring in the SJRRP area is currently occurring or is anticipated in the future.

Additionally, no adult Chinook salmon monitoring occurs within the mainstem SJR. However, adult Chinook salmon are enumerated at fish weirs on the two main tributaries of the SJR: Stanislaus and Tuolumne rivers. The Tuolumne River weir is operated at River mile 2 from January 1 to December 31. The weir has a fish trap installation with a VAKI Riverwatcher that is operated from April 1 to June 30 and October 1 to December 31. Two weirs were added on the Tuolumne River in 2015; one located on the south side of the river channel just downstream of the TID powerhouse, the second is on the north side of the river channel downstream of the plunge pool below La Grange Dame. Both weirs are equipped with video cameras in a fish trap installation and visual surveys are conducted upstream and downstream of each weir. The Stanislaus River weir is operated at River mile 2.1 from January 1 to December 31. The weir has a fish trap installation with a VAKI Riverwatcher that is operated from April 1 to June 30 and October 1 to December 31. No genetic samples are taken of adult Chinook salmon during the operation of the Tuolumne or Stanislaus weirs.

Table 1. Chinook Salmon Monitoring Actions within the SJRRP area Conducted by the SJRRP to Date

Monitoring Action	GSI	Summary	PBT	Summary	Surrogate	Summary	JPE	Summary	Mass Marking	Summary
Carcass Survey	N/A	N/A	X	Genetics for database	N/A	N/A	X	Female Chinook salmon escapement	N/A	N/A
Redd Survey	N/A	N/A	N/A	N/A	N/A	N/A	X	Female Chinook salmon escapement	N/A	N/A
Downstream Migrant Trapping	N/A	N/A	N/A	N/A	X	Release trigger; Estimate of natural yearling spring-run migrants for use in winter-run operational trigger and incidental take adjustment calculation; Capture of naturals for tagging - comparison of natural vs. surrogate fish	X	Egg to fry survival; Fry to smolt survival; Capture of smolts for tagging - Smolt to Delta survival	X	Capture of natural fish for mass marking
Redd Emergence Traps	N/A	N/A	N/A	N/A	N/A	N/A	X	Egg to fry survival	N/A	N/A
Spring-run released by SJRRP ad-clipped and CWTed	N/A	N/A	N/A	N/A	N/A	N/A	X	Smolt to Delta survival	X	Trial for mass-marking; Identification of SJRRP released fish at Delta facilities

Note: Each monitoring element that could contribute data for an accounting method under consideration is indicated with an X and then followed by a brief description.
GSI = Genetic stock identification
PBT = Parental based tagging
JPE = Juvenile production estimate

2.2 Juvenile Salmon Monitoring

2.2.1 SJRRP Monitoring

The SJRRP has used emergence traps in prior years and anticipates using them in the future on a sample of fall-run Chinook salmon redds within the SJRRP area to determine the number of eggs that survive to emerging fry (*i.e.*, egg to fry survival, Table 1).

Rotary screw traps (RST) and/or juvenile salmon weirs are anticipated to be used in one to several locations within the SJRRP area to monitor emigration of juvenile salmon (Table 1). With proper trap efficiency trials, the RST and/or juvenile salmon weirs could be used to estimate the total number of juvenile salmon produced within the SJRRP area. The RSTs and/or juvenile salmon weirs could also be used to capture naturally-produced juvenile Chinook salmon to be marked and aggregated for surrogate releases (Table 1). There are limitations to using RSTs to monitor the entire juvenile Chinook salmon migration period because they must be raised out of the water column during high flow periods and during very low flows they cannot properly operate. It may be possible to develop a relationship between flow and fish abundance so that fish abundance could be extrapolated through periods when the RSTs cannot be fished.

A sample of juvenile Chinook salmon produced in the hatchery and/or naturally-produced fish captured by the trapping efforts may be tagged with PIT-tags and/or acoustic tags in order to track their migration and growth rates, habitat usage, and survival in the SJR and the Delta. Pilot scale PIT and acoustic tag juvenile Chinook salmon tracking projects have already been performed as part of the SJRRP (SJRRP 2013b, SJRRP 2013c).

Juvenile hatchery CV spring-run Chinook salmon released into the SJR by the SJRRP will all be coded wire tagged (CWT) and adipose fin-clipped in order to easily identify them and is required by the ESA section 10(a)(1)(A) (Permit No. 17781). In addition, CWT recoveries and/or PIT-tag detections from adult Chinook salmon that return to the SJR to spawn will provide an estimate of smolt to adult return rates.

2.2.2 Non-SJRRP Monitoring

The non-SJRRP monitoring in the SJR is funded through decisions made outside of the SJRRP. Some of these monitoring projects have uncertainty in their funding or have the potential to be scaled back in scope. Due to this uncertainty, caution should be taken in implementing any accounting technique that relies on a monitoring project that is funded outside of the SJRRP.

The Mossdale trawl on the SJR is conducted year round and performed jointly by the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Wildlife (CDFW) (Table 2). The Mossdale trawl is performed using a Kodiak trawl net and is conducted from two miles downstream of Mossdale Landing County Park to just upstream of the Old River confluence. The CDFW performs the Mossdale trawl from April to mid-June and samples at a higher frequency (5-7 days per week) due to this time period being the peak of emigration for Chinook salmon smolts from the entire SJR basin. The USFWS performs the Mossdale trawl during the rest of the year and samples only three days per week. Capture in the Mossdale trawl of CWTed and/or PIT tagged Chinook salmon released by the SJRRP could provide an estimate of migration rate and survival through the SJR.

The Prisoners/Jersey Point trawls were implemented in winter and spring of 2015 as a drought action. The primary purpose of these trawling efforts was to determine if delta smelt (*Hypomesus transpacificus*) were occupying this part of the Delta and, therefore, provide advanced warning to the CVP/SWP export facilities that delta smelt were close to being subjected to entrainment by the facilities. In addition, this trawl effort also helped determine where ESA-listed Chinook salmon juveniles were located and, therefore, provide advanced warning to CVP/SWP export facilities of the presence of listed salmonids. There are no operational triggers in the CVP/SWP BO related to capture of listed salmonids in the Prisoners/Jersey Point trawls. Future monitoring at Prisoners/Jersey Point trawls is uncertain.

The Chipps Island trawl is conducted year round by the USFWS and is typically performed three days per week, but during certain sampling periods is performed up to seven days per week (Table 2). The frequency of trawling effort at Chipps Island is affected by the Delta smelt incidental take allowance; sampling has been halted on occasion. The Chipps Island trawl is performed using a midwater trawl net and conducted upstream of the western tip of Chipps Island (western Delta). Capture in the Chipps Island trawl of CWTed and/or PIT tagged Chinook salmon released by the SJRRP could provide an estimate of migration rate and survival through the SJR and Delta.

One of the limitations with trawl surveys is very low capture efficiency (Pyper *et al.* 2013, Speegle *et al.* 2014). This very low capture efficiency would require SJRRP release groups to be very large in order to capture enough CWTed Chinook salmon in the trawl surveys (*i.e.*, have a large enough sample size) to provide accurate migration rate and survival estimates. In addition, survival rates of migrating juvenile Chinook salmon are typically very low through the lower SJR and the South Delta (Buchanan *et al.* 2013). This very low survival would require even larger SJRRP releases to ensure that enough juvenile Chinook salmon reach the western Delta in order to provide a sufficient likelihood of captures from the Chipps Island trawl. Survival of juvenile Chinook salmon migrating through the SJR below the Merced River confluence was indirectly studied by CDFW using releases of CWTed fall-run Chinook salmon juveniles raised at the Merced River Hatchery. Different release locations were used in the Merced and San Joaquin rivers. Smolt-to-adult survival was calculated for the different CWT release locations by year. Smolt-to-adult survival for 4 years of releases at Merced River Hatchery ranged from 0.17% to 0.01% (California HSRG 2012). Smolt-to-adult survival for 5 years of releases at Jersey Point on the SJR ranged from 1.01% to 4.27% (California HSRG 2012). Smolt-to-adult survival generally increased as juvenile salmon releases were made further downstream in the SJR suggesting that the further upstream the releases are made the lower the survival fish will experience. This report provides some evidence of low survival of juvenile Chinook salmon in the SJR from the Merced River confluence to the Delta. Further study of the survival of rearing and migrating juvenile Chinook salmon survival in the SJR between the Merced River confluence and the Delta is warranted. Survival in this segment of the SJR may be a major limitation for SJR CV spring-run Chinook salmon. The previously discussed study used hatchery fish and it is unknown how well hatchery-produced salmon perform as surrogates for naturally-produced SJR Chinook salmon. A smolt survival study using acoustic tags in the SJR below the Merced River confluence would provide valuable information about migrating juvenile Chinook salmon.

Beach seining is conducted by the USFWS in the lower SJR, the South and Central Delta, and San Francisco and San Pablo bays, as part of their Delta Juvenile Fish Monitoring Program

(Table 2). The beach seining is typically conducted once per week at each location with one seine pass per location. Capture of CWTed and/or PIT-tagged Chinook salmon in the USFWS' beach seining efforts would provide similar data as the trawl surveys, namely migration rate and occupancy. However, there is some evidence that beach seining captures primarily wild fish (Barnard *et al.* 2015). This suggests that the beach seining would only be useful to the SJRRP in providing data from SJRRP-tagged hatchery fish. Capture probability is incomplete and variable for beach seining but preliminary data suggest that it can exceed 60% for juvenile Chinook salmon within a sample area (Perry *et al.* 2015). Based on sampling relatively small areas of the river coupled with incomplete detection, the number of juvenile Chinook salmon captured during the beach seining efforts compared to the total population size of juvenile Chinook salmon is very small resulting in a very small probability of capturing a SJRRP-tagged fish during the beach seining efforts. Beach seining is typically performed to determine occupancy of targeted fish at a location and to capture them to measure their size and/or determine their health. All adipose-clipped fish captured in the beach seining efforts are sacrificed in order to extract and read their CWTs. Beach seining at the same location and time period for multiple years can provide a rough estimate of yearly relative abundance. Fixed point sampling, however, does not often represent all habitats within their sampling extent, which may over or under represent juvenile salmon abundance and distribution.

