Request to Amend Endangered Species Act (ESA) Section 7(a)(2) Biological Assessment

and

Request for Consultation pursuant to the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act

associated with

Temporary Changes to the Fall Chinook Salmon Production at the Coleman National Fish Hatchery

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Introduction

The U.S. Fish and Wildlife Service (Service) requests to amend the 2014 biological opinion, Section 7 consultation, with amendments, in accordance with the Endangered Species Act (ESA) of 1973, regarding the effects of facilities and operations of the Coleman National Fish Hatchery (Coleman NFH). This proposed amendment pertains to the Service's role in a proposed collaborative study of an experimental production program of Sacramento River fall Chinook Salmon (SRFCS; Oncorhynchus tshawytscha) fed fry. In combination with the existing production targets of SRFCS smolts at Coleman NFH, the newly proposed fry program will result in an increase of total SRFCS production. Implementation of the proposed study will bring about changes to the operations of the fall Chinook Salmon production program at the Service's Coleman NFH. Temporary changes resulting from implementation of the proposed study are intended to improve success at achieving the hatchery's annual adult contribution target of 120,000 SRFCS. In doing so, these actions are intended to promote increased opportunity for salmon harvest in ocean and inland fisheries, bolster and improve the number of natural spawning SRFCS in the Central Valley and increase the diversity of juvenile life history strategies exhibited by SRFCS, thereby contributing to improved population stability and resiliency (Lindley et al. 2009, Huber and Carlson 2015, Sturrock et al. 2019).

Program changes being proposed at the Coleman NFH are part of a larger study being developed in coordination with the California Department of Fish and Wildlife (Department) and a consortium of stakeholders referred to as the Bridge Group (listed below). The broader study plan will investigate experimental production programs of SRFCS fry at the Coleman National Fish Hatchery (Coleman NFH) and two State-operated salmon hatcheries in California's Central Valley. At a basin-wide scale, the actions proposed through this study will attempt to address high variability in year class strength of SRFCS, the current collapse of SRFCS, and the consequent closures to salmon fishing seasons that have resulted in severe hardships to the communities that rely on them (National Marine Fisheries Service [NMFS] 2022a).

The proposed actions will be conducted using a research framework that will focus on learning as a primary objective. A key component of study planning and execution will be the development and implementation of a monitoring program that will accommodate fishery management objectives and support decision-making associated with study execution. The Service and Department are collaborating on the development and implementation a robust monitoring plan that will be used to evaluate the benefits and incidental effects resulting from proposed actions.

The Bridge Group is comprised of Northern California farming and fishing advocates, including the Northern California Water Association (NCWA), Sacramento River Settlement Contractors (SRSC), California Rice Commission (CRC), Glenn Colusa Irrigation District (GCID), Pacific Coast Federation of Fishermen's Association (PCFFA), Nor-Cal Guides & Sportsmen's Association (NCGASA), and Golden Gate Fishermen's Association (GGFA). These organizations represent the entire ocean and inland salmon fishing industry in California, as well as a large constituency of agricultural water users in the Upper Sacramento Valley.

Proposed Actions

The Service, in cooperation with the Department and the Bridge Group, are working collaboratively to develop and implement a study plan associated with a large-scale expansion of SRFCS production at Central Valley hatcheries, including the Coleman NFH. The study will focus on experimental releases of fed fry, a hatchery practice that has not recently been part of Central Valley SRFCS production programs. Hatchery liberations of fed fry will occur throughout the Sacramento River basin and employ a variety of release strategies.

This study is being developed and implemented at a fast pace but in a thoughtful manner. The fast timeline and large scale of these proposed actions is intended to respond to the scale and significance of the current crisis facing SRFCS. This proposed study responds to a catastrophic collapse of SRFCS, predictions of continued "boom-or-bust" cycles of SRFCS abundance associated with habitat limitations, climate change, water management, current management hatchery practices, and the recognition that a "business as usual" approach will not improve the current situation (Lindley et al. 2009). The proposed study implements a novel management approach to improve the stability and resiliency of this highly important species.

Phased Approach to Implementation

The decision to implement this large-scale study was made only recently and planning is ongoing, even as this biological assessment is being prepared. Elements of the study design are not yet finalized; however, extensive planning and preparations are occurring at a rapid pace and important decisions are being made in real-time. The Service recognizes the importance of completing thorough and complete planning efforts to guide the thoughtful execution of proposed study. The Service and Department are committed to completing and implementing the proposed study actions, including the development and implementation of a comprehensive monitoring program.

The Service recognizes that the scale of the current situation merits a response that is both considerable and prompt. To respond to the current crisis with urgency requires that management actions begin prior to completing all aspects of project planning. To accommodate these two important needs, the Service proposes a phased approach to project implementation. The intent of a phased approach is to implement a scaled-down set of project actions rapidly, to respond to the urgency and severity of the crisis facing SRFCS, while providing additional time to develop a complete and comprehensive plan for a large-scale, long-term study.

Hatchery actions being proposed in this biological assessment are limited to Phase I of the planned federal actions, which is limited to those actions associated with the 2023 SRFCS spawning season at the Coleman NFH. Phase II of study actions will begin with the 2024 SRFCS spawning season. Prior to the 2024 SRFCS spawning season, the Service will submit an additional amendment request, along with completed plans for study execution and monitoring. This phased approach is intended to provide additional time to develop a more-complete description of project actions, prior to proceeding with full-scale implementation of the study. A brief overview of these two phases is presented below and a more thorough description of Phase I actions can be found in the Description of Proposed Actions.

Phase I

The present amendment request pertains only to the actions described in Phase I. Phase I of the proposed study will begin with the 2023 SRFCS spawning season at the Coleman NFH. During Phase I, experimental releases of fed fry at the Coleman NFH will target 3 million. Actual production of fed fry could vary by 15% depending on availability of brood fish, incubation success, post-hatch survival, and additional sources of variability. Hatchery production of fed fry will be supplemental to standard production (12 to 13.8 million) of SRFCS smolts at Coleman NFH. If broodstock limitations result in reduced egg collections relative to the full suite of hatchery production targets, priority will be given to fulfilling the smolt production target of 12-13.8 million.

Liberations of SRFCS fed fry will occur using a variety of management strategies, including direct releases into Battle Creek and the Sacramento River and liberations of fed fry into flooded agricultural fields and wetlands, where fry will be afforded the opportunity for extended rearing. An extensive monitoring program associated with hatchery releases of fed fry is being developed to compare the efficacy of different fry release strategies under varying environmental conditions. Releases of fed fry associated with Phase I will be restricted to only the 2023 spawning season, and the study will advance to Phase II beginning with the 2024 spawning season.

Phase II

The Service is not currently requesting an assessment of Phase II actions and this summary is provided for purpose of informing NMFS of the Service's vision for full-scale implementation of the study design. Implementation of Phase II will begin with the 2024 SRFCS spawning season at the Coleman NFH. During Phase II, experimental releases of fed fry at the Coleman NFH will total from 7 to 14 million annually dependent on broodstock returns. Hatchery production of fed fry will be in addition to standard production (12 to 13.8 million) of SRFCS smolts at Coleman NFH. Fry liberations will occur using a variety of management strategies, including direct releases into Battle Creek and the Sacramento River and liberations of fed fry into flooded agricultural fields and wetlands, where fry will be afforded the opportunity for extended rearing. An extensive monitoring program associated with hatchery releases of fed fry is being developed to compare the efficacy different fry release strategies under varying environmental conditions. Releases of fed fry associated with Phase II of the study will be conducted for period of nine years, for a total study term of 10 years. The 10-year term of this study will provide opportunities for learning and adaptive responses of study actions. Additionally, the 10-year term of the study will provide an opportunity to experiment with fry releases across a range of environmental conditions, encompassing three successive generations of SRFCS.

Basis of Proposed Study

The study actions proposed in this biological assessment differ from the program description of standard operations at the Coleman NFH, as described in the existing biological assessment (Service 2011) and previously assessed by NMFS in a biological opinion (NMFS 2014a). Changes to proposed hatchery operations are intended to promote increased abundance of SRFCS originating at the Coleman NFH, leading to more consistency in attaining the hatchery's annual contribution target of 120,000 adults to ocean and inland fisheries and spawner escapement. Since 2013, the Coleman NFH has not been successful at achieving its annual target of 120,000 SRFCS adults contributing to harvest plus escapement. Furthermore, the Coleman NFH adult contribution target will not likely be achieved in either 2023 or 2024, based on the expectation of sparse adult returns stemming from a variety of environmental and ecological challenges, including severe drought, predation, poor ocean conditions, and thiamine deficiency complex (Lindley et al. 2009; Nobriga et al. 2021; McIntuff et al. 2022; Service unpublished data). Actions proposed in this biological assessment will address some of the primary factors that have contributed to insufficient and highly variable annual rates of adult contribution.

