STATE WATER RESOURCES CONTROL BOARD
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

DRAFT INITIAL BIOLOGICAL GOALS FOR THE LOWER SAN JOAQUIN RIVER

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DRAFT LOWER SAN JOAQUIN RIVER BIOLOGICAL GOALS

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Introduction

1.1 Introduction

In December of 2018, the State Water Resources Control Board (State Water Board) adopted revisions to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) including updating the flow objectives for the reasonable protection of fish and wildlife in the lower San Joaquin River and its three eastside tributaries, the Stanislaus, Tuolumne, and Merced Rivers and a program of implementation to achieve the objectives (LSJR flow update). The Office of Administrative Law (OAL) approved the regulatory action on February 25, 2019. The State Water Board is also currently in the process of updating flow related objectives in the Bay-Delta Plan for the reasonable protection of fish and wildlife in the Sacramento River and Delta and associated tributaries as well as other Bay-Delta Plan objectives and associated portions of the program of implementation (Sacramento/Delta update).

The recently approved LSJR flow and planned Sacramento/Delta updates to the Bay-Delta Plan are intended to provide for the reasonable protection of fish and wildlife beneficial uses by supporting and maintaining conditions necessary for the natural production of viable native fish and aquatic species populations rearing in, or migrating through the Bay-Delta Estuary. Biological goals are quantitative metrics that the State Water Board will use to assess if the actions it is taking under the Bay-Delta Plan, and in coordination with state agencies and other entities to implement the plan are making sufficient progress towards the Plan's objectives of achieving and maintaining the natural production of viable native fish and aquatic species populations. Biological goals can also inform adaptive management actions during implementation and help determine whether future changes to the Bay-Delta Plan and its implementation are needed, including actions by the State Water Board (water right and water quality actions) and actions by other entities (e.g. fishing regulations, hatchery management, habitat restoration, etc.).

The LSJR flow update requires the development of biological goals for the LSJR within six months of OAL approval of the amendments. This draft report identifies proposed initial biological goals for the LSJR that are focused on fall-run Chinook salmon in conformance with the 2018 Bay-Delta Plan. Fall-run chinook salmon were selected due to their more abundant status than other sensitive indicator species and the availability of information and monitoring data for this species. After consideration of public comments and any needed changes to the draft initial biological goals for the LSJR, the goals would be brought to the State Water Board for possible approval as early as the end of 2019.

The biological goals are intended to evolve as scientific understanding of the Bay-Delta watershed evolves. Even after approval, the biological goals would be subject to change by the State Water Board based on new information and changing circumstances. The need for potential future modifications of the initial goals was identified in the 2018 Bay-Delta Plan and recommended by the Independent Scientific Advisory Panel (ISAP), discussed below. Possible changes could include the addition of other species or environmental goals for habitat conditions that contribute to the biological goals such as temperature, instream and off-stream habitat acreage, and other factors. In addition to the goals, a set of proposed principles for developing biological goals is identified. These principles were used in the development of the draft initial biological goals for the LSJR and will guide both the refinement of the initial goals and the development of additional goals.

The State Water Board contracted with the Delta Stewardship Council's Delta Science Program to convene an ISAP to provide recommendations on the development of biological goals for the Bay-Delta Plan. The State Water Board received those recommendations in April 2019, and they informed this draft report as did other efforts to develop biological goals (or similar products) and input from California Department of Fish and Wildlife (CDFW) staff. The 2018 Bay-Delta Plan states that the State Water Board will seek recommendations on biological goals from experts in LSJR and tributary flow management, hydrology, operations and assessment needs including CDFW, the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and water diverters and users on the tributaries as well as State Water Board staff and nongovernmental organizations. The 2018 Bay-Delta Plan envisions that the Stanislaus, Tuolumne, and Merced (STM) Working Group, when fully formed, will be comprised of a subset of representatives from these types of entities and agencies. The State Water Board is sensitive to the fact that many of these same entities and organizations are currently engaged in working groups discussing the development of a potential VA and that the establishment of the STM Working Group may distract from those efforts. Therefore, the State Water Board is initiating the STM Working Group in a limited manner by assigning an STM Coordinator. Staff from the entities and organizations that are identified in the 2018 Bay-Delta Plan for potential future STM Working Group participation are included on the distribution list for this draft report and are invited to provide input to the State Water Board's STM coordinator who is identified in the cover letter to this draft report.

In a separate process, VA parties are developing a set of biological and environmental targets (BETs) designed to evaluate effectiveness of proposed VA assets. It is envisioned that the VA BETs would nest under and contribute toward meeting overall Bay-Delta Plan biological goals. Biological goals have a broader scope and apply to all of the actions needed to reasonably protect fish and wildlife, including actions applied to tributaries that do not participate in a VA, and recommended non-flow measures that can be achieved by other organizations outside the Water Board's authority (e.g. ocean harvest, hatchery management, etc). The biological goals identified in this report have been developed in coordination with efforts to develop VA BETs and coordination between these efforts will continue as the biological goals and BETs are refined prior to finalization.

1.2 Bay-Delta Watershed Background

The Bay-Delta watershed includes the Sacramento and San Joaquin river systems, the Delta, Suisun Marsh, and San Francisco Bay. The Sacramento and San Joaquin river systems, including their tributaries, drain water from about 40% of California's land area, supporting a variety of beneficial uses of water. The Bay-Delta is one of the most important ecosystems in California as well as the hub of California's water supply system. As the largest tidal estuary on the west coast of the Americas, it provides habitat to a vast array of aquatic, terrestrial, and avian wildlife in the Delta, San Francisco Bay, and near-shore ocean, as well as a diverse assemblage of species upstream of the Delta. The Sacramento and San Joaquin rivers and the Delta also provide a portion of the water supply for two-thirds of Californians, a variety of industrial purposes, and millions of acres of farmland, in addition to supporting commercial and recreational fishing and boating businesses on the rivers, the Delta, the Bay, and into the ocean.