At the SWP Skinner Fish Collection Facility, fish are guided past a series of louvers, and secondary channels into large holding tanks where they are salvaged. Samples of the fish are taken every two hours or less from the holding tanks, identified, counted and measured by trained California Department of Water Resources staff. Chinook salmon are treated and recorded in different ways depending on whether they are marked or non-marked as shown in Figure 1. CWTed fish are sacrificed and CWT read within 24 hours and reported to CDFW, which subsequently reports the tag information to the Data Assessment Team (DAT) and Delta Operations for Salmonids and Sturgeon (DOSS) team.

The Bureau of Reclamation follows a similar process at the CVP Tracy Fish Collection Facility as shown in Figure 2.

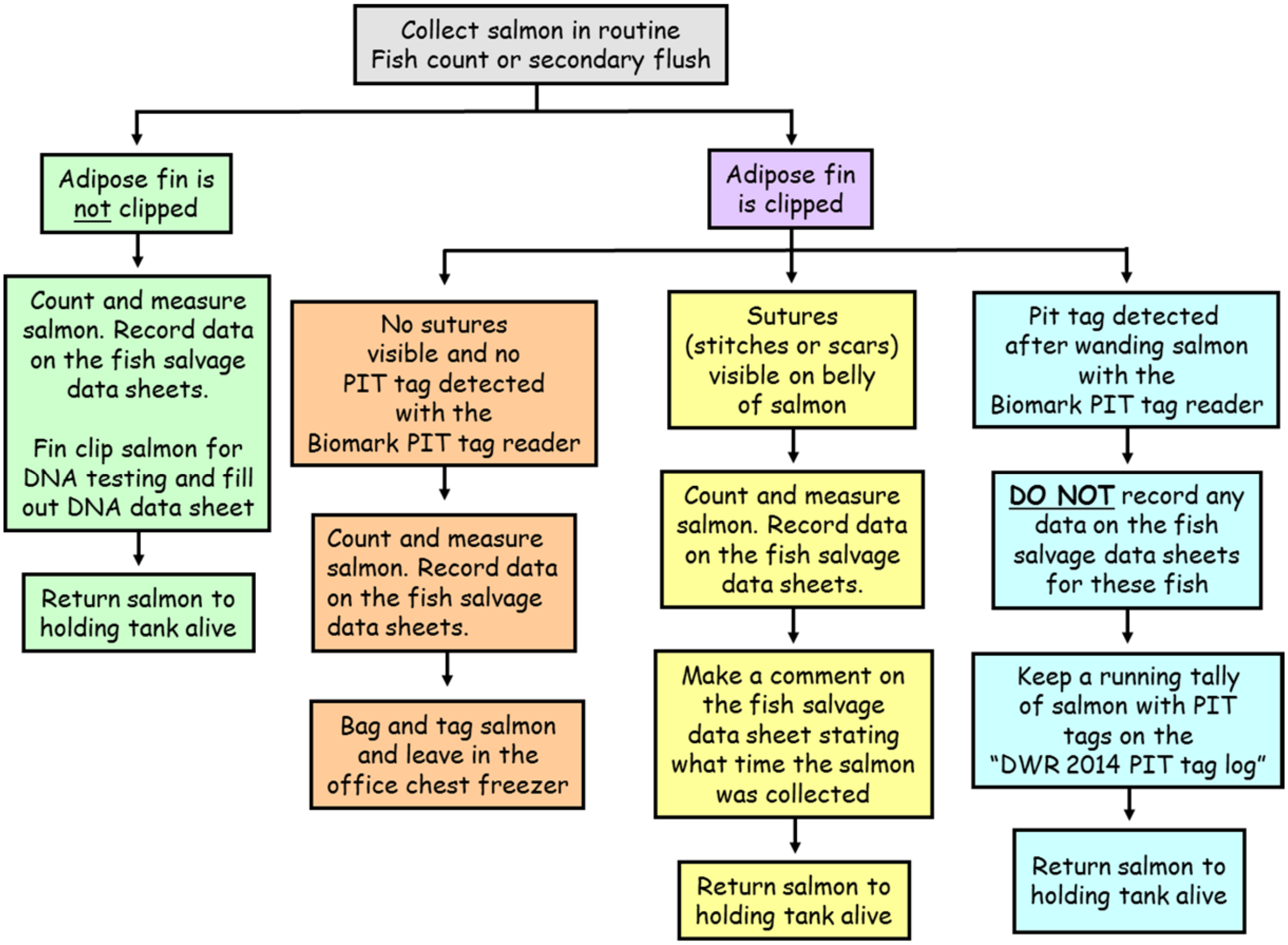

Figure 1. Procedures for Chinook Salmon at Skinner Fish Collection Facility

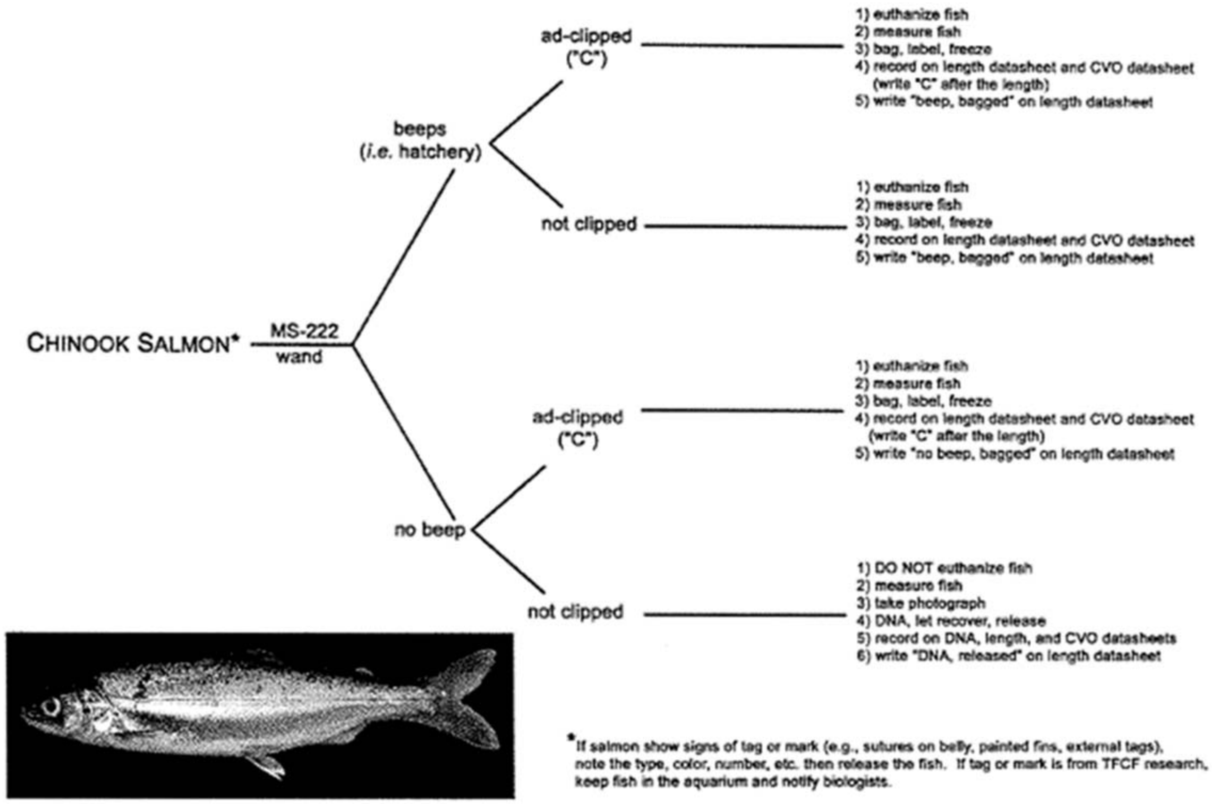

Figure 2. Chinook Salmon Handling Procedure at the Tracy Fish Collection Facility

Table 2. Chinook Salmon Monitoring Actions in the San Joaquin River and the Delta Conducted by Others to Date

Monitoring Action	GSI	Summary	PBT	Summary	Surrogate	Summary	JPE	Summary	Mass Marking	Summary
Mossdale Trawl	N/A	N/A	N/A	N/A	X	Location of surrogate fish	X	Smolt to Delta Survival	X	Location and identification of SJRRP fish
Chipps Island Trawl	N/A	N/A	N/A	N/A	X	Location of surrogate fish	N/A	Smolt to Delta Survival	X	Location and identification of SJRRP fish
Beach Seining	N/A	N/A	N/A	N/A	X	Location of surrogate fish	N/A	N/A	X	Location and identification of SJRRP fish
Delta Facilities Fish Sampling	X	Winter-run sized Chinook salmon juveniles assigned to winter-run or not	X	Identification of juvenile as a SJRRP fish given that its' parents are in the PBT database	X	Capture of surrogate fish expanded to account for natural fish	N/A	N/A	X	Identification of SJRRP fish

Note: Each monitoring element that could contribute data for an accounting method under consideration is indicated with an X and then followed by a brief description.
GSI = Genetic stock identification
PBT = Parental based tagging
JPE = Juvenile production estimate

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3.0 SJRRP Spring-Run Chinook Salmon Reintroduction Phases

The SJRRP has begun the reintroduction of CV spring-run Chinook salmon in a phased approach. The first phase consists of hatchery-produced Chinook salmon fish releases. As adults from these hatchery releases return to the SJR and spawn naturally, the second phase of reintroduction will begin. This phase will consist of a mix of hatchery- and naturally-produced fish. The third phase occurs as hatchery releases are phased out and only focus on study needs (RST calibration and survival studies) and natural production approaches 100%.