Rates of survival and adult contribution of hatchery SRFCS from the Coleman NFH are affected by a multitude of factors following their liberation into the wild. The contribution of SRFCS from the Coleman NFH is primarily affected by the environmental conditions in the emigration corridor (Michel et al. 2015, Michel et al. 2018, Michel et al. 2021, Perry et al. 2018) and the Pacific Ocean (Lindley et al. 2009). These important salmon habitats are susceptible to the over-arching effects of an extreme and variable climate. Extreme climatic cycles associated with a changing climate have imposed a significant influence over Coleman NFH release practices during recent years. The standard hatchery practice of releasing SRFCS smolts on-site in Battle Creek, which is necessary to achieve a strong imprint to Battle Creek and promote adequate returns of hatchery brood fish, has been especially confounded during recent years of extreme drought, when the migratory corridor is degraded by low flows and elevated water temperatures (Hanak and Lund 2012, Michel et al. 2021, Munsch et al. 2019). The following section describes how climate change and standard hatchery release practices have interacted to affect adult contribution rates of SRFCS from the Coleman NFH.

Background

The Coleman NFH was constructed in 1942 as the principal feature to mitigate for impacts to Central Valley salmon and steelhead resulting from the construction of Shasta Dam, the keystone of the Central Valley Project. The Service produces fall and late-fall Chinook Salmon and steelhead at the Coleman NFH. In terms of numerical abundance, fall Chinook Salmon are the hatchery's primary production stock; the SRFCS program at Coleman NFH program is the largest hatchery program in the Central Valley with an annual production of 12 million fish.

Fall Chinook Salmon produced at the Coleman NFH and four State-operated Central Valley salmon hatcheries are the primary contributor to the state's ocean commercial fishery, ocean sport fishery, and freshwater sport fishery. In 2020, hatchery SRFCS comprised an estimated 62% of ocean salmon harvest south of Cape Falcon, OR, 73% of inland sport harvest, and 74% of total Central Valley SRFCS escapement (Dean and Lindley 2023, PFMC 2023). From 2010-2018, hatchery origin fish comprised an average of 69% (range: 53%-81%) of SRFCS spawner escapement across natural spawning areas in the Central Valley (Dean and Lindley 2023).

Salmon fishing industries contribute substantial economic value to California and across the West Coast. In California and Southern Oregon, ocean commercial and sport salmon fishing are a major economic driver for port communities. Central Valley SRFCS comprise the majority of harvest in ocean sport and commercial salmon fisheries south of Cape Falcon (PFMC 2016 – ACI 2020 CFM Report, Dean and Lindley 2023). Additionally, direct and indirect economic impacts of freshwater sport fishery for SRFCS, including fishing guide services, bait and tackle commerce, boat and fuel, hotels, and many other associated industries contribute substantially to inland Central Valley economies (Ransom 2001).

Current production Targets and Release Strategy

The annual production target of 12 million SRFCS smolts at the Coleman NFH has been in place since 2001. Spawning of SRFCS at the Coleman NFH occurs from early October to mid-November and juvenile salmon are reared on station until they reach a target size of 90 fish per pound (fpp). Based on SRFCS spawn timing and typical rates of development at the hatchery, target release sizes of Coleman SRFCS are typically achieved from late-March to early May. To promote a strong imprint of juveniles to Battle Creek, SRFCS smolts are released into Battle Creek, immediately downstream of the hatchery's barrier weir.

Development of Current Production Targets and Release Practices

Current production strategies and targets for SRFCS at the Coleman NFH were developed over a period of nearly sixty years. Beginning with the initial spawning of SRFCS at the Coleman NFH in 1943 and continuing for the first twenty years of hatchery operations, most SRFCS produced at the Coleman NFH were liberated at the fry developmental stage. During these early years, annual releases of SRFCS fry from the Coleman NFH commonly exceeded 20 million and peaked at more than 39 million in the early 1950s (Figure 1).

By the early 1960s, large scale releases of tens of millions of Chinook Salmon fry were largely abandoned at the Coleman NFH and throughout salmon hatcheries across the Pacific Coast in favor of producing a lower number of salmon smolts. This change in propagation strategies was feasible based on improvements to hatchery facilities and fish culture techniques and compelling evidence showing improved adult contributions resulted from producing larger, smolt-sized juveniles.

A fry release program was temporarily reinstated at the Coleman NFH in the 1980s and 1990s. At the same time, similar fry production programs were conducted at other hatcheries across the Pacific Coast attempting to increase adult contributions by promoting rearing in natural habitats (Kostow 2009). However, unlike the previous fry program at the Coleman NFH, the reinstated fry program was intended to complement a full-scale smolt production program and the collection of "extra" eggs for fry releases were supplemental to the full smolt production target. All releases of SRFCS fry from the Coleman NFH were terminated after 1999, based on their generally decreased contributions, relative to smolt releases, and the recognition of their increased potential for imposing harmful effects to naturally produced salmon through competitive interactions. A term and condition of the 2011 Biological Opinion associated with fish production at the Coleman NFH currently limits total production of SRFCS to no more than 15% more than the annual production target of 12 million smolts.

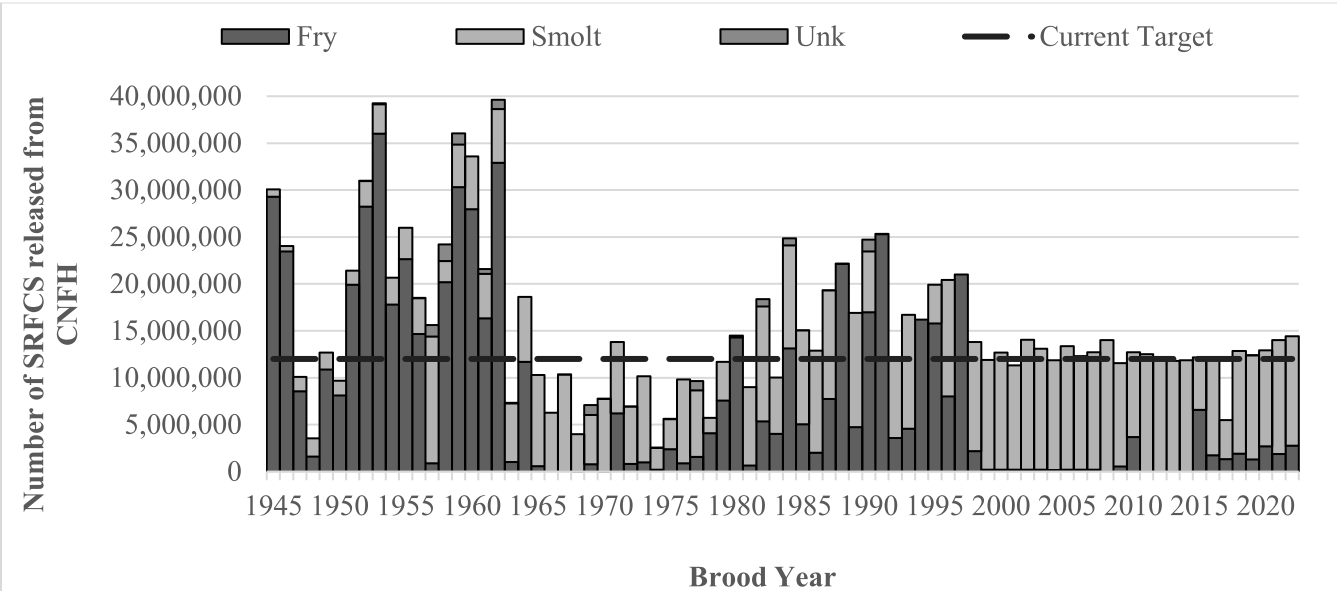

Figure 1. Number of Sacramento River fall Chinook Salmon released annually from Coleman National Fish Hatchery from 1945 through 2022. Fish are categorized as fry (<70 mm average size) or smolt (≥ 70 mm average size).

Adult Contribution Target

The production and release of juvenile salmon does not, by itself, fulfill the intent and purpose of a hatchery production program. The primary purpose of the Coleman NFH SRFCS production program is to augment ocean sport and commercial fisheries and the sport fishery in the Upper Sacramento River while providing sufficient escapement of adults back to Battle Creek to satisfy needs for future broodstock. The total annual contribution target of SRFCS adults from the Coleman NFH is 120,000 (1% of smolt releases). Adult contributions occur through harvest in ocean and freshwater fisheries plus spawner escapement, including returns to the hatchery and natural spawners in Battle Creek. Of this total, at least 10,000 fall Chinook must return to Battle Creek to satisfy annual broodstock needs associated with a stable level of hatchery production. If more adult SRFCS return to Battle Creek than are required to fulfill broodstock needs at the Coleman NFH, a target of 20,000 spawners are left in Battle Creek to spawn naturally.

Temporal trends of Adult Contribution

The number of Coleman NFH fall Chinook Salmon adults contributing annually to harvest and spawner escapement has varied substantially since the mid-1990s. Four distinct periods of adult contribution are evident (Figure 2).

1995 to 2003: From the early 1990's through 2003, SRFCS produced at the Coleman NFH consistently achieved or exceeded the annual contribution target of 120,000 adults. In the early 2000s, spawner escapement of Coleman NFH SRFCS was so high that natural resource co-managers expressed concern about the perceived impacts of "over-escapement" in Battle Creek to natural salmonid populations. Based on these concerns, the hatchery began actively managing the number of natural spawners in lower Battle Creek to limit overcrowding and pre-spawn mortality and encourage increased natural spawning success.