It is widely recognized that the Bay-Delta ecosystem is in a state of prolonged decline. Changes in land use due to agricultural practices, urbanization, and flood control combined with substantial and widespread water development, including the construction and operation of the Central Valley Project (CVP) and State Water Project (collectively, Projects), have been accompanied by significant declines in nearly all species of native fish, as well as other native and nonnative species dependent on the aquatic ecosystem. Fish species have continued to experience precipitous declines in recent years. In the early 2000s, scientists noted a steep and lasting decline in population abundance of several native estuarine fish species that has continued and worsened during the sustained drought during 2012-2016. Simultaneously, natural production of all runs of Central Valley salmon and steelhead remains near all-time low levels.

Chapter 2
Approach and Principles for Developing Biological Goals

2.1 Approach to Developing Biological Goals

The approach to developing the biological goals principles, and the initial biological goals identified in this report, was based on current bodies of work for this and similar purposes, including existing state and federal requirements, other major efforts completed by state and federal agency staff and stakeholders to identify quantitative biological goals for salmon and other species, and recommendations from the ISAP. Each of the sources of information that informed the development of this report is described further below.

2.1.1 Salmon Doubling

The Central Valley Project Improvement Act (CVPIA), a federal law enacted in 1992, mandated changes in the management of the CVP, particularly for the protection, restoration, and enhancement of fish and wildlife. The CVPIA added fish and wildlife as project purposes and, among other actions, established the Anadromous Fish Restoration Program (AFRP) to "implement a program which makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley Rivers and streams will be sustainable, on a long term basis, at levels not less than twice the average levels attained during the period of 1967-1991." The State Fish and Game Code includes analogous provisions for salmon doubling (Fish and Game Code § 6902). The Salmon Protection Objective in the Bay-Delta Plan similarly requires that "water quality conditions shall be maintained together with other measures in the watershed sufficient to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and Federal law." These state and federal provisions are generally referred to in this document as salmon doubling goals.

The salmon doubling goals are stated in terms of "natural production" to achieve a self-sustaining, resilient population. As defined in Title 34 of CVPIA, natural production is estimated as the number of "…fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes." (CVPIA, section 3403(h). This metric is calculated using the natural-origin adult salmon returning to spawn in river (escapement) along with the commercial and recreational harvests of adult salmon. Natural-origin fish (wild fish) are the offspring of parents that spawned in the wild (e.g., in a river) while hatchery-origin fish are offspring of parents that spawned in a hatchery and were at least partially reared in a fish hatchery prior to release in a river or estuary.

Fish populations that depend on hatchery supplementation are not considered self-sustaining. California salmon fisheries heavily depend on artificial propagation from fish hatcheries to supplement stocks because they are not self-sustaining. In particular, hatchery production has become increasingly important in supporting ocean commercial and recreational and in-river fisheries for fall- and spring-run Chinook salmon and Central Valley steelhead. Central Valley fall-run Chinook salmon has the largest combined hatchery program in the state heavily supporting ocean and in-river fisheries (California Hatchery Scientific Review Group 2012). The proportion of natural-origin to hatchery-origin adult salmon returning to spawn in the Central Valley has been estimated but is not documented with sufficient monitoring data for fall-run Chinook salmon and other salmon runs. For that reason, the ISAP questioned the use of the salmon doubling goals. They also questioned the accuracy of the natural production estimates the AFRP developed for the 1967-1991 period and whether those estimates included a high enough proportion of hatchery fish. These factors were taken into consideration in development of the proposed goals.

2.1.2 Bay Delta Conservation Plan

The Bay Delta Conservation Plan (BDCP) was a proposal for a large-scale habitat conservation plan (HCP) pursuant to the federal Endangered Species Act and a natural community conservation plan (NCCP) pursuant to state law. The BDCP included new water diversion intakes in the north Delta, water conveyance tunnels through the Delta, and large-scale, long-term habitat restoration program within the greater Delta area. BDCP included a proposal for juvenile salmonid survival objectives in the Delta for the purpose of guiding conservation actions, adaptive management, and assessing BDCP performance relative to ecological outcomes.

The proposed BDCP was substantially modified in 2015. The HCP and NCCP components were removed and the water supply and habitat restoration components were bifurcated. Although the proposed BDCP did not advance as an HCP/NCCP, the proposed biological goals and objectives for salmonid survival through the Delta and summaries of scientific knowledge regarding survival in the upper portions of the watershed are valuable to inform this process and as starting points for salmonid biological goals for the Bay-Delta Plan.

2.1.3 Stanislaus River Scientific Evaluation Process

The Scientific Evaluation Process (SEP) was a multi-agency and stakeholder effort started in March 2013, to identify and synthesize the best available science on restoring ecological conditions in the lower San Joaquin River and its tributaries, including restoration of sustainable native populations of fall-run Chinook salmon, spring-run Chinook salmon, and steelhead. SEP participants included: CDFW, USFWS, U.S. Bureau of Reclamation, NMFS, American Rivers, The Bay Institute, Trout Unlimited, The Nature Conservancy, and others. In November 2016, the SEP participants released a draft report which was peer reviewed, and based on comments, revised and finalized in April 2019. The report is titled, Conservation Planning Foundation for Restoring Chinook salmon and Steelhead in the Stanislaus River (Conservation Planning Foundation Report) (Cain et al. 2019). The Conservation Planning Foundation Report is intended to provide a framework for ecological restoration efforts on the Stanislaus River. The report identifies watershed-specific criteria for restoration of the Stanislaus River that are based on the four key viable salmonid population (VSP) criteria—abundance, life history and genetic diversity, productivity and spatial structure (McElhany et al. 2000)—for Chinook salmon (spring- and fall-runs) and Central Valley Steelhead.