3.1 Phase 1 – Released Hatchery Fish Only (2014 – 2016)

Genetic tissue samples will be collected from all of the parent crosses of juveniles that are released into the SJRRP area. The genotypes of all parents will be housed in a database so that parentage inference analysis would be possible at a later date if necessary. The database will be available to undertake reassignment to the parentage based tagging baseline for individuals salvaged at the CVP/SWP facilities. The genetic testing is currently being performed by the NMFS Southwest Fisheries Science Center and the justification for it is outlined in their monitoring and analysis plan study proposal (SJRRP 2015).

In the first few years of the SJRRP, all reintroduced spring-run Chinook salmon will occur from active reintroduction efforts. All hatchery juveniles released will be adipose fin-clipped and CWTed. If captured at the CVP/SWP pumping facilities, they can be identified as SJR spring-run Chinook salmon and not included in incidental take afforded to CVP/SWP operations and not contribute to operational triggers.

3.2 Phase 2 – Natural Production and Continued Hatchery Releases (As Soon As Spring 2017)

In 2016, it is reasonable to expect that some released spring-run Chinook salmon will return to the SJR and spawn naturally. Once natural production occurs, unmarked juvenile spring-run Chinook salmon from the SJR will likely only affect the incidental take and operational trigger estimates if they reach the size of typical winter-run Chinook salmon smolts (100-200 mm fork length), or as older Chinook salmon juveniles; both of these are determined by length-at-date criteria (Harvey *et al.* 2014, del Rosario *et al.* 2013) and are migrating through the Delta at the same time as winter-run juveniles. Monitoring will determine whether spring-run Chinook salmon from the reintroduced population are reaching the winter-run size range when migrating through the Delta. If the SJR juvenile spring-run are within the winter-run size range when they reach the Delta then this issue could be addressed by one or more of the following methods:

1. Marked surrogate groups

2. Juvenile production estimate
3. Genetic assignment
4. Mass Marking

The purpose of this document is to provide information for a transparent and open process to identify accounting methods and weigh the biological validity and pros and cons of each of the four methods listed above.

3.3 Phase 3 – Phasing Out Supplementation (Date Uncertain)

During Phase 3 of the reintroduction process, the SJRRP expects that Chinook salmon populations within the SJRRP area will obtain a naturally-sustainable level, which would eliminate the need to use hatchery production for population supplementation.

The SJRRP would continue to assess Phase 2 outcomes and refine accounting methodologies as needed. Other accounting methods would be implemented if they have merit and are necessary.

4.0 Methods of Accounting for Incidental Loss at CVP/SWP Facilities of Reintroduced Spring-run Chinook Salmon

The purpose of this section is to identify the pros and cons of four primary methods of accounting for loss of SJR spring-run Chinook salmon at the Delta facilities. Assignment of juvenile Chinook salmon salvaged at the fish facilities to their run type (fall, late-fall, winter, and spring) is primarily done using a length-at-date growth model (Harvey *et al.* 2014). However, there is some momentum to move away from using the length-at-date growth model for run assignment since the comparison of length-at-date assignment with genetic assignment has revealed that there is a high degree of fork length range overlap between the four runs of salmon indicating that the length-at-date model is not as accurate at identifying a particular run as desired (Harvey *et al.* 2014). At present, genetic assignment is the most accurate method currently available to assign juvenile Chinook salmon to run type, although other methods such as morphometric models have been examined recently (Merz *et al*. 2014).

This method evaluation process is designed to enable the SJRRP to select the method that will be used for Phase 2 and 3 of the spring-run reintroduction in the SJR. Each method has the following outline as a guideline:

1. Explain the method in detail
2. Identify pros for SJRRP
3. Identify cons for SJRRP
4. Identify monitoring needs

4.1 Marked Surrogate Groups

If monitoring determines that SJR spring-run Chinook salmon downstream juvenile migrants fit the winter-run Chinook salmon size category, surrogate tagged juvenile Chinook salmon (ideally spring-run, but fall-run may be suitable for use as well) could be released in groups in response to a predetermined release trigger to estimate loss at the CVP/SWP facilities (Table 3). Surrogate release groups are typically tagged using an easy and inexpensive tag, such as a PIT-tag or a CWT in combination with an adipose-fin clip. Depending on the size of the surrogate release group it may be cost prohibitive to use PIT-tags. It would be possible to CWT and ad-clip all of the surrogate release group and also tag a subset of them with PIT-tags for additional information. However, sacrificing a PIT-tagged fish could lead to the loss of desirable information gained by the fish been released alive. An additional mark in conjunction with an ad-clip may be desired so that PIT-tagged fish are not sacrificed provided that this additional mark does not compromise swimming ability, or add variable or uncertainty to the representativeness of the group. If surrogate fish are reared and released by the SJRRP then they must be CWTed and ad-clipped as required in the 10(a)(1)(A) permit (#17781).

Table 3. Steps Required to Use the Surrogate Accounting Method

Step Number	Name	Detail
1	Trigger	Trigger(s) are determined which will result in the release of a surrogate release group
2	Release	Release of a tagged and/or marked surrogate release group
3	Estimate	Estimate number of naturally-produced spring-run Chinook salmon from the SJRRP area that are migrating/associated with the surrogate release group
4	Calculate Ratio	Calculate the ratio of marked surrogate fish to unmarked naturally-produced fish
5	Expand Salvage	Expand the salvage expansion of surrogate fish to estimate the number of unmarked fish entrained by the facilities
6	Subtract	Subtract the estimated number of unmarked spring-run Chinook salmon of winter-run size originating from the SJRRP area encountered at the CVP/SWP from the winter-run Chinook salmon operational trigger and incidental take statement

These surrogate groups would be released in proximity, time and space, to natural SJR spring-run Chinook salmon outmigration, so their migration, survival, and behavior are influenced by similar environmental processes. In addition, surrogate release groups are typically released at a similar size to their naturally-produced counterpart so that they have similar behavior, migration rates, and survival. Typically, a surrogate release trigger is used such as catch of naturally-produced yearling spring-run Chinook salmon in a RST or a flow increase due to a precipitation or snow-melt event. Multiple release groups would likely be used for this method following protocols established on the Sacramento River.

On the Sacramento River, late fall-run Chinook salmon juveniles, produced at Coleman National Fish Hatchery, are used for surrogate release groups for older ("yearling"), naturally-produced spring-run Chinook salmon smolts migrating from creeks such as Mill, Deer, Antelope, and Butte (DOSS 2012). The trigger for releasing the surrogate groups are late fall and early winter precipitation events that increase flows and stimulate yearling spring-run Chinook salmon to emigrate (DOSS 2012). To determine loss at the CVP/SWP facilities of wild yearling spring-run Chinook salmon migrating from tributaries to the Sacramento River, a surrogate approach is used. This approach is used because wild yearling spring-run Chinook salmon are unmarked and are impossible to differentiate from unmarked juvenile Chinook salmon from other Chinook salmon runs of similar size without the use of genetic stock identification. Determination of loss at the CVP/SWP using the surrogate releases is based on the percentage of the release estimated as lost at the export facilities, which is based on the number of fish recovered by the fish salvage facilities. A trigger for modification of export operations is reached when cumulative loss is greater than 0.5% of a surrogate release group at the CVP/SWP facilities (NMFS 2009; RPA Action IV.2.3). Late fall-run Chinook salmon juveniles from Coleman National Fish Hatchery are assumed to be good surrogates for wild yearling spring-run Chinook salmon since they are of similar size and released to migrate downstream at the same time as wild spring-run. NMFS assumes that minimizing loss of the surrogates at the CVP/SWP is in turn minimizing loss of wild yearling spring-run Chinook salmon juveniles. The loss (take) of wild yearling spring-run Chinook salmon from the Sacramento River at the CVP/SWP facilities is not calculated because surrogates are used.

However, to use surrogate releases on the SJR to account for naturally-produced yearling spring-run Chinook salmon at the CVP/SWP facilities that originated within the SJRRP area would be more complicated than the surrogate technique used for Sacramento River yearling spring-run Chinook salmon. The surrogate technique used for Sacramento River wild yearling spring-run Chinook salmon is performed to ensure that no more than a certain percent of the surrogate yearlings are lost at the CVP/SWP facilities. For the SJR, the naturally-produced spring-run Chinook salmon have to be determined as not winter-run Chinook salmon so that they are not used in the operational trigger calculations or incidental take estimates and to accomplish this goal requires more information.