2004 to 2010: The SRFCS adult contribution target at Coleman NFH was not achieved from 2004 to 2010. Previously expressed concerns about over-escapement of hatchery SRFCS were abated when the abundance of SRFCS from the Coleman NFH and State-operated salmon hatcheries was reduced to a historically low level. The cause of this historical "collapse" of Central Valley SRFCS was attributed to anomalously poor ocean productivity in 2005 and 2006, resulting in large-scale collapse of the ocean food web (Lindley et al. 2009).

2011 to 2013: The annual contribution target of SRFCS from the Coleman NFH was achieved during 2011, 2012, and 2013. These three successive SRFCS cohorts from the Coleman NFH benefitted from favorable environmental conditions during spring, coincident with the timing of smolt releases from the Coleman NFH. These three cohorts also benefitted from increased contributions resulting from a decision to truck 10% of SRFCS smolts to the San Pablo Bay to rebuild the stock following the recent fishery collapse.

2014 to present: From 2014 to 2022, total contribution of adult SRFCS from the Coleman NFH was not sufficient to achieve the target of 120,000 during any year. These cohorts were affected by multiple stressors, including unfavorable conditions in the emigration corridor during recurrent periods of severe drought (2012-2015, 2018, and 2020-2022) and shortage of broodstock (2017) resulting from high rates of straying of previous cohorts released into San Pablo Bay. Failure to achieve the contribution target is predicted to extend through 2024, based on an expectation of poor survival of the 2020 and 2021 cohorts resulting from severe drought.

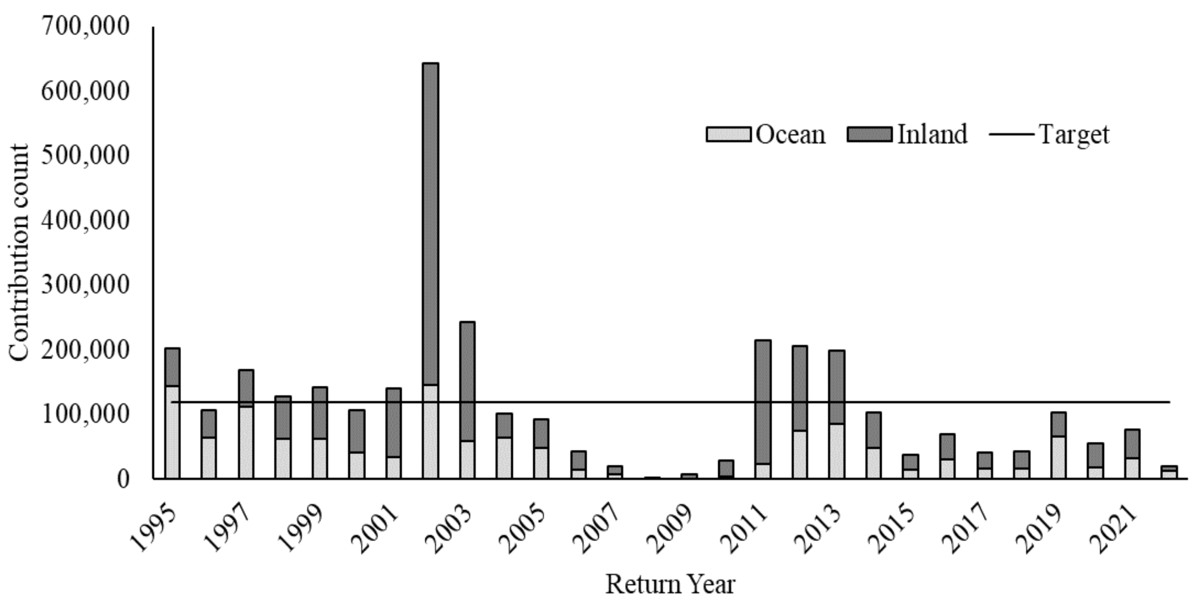

Figure 2. Total adult contribution by Coleman NFH SRFCS from return years 1995–2022. Contribution is grouped by ocean (e.g., commercial and sport fishing) and inland freshwater recoveries (includes sport fishing, hatchery returns, etc.).

Environmental Influences in the Migratory Corridor

Standard practice at the Coleman NFH is to release SRFCS smolts into Battle Creek during April; this release practice is commonly referred to as being "on-site". Production releases of SRFCS are smolting and physiologically capable of transitioning to saltwater residence. However, the Coleman NFH is the furthest inland salmon hatchery in California's Central Valley and SRFCS smolts must migrate more than 270 miles from Battle Creek to reach saltwater. SRFCS smolts produced at the Coleman NFH move rapidly through the emigration corridor and most reach the Delta within one to two weeks following their liberation into Battle Creek (US Fish and Wildlife Service, unpublished data). Travel speeds are decreased, and mortality is increased, during periods of low flow (Zeug et al. 2020; Michel et.al. 2021).

On-site releases of SRFCS are highly influenced by environmental conditions in the migratory corridor and survival during emigration is a primary factor influencing the level of adult contribution of annual cohorts. Environmental conditions in the Sacramento River and Delta are highly variable during April and May. When smolt releases can be timed to coincide with spring storm events, hatchery release groups benefit from elevated turbidity and increased and highly variable river flows - conditions that tend to increase the rate of downstream movement by emigrating salmon smolts and improve protection from predators (Michel 2019). Conversely, when smolt releases must occur during conditions of dry weather, low and stable river flow and clear water are associated with decreased rates of downstream movement and increased susceptibility to predation (Michel 2021). Water management operations further compounds this situation during dry years, as reservoir releases are reduced during March and April to conserve water for urban, agricultural, and natural resource needs throughout the summer months.

Periods of Severe Drought

Recent periods of severe drought provide an illustration of the extreme effects degraded river conditions can have on the survival of SRFCS smolts released from the Coleman NFH. For the past 15 years, severe drought has been a recurrent feature in California's Central Valley, including the multi-year periods 2007-2009, 2012-2016 and 2020-2022. These multi-year periods of severe drought have been separated by isolated years of normal to above-normal rainfall (2011, 2017, 2019, 2023). The extreme and increasing variability of this climate pattern was predicted for California because of a changing climate (Diffenbaugh et al. 2015). Concerningly, these extreme and highly variable conditions are expected to occur with increased regularity in the future.

Emergency Release Strategies

During recent periods of severe drought, migratory conditions in the lower Sacramento River and Delta have, at times, become so degraded during April and May that the Service has been compelled to implement emergency release strategies at the Coleman NFH to preclude the complete loss of juvenile SRFCS during their downstream emigration. Two emergency release strategies that are used to mitigate for the expectation of extremely high losses of juvenile salmon during their emigration are (1) transporting and releasing juvenile salmon to downstream locations, including direct releases into the San Pablo Bay, and (2) releasing juvenile salmon prior to achieving the target release size and degraded conditions in the migratory corridor. Although each of these emergency release practices provides some utility in preventing a catastrophic loss during emigration, neither strategy has been completely effective at fulfilling all the goals of the SRFCS program at Coleman NFH. Thus, implementation of these emergency release strategies requires a compromise to achieving all the goals of the SRFCS program. A third experimental strategy that could potentially benefit the survival of Chinook salmon smolts emigrating from the upper Sacramento River during the spring, including SRFCS smolts released from the Coleman NFH, is the use of managed pulse flows. An ongoing study is designed to investigate the value of managed pulse flows from Shasta Reservoir at increasing survival of downstream migrants (USBR 2021). However, execution of study plans has been confounded, especially during years of dry hydrology, by competing demands for limited supply of cold water.

Trucking Juveniles to the San Pablo Bay

Transporting juvenile SRFCS from Coleman NFH via truck to downstream release locations is an effective strategy for avoiding adverse conditions in the emigration corridor and promoting high rates of contribution to ocean fisheries. Similar benefits are achieved by conducting San Pablo-San Francisco Bay (Bay) releases of fall Chinook Salmon from State-operated hatcheries. Whereas releases into the lower Sacramento River and Delta have shown mixed results, releases at San Pablo Bay have been shown to consistently yield substantially increased rates of contribution to ocean fisheries, relative to upriver releases (Dean and Lindley 2023; Letvin et al. 2021a; Letvin et al. 2021b). As a result, Bay releases from the Coleman NFH do not generally return to upriver spawning areas and do not appreciably contribute to inland sport fisheries upstream of the Feather River, which is a goal of the SRFCS program.

While all Central Valley hatcheries experience a clear benefit from Bay releases, with substantially increased contributions to the ocean fishery, the Coleman NFH is unique amongst Central Valley salmon hatcheries in the scale of risks this action confers to the sustainability of hatchery operations; whereas Bay releases of SRFCS from State hatcheries result in increased straying, enough Bay-released fish return to these facilities to satisfy the hatchery’s future needs for broodstock. The practice of sharing of eggs between State-operated facilities (particularly Mokelumne Fish Hatchery), which are all lower in the river system, further mitigates this risk of broodstock shortages associated with Bay releases. This contrasts to Bay releases from the Coleman NFH, which stray at a rate approaching 100% (Niemela 1996; Sturrock et al. 2019; Letvin et al. 2020) and for which egg transfers are not commonly used as a mitigative action. As a result, Bay releases from the Coleman NFH do not appreciably contribute to future needs for hatchery broodstock and conducting large-scale Bay releases is, therefore, not compatible with a sustainable hatchery program at the Coleman NFH.