The Conservation Planning Foundation Report identified quantitative criteria for demonstrating restoration on the Stanislaus River for the attributes that could be controlled by in-river conditions. The report did not specifically develop criteria for abundance at a river-specific scale because abundance is not completely controlled by conditions in the river (e.g., ocean survival). Additionally, no specific criteria were established for increasing spatial structure as the report only described the salmonid population of a single river system, the Stanislaus River. The Conservation Planning Foundation Report includes quantitative benchmarks for the remaining attributes such as productivity (stage-to-stage survival rates in freshwater), juvenile life history diversity (size at and timing of migration), and genetic interactions with other runs and hatchery fish in the Stanislaus River. The SEP participants plan to develop similar information for the Merced, Tuolumne, and lower San Joaquin rivers in the future.

2.1.4 ISAP Report on Bay-Delta Plan Biological Goals

As previously noted, the Delta Science Program convened the ISAP at the request of the State Water Board to recommend scientifically defensible methods for formulating quantitative biological goals that can be used to assess progress toward achieving protection of fish and wildlife beneficial uses in the Bay-Delta and the associated narrative objectives included in the Bay-Delta Plan. The ISAP was composed of six scientists with expertise in aquatic ecology; population dynamics; Pacific salmon; and native fishes in the San Francisco Estuary, freshwater, estuarine, marine, and coastal ecosystems. The ISAP began their review of background materials in late 2018 and released a draft report, titled “Developing Biological Goals for the Bay-Delta Plan: Concepts and Ideas for an Independent Science Advisory Panel” (ISAP Report) in February 2019. The ISAP presented its draft recommendations describing methods for formulating biological goals to the State Water Board at a public meeting on March 4, 2019 and considered public and State Water Board staff input. The ISAP completed and released a final report on April 22, 2019.

The ISAP Report describes methods that may be used to determine ecological responses to management actions (e.g., flow or non-flow habitat restoration actions). The ISAP Report contains recommendations for metrics to track changes in ecological responses for salmonids, other Bay-Delta fish species, and ecosystem processes in the San Francisco Bay, Delta, and tributaries. For these metrics, the ISAP recommends tracking abundance and distribution and establishing a goal of increasing abundance, productivity, and distribution rather than establishing a specific quantitative value for a biological goal.

For salmonids, the ISAP supports methods to develop biological goals based on the VSP criteria of abundance, productivity, spatial structure and diversity, while emphasizing "abundance and productivity are the most important and intuitive metrics for setting biological goals." The ISAP recommended evaluating salmonid abundance and productivity by developing stock-recruitment (SR) relationships that incorporate density dependence in survival rates. The ISAP also recommended tracking trends in productivity and abundance in response to management actions rather than setting specific targets for abundance or productivity.

The ISAP reviewed the Conservation Planning Foundation Report's approach to developing quantitative biological goals for fall-run and spring-run Chinook salmon and Central Valley steelhead on the Stanislaus River. The panel observed that the draft report (released in 2016) was well written, thorough, and contained valuable information. The ISAP identified several constructive criticisms while noting that a comprehensive review of the draft report was beyond the scope of the charge to the panel and that it was easier to identify a few critical comments than to the discuss multiple strengths of the approach. The Conservation Planning Foundation Report's approach was developed in collaboration among five state and federal agencies, a public utility, and four conservation organizations over the span of six years. The ISAP Report was completed in a shorter time period by established scientists with many decades of experience and expertise in aquatic ecology, population dynamics, and fish biology. Recommendations from the ISAP Report are incorporated into the initial biological goals to the extent they are consistent with requirements to establish quantitative biological goals and are possible to develop within the timeline for State Water Board consideration of biological goals.

2.2 Principles for Developing Biological Goals

This section identifies the principles that were used to develop the proposed biological goals. These principles are also proposed for making refinements to these goals and additional goals. The proposed principles are intended to guide and provide consistency during development of biological goals in the watershed's different locations and for various types of habitat and fish species.

2.2.1 Principles for Developing Initial Biological Goals for Native Bay-Delta Fish Species

- Use available scientific information to establish a numeric value or range of values for biological goals.
- Express goals in terms that are specific, measurable, achievable, relevant (quantitative and focused on results), and time bound.
- Goals for salmonids should be developed for each of the four VSP parameters: 1) abundance, 2) productivity, 3) diversity, and 4) spatial structure.
- Goals for other (non-salmonid) fish species in the watershed should:
    - Use the VSP parameters, in principle, when data are available.
    - Consider indicator species and species assemblages as metrics to track populations or communities and habitat changes and to represent responses of multiple fish species.
- Environmental metrics may be proposed as environmental goals to track the quality and/or quantity of aquatic habitat in response to management actions. Examples of environmental metrics include temperature, dissolved oxygen, or other metrics that document the quality and quantity (spatial and temporal extent) of available habitat.
- Use an adaptive management approach to review and potentially refine goals if and/or when new information developed through monitoring and evaluation activities or other relevant sources of scientific information becomes available.

Chapter 3
Initial Biological Goals for LSJR Fall-Run Chinook Salmon

This section describes proposed LSJR biological goals for fall-run Chinook salmon for the Stanislaus, Tuolumne, and Merced Rivers as required by the 2018 Bay-Delta Plan. As discussed above, the Bay-Delta Plan states that biological goals for LSJR salmonids will be developed for the VSP criteria of abundance, productivity as measured by population growth rate, genetic and life history diversity, and population spatial structure. Using the VSP criteria as a foundation for salmonid biological goals acknowledges that self-sustaining populations cannot be characterized by an individual population attribute, for example, abundance. Rather, all VSP parameters should be used to evaluate the sustainability of a given population. The proposed biological goals for each of these parameters is described below.