The additional information necessary would be an estimate of the number of naturally-produced yearling spring-run Chinook salmon smolts produced within the SJRRP area each year so that an estimate of the ratio of marked surrogate fish to unmarked wild fish can be made. A known number of marked surrogate yearling-sized Chinook salmon would be released into the SJR as a release group at an appropriate location using a predetermined trigger, likely RST captures of wild yearling spring-run Chinook salmon. A power analysis (see Buchanan 2013) could be conducted to determine the number of surrogates needed to proportionately represent the wild SJR spring-run Chinook salmon population. Multiple release groups would likely be used in response to multiple peaks in RST catch or released around the RST peak catch with each release group separated by a certain amount of time. The RST captures of wild yearling spring-run Chinook salmon could then be expanded, using trap efficiency, to estimate the total number of wild yearling spring-run Chinook salmon produced within the SJRRP area for the specific period of time that is associated with a release group. The number of marked surrogate fish released in a group is known and the production of unmarked yearling wild fish is estimated, which allows for the ratio of unmarked to marked fish to be calculated.

To estimate the loss at the CVP/SWP facilities of wild yearling spring-run Chinook salmon from the SJR, the estimated loss of marked surrogate fish would be expanded to account for their unmarked wild counterparts using the ratio of marked to unmarked fish. For example, suppose that 5,000 marked surrogate fish were released during one release group and that unmarked yearling spring-run Chinook salmon production was estimated to be 50,000 fish associated with that time period of release resulting in a marked to unmarked ratio of 1:10. The estimate of marked surrogate fish loss at the CVP/SWP was 5, for example, and the resulting estimate of unmarked fish lost at the CVP/SWP would be 50, by expanding using the marked to unmarked ratio of 1:10. This loss of 50 unmarked wild yearling spring-run Chinook salmon from the SJR would then be subtracted from the total estimated loss of unmarked winter-run size Chinook salmon at the CVP/SWP and so they would not contribute to operational trigger estimates.

Using juvenile Chinook salmon downstream migration data collected using RSTs and/or other kinds of traps and incorporating some guidance from the Fisheries Management Plan (SJRRP 2010) in relation to population targets, we can develop a framework for the number and size of yearling juvenile spring-run Chinook salmon expected to reach the Delta and design a surrogate release plan.

Surrogate tagged fish could also be used as indicators for when juvenile wild SJR spring-run Chinook salmon would be arriving at the Delta facilities. If Sacramento River monitoring indicates that juvenile winter-run Chinook salmon are not reaching the Delta at that time then SJR spring-run could be discounted from the incidental take limits and operational triggers.

An additional factor that could be important to research is the suitability of the surrogate fish. If hatchery-origin surrogate fish have a different survival rate or use different migration routes through the SJR and Delta at a different rate than wild fish, then it could have ramifications for the loss calculation at the CVP/SWP facilities. For example, if hatchery-origin surrogate fish have a lower survival rate to the Delta than wild fish, then the ratio of marked-to-unmarked fish could be 1:10 at the start of the migration, but by the time the fish reach the Delta then the ratio is 1:15. If the loss expansion was based off of the 1:10 original ratio but in actuality the ratio was 1:15, then the estimate loss of wild yearling SJR spring-run Chinook salmon would be an underestimate. In this situation of an underestimate loss of wild yearling SJR spring-run Chinook salmon, 5 fish would be unaccounted for and potentially counted as winter-run Chinook salmon. In an alternative scenario, suppose that surrogate fish were more likely to take a migration route that resulted in them being more susceptible to being entrained at the CVP/SWP facilities. Surrogate fish use this migration route more frequently such that they show up in a ratio of 1:5 instead of 1:10. In this scenario if the loss expansion was based, again, off a 1:10 ratio but was in actuality only a 1:5 ratio then the estimated loss of wild yearling SJR spring-run Chinook salmon would be an overestimate. In this situation of an overestimate of wild yearling SJR spring-run Chinook salmon loss, more fish would be considered wild SJR fish when they were actually winter-run Chinook salmon. In light of these possible scenarios and their ramifications for the CVP/SWP winter-run Chinook salmon operational triggers and incidental take allowances it would be important to research/evaluate the suitability of using surrogates for wild fish.

4.1.1 Pros for SJRRP

One advantage of this accounting method to the SJRRP is the CVP/SWP fish facilities will be directly looking for surrogate released fish. Given in-river monitoring by the SJRRP, efforts to release surrogate fish during the majority of the natural SJR yearling spring-run Chinook salmon emigration period are likely feasible.

4.1.2 Cons for SJRRP

The recovery of surrogate release fish and the subsequent indirect estimation of loss of naturally-produced fish, using the estimated ratio of marked to unmarked fish, relies on two major assumptions. The first major assumption is that the estimate of the number of yearling Chinook salmon outmigrating from the SJRRP area is accurate. An estimate could be made using downstream migrant traps that are operated and calibrated properly (using trap efficiency trials). The second major assumption is that the hatchery surrogate fish are good surrogates for wild yearling spring-run Chinook salmon, that they have the same behavior, migration rate and survival to the CVP/SWP facilities as the wild fish. The second assumption is currently used at the fish facilities to minimize take of yearling spring-run Chinook salmon from Sacramento River tributaries (NMFS 2009).

Chinook salmon would have to be raised to yearling size at the San Joaquin Conservation and Research Facility in order to be suitable surrogates. Raising Chinook salmon to yearling size would be a deviation from normal hatchery practice which could create a timing issue between when the need to use surrogates is identified and when implementation would occur.

4.1.3 Monitoring Needs

4.1.3.1 Metrics Required for Method

The size range of naturally-produced yearling spring-run Chinook salmon smolts migrating downstream from the SJRRP area would need to be determined so that similarly-sized surrogate fish can be released.

An estimate of the number of naturally-produced yearling spring-run Chinook salmon that are outmigrating from the SJRRP area is required to estimate the number of winter-run size fish produced in the SJRRP area that are encountered at the Delta Facilities. This estimate could be made using RST or other downstream migrant trap catch given that the traps are operated and calibrated properly. An estimate of yearling spring-run Chinook salmon migrants could also be made at a fish passage construction site (Sack Dam, for example) if a juvenile fish bypass with a trap and/or video system (VAKI Riverwatcher, for example) were constructed.

Monitoring would need to determine if SJR spring-run Chinook salmon fit the older juvenile or winter-run size category. If SJR spring-run Chinook salmon juveniles do not fit the older juvenile category or the winter-run size category then no operational triggers would occur due to their presence. If direct monitoring does not provide the necessary information then the development of a survival and growth model could be considered.

4.1.3.2 Locations for Monitoring

Capture of surrogate fish at the following monitoring stations would help determine where the wild yearling spring-run Chinook salmon are located at that time during their migration to the ocean and help determine migration and survival rates:

- Juvenile bypass at dams (i.e. Sack Dam) or constrictions (i.e. culverts under roads) within the SJRRP area
- RST and downstream migrant traps within the SJRRP area
- Mossdale Landing Kodiak Trawls, CDFW
- Chipps Island Mid-water Trawls, USFWS
- Beach seining sites, USFWS
- PIT-tag arrays in the SJRRP area and the lower SJR
- Acoustic-tag arrays in the SJRRP area and the lower SJR.

4.1.3.3 Physical Marking and Accounting Methods

Hatchery-produced surrogate fish will be surrogates for naturally-produced juvenile spring-run Chinook salmon in the older size category and large enough to tag with most tagging methods. The hatchery-produced surrogate juvenile Chinook salmon could easily be tagged with a PIT-tag or a CWT and adipose fin-clip. The Delta Facilities currently only scan salvaged fish for full duplex PIT-tags and not for half duplex tags, which are the kind that the SJRRP uses. It would be possible for the Delta Facilities to start implementing scans for half duplex PIT-tags as well. The Delta Facilities do currently look for an adipose fin-clip on juvenile Chinook salmon which indicates that it contains a CWT. The only drawback to using CWTs is that the fish has to be sacrificed in order to retrieve the tag.

4.2 Genetic Assignment

This suite of techniques may become more useful as the proportion of naturally-produced juveniles increases.

4.2.1 Genetic Stock Identification

Genetic Stock Identification (GSI) uses a noninvasive and nonlethal sampling approach to identify individuals to stock/parent/brood stock of origin. By using microsatellites or single nucleotide polymorphisms (SNPs), genetic laboratories are able to identify individuals with high accuracy to groups/population/parents incorporated into genetic baselines. The NMFS and SJRRP has coordinated with the Chinook salmon genetic sampling effort planned for 2015/2016 at the CVP/SWP fish facilities to confirm that the tissue samples being collected can be used for reintroduced spring-run identification at a later date and that fish are being sampled in the date and size range where natural production of SJR spring-run Chinook salmon may be occurring. The CVP and SWP fish facilities have standard operating procedures that are followed for all of the genetic samples that are collected. This ensures that no samples get cross contaminated and that proper chain of custody is followed. The tissue for genetic sampling collected at the CVP/SWP fish facilities is an approximately 1 mm by 1 mm sized portion excised from the tip of the caudal fin using surgical scissors.

The GSI method has not been able to distinguish Feather River Hatchery spring-run Chinook salmon from Feather River Hatchery fall-run Chinook salmon as of January 2014. This could be problematic for the SJRRP if reintroduced fish have to be accurately identified because Feather River Hatchery spring-run Chinook salmon are currently being used for reintroduction. Once the permits are in place, the SJRRP intends to incorporate wild spring-run Chinook salmon from Sacramento River tributaries into the broodstock program to increase genetic diversity. However, at the CVP/SWP export facilities only winter-run Chinook salmon operational triggers or its incidental take limit could be impacted by reintroduced spring-run Chinook salmon because the surrogate approach is used for wild yearling spring-run Chinook salmon. The SJRRP does not have to identify a winter-run Chinook salmon sized fish as a SJRRP fish at the fish facilities, it solely has to determine that it is not a winter-run Chinook salmon (Table 4). Currently, GSI can very accurately discriminate winter-run from other runs of Chinook salmon in the CV (Banks et al. 2014, Garza et al. 2008, and Harvey et al. 2014).