As an example, all brood year 2014 SRFCS produced at the Coleman NFH were trucked off-site for release, due to conditions of severe drought. Three years later, when these trucked releases were expected to return as adults, Battle Creek saw the lowest run in over 40 years, and despite additional efforts to collect broodstock and gametes from other locations (e.g., Keswick Dam fish trap and Nimbus Fish Hatchery) the Coleman NFH was able to fulfill less than half of its total broodstock needs. As a result, juvenile releases from brood year 2014 were limited to approximately 5.5 million smolts, less than half the hatchery’s annual production target of 12 million (Austing and Niemela 2018). These drawbacks of Bay releases for Coleman NFH limit the utility of this emergency release strategy and make the effects of severe drought especially pronounced and uniquely detrimental to the SRFCS program at Coleman NFH.

Early Releases

Another strategy currently being evaluated for its effectiveness at mitigating for poor conditions in the emigration corridor during years of drought is liberating juvenile SRFCS prior to achieving target size. A decision to release SRFCS at a less-than-target size enables their liberation as early as mid-March, providing them the opportunity to emigrate prior to the migratory corridor becoming uninhabitable. Releases prior to mid-March have not been achievable at the Coleman NFH due to the requirement to mark and tag a representative fraction of SRFCS, as is required by the Valley-wide constant fractional marking program. Because SRFCS must be at least 180 fpp to receive a constant fractional mark and tag, this early release strategy can be used for only the early portion of the SRFCS spawning distribution (i.e., offspring of earliest spawned fish) at the Coleman NFH.

A study to evaluate the early release strategy was initiated in in 2016 (brood year 2015) and, thus, only preliminary results are currently available. Based on results-to-date, adult contributions of sub-smolt, early SRFCS release groups have been mixed, with some early release groups producing adult returns at rates higher than those of later releases of target-size smolts, whereas other early release groups have yielded adult contribution at levels that are lower than smolts released at target size. There is some indication in the data that early releases of under-sized fish may contribute relatively well during years of drought, especially when early releases can be opportunistically timed to occur with weather events and prior to the degradation of the migratory corridor. However, this potential benefit of early releases may diminish during years when early releases cannot be synced with weather events and when the migratory corridor remains suitable for emigrating SRFCS smolts during April. In these situations, releases of smolts are expected to outperform early releases of under-sized fish.

<u>Summary of the Effects of Drought on Coleman SRFCS</u>

Climate is an important factor influencing the survival and abundance of hatchery SRFCS from the Coleman NFH. Degraded river conditions caused by drought confound standard release practices and impair the survival of SRFCS smolts. The Coleman NFH is the furthest inland salmon hatchery in California's Central Valley and salmon smolts liberated on-site during periods of drought must emigrate more than 270 miles through an emigration corridor that is degraded by conditions of low flows and warm water temperatures. The recent 15-year period has encompassed three multi-year periods of severe drought.

Since 2014, standard SRFCS production and release practices at the Coleman NFH, which were previously successful at achieving the annual adult contribution target of 120,000, have not achieved a similar level of success. Recurrent periods of severe drought have confounded on-site releases of salmon smolts and alternative release practices of trucking fish off-site and early releases have not been completely successful at mitigating the effects of drought. Michel (2019) reported that streamflow during emigration was the principal factor determining survival to adult. The clear association between low levels of adult contribution and the degradation of the migratory corridor during years of severe drought demonstrates a hatchery release strategy that is out-of-sync with the changing environment. Recent conditions of persistent drought and extreme variability of climate patterns were predicted for California as a consequence of a changing climate and these conditions are expected to be further exacerbated in the future (California Climate Commons, http://climate.calcommons.org/article/central-valley-change).

Such a “boom-or-bust” relationship has been predicted for SRFCS as a result of multiple intersecting factors, including a high reliance on hatchery stocks to augment intensive fishery harvest, comparatively low levels of natural production, highly standardized rearing and release practices at all Central Valley hatcheries (i.e., releasing ocean-ready smolts in the spring), and environmental conditions that are becoming increasingly extreme and highly variable (Lindley et al. 2009, Huber and Carlson 2015, Willmes et al. 2018, Sturrock et al. 2019). Because standardized hatchery practices that are mis-matched with a changing environment contribute to this pattern of extreme volatility, it’s unlikely that increased hatchery production alone will resolve this situation. To the contrary, Lindley et al. (2009) stated, “Simply increasing the production of fall Chinook Salmon from hatcheries as they are currently operated may aggravate this situation by further concentrating production in time and space.”

Diversification of hatchery release strategies

Several researchers have hypothesized that increased diversity of SRFCS life history strategies should lead to increased stock stability and resiliency in a highly variable environment (Lindley et al. 2009, Huber and Carlson 2015, Nelson et al. 2019, Sturrock et al. 2019). Diversification of production and release strategies at Central Valley salmon hatcheries, including the Coleman NFH, may help to buffer swings of adult contribution associated with environmental stochasticity. An alternate to Coleman NFH's standard release practice of liberating smolts on-site in April, is to distribute SRCFS releases at various locations, sizes, and dates within the Sacramento River watershed. Juvenile salmon released at smaller sizes, earlier developmental stages, and in different locations of the watershed would experience a diversity of environmental conditions and, in turn, should be expected to express increased variation in growth, emigration timing, and ocean entry times. Increased diversity of hatchery release strategies is hypothesized to lead to the expression of variable life history strategies (Lindley et al. 2009, Huber and Carlson 2015, Nelson et al 2019). Thus, the practice of releasing SRFCS from the Coleman NFH across a range of developmental stages could buffer the risks associated with a single environmental catastrophe, such as the severe degradation of the migratory corridor during drought, and thereby contribute to increased stock stability and resiliency.

The strategy of releasing juvenile SRFCS across a range of developmental stages may also contribute to expanding life-long diversity within SRFCS. For example, rates of growth during juvenile life stages are known to influence age and size at maturity (Hankin 1990). Therefore, increased diversification of juvenile release practices could help to distribute the adult contribution of each cohort across multiple years, further buffering the tendency for boom-or-bust fluctuations across multiple year classes (Satterthwaite and Carlson 2015).

Importance of Juvenile Rearing and Floodplain Habitats

Changes to hatchery release practices that include the liberation of juvenile salmon across a wider range of developmental stages will necessitate that juveniles spend prolonged residence in the freshwater environment. Historically, an estimated four million acres of floodplains and seasonally inundated off-channel river habitats provided an important resource of food and refuge for rearing juvenile salmonids. An estimated 95-98% of these historical floodplain and tidal wetland habitats in the Sacramento River and Delta have been lost or are currently inaccessible to salmon (Whipple et al. 2012). The loss and degradation of floodplain habitats in the Central Valley is a primary factor contributing to the decline of native fish species, including Chinook Salmon (Sommer et al. 2001b).

The loss and degradation of critical salmon rearing habitats has also contributed to the current reliance on fish hatcheries and smolt release practices for maintaining salmon stocks capable of sustaining current levels of harvest. Fall Chinook Salmon smolts, liberated from the Coleman NFH during April, are ocean-ready and transit rapidly through the emigration corridor. The rapid downstream movement of hatchery smolts decreases their duration of freshwater residence and reduces their dependence on nursery habitats that are important to earlier developmental stages. The loss of most floodplain habitats in the Sacramento River and Delta has been especially detrimental to SRFCS fry, which depend on the food and safety provided in shallow water nursery areas (Sommer et al., 2001b).

The Potential of Managed Nursery Habitats

Recent research shows promise in the potential to implement management practices that capitalize on the availability of existing irrigation infrastructure, in combination with flooded agricultural fields, to serve as high quality Chinook Salmon nursery habitats in the Sacramento River Valley (Sommer et al. 2001a, Corline et al. 2017, Katz et al. 2017, Holmes et al. 2021). Nearly half a million acres of the Sacramento River Valley are used for rice production (USA Rice; https://www.usarice.com/thinkrice/discover-us-rice/where-rice-grows/state/california).

Seasonal inundation of rice fields during winter months is a commonly used practice in California's Central Valley to promote the decomposition of rice stubble after harvest. When purposefully managed, the shallow water habitats of inundated rice fields have been shown to provide an abundant source of zooplankton, capable of supporting the rapid growth of juvenile Chinook Salmon (Goertler et al. 2017, Holmes et al. 2021). Juvenile Chinook Salmon reared in inundated rice fields for several weeks exhibit rates of growth that are substantially increased relative to adjacent river channels. Larger body size at emigration and ocean entry provides a survival advantage to juvenile salmonids, and these benefits are conferred to increased adult contributions (Mahnken et al. 1982, Dickhoff et al. 1995, Woodson et al. 2013). This information suggests it may be possible to manage rice field and wetland habitats differently, in a manner that better fulfills the needs of early life history stages of SRFCS. In doing this, rice fields and wetland habitats segregated from the migratory corridor may effectively function as surrogates for the historically abundant floodplain habitats of the Central Valley. In combination with modified hatchery practices that liberate Chinook Salmon at earlier stages of development, this management practice is hypothesized by Katz et al (2021) to potentially increase the quantity and quality of juvenile salmonid rearing habitats, which should promote increased life history diversity within Central Valley salmon stocks and buffer the effects of environmental change.