3.1 Abundance Goals

Population abundance is a key measure of population viability for any species. Abundance refers to the number of organisms in a population. High abundance populations (larger populations) are less likely to become extinct than low abundance (smaller) populations because they are more resilient to environmental stressors and catastrophic events. NMFS defines salmon abundance as “the number of adult fish returning to spawn, measured over a times series” (National Oceanic and Atmospheric Administration [NOAA] 2006). For the purpose of developing biological goals for abundance, an escapement metric is proposed. Escapement refers to the number of adult fish returning to the spawning ground. Escapement was chosen as the goal because it eliminates the need to include estimates of ocean and recreational harvests that occur prior to spawning and because escapement is reliably monitored every year. In California, annual escapement estimates are produced for salmonid bearing tributaries from multiple field surveys with carcass surveys being the dominant method (CDFW 2019). Initial fall-run Chinook salmon escapement goals for LSJR tributaries are proposed in Table 1. The proposed escapement goals are consistent with the salmon doubling goals identified in existing state and federal requirements discussed above with provisions for real world considerations related to our ability to distinguish between hatchery fish and naturally spawned fish and the time it takes to detect trends in abundance given natural variation in salmon populations due to hydrologic and other conditions.

Table 1. LSJR Fall-Run Chinook Salmon Escapement Goals

River	Escapement Goal as a 6-Year Running Average	Progress Assessment[1]
All	Positive generational trend in escapement, measured as a 5-year geometric mean	Until numeric abundance goals are met
Stanislaus River	9,600	Year 6, measurable progress Year 9, substantial progress Year TBD*, achieve the goal
Tuolumne River	17,800	Year 6, measurable progress Year 9, substantial progress Year TBD, achieve the goal
Merced River	9,000	Year 6, measurable progress Year 9, substantial progress Year TBD, achieve the goal

*To be determined based on public comment and other relevant information

The first and most basic abundance goal identified above is a positive generational trend in escapement over time until the identified numeric abundance doubling goals are met and that thereafter abundance levels are maintained at that level. Progress toward meeting the escapement goal is proposed to be measured and reported annually but fully detecting whether the goal has been met will take time.[2] Salmon populations characteristically experience wide variations in abundance even under pre-development conditions due to variable hydrology and ocean food supplies, catastrophic events, and other factors. As such, to detect a trend following management actions (e.g., habitat improvement through flow increases or channel improvement) with confidence will take several generations. The State Water Board is specifically seeking comments on the time interval that should be identified for achievement of these goals. The State Water Board is considering a15-year time interval,which encompasses a large enough sample size (5 generations of salmon) to detect an overall abundance trend given natural fluctuations and statistical confidence.

Progress toward meeting the escapement goal is also proposed to be assessed for intermediate progress starting at year 6 after the beginning of implementation providing time for two generations of salmon to return to the spawning grounds. By year 6 it is expected that measurable progress toward meeting the escapement goal would be made. For the purposes of these biological goals measurable progress means a reversal of declines and statistically significant detectable levels of improvement in escapement from the start of implementation period (95%

[1] Year number after implementation begins.

[2] ISAP (2019) “Bradford et al. (2005) found that monitoring had to be conducted over a period of 4-6 generations (20-30 years for a Chinook population with a maximum age-at-return of 5 years) given a substantial increase in productivity from the flow or habitat treatment (e.g., 50% increase) and reasonably precise estimates of abundance (CV=20%).” Page 107.

confidence level). Regular progress assessments are proposed to continue annually thereafter. By year 9 when information is available for 3 generations of salmon, substantial progress toward achieving the goals would be expected. For the purposes of these biological goals substantial progress means improvements on a trajectory that the goal could be reasonably met.

Escapement data are currently compiled by CDFW's Anadromous Assessment Unit (GrandTab) on an annual basis and can be used to assess progress toward meeting the escapement goals. However, as discussed above, currently data are not available to distinguish hatchery from natural origin fish. Since 2007, the constant fractional marking program (CFM) has ensured that at least 25% of all fall-run Chinook hatchery fish are tagged with coded-wire tags (CWT) and are adipose fin clipped for visual identification. However, marking only one quarter of the hatchery fish prevents monitoring programs from effectively distinguishing between hatchery and natural origin fish on the spawning grounds. For that reason and also due to the issues with the salmon doubling estimates that the ISAP raised, for the purposes of the initial LSJR biological goals, it is proposed that initially, natural and hatchery origin fish be counted toward meeting the escapement goal until hatchery marking increases enough to credibly characterize the proportion of hatchery origin fish in the population. In the interim, increasing total escapement (natural and hatchery origin fish) demonstrates an improvement in habitat conditions for in-river rearing and spawning.

The ISAP recommended the use of SR models for tracking adult or juvenile abundance and productivity in addition to, or instead of, establishing quantitative biological goals for abundance and productivity. An SR model describes the relationship between the number of spawners (the stock) and the total number of adult recruits they produce. This document will refer to adult fish that return to spawn as "spawners" and juvenile fish that survive to the ocean environment as "recruits."