Table 4. Steps Required to Use the GSI Accounting Method

Step Number	Task	Detail
1	Genetic tissue sample	Take a genetic tissue sample from all winter-run sized juvenile Chinook salmon encountered in the fish salvage operations
2	Genetic Determination	Determine genetically whether the tissue sample was from a winter-run Chinook salmon using GSI with the 96 SNP panel developed for the Central Valley Chinook salmon runs
3	Evaluate operational trigger and ITS	A) Positive for winter-run: If the tissue sample is assigned as a winter-run Chinook salmon, then it will be expanded based on salvage and loss expansion calculations and will apply to the operational trigger and incidental take limit for winter-run Chinook salmon B) Negative for winter-run: If the salvaged fish is not assigned as a winter-run Chinook salmon then the operational trigger and incidental take limit for winter-run Chinook salmon will not be effected

New techniques are also being discovered that improve GSI. Hess *et al.* (2011) found that using SNP markers in GSI provided increased information when a total of 92 SNPs were used. Ozerov *et al* (2013) found that DNA pooling and SNP-Arrays greatly improved the accuracy of GSI. As part of the SJRRP genetic contract between CDFW and UC Davis, UC Davis developed a new 144 SNP panel for CV spring-run Chinook salmon. The researchers indicate that they can distinguish Feather River spring-run from winter-run, fall-run, and Deer, Mill, and Butte Creek spring-run Chinook salmon. However, the study has not been published yet and it may have a higher error rate than conducting a parentage assignment.

4.2.2 Pros for SJRRP

GSI provides a way to conduct nonlethal sampling to determine non-SJR natural origin spring-run Chinook salmon. This method appears highly accurate using SNP panel developed for California Chinook salmon. Winter-run Chinook salmon can be accurately discriminated from other runs of Chinook salmon in the CV using this methodology. In addition, genetic assignment can be integrated across sites regardless of marking and size of fish.

4.2.3 Cons for SJRRP

The current processing time for genetic identification is longer than CWT or PIT-tag identification. During discussions with agencies and stakeholders, issues such as chain of custody for tissue samples, location of genetic laboratories, and acceptance of this method among agencies were identified. These issues may cause a delay for implementing operational changes to minimize fish loss.

4.2.4 Monitoring Needs

Tissue samples would need to be collected from non-ad-clipped juvenile Chinook salmon at facility in the winter-run and older juvenile size range. Genetic analysis of these fish would need to be conducted on a reasonable timeline in order to account for them relative to Delta Facility operations.

4.3 Parentage Based Tagging and Parentage Inference Analysis

Parentage based tagging (PBT) and parentage inference analysis (PIA) may allow juvenile Chinook salmon, and especially spring-run, to be assigned to the SJRRP that would not have been able to be assigned using GSI (Table 5). However, identifying a fish as being from the SJRRP is not technically necessary, it only has to be determined whether a fish is a winter-run Chinook salmon. The use of PBT involves the annual sampling and genotyping of individuals comprising the parental generation of a population to create a database of their genotypes for future parentage assignment of their progeny. Parentage inference analysis uses the genotyping of adult salmon mating pairs done for PBT to infer, at a later date, that a captured salmon is an offspring of that mating pair. The technique is also known as intergenerational genetic tagging and is described by Starks *et al.* (2014) as "the genotyping of parental individuals and using their genotypes as genetic tags that are recovered when the offspring of the parental generation are genotyped using the same (genetic) markers". Steele *et al.* (2013) demonstrated with hatchery steelhead in Idaho that the technique can be used to accurately identify the stock of origin using fewer than 100 SNPs.

Table 5. Steps Required to Use the Parental Based Tagging and Parental Inference Analysis Accounting Method

Step Number	Name	Detail
1	Genetic tissue sample from all SJRRP area spring-run spawners	Take a genetic tissue sample from all spring-run Chinook salmon that return to spawn in the SJRRP area, including fish spawned at the SCARF.
2	Perform PIA on tissue sample	Use parental inference analysis on the genetic tissue sample from a winter-run sized juvenile Chinook salmon captured at the Delta facilities. Parental inference analysis will determine whether it is a SJRRP fish or not given that genetic tissue samples were collected from its' parents returning to spawn in the SJRRP area.
3	Evaluate operational trigger and ITS	A. Positive for SJRRP spring-run: If parental inference analysis determines that the salvaged winter-run sized juvenile Chinook salmon is a SJRRP fish then the operational trigger and incidental take limit for winter-run Chinook salmon will not be effected. B. Negative for SJRRP spring-run: If the salvaged winter-run Chinook salmon is determined using parental inference analysis to not be a SJRRP fish then the fish will be considered a winter-run and apply to the operational trigger and incidental take limit.

The genetics group from NMFS' Southwest Fisheries Science Center has a contract through the SJRRP to perform PBT and PIA. All adult Chinook salmon, including spring-run and fall-run, released into the SJR are anticipated to be genotyped for the purpose of PBT and a genetic database will be created for the SJRRP that contains the results for all of the genotyped Chinook salmon. Adult fall-run Chinook salmon captured in the SJR above the confluence with the Merced River as part of the trap and haul operations are anticipated to be sampled and genotyped with the 96 SNP panel. Any spring-run Chinook salmon that are trapped and hauled are anticipated to also be sampled and genotyped with the 96 SNP panel. The genotyping of adult fall and spring-run Chinook salmon allows for the identification of their juvenile offspring by PIA.

In addition to PBT, PIA is anticipated to be performed for adult and juvenile Chinook salmon returning to and produced in the SJRRP area. PIA would be performed on unmarked (natural origin) juvenile Chinook salmon captured as part of the SJRRP RST/juvenile monitoring efforts. PIA of natural origin juvenile Chinook salmon allows for identification of offspring of specific trap and haul adults and the minimum number of natural origin crosses produced within the SJRRP area. Results from the juvenile Chinook salmon PIA would include; the identification of both parents for each individual, estimation of the total number of crosses that took place within the river, family line contribution, and identification of crosses not attributable to the SJRRP operations. PIA is anticipated to be conducted annually for any adult Chinook salmon returning to the SJRRP area that could potentially be progeny of fish previously genotyped and recorded in the SJRRP genetic database.

4.3.1 Pros for SJRRP

PIA would be able to identify a juvenile Chinook salmon as a SJR spring-run Chinook salmon given that genetic samples were collected from both of the parents. Even if genetic samples were not collected from both of the parents this technique may still be able to fairly accurately determine if a juvenile Chinook salmon is a SJR spring-run Chinook salmon (see Steele *et al.* 2013).

4.3.2 Cons for SJRRP

This method may also have issues similar to the GSI method concerning genetic sample processing time at the Delta facilities. Ideally, genetic samples would need to be collected from all of the spring-run Chinook salmon that return to spawn in the SJR during a given year so that the progeny from all mating pairs can be identified. It may be very difficult to impossible to collect a genetic sample from all returning spring-run Chinook salmon when salmon are able to migrate to their spawning location unassisted (*i.e.*, there is full river connectivity and passage). Some parents that were missed during passage surveys may be accounted for during carcass surveys. However, the average Chinook salmon carcass encounter rates range from 35% to 49% for the surveyed tributaries to the SJR. For the purposes of Delta facility accounting though, we would only need to identify that a salvaged fish is not a winter-run, which would not involve completely PBT for every mating pair.

4.3.3 Monitoring Needs

Tissue samples for genetic analysis would need to be collected from all (or most) spawning SJR spring-run Chinook salmon in the SJRRP area and their offspring.

4.4 Juvenile Production Estimate

Development of a juvenile production estimate (JPE) for the SJR spring-run Chinook salmon could aid in determining the share of SJRRP fish that are entrained at the CVP/SWP facilities (Table 5). A JPE has been developed and used for years for winter-run Chinook salmon in the Sacramento River. A JPE uses estimates of female adult Chinook salmon escapement, average number of eggs produced per female, survival from egg to fry, survival from fry to smolt, and survival from smolt to the Delta to estimate the number of smolts that will enter the Delta in a given year. An estimate of the number of smolts that enter the Delta in a given year is used to establish a limit for loss at the Delta Facilities. For SJR spring-run Chinook salmon, an estimate of survival from fry to yearling smolt is necessary since yearling spring-run Chinook salmon may overlap in size and timing in the Delta with winter-run Chinook salmon and could, therefore, effect operational triggers. Data on adult escapement, the number of eggs produced per female, and the different juvenile life stage survival probabilities would need to be collected for a number of years to develop a JPE. Collecting these data would require several years of monitoring naturally-producing spring-run in the SJR (7/23/13 Issue Paper).