Description of Proposed Action

Objectives

The actions proposed in this study will implement temporary changes to the production targets and release protocols of SRFCS at the Coleman NFH intended to promote improved success at achieving the hatchery's contribution target of 120,000 adults annually. Reaching the adult contribution target consistently will support increased salmon harvest in ocean and inland fisheries and promote increased escapement to natural spawning areas and hatcheries.

Furthermore, the proposed actions will promote increased diversity of life history strategies of SRFCS, possibly contributing to improved population stability and resiliency. Proposed changes to operations at the Coleman NFH will be implemented using a scientific framework, which emphasize monitoring and evaluation as essential components. A robust program of monitoring and evaluation is currently being developed and will be used to assess the effectiveness of the proposed actions and incidental effects of proposed actions to ESA-listed species.

Changes to Standard Operations in the Coleman NFH SRFCS Program

Implementation of the proposed study will bring about substantial changes to the existing SRFCS program at Coleman NFH, including a new program goal, an increased annual production target, and modified strategies of rearing and release, including providing fish for extended rearing in inundated agricultural fields and off-channel wetlands. An overview to these changes of the Coleman NFH SRFCS program, consistent with the format of a Hatchery and Genetic Management Plan (HGMP), is provided to contrast operational areas where hatchery protocols will change as a result of implementation of proposed study actions (Appendix A). Aspects of program operations that are not addressed in Appendix A (e.g., hatchery facilities) or assessed in this biological assessment remain unchanged from the those described in the 2011 biological assessment and 2014 HGMP for the SRFCS program. A more complete description of standard operations in the Coleman SRFCS propagation program is provided in the 2011 biological assessment (Service 2011) with amendments and the Coleman SRFCS HGMP (Service 2014).

Overview of Study Design for the 2023 Spawning Season

A study will be implemented to assess the adult contributions of SRFCS fed fry from the Coleman NFH towards the hatchery's contribution goal of 120,000 adults. The Service will propagate a target of 3 million SRFCS at the Coleman NFH during the 2023 spawning season for planned releases as fed fry. Actual production of fed fry could vary by 15%, depending on availability of brood fish, incubation success, post-hatch survival, and additional sources of variability. Production of fed fry associated with this study will be in addition to standard production targets of SRFCS smolts at Coleman NFH. If egg collections limit achievement of the full suite of hatchery production targets, priority will be given to fulfilling the smolt production target of 12-13.8 million.

Groups of fed fry from the Coleman NFH will be liberated during January and February at a size of approximately 500 fpp, equivalent to a size of 40-50 mm. Three groups of approximately 1 million fish will be allocated to each of three general release strategies, including (1) direct releases into Battle Creek via pumping fish from raceways, (2) trucked releases liberated directly into the Sacramento River between Battle Creek and Colusa, and (3) trucked releases into managed floodplain-type habitats (e.g., refuge wetlands and inundated agricultural fields) where hatchery fry will be provided an opportunity to remain for extended rearing in a semi-natural environment. These three release strategies are hereafter referred as "Battle Creek", "Sacramento River", and "Surrogate Floodplain", respectively.

Battle Creek Releases
Direct releases of fed fry into Battle Creek will be accomplished via pumping fish directly from raceways, using a fish pump and standard hatchery protocols. Hatchery staff are experienced in this release practice and do not anticipate major complications to result from releasing SRFCS at the fed fry stage vs. the standard smolt stage of development.

Sacramento River Releases
Off-site releases of fed fry into the Sacramento River will be accomplished by transporting fish to the release site via a fish distribution truck. The geographic range of release locations currently being considered spans from Red Bluff to Colusa, but releases outside of this range may be used, depending on the availability of suitable release sites, environmental conditions, and other factors. Acceptable release sites include boat ramps with improved access to the Sacramento River. Hatchery staff are experienced with transporting SRFCS smolts to off-site release locations as distant as San Pablo Bay. Sacramento River Releases of fed fry associated with this study will be considerably closer to the hatchery than San Pablo Bay, which lessens the travel time and decreases concerns about transport losses. However, hatchery staff are not experienced in transporting the large numbers of fry associated with this study design. Therefore, we expect that some experimentation with transport strategies (e.g., transport vehicle, transport densities) will be necessary to execute fish transport for Sacramento River Releases.

Surrogate Floodplain Releases
We use the term "Surrogate Floodplains" to describe managed agricultural fields and wetlands that will be evaluated in our study for their ability to replace some of the benefits to Chinook salmon rearing that were previously associated with natural floodplains. Releases of fry into Surrogate Floodplain habitats will be accomplished via a fish distribution truck, like the process used for Sacramento River Releases. Transporting fish by truck to either location entails risk of accident or mishap that could threaten the survival of fish being moved. Study cooperators will dedicate sufficient effort towards pre-release reconnaissance scouting to ensure release locations afford suitable access and facilities for off-loading fry. The Coleman NFH manager will maintain final decision-making authority regarding suitability of all release locations.

The Surrogate Floodplain site selected for the release of brood year 2023 SRFCS fry from the Coleman NFH is Knaggs Ranch (38.698431˚N, -121.658506˚W; Figure 2), located in the northern Yolo Bypass. The Knaggs Ranch and the Yolo Bypass have been the site of extensive research (Corline et al. 2017, Katz et al. 2017, Sommer et al. 2001a, Holmes et al. 2021) associated with the assessment and management of salmon rearing on Surrogate Floodplain habitats. The landowners of Knaggs Ranch are supportive of the proposed study. Katz et al. (2017) provide a description of the Knaggs Ranch property and the fields that will be used for this study and describe the proximity and relationship of the property to Yolo Bypass and Sacramento River migratory corridor.

Salmon fry will be monitored while occupying Surrogate Floodplain habitats. Water temperature and oxygen will be continuously monitored to ensure that environmental conditions are maintained to support salmon growth and survival. Observers will periodically monitor fish to estimate growth, survival, and egress to the emigration corridor. Monitoring information will feed into real-time decisions concerning water and fish management. Study cooperators at U.C.

Davis have substantial research experience in using these habitats to rear juvenile salmon. We anticipate that forced liberations of juvenile salmon from Surrogate Floodplain habitats will occur on or before March 1, 2024, but the actual timing may change depending on the approach used to manage the Surrogate Floodplain fields and environmental conditions. Earlier releases may be necessary to mitigate for unfavorable environmental conditions in Surrogate Floodplains, such as those that are expected during conditions of drought. During these conditions, concerns of elevated water temperatures or low levels of dissolved oxygen may trigger decisions to liberate salmon from Surrogate Floodplains prior to March 1. Excessive and uncontrollable predation is another factor that may trigger a decision of a forced early release from Surrogate Floodplain fields. It is also possible that environmental conditions could result in flooding of the Yolo Bypass. In this situation, the entire Yolo Bypass becomes inundated by high flows in the Sacramento River, creating a condition where salmon being reared in Surrogate Floodplain fields are afforded free movement to the migratory corridor.