Established SR models can be used to identify the effects of local management actions (e.g., flow, water temperature, habitat restoration) and long-term trends in productivity and abundance. However, it will take time to build SR models given that available watershed specific data need to be compiled by State Water Board staff and some data may not be available for each LSJR tributary. To create an effective SR model, age composition in spawning adults is needed to correctly allocate returning adults back to their corresponding brood year (hatch year) as Chinook salmon mature and return to natal streams for spawning as 2- to 5-year old fish. To do this, brood tables that include information about a group of spawners that were hatched in the same year need to be prepared identifying the brood year, the number of adult spawners, and the total number of progeny (returning adults) produced by those spawners. This information is not yet available and/or compiled and will take time to develop for each of the tributaries.

The ISAP identified three key metrics of sampling that are required to effectively develop SR models for the LSJR tributaries. First, routine monitoring is required to quantify the escapement of adult Chinook salmon to conduct age structure analysis. Second, a consistent and comprehensive measure of hatchery influence in spawning populations of Chinook salmon is needed. Third, effective monitoring of juvenile survival and tributary covariates to relate management actions to changes in recruitment rates are needed. Monitoring of important physical, chemical, and biological covariates is not routinely collected on all the tributaries. Temperature, flow, and floodplain activation will need to be regularly monitored to build SR relationships that reliably assess management actions. State Water Board staff are compiling available fish and environmental data needed to produce brood tables and build simple SR models for LSJR tributaries. Initial escapement and juvenile survival goals can be revised when SR models become available, hatchery marking increases enough to reliably count natural origin fish, and/or when other relevant information becomes available.

3.2 Productivity Goals

Productivity describes the population growth rate of a species, and productivity can be expressed in full life cycle terms or juvenile terms. Positive population growth is necessary to increase abundance over time. In full life cycle terms, positive population growth occurs when the number of spawners that were hatched in the same year (cohort) is greater than the number of spawners that produced them. The Cohort Replacement Rate (CRR) is a simple way to describe full life cycle productivity (number of cohort spawners produced per spawner). If a cohort's returning spawners outnumber their parental spawners, the CRR is greater than one and abundance will increase. In juvenile terms, productivity is expressed as juvenile survival (e.g., tributary survival) or as the number of juvenile fish per spawner from the same cohort (recruits (R) per spawner (S) or R/S).

3.2.1 Full Life Cycle Productivity Goals

Initial productivity goals for LSJR fall-run Chinook salmon are expressed as CRR and are proposed in Table 2. The first and most basic productivity goal is a positive trend in CRR until a CRR of greater than 1 is attained. Goals are also proposed for both pre and post-fishing to account for the commercial and recreational ocean and inland salmon fishery or other mortality that may remove adult salmon from the population of potential spawners. The post-fishing CRR goal of greater than 1 is a foundational goal because it represents the basic concept that the population must at least replace itself to persist over time, and the population must more than replace itself to grow. Post-fishing CRR will be derived from within river spawner escapement to incorporate all losses that may prevent a fish from returning to spawn in its natal river or stream.

The pre-fishing CRR[3] goal of greater than 1 and greater than the post-fishing CRR is meant to provide for fishing practices in the productivity goals. The pre-fishing CRR must be greater than 1 and greater than the post-fishing CRR for the population to persist, grow, and sustain commercial and recreational fishing. It is difficult to be certain about how much greater than one the pre-fishing CRR must be at this time to accommodate commercial and recreational fisheries and have a growing population so this portion of the goal is narrative at this time but can be modified in the future.

Table 2. LSJR Fall-Run Chinook Salmon Full Life Cycle Productivity Goals

Productivity Metric	Goal	Progress Assessment[4]
CRR Trend[5]	Positive generational trend until a CRR > 1 is met, measured as a 5-year geometric mean	Until numeric productivity goals are met (year 15)
Pre-Fishing CRR [6]	Pre-Fishing CRR > 1 and > post-fishing CRR until abundance goals met and then sustained, measured as a 5-year geometric mean	Year 6, measurable progress Year 9, substantial progress Year 15, achieve the goal
Post-Fishing CRR[7]	Post-Fishing CRR > 1 until abundance goals met and then sustained CRR > 1, measured as a 5-year geometric mean as a 5-year running average	Year 6, measurable progress Year 9, substantial progress Year 15, achieve the goal

Progress toward meeting the productivity goals will be assessed annually. The proposed 15-year time interval for achieving the goal provides time for the goals to be met. By year 6 when information is available for 2 full generations of salmon, it is expected that measurable progress toward meeting the CRR productivity goal would be made by demonstrating a reversal of declines and statistically significant level of improvement in CRR. By year 9 when information is available for 3 full generations of salmon, substantial progress toward achieving the goals would be expected and demonstrated by improvements in productivity on a trajectory that the productivity goals should be reasonably met after 5 generations or 15 years after the implementation.

[3] Pre-fishing CRR are derived using harvest and spawner escapement data for a given year.

[4] Year number after implementation begins.

[5] ISAP (2019). Developing Biological Goals for the Bay-Delta Plan: Concepts and Ideas from an Independent Scientific Advisory Panel. April 2019, section 4.6, pages 109-110.

[6] Ibid

[7] Ibid

3.2.2 Juvenile Productivity Goals

To help to inform management actions, evaluating productivity of Chinook salmon at juvenile life-stages in the river and Delta is important. Productivity during these life stages is critical to producing adult spawners and meeting the overall CRR and abundance goals. Early life stages include egg, alevin, fry, parr, and smolt.[8] Early life-stage productivity can be expressed as the number of juvenile fish per spawner or as a percent survival such as percent egg-to-smolt survival or percent egg-to-freshwater exit survival (i.e., outmigrant survival) because juvenile Chinook salmon migrate out of the freshwater environment throughout the fry, parr, and smolt life stages. Freshwater exit survival includes survival from all three of these juvenile life stages to the estuary. Table 3 shows the initial fall-run Chinook salmon productivity goals for juvenile survival. The productivity metric for juvenile survival has two different components: one for the riverine portion (eggs to the Delta entry) and one for through-Delta survival to the ocean. The goals are presented as numeric ranges which are based on the Conservation Planning Foundation Report and peer-reviewed literature referenced below. The survival ranges are expected to contribute to meeting the CRR for the juvenile component of the lifecycle.