Table 6. Steps Required to Use the JPE Accounting Method

Step Number	Name	Detail
1	Develop parameters for JPE	A. Female escapement: An estimate of the number of female Chinook salmon that returned and spawned for a given year is needed. Female escapement can be estimated using a carcass and/or redd survey. B. Average number of eggs per female: The average number of eggs per female Chinook salmon can be estimated at a hatchery on the river system of interest or a value can be used from the literature. C. Egg to fry survival: Egg to fry survival can be estimated by putting emergence traps on a subsample of redds and then counting the number of fry that emerge. It can be indirectly estimated based on an estimate of fry production. Alternatively, a value from the literature could be used. D. Fry to smolt survival: Fry to smolt survival can be estimated through downstream migrant trapping using traps, such as RSTs, that are properly calibrated using efficiency trials. E. Smolt to Delta survival: Smolt-to-Delta survival can be estimated using mark-recapture estimates with tagged fish. Smolt survival has been estimated using acoustic telemetry. It has also been estimated using release groups of CWTed fish that are then recaptured in trawl surveys.
2	Apply JPE	Use the JPE to estimate the number of SJR spring-run smolts entering the Delta in a given year and factor that number into the equation used to establish a limit for loss of winter-run sized juvenile Chinook salmon at the Delta facilities.

Escapement is the number of salmon that return to a river for spawning during a given year. Escapement is typically estimated by counting the number of fish that pass a counting weir during their spawning migration or by performing carcass and/or redd surveys in the segment of river that supports salmon spawning. The escapement estimate for the JPE is actually the number of female Chinook salmon that returned to spawn and so an estimate of the ratio of male-to-female salmon is required. The male-to-female salmon ratio estimate can be obtained from a weir or carcass survey. The estimated percent of the spawning run that is female is then multiplied with the total escapement estimate to get an estimate of the number of female salmon that returned to spawn. The USFWS currently conducts carcass and redd surveys for fall-run Chinook salmon in the SJRRP area and is anticipated to also perform these surveys for spring-run Chinook salmon once these fish start returning to the SJRRP area. Until all of the connectivity and fish barrier issues in the mainstem of the SJR within the SJRRP area are fixed, most of the spring-run Chinook salmon would likely be trapped and hauled around the barriers and released in Reach 1 where the spawning habitat is located. The necessity to use trap and haul, except in large flood events, would ensure that the number of female spring-run Chinook salmon released into Reach 1 would be known.

Pre-spawning mortality is the number of female salmon that die in the river before spawning. Pre-spawning mortality can result for many reasons, including stress due to high water temperatures, predation, disease, poor water quality, or stranding. An estimate of pre-spawning mortality can be obtained in several ways. Pre-spawn mortality surveys can be performed by floating/snorkeling the river prior to the spawning period to count dead fish. During the carcass survey fresh female salmon carcasses that are captured can be cut open to determine if they spawned or not. The final way would be to compare the number of females observed to pass a weir with the total number of redds that were observed during the redd survey or with the number of spawning females estimated by a mark and recapture carcass survey.

Fecundity is the number of eggs that are produced by a female salmon. Fecundity is typically estimated at hatcheries where the number of eggs per female is counted in a sample of returning female salmon. The number of eggs per female could be counted in a sample of female spring-run Chinook salmon that return to the San Joaquin Conservation and Research Facility to generate an estimate of fecundity.

Survival from egg-to-fry can be estimated either directly or indirectly. To estimate it directly, a sample of redds can be capped with emergence traps to estimate the number of fry that emerge from one redd. However, using emergence traps is labor intensive and disruptive (walking and working in river in the vicinity of salmon redds). To estimate egg-to-fry survival indirectly, the difference is calculated between the estimate of total number of eggs deposited in redds by female salmon (escapement of female salmon x average number of eggs/female) and the estimate of number of fry produced through use of downstream migrant traps (number of fry captured x trap efficiency). The SJRRP studied egg survival in the SJR in 2011 and 2012 and studied egg and emergence survival in 2013, 2014 and 2015.

Fry-to-smolt survival can also be estimated through use of downstream migrant traps. Ideally, two different trap locations would be used. One trap location would be immediately below the segment of river that is used by Chinook salmon for spawning and so would generate an estimate of the number of fry produced. The second trap location would be further downstream, below where most juvenile salmon rearing occurs, and would estimate the number of smolts that were produced. The estimate of number of fry produced would then be compared with the estimate of the number of smolts produced to determine survival in that reach of the river.

Pilot scale RST monitoring in the SJR occurred in 2013 from March to June at State Route 99 using one RST. RST monitoring in the SJR began again in December 2013, with traps in two locations: State Route 99 and San Mateo Crossing. However, the traps were only able to fish through the beginning of February 2014 because flows were reduced at that time preventing the RSTs from functioning properly. RST sites that allow for operation during most flow scenarios are being investigated. However, in low water years there may be no sites available that allow for proper RST operation and another trapping technique such as juvenile fish weirs may be necessary.

There are a couple of methods that could be used to estimate survival during smolt migration. The number of smolts that were estimated to be produced, through use of downstream migrant traps, could be compared with an estimate of the number of smolts entering the Delta through capture of smolts in the Mossdale Trawl or other monitoring activities in the Delta. The other method would be to tag smolts with an electronic tag, such as an acoustic, radio, or PIT-tag, and track the movement and survival of the tagged fish.

Acoustic telemetry using fixed antennas and receivers has been used to track hatchery fall-run Chinook salmon smolt migration in the SJR below Friant Dam for 3 years (2011 - 2013). Releases of acoustically-tagged smolt groups have occurred at different locations within the SJR during the 3 years, but at least one group of smolts has always been released below Friant Dam during all 3 years. In 2011, releases of acoustically-tagged smolts into the SJR occurred below Friant Dam and at San Mateo Crossing. In 2012, releases occurred below Friant Dam and at the upstream end of Reach 5. In 2013, releases occurred below Friant Dam, at Highway 41, at Highway 99, and below Highway 165. In 2011, the acoustic arrays in the SJR only extended from below Friant Dam to the end of the SJRRP area. In 2012 and 2013, the acoustic arrays extended to below the Stanislaus River confluence allowing smolts to be tracked for a longer distance during migration through the lower SJR.

Monitoring of hatchery fall-run Chinook salmon smolt emigration in the SJR using PIT-tags occurred in 2012 and 2013. The salmon were tracked using six PIT-tag antenna arrays installed in the SJR from below Friant Dam to San Mateo Crossing with three arrays in Reach 1 and three in Reach 2 during both years. In 2012, three groups of PIT-tagged smolts were released at the most upstream location in Lost Lake in April while in 2013 the three releases occurred below Friant Dam, with one release occurring in March and the other two in April.

4.4.1 Pros for SJRRP

As part of a JPE, there is a set of metrics (production estimate, survival, etc.) that is required to account for SJR spring-run Chinook salmon in the CVP/SWP loss calculations. In addition to providing a tool for spring-run accounting, the JPE might be a more useful near term metric for SJRRP reintroduction success than adult escapement.

The accuracy of survival estimates used in the JPE for winter-run are improving. In 2013, NMFS incorporated new data from 6 years of Chinook salmon acoustic tag studies into the winter-run JPE, which included one year of tagged winter-run and 5 years of tagged late fall-run. The JPE calculation is moving towards relying on direct estimates with the species of interest. Thus, obtaining survival information using tagged winter-run, instead of using late fall-run juveniles as surrogates, as was discussed earlier, will lead to a more accurate calculation. This approach could be applied to the SJR spring-run Chinook salmon juvenile survival estimate.

4.4.2 Cons for SJRRP

A SJR CV spring-run Chinook salmon JPE would provide the production estimate of a cohort, but would not indicate a number of juveniles at risk of being entrained at the Delta Facilities on a daily basis, so that this method would likely not meet the need and intent.

Producing a JPE for SJR spring-run Chinook salmon would require substantial assumptions and an intensive monitoring program to derive the necessary parameter estimates. There are many assumptions inherent to a JPE unless intensive monitoring data are collected every year to provide the parameter estimates for the JPE. Juvenile salmonid life stage survival varies from year to year due to environmental variables such as streamflow, water temperature, and predation pressure. Therefore, juvenile life stage survival is where most of the uncertainty arises as has been experienced with the Sacramento River winter-run JPE. NMFS has been including 95% confidence intervals in its winter-run Chinook JPE since 2010; these confidence intervals have been relatively wide.

In addition, it is difficult to get accurate estimates of egg-to-fry survival and fry-to-smolt survival. In recent years, more accurate estimates of smolt survival have become possible due to improved acoustic tagging technology. Relying on literature values for Chinook salmon from other systems or for other races (*i.e.*, fall-run) prior to developing inputs from the SJR spring-run Chinook population may overestimate spring-run juvenile production which could negatively impact listed species being taken at the Delta facilities.

4.4.3 Monitoring Needs

Monitoring plans would be developed that evaluate specific parameters that are needed for the JPE. These parameters are: 1) in-river escapement; 2) ratio of male-to-female spawners; 3) egg loss due to temperature and; 4) survival (egg-to-fry) (fry-to-yearling smolt) (yearling smolt-to-Delta).

4.5 Mass Marking

Initially, 100% of the SJRRP hatchery-reared spring-run Chinook salmon juveniles are CWTed and adipose fin-clipped, assuring that all of the experimental population of juveniles can be identified and removed from the operational triggers for the CVP/SWP facilities. As natural production gradually increases the SJRRP will need to determine if some form of marking should be considered for the natural production. If marking of natural production is implemented, then the procedure for identifying those marked individuals and removing them from the operational triggers and incidental take limit would need to be developed. The feasibility of collecting outmigrating naturally-produced juveniles for marking using screw traps, beach seining, and trawling needs to be considered. It may be possible to collect 100% of juveniles at diversion dams during base flows, but not at high flows when the majority of juveniles are migrating. The SJRRP would want to use a non-lethal form of unique identification to reduce unintentional mortality of the reintroduced population. To achieve this, the SJRRP could encourage agencies to tag natural SJRRP production without an adipose-fin clip, so these fish are not sacrificed and mistaken for adipose-clipped hatchery-origin fish.