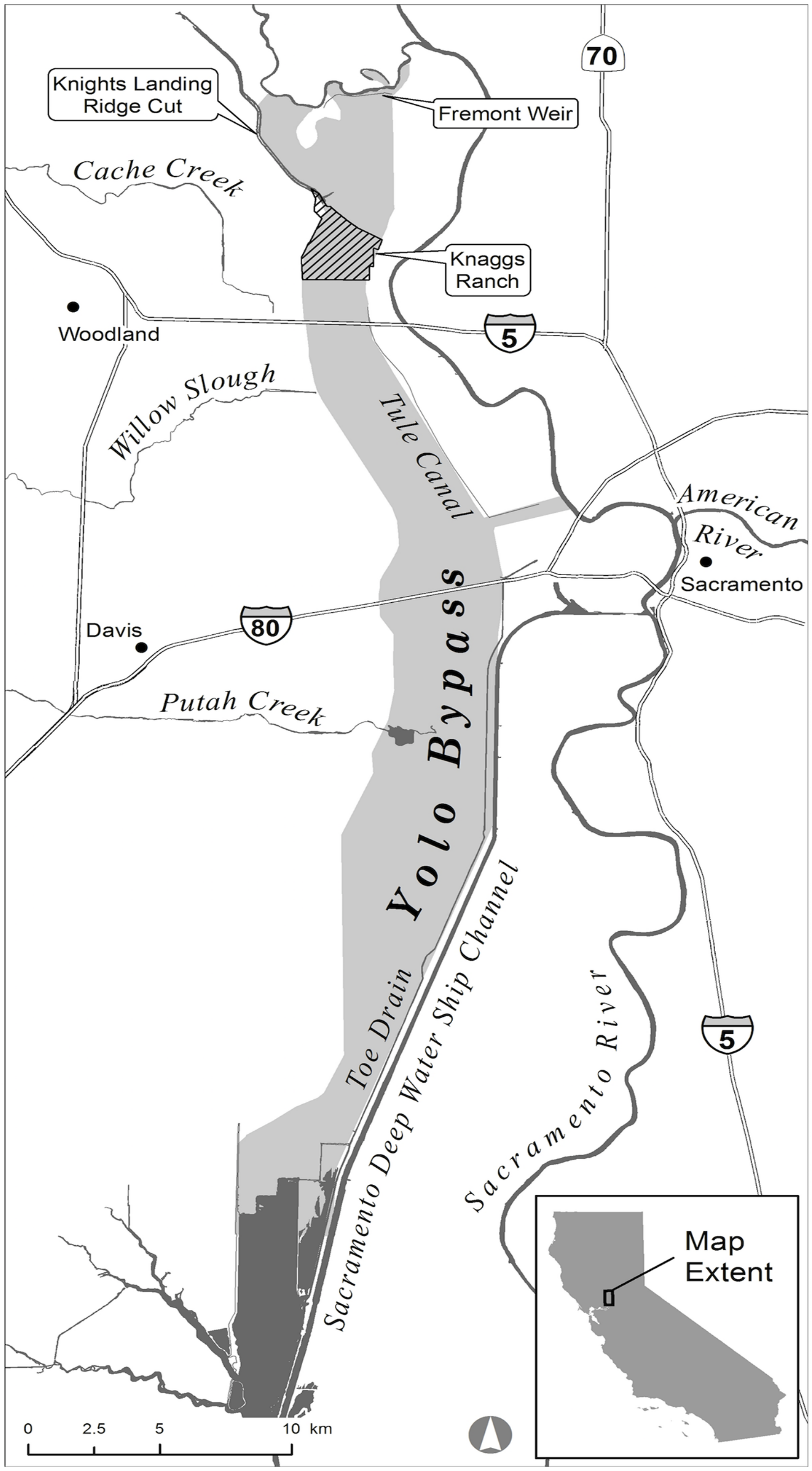

Figure 3. Map of the Surrogate Floodplain site at Knaggs Ranch, including location within the Yolo Bypass along the Sacramento River (Source: Katz et al. 2017)

Movement of fish from Surrogate Floodplain fields is also influenced by the field management strategy. Management of fish released on Surrogate Floodplain fields can be accomplished using either static or active management strategies. Static field management involves taking measures to ensure that stocked fry are maintained captive in the Surrogate Floodplain habitats until a decision is made to liberate them into the wild. For example, a passively managed agricultural field will be managed to be inundated using solid flash boards, which limit the egress of both water and fish. Thus, static management provides managers with increased certainty about the size, condition, and timing of hatchery releases into the wild and may be useful to ensure that fish maximally benefit from the opportunity of increased growth and limit spatial and temporal overlap with naturally produced salmonids following their liberation into the wild. This contrasts to an active management of Surrogate Floodplain habitats, which involves the rearing of salmon in fields they can egress volitionally. For example, downstream flash boards can be notched to provide an opportunity for volitional egress to the migratory corridor. An actively managed Surrogate Floodplain habitat may thereby encourage the expression of diverse migratory types of juvenile salmon. The management strategy for the planned release of brood year 2023 at Knaggs Ranch in 2023 will be identified in the annual work plan, when completed.

Selecting Knaggs Ranch for phase I in 2023 has several benefits, including the proximity to the Delta and SRFCS migratory corridor. Fish released from the Knaggs Ranch will emigrate downstream and exit the Yolo Bypass in the Northwest Delta. This area is downstream of the Central Delta, where mortality rates are significantly higher due to predation, poor water quality, and the influences of delta pumping facilities (Katz et al. 2017). As an added benefit, hatchery SRFCS reared in the Yolo Bypass have a reduced opportunity to interact with ESA-listed salmonids emigrating through the river corridor, which may be size-disadvantaged, until later in their migrations.

Need for Flexibility

The operational strategies and production targets described in this study plan should be interpreted as being flexible and subject to change. The need for flexibility in planning and executing project actions is important to respond in real-time to uncertainties and changing conditions, such as the availability of broodstock, weather and environmental conditions, and limitations associated with staffing or facilities at the Coleman NFH. Furthermore, many of the strategies being proposed in this study are novel and have not been previously attempted at the Coleman NFH. As a result, there is uncertainty about the hatchery's ability to achieve success in some of the proposed activities and or to achieve the proposed increases of hatchery production on an annual basis. Propagation and culture of salmonids is not completely predictable in the sense that fish do not always spawn, hatch, and grow at times and rates that follow a reliable schedule. Furthermore, fish culture is affected by environmental conditions. The development of juvenile SRFCS is influenced by factors such as spawn date, water temperature and turbidity, fish densities and food conversion efficiencies, and disease. Depending on these and other factors, the date and size that SRFCS fry are ready to be outplanted may occur sooner or later than timelines currently outlined. Lastly, the proposed study actions will be accompanied by a robust monitoring program, and program actions are intended to be adaptable based on real-time information coming from monitoring; study plans may be adjusted or cancelled to reduce the risks of planned activities, to improve the benefits of proposed actions, or to reduce unintended effects to ESA-listed species.

Project Facilitation and Implementation

Implementation of study actions will be guided by a Technical Team comprised of representatives of the Service and project cooperators. Project activities will be described in both an overarching study plan and an annual work plan. Because of the fast-moving pace of this project, neither of these planning documents have been completed. Both the study plan and annual work plans are currently in the process of development.

While the Technical Team will provide guidance and recommendations regarding all aspects of study design and execution, the team's expertise will be particularly important with respect to the Surrogate Floodplain Release strategy. Members of the technical team are recognized experts in the experimental strategy of rearing salmon on Surrogate Floodplain habitats, whereas the Service and Department are generally inexperienced with this approach to aquaculture. Surrogate Floodplains will require management decisions to be made in real-time, and monitoring information from Surrogate Floodplain habitats will be provided to the Technical Team, who will be responsible for making decisions concerning water management. The Technical Team will also provide recommendations to the Fish Agencies regarding the forced liberations of fish from Surrogate Floodplain habitats, for which the Fish Agencies maintain ultimate decision-making authority.

Monitoring and Evaluation

The primary method of monitoring proposed for this study is Parentage-Based Tagging (PBT), a genetics-based tool applicable for fishery assessments. Parentage-based tagging is needed for this study because fry will be released when they are smaller than minimum size needed to receive a coded-wire tag. However, PBT provides numerous benefits to coded-wire tags, including the opportunity to conduct non-lethal sampling, the ability to identify sex, and the ability of genetic stock identification (GSI) of incidentally captured, non-target fishes (Beacham et al. 2021). Thus, application of PBT technology in the monitoring of the actions proposed in this study has the potential to provide substantially more information to existing salmon monitoring programs.

The Department, cooperators on this study, are leading the effort to develop and implement a robust monitoring program for this study. The Department coordinates and conducts most salmon monitoring across the Central Valley, as well as monitoring of salmon harvest in ocean fisheries. To accommodate the needs of monitoring for this study, the Department will adjust existing ocean and inland sampling programs to include the collection of fin tissue samples that will be needed to estimate adult contributions of fry releases. Furthermore, parentage assignments will facilitate the comparison and evaluation of different release strategies. Genetic samples will be collected across a wide range of monitoring programs, including the ocean commercial and sport fisheries, freshwater creel surveys, Central Valley hatcheries, and escapement to natural spawning areas. The Department recognizes the importance of incorporating the PBT data resulting from this monitoring into the Ocean Harvest Model and is working with NMFS to develop and implement the appropriate adjustments to the model. A draft PBT monitoring plan is in development and will be submitted by the Department as a supplement to this biological assessment. The Service is working with the Department to secure funding that will be needed for this program.

Regulatory and Environmental Baseline

Regulatory Framework

The purpose of this biological assessment is to determine if the proposed study actions may jeopardize the continued existence of ESA-listed fish species that fall under the jurisdiction of NMFS. Information presented in this biological assessment has been prepared in accordance with Section 7 of the ESA. Under Section 7(a)(2) of the ESA, a federal agency that authorizes, funds, or carries out activities must not jeopardize the continued existence of any ESA-listed species or adversely modify designated critical habitats (16 U.S. Code [USC] 1536(a). This biological assessment will also evaluate effects of proposed actions on Essential Fish Habitat (EFH) as required under 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600

Action Area

The action area for an ESA section 7 consultation is defined as all areas that may be affected directly or indirectly by the federal action, and not just the immediate project site(s) involved in the action. For the purpose of this biological assessment, the action area extends from locations where SRFCS will be reared, including the Coleman NFH and associated off-station rearing locations (including inundated agricultural fields or wetlands); and extend throughout the emigration corridor, including all areas accessible to anadromous fishes, such as the Sacramento River, tributary streams, and flooded bypasses, canals, and ditches; throughout the Sacramento-San Joaquin Delta and San Francisco Bay, and all areas of the Pacific Ocean inhabited by Central Valley Chinook Salmon.