Table 3. LSJR Fall-Run Chinook Salmon Juvenile Survival Goals

Productivity Metric	Goal	Progress Assessment[9]
Juvenile Productivity Trend	Positive trend in juvenile survival until abundance goal is met, measured as a 5-year geometric mean	Until numeric abundance goals are met (year 15)
LSJR tributary (egg) to Mossdale survival (SJRS)	SJRS ≥ 5.5–20%[10] as a 5-year geometric mean	Year 6, measurable progress Year 9, substantial progress Year 15, achieve the goal
LSJR at Mossdale to Chipps Island (Through-Delta) Survival (SJDS)	SJDS ≥ 20–50%[11] as a 5-year geometric mean	Year 6, measurable progress Year 9, substantial progress Year 15, achieve the goal

The rate of juvenile survival through the LSJR and the Delta is not fully understood or documented. Nonetheless, multiple studies have estimated through-Delta

[8] Eggs are in nests referred to as redds; alevin are larval fish with an egg sac for food; fry are small juvenile fish less than 45-55 mm (1.7 inches) that have recently emerged from nests; parr are juvenile fish larger than 60 mm (2.4 inches) but less than 90 mm (3.5 inches); smolts are larger than 90 mm (3.5 inches) and have started to transform physiologically to adapt to marine environments.

[9] Year number after implementation begins.

[10] Cain et al. (2019). Conservation Planning Foundation for Restoring Chinook Salmon (*Oncorhynchus tshawytscha*) and O. mykiss in the Stanislaus River. Seattle, WA. April 2019. Pages 50-55.

[11] Ibid.

juvenile survival for LSJR Chinook salmon. Survival estimates in other watersheds (i.e., Columbia and Thompson Fraser rivers) have also been documented (Buchanan et al. 2018; Dietrich et al. 2016; Welch et al. 2008). Based on these studies, there is significant evidence indicating that juvenile survival is considerably higher in other west coast rivers occurring in the northern portion of the range of salmon. The survival studies also indicate that outmigration survival varies between years and populations, and that survival correlates with environmental conditions such as flow, temperature, and turbidity. The proposed goals are articulated as a range based on these considerations.

Additional information on juvenile survival is needed to further refine the proposed juvenile survival goals. Critical information is lacking for understanding tributary survival rates from the egg stage to the juvenile stage to the confluence with the mainstem river. Furthermore, information on the survival rate in the mainstem San Joaquin to the Delta is also not well documented. Estimating survival rates in the tributaries and the mainstem river requires either enumerating juvenile fish that are captured in rotary screw traps (RSTs), trawl nets and beach seines, by passive detection with acoustic tags, or other new methodologies that may be developed. Further studies are needed on the tributaries and the mainstem river to better understand juvenile survival and the environmental variables that influence the rate. The proposed survival ranges could be re-evaluated and refined based on the availability of new information and routine monitoring.

Available information indicates that current juvenile survival in the LSJR and Delta is low with some reports of through-Delta survival at less than 5% (Buchanan et al. 2018, Cain et al. 2019). However, through-Delta survival estimates reported in the Vernalis Adaptive Management Plan's[12] 2011 annual technical report show that higher survival occurred between 1994 and 2001 (i.e., 80 percent in 1995; 40 percent from 1997-1998; 20 percent from 2001-2006; SJRGA 2011), which suggests that the proposed LSJR through-Delta juvenile survival goal is achievable. Annual assessments of juvenile survival through the Delta should be measured to further inform the achievability of the goals and to identify successful migration routes with higher survival as well as locations and time periods that show low survival.

3.3 Diversity Goals

Population diversity is an important VSP parameter that contributes to population stability, resilience and persistence. Diversity is generally represented by genetic and life-history (phenotypic) variation. A more diverse population spreads and

[12] The Vernalis Adaptive Management Plan was an experimental management program proposed by parties to the San Joaquin River Agreement in lieu of meeting the pulse flow objective included in the 1995 Bay-Delta Water Quality Control Plan.

reduces the risk of extinction associated with habitat and climate changes across genetic differences and life history strategies to ensure survival across a broad range of resource availability and habitat conditions. Providing habitat conditions that allow for the full expression of genetic and life-history diversity is important for maintaining these population characteristics and the long-term sustainability of salmon populations in the Central Valley.

3.3.1 Genetic Diversity Goals

Genetically inherited traits give Chinook salmon the ability to navigate freshwater and ocean habitats and return to spawn in natal rivers, or near natal rivers. Genetic differences among Chinook salmon persist because many of the life history traits such as the season of adult migration, are genetically inherited. At a finer scale, individual fish may have locally adapted gene complexes that improve survival of their offspring in local habitats. The ability to maintain these adaptations is important to the continued survival of fish in highly variable habitat conditions.

Artificial propagation of Chinook salmon in hatcheries can change the genetic composition of hatchery fish away from the genetic characteristics that enabled fish of natural populations to better survive and reproduce. The presence of significant numbers of hatchery fish “pollutes” the genetic pool for natural salmonid populations when the two interbreed. Many hatchery programs have disrupted the natural selection of population characteristics that are tailored to local conditions. Local adaptation is important because it maximizes the viability and productivity of the population, maintains biological diversity within and between populations, and enables the population to adjust to changing conditions that are often present with California’s highly variable hydrologic conditions. Hatchery operations can also cause unintended negative ecological interactions whereby hatchery fish compete for food and space, prey upon natural-origin fish, and transfer disease. The ISAP (2019) contains a summary of hatchery impacts on natural-origin fish (See box 4.2, page 99).