Mass marking could be used to identify all of the naturally-produced SJR juvenile spring-run Chinook salmon at the Delta Facilities. To use this method, all naturally-produced juvenile spring-run Chinook salmon would be captured at some location in the SJR and then marked. Some of the marking options include pan-jet or Calcein dye, or a tag such as a PIT/acoustic tag. CWT could be used as an appropriate tag, but ideally natural fish receiving these tags would not be adipose-fin clipped. All adipose-fin clipped juvenile Chinook salmon are currently sacrificed, and this intentional mortality is not desirable for natural origin SJR Chinook salmon. Thus, tagging without an adipose fin-clip ("stealth tagging") could be utilized solely for natural origin fish originating from reintroduction programs, including the SJRRP. It would be impossible to catch all of the juvenile spring-run Chinook salmon produced within the SJRRP area using common monitoring devices such as RSTs. RSTs in medium sized rivers are performing very well if they have a 5-10% capture efficiency (*i.e.*, they are capturing 5-10% of the juvenile Chinook salmon that are migrating past the point in the river where the trap is located). In order to have 100% capture efficiency of juvenile Chinook salmon a different trapping technique, such as a bypass juvenile fish collector would have to be constructed at a location (Sack Dam, for example) where fish passage is going to be implemented. However, a bypass juvenile fish collector would most likely perform poorly when there are high to flood flows (like almost all other trapping methods).

A hybrid surrogate and mass marking technique could also be used. All naturally-produced juvenile spring-run Chinook salmon captured during juvenile downstream migration monitoring using RSTs and/or some other trap type would be marked using an appropriate method. The total number of naturally-produced juvenile spring-run Chinook salmon that are migrating past the trap site could be estimated given that the trap(s) are properly calibrated. The ratio of marked to unmarked naturally-produced juvenile spring-run Chinook salmon could then be used to subtract from operational triggers and the incidental take limits at the Delta Facilities.

For example, if the RSTs captured and subsequently marked 10,000 juvenile spring-run Chinook salmon and the estimate of the total number of downstream migrating juvenile spring-run Chinook salmon was 400,000, then each marked fish would represent 39 unmarked fish. So the marked to unmarked ratio of one to thirty nine would be used to subtract SJR spring-run from the operational triggers at the Delta facilities. However, yearling spring-run Chinook salmon is the most likely life history type to effect the winter-run Chinook salmon operational triggers because they are in the Delta during a similar time and size as winter-run. It is unknown what percentage of spring-run Chinook salmon in the SJR will adopt the yearling life history strategy and therefore how many will be subject to potential capture by downstream migrant traps. The Fisheries Management Plan (SJRRP 2010) hypothesized that up to 10% of juvenile spring-run Chinook salmon may adopt the yearling life history strategy. Depending on the population size of juvenile spring-run Chinook salmon in the SJR and what percentage adopt the yearling life history strategy, it may be possible to capture enough of them in traps to have adequate numbers of tagged surrogate fish.

4.5.1 Mass Marking Methods

The possible mass marking methods that could be implemented are discussed in the following section and the pros and cons of each method are outlined. Some pros and cons are highlighted in the text of each section followed by a table summarizing all the pros and cons.

4.5.1.1 Tags

4.5.1.1.1 PIT Tags

PIT-tags have a unique binary identification code associated with each one of them which is transmitted when interrogated by a detection device. This is accomplished through use of an electromagnetic field produced by the detection device which provides power to the PIT-tag to transmit its unique code to the detection device; the code is then displayed alphanumerically.

This technology is referred to as radio-frequency identification. Antennas with associated transceivers can be installed throughout a river system to track the movements of each individually PIT-tagged fish. A computer connected to the transceiver stores the alphanumeric code and time that each PIT-tagged fish passes the antenna. Tagged fish can also be detected when captured in traps, such as RSTs, or when seining using a hand held scanner. PIT-tags in juvenile salmonids are typically implanted subcutaneously in the abdominal region. PIT-tags come in various sizes, and the size of the PIT-tag is matched to the size of the fish so as to be as unobtrusive as possible. The trade-off is that the larger the tag the larger the read range possible to detect the tag. Fish that are PIT-tagged by an experienced tagger typically have minimal tag loss. PIT-tags do not wear out, allowing fish to be tracked for their lifetime. For salmonids, this allows juveniles to be tracked as they are migrating out to the ocean as smolts and for adults to be tracked as they return back to the river to spawn. PIT-tags are relatively inexpensive, particularly when purchased in bulk. PIT-tag antennas can be expensive to install, particularly on large river systems. However, once they are installed, they are relatively inexpensive to maintain and operate. Instream antennas that span the river channel are vulnerable to damage and/or loss at high flows. PIT-tag antenna systems are commonly used in small streams and are becoming more commonly used in large river systems. An extensive use of PIT-tagging and antennas has been undertaken on the Columbia River system to track juvenile and adult salmonids, particularly as they pass hydropower dams that are part of the Federal Columbia River Power System (FCPRS). The pros and cons of using PIT-tags as a mass marking method are summarized in Table 7.

Table 7. Pros and Cons of PIT Tags

Pros	Cons
Inexpensive (tags) Track individual fish Lasts for lifetime of fish Non-lethal to read tag High tag retention Minimal tagging mortality Can calculate reach specific survival Negligible effect on behavior and survival	Antenna arrays can be expensive to install (particularly in large rivers) Antenna efficiency can be an issue in some locations Antennas vulnerable to damage or loss in high flows Data processing can be time consuming

4.5.1.1.2 Coded Wire Tags

A CWT is a section of magnetized stainless steel wire that is typically 1.1 millimeter (mm) long and 0.25 mm in diameter. The wire has a series of decimal separated numbers (typically 6) etched into it that can either be used to denote individual fish or a batch of fish to be released. In juvenile salmonids, the CWT is typically implanted in the snout using a special applicator manufactured by Northwest Marine Technology. Northwest Marine Technology also manufactures a fully automated tagging trailer that can CWT large numbers of fish very efficiently (can CWT and adipose fin clip over 60,000 fish in 8 hours using two personnel). A syringe injector can also be used in the field to insert a CWT. A CWT is typically not visible externally, so fish that are tagged with a CWT are usually also adipose fin-clipped to denote that the fish contains a CWT. CWTs can also be detected by passing the fish in front of a magnetic scanner, which will beep or flash when metal is detected, since the wire is magnetized. Fish must be sacrificed in order to extract and then read the tag. The CWT must be magnified to read the code. The pros and cons of using CWTs as a mass marking method are summarized in Table 8.

Table 8. Pros and Cons of Coded Wire Tags

Pros	Cons
Small Inexpensive (tags) High tag retention Minimal tagging mortality Negligible effect on behavior and survival	Fish must be recaptured and sacrificed to read tag Only provides two data points; point of release and point of recapture Expensive to purchase tagging equipment Tags not externally visible Fish must reach a certain length before being tagged

4.5.1.1.3 Visible Implant Elastomer Tags

A visible implant elastomer (VIE) tag is a colored, fluorescent silicon elastomer that is injected into translucent tissue so that it is externally visible. The elastomer hardens into a pliable solid within 24 hours. The VIE is injected using a hand held syringe or marking gun. Various locations that contain translucent tissue can be tagged on juvenile salmonids including: the adipose eyelid, the base of the dorsal, anal, adipose, pectoral, and pelvic fins, and in the jaw. The elastomer comes in various colors and will fluoresce under UV light. There appear to be some issues with tag shed rates and detection rates six months post tagging. Fish that are greater than 100 mm appear to have better tag detection rates. The pros and cons of using VIE as a mass marking method are summarized in Table 9.

Table 9. Pros and Cons of Visible Implant Elastomer Tags

Pros	Cons
Inexpensive Negligible effect on behavior and survival Non-lethal to observe tag Tag visible externally Minimal tagging mortality Intended as a batch mark	Appears to have lower tag retention that other tags (CWT and PIT) Tag detection issues for periods greater than 6 months Marking gun is expensive Best for marking fish greater than 100 mm FL Tags not easy to apply (Taggers need training and practice)

4.5.1.2 Dyes

4.5.1.2.1 Bismarck Brown

Bismarck brown is an immersion dye that will stain tissue an orange brown color. Fish are typically immersed in water containing the dye, at a concentration around 1.6 grams/20 gallons, for 45 to 60 minutes. Bismarck brown has commonly been used to mark fish as part of downstream migrant trap efficiency trials. The Bismarck brown stain only stays easily visible for 1 to 4 days, with mark retention for up to one week. The quality of the stain also often varies between fish in a batch and among batches. The pros and cons of using Bismarck Brown dye as a mass marking method are summarized in Table 10.

Table 10. Pros and Cons of Bismark Brown

Pros	Cons
Inexpensive Mark large number of fish in a batch Negligible effect on behavior Non-lethal to observe tag Minimal tagging mortality Suitable for tagging fry	Short duration of mark (<1 week) May reduce survival; easier for predators to single out Dye immersion needed for 45-60 minutes

4.5.1.2.2 Calcein

Calcein is an immersion dye that marks calcified fish tissues including scales and fin rays. The Calcein mark is invisible to the naked eye and can only be seen when exposed to UV light, it fluoresces green. Calcein can be used to mark large numbers of fish, including salmon fry, efficiently and inexpensively. There appears to be mark deterioration issues for marked fish that are exposed to sunlight and for time periods greater than 6 months. The pros and cons of using Calcein as a mass marking method are summarized in Table 11.