Species Considered

All ESA-listed anadromous fishes and their critical habitats considered in this biological assessment fall under the regulatory jurisdiction of NMFS, and include:

- Sacramento River winter-run Chinook Salmon *Oncorhynchus tshawytscha* evolutionarily significant unit (ESU);
- Central Valley spring-run Chinook Salmon *Oncorhynchus tshawytscha* ESU;
- Central Valley steelhead *Oncorhynchus mykiss* distinct population segment (DPS);
- Southern DPS of Green Sturgeon *Acipenser medirostris*; and,
- Southern Resident population of killer whale *Orcinus orca*

Status of ESA-Listed Species and Critical Habitat within Project Area

Sacramento River Winter Run Chinook Salmon

Status

Natural- and hatchery-origin winter Chinook Salmon from the Sacramento River are included in the Central Valley ESU for the species and are state and federally listed as endangered. NMFS listed these salmon as threatened under the emergency listing procedures for the ESA (16 U.S.C.R. 1531-1543) on August 4, 1989 (54 FR 32085). A proposed rule to add winter Chinook Salmon to the list of threatened species beyond expiration of the emergency rule was published by the NMFS on March 20, 1990 (55 FR 10260). Winter Chinook Salmon were formally added to the list of federally threatened species by final rule on November 5, 1990 (55 FR 46515), and they were listed as a federally endangered species on January 4, 1994 (59 FR 440). Critical habitat for winter Chinook Salmon has been designated from Keswick Dam (RM 302) to the Golden Gate Bridge (58 FR 33212; June 16, 1993). Winter Chinook Salmon have been listed as endangered under the CESA since September 22, 1989 (California Code of Regulations, Title XIV, Section 670.5). A recovery plan was published for Sacramento River winter Chinook Salmon, SCS and the DPS of California Central Valley Steelhead in July 2014 (NFMS 2014).

Critical Habitat
See Federal Register Notice for detailed description of critical habitat (58 FR 33212; Figure B.2).

Central Valley Spring Run Chinook Salmon

Status
Central Valley spring Chinook Salmon (SCS) are state and federally listed as a threatened species. On March 9, 1998, the NMFS published a proposed rule to list SCS as endangered under the ESA (63 FR 11482). On March 24, 1999, the NMFS extended the final deadline for a listing determination for SCS until September 9, 1999 (63 FR 14329). The NMFS published the final rule to declare SCS a threatened species on September 16, 1999 (64 FR 50393). Critical habitat for SCS was designated on September 2, 2005 (70 FR 52488). Central Valley spring Chinook Salmon have been listed as threatened under CESA since February 5, 1999 (California Code of Regulations, Title 14, Section 670.5). Central Valley spring Chinook Salmon are included in recovery plan published by NMFS in 2014. A 2015 assessment of population status indicated SCS were in a declining risk trend and exist at a moderate risk of extinction. The viability of the SCS ESU. A more recent assessment (NMFS 2023) concluded that the viability of SCS had declined since 2015 and the species faces an increased risk of extinction. Emergency actions have been implemented to collect SCS juveniles to start a captive broodstock program to guard against extinction. Central Valley spring Chinook Salmon are being by the Department for reintroduction to the San Joaquin River. Central Valley Spring Chinook Salmon are not currently propagated by the Service.

Critical Habitat
See Federal Register Notice for detailed description of critical habitat (70 FR 52488; Figure B.1).

Central Valley DPS Steelhead

Status
Central Valley steelhead are federally listed as a threatened species. On August 9, 1996, the NMFS published a proposed rule to list Central Valley steelhead as endangered under the ESA of 1973 (61 FR 41541). On August 18, 1997, NMFS deferred a final listing decision for Central Valley steelhead for six months, citing substantial scientific disagreements concerning the geographical extent of the Central Valley ESU. On March 19, 1998, the NMFS published a final rule (63 FR 13347) to list California's Central Valley steelhead as threatened under the ESA. Critical habitat, which includes Battle Creek, was finalized on September 2, 2005 (70 FR 52488). Central Valley steelhead are included in the recovery plan published by NMFS in 2014. Currently, steelhead are not listed under the CESA, but are categorized by the Department as a "Species of Special Concern" (Moyle et al. 2015). Steelhead is the term given to the anadromous life history form of O. mykiss, whereas freshwater residents are frequently referred to as rainbow trout.

Critical Habitat
See Federal Register Notice for detailed description of critical habitat (70 FR 52488; Figure B.3).

<u>Southern Resident Killer Whale</u>

Status
The DPS of Southern Resident killer whale were designated as "depleted" under the Marine Mammal Protection Act (MMPA; May 29, 2003, 68 FR 31980) in May 2003. Depleted status under the MMPA is defined as any case in which (1) the Secretary, after consultation with the Marine Mammal Commission and the Committee of Scientific Advisors on Marine Mammals established under MMPA title II, determines that a species or population stock is below its optimum sustainable population; (2) a State, to which authority for the conservation and management of a species or population stock is transferred under section 109, determines that such species or stock is below its optimum sustainable population; or (3) a species or population stock is listed as an endangered species or a threatened species under the ESA. The Southern Resident killer whales DPS was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). A Recovery Plan for Southern Resident killer whales (NMFS 2008) was published in January 2008.

Critical Habitat
The Southern Resident killer whales DPS was listed as endangered under the ESA on November 18, 2005 (70 FR 69903; Figure B.4.).

<u>Southern DPS Green Sturgeon</u>

Status
Green Sturgeon was petitioned for listing under the Endangered Species Act in June 2001. A study of the species' status determined that North American green sturgeon is comprised of two Distinct Population Segments (DPS): the northern DPS and the southern DPS. Both groupings were added to the list of Candidate Species. The Northern DPS of green sturgeon consists of populations north of and including the Eel River. The Southern DPS of Green Sturgeon consists of populations originating from coastal watersheds south of the Eel River and the Central Valley of California. In 2003, the NMFS determined that listing was not warranted (68 FR 4433). However, because of remaining uncertainties about the structure of the population and status of the species, NMFS added both the northern and southern DPS to the list of Species of Concern (69 FR 19975). A subsequent re-evaluation of the two DPS, in April, 2005, resulted in NMFS proposal to list the southern DPS of green sturgeon. The northern DPS did not warrant listing due to the presence of two spawning populations and continued spawning in other rivers. The Southern DPS of Green Sturgeon was listed as threatened on April 7, 2006 (71 FR See Federal Register Notice for detailed description of critical habitat (74 FR 52300).17757). Critical habitat was designated for the southern DPS of green sturgeon on October 9, 2009 (74 FR 52300). A final recovery plan for the southern DPS of Green Sturgeon was published by NMFS on August 21, 2018 (NFMS 2018).

Critical Habitat
Critical habitat was designated for the southern DPS of green sturgeon on October 9, 2009 (74 FR 52300; Figure B.5.).

Effects Analysis of Proposed Action on ESA-listed Species and Critical Habitats

This amendment to the 2011 biological assessment modifies the project description that was assessed in the 2014 NMFS biological opinion. The following effects analysis is provided to contribute to the NMFS assessment of whether the proposed activities are likely to jeopardize the continued existence of listed species or to result in the destruction or adverse modification of critical habitats. Efforts to decrease risk of federal actions to listed species is required by take provisions of the ESA. This assessment adds to that from the Service's 2011 biological assessment and considers incremental impacts resulting from the proposed changes to the program description.

Activities associated with this project will likely result in increased effects to ESA-listed species, relative to those described and assessed in the existing biological assessment and biological opinions, respectively. Effects to ESA-listed species will result from the following proposed actions: increased hatchery production of SRFCS, release of hatchery SRFCS at an earlier (e.g., pre-smolt) developmental stage, and releases of hatchery SRFCS at off-site locations. These actions may affect ESA-listed species at all life stages, including juvenile, subadult, and adult. Furthermore, project actions may adversely modify designated critical habitats of ESA-listed salmonid species.

In the Service's 2011 biological assessment of the Coleman NFH, potential impacts to ESA-listed species were considered in the following areas:

- Facility maintenance and construction, including impacts from: grounds maintenance and site disturbances,
- On-site fish production operations, including impacts from: water intakes and consumption, water discharge, broodstock congregation and collection, broodstock selection, mating and genetic implications, and incubation and rearing,
- Juvenile releases, including impacts from disease, predation, masking, nutrient cycling, competition-displacement, harvest, escapement, straying, and decoying (i.e., abundance induced attractions of adults to Battle Creek).

We believe that much of the effects assessment provided in the Service's 2011 biological assessment remains complete and valid with respect to the changes to hatchery operations proposed through this amendment. For example, the effects assessment in the Service's 2011 biological assessment is unchanged with respect to SRFCS smolt releases, broodstock collection activities, processes of hatchery water delivery or discharge, or because of increased effects of disease. We also find that the proposed study will not confer increased risk of predation to ESA-listed species at the juvenile life stage. The modified production targets and release strategies being proposed in this action are, however, likely to increase effects to ESA-listed species, including Central Valley Steelhead, winter-run Chinook Salmon and SCS through competition and displacement at the juvenile life stage. It is also possible for increased effects to SCS to occur at the adult stage through genetic introgression (e.g., hybridization) and redd superimposition. Effects of this action are not likely to affect green sturgeon due to habitat partitioning but may benefit the DPS of Southern Resident killer whale by increasing the abundance of a primary prey source. Implementation of the proposed actions the Yolo Bypass are likely to modify critical habitats of spring Chinook, steelhead, and green sturgeon. We describe and assess the potential for these impacts in the following assessment.