Identifying the contribution of hatchery-origin fish to a population is essential for assessing the status, fitness, and resilience of salmon populations. Hatchery-origin spawners often make up a large proportion of the total Chinook salmon escapement in Central Valley tributaries, especially for fall-run Chinook salmon (e.g., Willmes et al. 2018). There is a considerable amount of evidence showing that productivity of hatchery-origin salmonids is considerably lower than that of wild-origin fish (Araki et al. 2008; Ford et al. 2016).

The effects of a hatchery on a naturally spawning population depend on hatchery practices and differences in selective pressures in wild and hatchery environments. Salmon produced in hatcheries frequently spawn in streams and interbreed with natural-origin fish which can cause a reduction in the productivity of the overall population (Chilcote et al. 2011). The proportion Hatchery Origin Spawners or pHOS in a population is a key metric for tracking the genetic composition of the natural spawning population because artificial propagation tends to decrease the genetic variability of the natural population from which it is derived. Proportionate Natural Influence (PNI) represents the reproductive success of the population and is another important metric for tracking hatchery practices and adverse effects of hatchery salmonids on natural populations.

The ISAP (2019) recommends reducing the pHOS on the in-river spawning habitats and increasing the PNI which will contribute to an increase in the natural production of fall-run Chinook salmon. This will occur by increasing the productivity of natural spawners, allowing the species to adapt to local conditions, and reducing genetic homogeneity associated with domesticated hatchery salmon.

The first step toward reducing pHOS is for individual hatcheries in the Central Valley to produce Hatchery and Genetic Management Plans (HGMPs) for fall-run Chinook and for those hatcheries to increase marking of hatchery fish so that pHOS can be accurately measured. The following rivers in the Central Valley have hatcheries that produce fall-run Chinook: Battle Creek, Feather River, American River, Mokelumne River, and Merced River. The hatcheries that operate on these rivers would need to develop HGMPs and implement them to accurately estimate and reduce pHOS and increase PNI.

Table 4 contains initial genetic diversity goals for LSJR fall-run Chinook. These include incremental steps in reducing pHOS. Monitoring for other genetic diversity goals for increasing the PNI may be developed later after progress is shown toward achieving genetic diversity goals for pHOS.

Table 4. LSJR Fall-Run Chinook Salmon pHOS Genetic Diversity Goals

Genetic Diversity Metric	Goal	Progress Assessment
pHOS	Decreasing trend, as a 5-year running average[13]	Assessed on an ongoing basis
pHOS	≤ 50%, as a 3-year running average	Year 9 after beginning of implementation
pHOS	≤ 20%, as a 3-year running average[14]	Year 15 after beginning of implementation

[13] ISAP (2019). Developing Biological Goals for the Bay-Delta Plan: Concepts and Ideas from an Independent Scientific Advisory Panel. April 2019. Section 4.6, page 111.

[14] Cain et al. (2019). Conservation Planning Foundation for Restoring Chinook Salmon (Oncorhynchus tshawytscha) and O. mykiss in the Stanislaus River. Seattle, WA. April 2019. Table 13, page 69.

3.3.2 Life History Diversity Goals

Life history diversity can be defined as the variation in traits (e.g.,, run timing, developmental rate) that allow a species to exhibit multiple life history strategies. These multiple strategies enable use of a wider array of environments (McElhany et al. 2000). Life history diversity is a crucial component of population resilience, which describes the ability of a population to persist following disturbances across variable environmental conditions. Variation in life-history traits such as migration, spawning, and rearing times in local subpopulations (i.e., fish population in a tributary) reduces extinction risk at larger scales so that an environmental disturbance does not affect an entire population. In the Central Valley, the existence of four runs of Chinook salmon (winter-, spring-, fall-, and late fall-runs) with asynchronous spatial and temporal distributions allow them to occupy and use a range of ecological niches. Maintenance of multiple and diverse salmon stocks that fluctuate independently of each other would render a stabilizing portfolio effect to the existence of the overall salmon population in the region (Sturrock et al. 2015). Preserving and restoring life history diversity of salmonids is an integral goal of species conservation and attaining the narrative objective for LSJR native salmon.

Fall-run Chinook salmon juveniles migrating out[15] of the Central Valley system leave their natal rivers and streams at difference sizes, times of the year, and ages. It is thought that this life history variation contributes to their population sustainability, and thus is central to many recovery efforts. Individuals with distinct migratory phenotypes may experience differential survival and thus contribute to a population's resiliency.

3.3.2.1 Timing of Migration for Size Classes Goals

The migration of juvenile Chinook salmon with different life history strategies across a broad migration window is a good indicator that the river environment is supporting the various juvenile life history strategies that are characteristic of resilient salmon populations. The Conservation Planning Foundation Report used the presence of juvenile outmigrants measured on a weekly basis for each size class of juveniles to develop migration windows for each size class in the Stanislaus River. The migration time windows were based on historical timing of migration data collected at the Caswell RST on the Stanislaus River from 1996 to 2014 (see Zeug et al. 2014; and Sturrock et al. 2015). The parr and smolt migration windows were set to one to two weeks earlier than what was typically detected to reflect the desire to produce faster growth rates in-river which would result in the earlier appearance of larger size classes among outmigrants. Migrating juveniles with different life history strategies

[15] Emigration is a term commonly used to describe juvenile "outmigration" from freshwater tributary and mainstem river systems. Emigration can be used interchangeably with "outmigration."

can be detected by installing and maintaining RSTs at (or close to) the mouth of each tributary river or stream during the migration time window.