Table 11. Pros and Cons of Calcein

Pros	Cons
Inexpensive Mark large number of fish in a batch Negligible effect on behavior and survival Non-lethal to observe tag Minimal tagging mortality Suitable for tagging fry	Mark retention issues for periods greater than 6 months Need special equipment to observe mark

4.5.1.3 Marks

4.5.1.3.1 Fin-clips

Marking fish using a fin-clip involves full or partial excision of a fin. For juvenile salmonids, the most common fin-clip has been the adipose fin-clip, in which the entire adipose fin is removed. The adipose fin-clip has typically been used to denote that the fish contains a CWT and/or is of hatchery origin, so clipping wild SJR spring-run Chinook salmon could complicate management. Recent research has suggested that an adipose fin helps improve the swimming efficiency of fish in turbulent waters, so removal may have a negative impact on the fish, contrary to prior belief that the adipose fin was a vestigial fin that served no purpose. Another common clip has been to remove part of the maxillary bone. The maxillary can be either clipped off of the right or the left side of the fish. Some fins will fully or partially regenerate after they have been clipped. There can be issues with delayed mortality in fin-clips. The pros and cons of using fin-clips as a mass marking method are summarized in Table 12.

Table 12. Pros and Cons of Fin-Clips

Pros	Cons
Inexpensive Non-lethal to observe tag Efficient Suitable for tagging parr size or larger fish	Adipose fin may be beneficial to salmon Delayed mortality Regeneration Hatchery-origin fish are adipose fin-clipped

4.5.1.3.2 Freeze Branding

To mark fish using a freeze brand a brand tool is cooled (usually using dry ice or dry ice mixed with acetone) and placed on the desired location on the fish. The mark will appear on the fish after a day or two and last up to six months. Freeze branding is best used for short term batch marking of fish. Freeze branding has typically been used for short term mark-recapture experiments, such as downstream migrant trap efficiency trials. The pros and cons of using freeze branding as a mass marking method are summarized in Table 13.

Table 13. Pros and Cons of Freeze Branding

Pros	Cons
Inexpensive Non-lethal to observe tag Negligible effect on behavior and survival Efficient Suitable for tagging fry	Lasts six months or less

4.5.2 Pros for SJRRP

A hybrid surrogate-mass marking technique may be relatively easy to implement since it will be taking advantage of monitoring that is already occurring. For this technique to work, the downstream migrant traps would have to be operated consistently and calibrated properly using trap efficiency trials.

4.5.3 Cons for SJRRP

The downstream migrant traps may not be able to catch enough fish, particularly yearlings, to have adequate-sized releases of mass marked surrogate fish. Yearling-sized fish typically have lower capture efficiencies than fry-and parr-sized fish.

4.6 Other Challenges

4.6.1 Straying Rates

Straying of SJR origin spring-run Chinook salmon adults into other tributaries within the San Joaquin and Sacramento rivers, which may result in successful spawning and juvenile survival, could lead to salvage of older juveniles of SJR heritage. This straying could increase older juvenile losses at the Delta facilities. Misclassification of older juveniles belonging to the late fall/fall Chinook salmon populations may occur during the late fall and early winter when these fish are recovered in sufficient numbers to trigger export reductions at the CVP/SWP per RPA Action IV.3.

However, the fish agencies hypothesize that straying rates of SJR origin spring-run Chinook salmon will remain within the naturally-occurring stray rates for Chinook salmon seen in other river basins. The limited information collected on “natural” straying rates of CV Chinook salmon suggest that they are on the order of 2-5% (NMFS and CDFG 2001). Since the straying rate of spring-run Chinook salmon reintroduced into the SJR is predicted to be low and similar to natural rates it will thus have a minimal effect on number of CV spring-run Chinook salmon migrants leaving other creeks and rivers. This minimal effect on the number of spring-run Chinook salmon migrating out of other creeks and rivers that have CV spring-run Chinook salmon populations will therefore not impose more than *de minimus* water supply reductions, additional storage releases, or bypass flows on unwilling third parties. Further, the potential effect from SJR strays to the Sacramento River system must also be evaluated with consideration of Sacramento River basin fish straying to the SJR. If SJR spring-run Chinook salmon straying is determined to be higher than natural levels, NMFS will adjust its’ annual methodology to account for SJR spring-run Chinook salmon at the CVP/SWP Delta facilities as necessary to ensure that the *de minimus* standard is met.

SJR spring-run Chinook salmon straying is anticipated to be accounted for within existing CV Chinook salmon monitoring. All hatchery spring-run Chinook salmon released into the SJR will be CWTed and ad-clipped. The recovery of ad-clipped Chinook salmon carcasses during carcass surveys in other rivers and creeks within the Sacramento-San Joaquin River system would allow for determination of straying. In all Chinook salmon carcass surveys in California the head of an ad-clipped carcass is collected so that the CWT can be recovered and read. The number code on the CWT allows for determination of run and where that fish was released as a juvenile. Straying of natural origin SJR spring-run Chinook salmon will be more difficult to track than those of hatchery origin but it is still possible. If fewer than expected natural origin spring-run Chinook salmon are returning to the SJR to spawn and other systems are recording more spring-run Chinook salmon than expected then that would be a good indication that there is a straying problem and it is worth investigating. It may be possible to differentiate SJR natural origin spring-run Chinook salmon from other spring-run Chinook salmon populations using genetic analysis. Genetic tissue samples collected during Chinook salmon carcass surveys in rivers and creeks that contain spring-run Chinook salmon populations in California may potentially be used to determine if any of those fish were strays from the SJR or the Sacramento River basin. If genetic analysis does not work then it may be possible to use otolith isotope ratios to determine whether a Chinook salmon carcass was of SJR origin.

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5.0 Recommendation for Implementation

This section provides a logical scientific basis for development and implementation of one or more method(s) to account for SJR spring-run Chinook salmon at the Delta Facilities. The recommendations for implementation are provided by reintroduction phase. The details regarding the specific study design and implementation of a particular method are not yet developed and thus not presented in this document.

The current methods for accounting for spring-run and winter-run Chinook salmon at the CVP/SWP Delta facilities may change due to a future CVP/SWP BO or recommendations from the annual review process for the current CVP/SWP BO. Any accounting methods for SJR spring-run Chinook salmon implemented by the SJRRP is anticipated to be integrated with any changes in system-wide accounting for winter-run and spring-run at the Delta Facilities.

5.1 Phase 1 – Released Hatchery Fish Only (2014 – 2016)

The SJRRP expects that natural production of spring-run Chinook salmon will occur in 2017 at the earliest. Until then, all juvenile spring-run Chinook salmon released into the SJR will be adipose fin-clipped and CWTed so that they can be identified at any point upon capture, including at the Delta Facilities.

During Phase 1 the SJRRP will prepare for Phase 2 by determining the feasibility of surrogates, surrogate/mass marking combination or genetic sampling. Developing a JPE will not be pursued at this time. The SJRRP will work with the current genetic sampling efforts occurring at the Delta Facilities to decide if naturally produced SJR CV spring-run Chinook salmon can be accounted for under the current operating procedures or if changes are needed.

The current juvenile Chinook salmon accounting methodology at the Delta Facilities uses biologists at CVP/SWP fish facilities to record, measure and sacrifice all adipose fin-clipped fish. Salvaged fish are to be processed within 24 hours and reported to CDFW, which then reports to the DAT and DOSS groups within 24 hours. Accounting of SJRRP spring-run during Phase 1 would use the existing staff and process. Regardless of the technique(s) employed, the accounting methodology will need to be developed for sampling and reporting procedures, assignment of responsibility, and reporting timelines and staffing requirements.

In 2016, the SJRRP will further investigate the use of two methods to account for SJR spring-run Chinook salmon at the Delta Facilities; surrogates (representative batches or mass marking) and genetic identification. Steps of this investigation are outlined here:

1. Identify the monitoring necessary and feasible to determine whether naturally-produced SJR spring-run are of the same size and migration timing as winter-run Chinook salmon in the Delta.
2. Investigate the feasibility and accuracy of using surrogates for accounting
    - Determine appropriate fish to use: size, run, hatchery vs. wild

- Identify fish capture and release locations
- Identify the appropriate and feasible fish mark type

3. Genetic identification for accounting
    - Determine adequacy of current winter-run Chinook salmon genetic testing at the Delta Facilities
    - Identify and resolve (to the extent of our control) potential issues with using genetic identification for meeting the *de minimus* requirement – fish tissue sample processing time, fish tissue sample chain of custody process, necessary agencies' commitment

5.2 Phase 2 – Natural Production and Continued Hatchery Release (As Soon As Spring 2017)

Natural production of SJR spring-run Chinook salmon is anticipated in spring 2017. Monitoring of naturally-produced SJR spring-run Chinook salmon will focus on determining the percentage of yearling migrants and the size and timing of spring-run Chinook salmon juvenile migrants.

The SJR spring-run accounting method determined implementable during Phase 1 will be implemented in Phase 2. This method will be closely monitored for accuracy and its ability to meet the *de minimus* criteria. An alternative method will be available for implementation if needed.

5.3 Phase 3 – Phasing our Supplementation (Date Uncertain)

During this phase, the SJRRP would have a self-sufficient spring-run Chinook salmon population. Hatchery production and releases to support the population would no longer be necessary or desired. At this point in time, the SJRRP would want to be reliant on an accounting methodology that does not require the release of marked fish (surrogates) or the capture of naturally-produced fish for marking.

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