Table 5 contains the initial emigration timing goals for each of the juvenile size classes for LSJR fall-run Chinook. This is a presence/absence goal which is met by positive detection (presence) of migrating fish each week during the time period identified for each size class (fry, parr, smolt).

Table 5. LSJR Fall-Run Chinook Salmon Emigration Timing Goals

Juvenile Size Class* (Phenotype)	Life History Diversity Goal Emigration Positive Detection Each Week near Mouth of Each Tributary	Progress Assessment
Fry	Last week of January to second week of April[16]	Year 6, incremental progress Year 9, additional incremental progress Year 15, achieve the goal
Parr	First week of February to last week of May[17]	Year 6, incremental progress Year 9, additional incremental progress Year 15, achieve the goal
Smolt	Third week of February – first week of June[18]	Year 6, incremental progress Year 9, additional incremental substantial progress Year 15, achieve the goal

* Size classes are defined as fry ≤ 45 millimeters (mm); parr 46-90 mm; smolt >90 mm.

3.3.2.2 Minimum Percentage for Size Classes at Migration Goals

Quantifying the relative contribution of fry, parr, and smolt outmigrants to adult populations has been largely limited due to technical difficulties associated with reconstructing movements of early stages of adult fish. Recent advances in techniques analyzing chemical markers recorded in otoliths enable reconstruction of the movement patterns of individual fish. In the Central Valley system, the otolith mineral analysis (strontium isotope ratio, $^{87}Sr/^{86}Sr$; Sr/Ca and Ba/Ca)[19] and radius measurements combined could be used to reconstruct the size at which returning adults from the same cohort outmigrated as juveniles (Miller et al. 2010; Sturrock et al. 2015). Outmigrating juveniles can also be sampled at (or close to) the mouth of each tributary river or stream using RSTs to estimate outmigrant timing, abundance,

[16] Cain et al. (2019). Conservation Planning Foundation for Restoring Chinook Salmon (Oncorhynchus tshawytscha) and O. mykiss in the Stanislaus River. Seattle, WA. April 2019. Table 9, page 62.

[17] Ibid.

[18] Ibid.

[19] Sr = Strontium; Ca = Calcium; Ba = Barium

and size. In the Stanislaus River, juveniles are sampled at the RST located in the river channel adjacent to Caswell Memorial State Park.

Table 6 shows the proposed LSJR life history diversity goals based on the cohort-specific proportions of the size classes (phenotypes) of outmigrating juvenile fish. These values are proposed in the Conservation Planning Foundation Report for the Stanislaus River and are derived from the returning adult otolith analyses for Central Valley rivers and streams (Miller et al. 2010; Sturrock et al. 2015).

Table 6. LSJR Fall-Run Chinook Salmon Minimum Percentage for Size at Migration Goals

Wet and Above Normal WYs Size Class* Minimum Percentage as a 3-Year Running Average at the Mouth of the Tributary	Below Normal, Dry, and Critical WYs Size Class Minimum Percentage as a 3-Year Running Average at the Mouth of the Tributary	Progress Assessment
Fry ≥ 20%[20]	Fry ≥ 20%[21]	Year 6, incremental progress Year 9, additional incremental progress Year 15, achieve the goal
Parr ≥ 20%[22]	Parr ≥ 30%[23]	Year 6, incremental progress Year 9, additional incremental progress Year 15, achieve the goal
Smolt ≥ 10%[24]	Smolt ≥ 20%[25]	Year 6, incremental progress Year 9, additional incremental progress Year 15, achieve the goal

* Size classes are defined as fry ≤ 45 mm; parr 46-90 mm; smolt >90 mm.

3.4 Spatial Structure Goals

Spatial structure refers to the geographic distribution of populations or individuals in a population. The spatial structure helps contribute to the persistence of a population through: (1) reducing the chance of catastrophic loss because groups of individuals are widely distributed spatially; (2) increasing the chance that locally

[20] Cain et al. (2019). Conservation Planning Foundation for Restoring Chinook Salmon (Oncorhynchus tshawytscha) and O. mykiss in the Stanislaus River. Seattle, WA. April 2019. Table 11, page 66.

[21] Ibid.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Ibid.

extirpated or dwindling groups will be rescued by recolonization; and (3) providing more opportunity for long-term demographic processes to buffer a population from future environmental changes. In addition, broader geographic extent may decrease the extinction risk. Restoring areas that support source populations can increase the overall stability of metapopulations by increasing the number of individuals available to support nearby populations.

The spatial structure of a population is made up of the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000). Spatial structure of a population depends on the amount of habitat available, the organization and connectivity of that habitat (i.e., habitat patches), and the relatedness and exchange rates of adjacent populations. Spatial structure influences the viability of salmonids because populations with restricted distributions and few spawning areas are at a higher risk of extinction from catastrophic environmental events than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, experiences more natural exchange of gene flow and life history characteristics.

Restoring and sustaining Chinook salmon populations in the tributary streams and rivers within the Delta watershed would contribute to the overall spatial structure of the Chinook salmon population (Evolutionarily Significant Unit or Distinct Population Segment) in the Central Valley watershed. McElhany et al. (2000) offers spatial structure guidelines to be considered for viable salmonid populations. Spatial structure guidelines are met when the number of habitat patches is stable or increasing, stray rates are stable, marginally suitable habitat patches are preserved, refuge source populations are preserved, and uncertainty is incorporated (McElhany et al. 2000; see box A9, Spatial Structure Guidelines on page 100). The initial approach for spatial structure biological goals in the LSJR is to achieve the abundance, productivity, and diversity goals on all three LSJR tributaries, the Stanislaus, Tuolumne, and Merced rivers.

Chapter 4
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