Effects of proposed actions to ESA-listed salmonid species can be categorized in two ways, including; (1) increased potential for competition, predation, and displacement at the juvenile life stages caused by releasing large numbers of hatchery produced fish into the environment, and (2) increased risks to naturally spawning adult salmonid populations that may result if hatchery fish stray into non-natal watersheds and disrupt spawning through hybridization or redd superimposition. Further discussion of these risks to listed-salmonids is below, in addition to assessment of non-salmonid ESA-listed species, and critical habitats.

Predation, Competition, and Displacement at the Juvenile Life Stage

Releasing hatchery SRFCS into the environment may alter ecological interactions via predation, competition, displacement, and disease transmission. These ecological risks of hatchery programs occur when hatchery fish interact with and detrimentally affect wild fish following their release into the natural environment. Substantial research has demonstrated that ecological interactions can have significant effects to the productivity and abundance of wild populations (see review in Kostow 2009). Concerns about ecological risks are increased when the number and proportion of hatchery fish is large relative to the numbers of wild fish, such as the situation with SRFCS and ESA-listed fish populations in California's Central Valley. Additional factors that affect ecological risks include relative sizes of hatchery and natural fishes, health and behavioral differences, extent of overlap in space and time, and habitat quality and system-wide carrying capacity.

Predation

Predation by hatchery SRFCS on ESA-listed fishes in the freshwater environment is unlikely to result from the proposed actions. For a hatchery salmon to predate on another fish the predator must have a substantial size advantage. Researchers have identified that some salmonids are capable of consuming prey items up to a maximum of 33% to 46% of their body length (Cannamela 1992, Pearsons and Fritts 1999). Piscivory of larger sized prey items by juvenile SRFCS is precluded by their small body size and gape limitations. Gape width has been proposed as a major factor controlling the onset of piscivory (Mittlebach and Persson 1998) and a major constraint to the maximum size of prey that can be ingested (Hoyle and Keast 1987, Hoyle and Keast 1988, Mittelbach and Persson 1988). Petrusso (1988) examined the feeding habits of juvenile SRFCS in the size range 33-91mm; a size range that includes the range of SRFCS that will be released in this study. Subyearling SRFCS are not highly piscivorous, but the authors did observe low levels of piscivory upon larval fishes, especially cyprinids and catostomids. No predation on salmonids was observed. Primary prey items of subyearling SRFCS were chironomids, which comprised 60% of their diet.

Sacramento River fall Chinook Salmon are ocean type and migrate during their first year of life (Yoshiyama et al. 1998; 2001). Although it may be physiologically possible for SRFCS to adopt a resident life history strategy, this possibility is precluded because SRFCS spawn on the Valley floor and, as a result, must emigrate and transition to saltwater residence by approximately June when environmental conditions in the lower river and Delta become inhospitable. Fry released as part of this study are expected to be 40-50mm and must grow to perhaps 80-90mm (Woodson et al. 2013) to be capable of ocean entry. Throughout their residence in the lower river and Delta, hatchery SRFCS fry are expected to be similarly sized to ESA-listed SCS, whereas sub-yearling winter-run Chinook Salmon will be larger than hatchery SRFCS. These size relationships will exist from the time hatchery fry are released through to their transition to saltwater. As a result of their similar sizes, hatchery releases of SRFCS fry are incapable of predating upon listed salmon populations in the freshwater environment.

Predation by sub-yearling SRFCS on juvenile steelhead or larval green sturgeon is also unlikely to result from the proposed actions. Green sturgeon larvae disperse from upriver spawning areas from May through August at a size of 20-60mm (Beamesdefer et al. 2007). Within a couple months of hatch, larval metamorphosis of juvenile green sturgeon is complete and juvenile green sturgeon disperse downstream at a size that is not likely to be vulnerable to predation by juvenile SRFCS (Deng et al. 2002). Similarly, yearling steelhead are much larger than SRFCS subyearling when releases of hatchery fry will occur in January and February, thus they are not susceptible to predation. Young-of-year steelhead are being spawned in upriver reaches of the watershed during January and February and, therefore, they occupy a different ecological niche and are not likely targets for predation by subyearling SRFCS.

<u>Competition and Displacement</u>
Assessing ecological risks of competition and displacement to ESA-listed juvenile salmonids resulting from proposed study actions is a daunting task, which is complicated by the complex nature of ecological interactions in the natural environment, highly variable environmental conditions, and a lack of critical information, such as environmental carrying capacity, and survival, movement, and behavior of hatchery fry. The obscured nature of competitive effects add to the difficulty of assessing risks; competition and displacement are difficult to observe or quantify at the landscape scale and measuring effects of competition and displacement resulting from even a very large hatchery release would be exceedingly difficult. Because of these constraints, in the Service's 2011 biological assessment of standard operations at the Coleman NFH we described and assessed ecological effects of the hatchery releases using a qualitative assessment. We use a similar approach to this risk assessment of proposed changes to hatchery operations. To supplement our qualitative assessment of ecological risks resulting from proposed releases of SRFCS fry, we have investigated the use of a modeling tool that attempts to quantify ecological risks resulting from hatchery releases. The modeling tool, called PCD Risk, simulates predation, competition, and disease impacts to naturally produced salmonids resulting from hatchery releases (Pearsons and Busack 2012). Model output estimates the number and proportion of wild fish that die from competitive interactions. Following the qualitative assessment, below, we present the quantitative results ecological impacts resulting from multiple runs of PCD Risk simulations.

Qualitative Assessment of Risks Resulting from Competition and Displacement
Ecological risks to ESA-listed salmonid populations at juvenile life stages resulting from competition and displacement will be increased as a result if implementing the study actions proposed in this assessment. Increased competition and displacement will result from the following aspects of proposed actions: (1) increased hatchery production, (2) releases of smaller-sized hatchery fish, and (3) off-site hatchery releases. An explanation of how these factors result in increased risks of competition and displacement follows:

(1) *Increased hatchery production*

The relative numbers of hatchery and natural fish in the environment is a key factor influencing risks from competition and displacement. Risks are increased with large hatchery releases, especially when hatchery fish outnumber species of management concern. Actions proposed in this study call for the release of three million fed fry, in addition to standard smolt production and ongoing experimental releases. Salmonid species of concern, including winter- and SCS and steelhead, are substantially less abundant than SRFCS, perhaps by an order of magnitude. This disparity in relative abundance increases the risks of density dependent effects. Large concentrations of hatchery fish have also been implicated in attracting predators, which also consume intermingled wild fish (Kostow and Zhou 2006); however, it is also possible that increased numbers of hatchery fish could reduce predation on comingled wild fish by serving as an alternate food source.

(2) *Releases of smaller-sized (presmolt) hatchery fish*

Hatchery SRFCS released through proposed actions will be smaller than winter Chinook Salmon and equally sized to spring Chinook Salmon. The relative sizes of hatchery SRFCS and ESA-listed salmon influences the outcome of competitive interactions. Hatchery fish that are larger than wild fish have a competitive advantage and frequently dominate interactions (Berejikian et al. 1996, Peery and Bjorn 2004). Behavioral differences between these fish, including increased aggression of hatchery fish, contributes further to competitive dominance (Peery and Bjorn 2004). Hatchery fish that are larger than co-occurring natural stocks may push natural fish into marginal rearing habitats, or into premature emigration, resulting in poor growth or survival (Rhodes and Quinn 1999).

Conversely, releases of hatchery fish at smaller sizes pose a different set of risks. Risks of competition and displacement are highest when hatchery fish and wild stocks must occupy a limited environment for longer time periods. Thus, the SRFCS program at the Coleman NFH releases smolts, which emigrate rapidly to the ocean after their release and don't coexist for an extended period prior to entering saltwater. Conversely, planned releases of SRFCS fry will require prolonged rearing in the freshwater environment prior to smolting, increasing the opportunity for competitive interactions. This extended period of population overlap in the freshwater rearing environment results in increased interactions and increased potential for density-dependent effects to naturally produced salmonids (Buhle et al. 2008, Kostow 2009)

(3) *Off-site releases*

Competitive interactions between hatchery releases and natural populations are of concern only when these groups overlap in space and time. Hatchery fish occupying habitats that fulfill important life history requirements of natural populations present the highest risk. Location of release is a key consideration to reduce risks, as a very high concentration of hatchery fish prior to their dispersal can quickly overwhelm the capacity of local habitats. Additionally, high concentrations of hatchery fish near release sites serve to attract predators, which consume both hatchery and natural fish in an intermingled congregation (Collis et al. 1995, Nickelson 2003). These risks are magnified when critical habitats are degraded or limited in availability. To reduce these risks, hatchery fish should be released in areas that promote dispersal and segregation from important habitats of natural salmonid stocks of concern (Kostow 2009).

Based on the actions called for in the study plan and the factors listed above, it is concluded through this qualitative ecological risk assessment that the proposed study actions will not likely lead to increases of direct predation by hatchery SRFCS. Study actions are likely to confer increased competition and displacement to ESA-listed salmonids, relative to the risks described for the Coleman SRFCS smolt program, which was assessed in the 2011 biological assessment.

Quantitative Assessment of Risks Resulting from Competition and Displacement
In addition to the qualitative effects assessment, we ran multiple simulations of the proposed hatchery releases using a modeling tool that produces quantitative estimates of take of natural origin fish resulting from ecological interactions of predation, competition, displacement, and disease. This modeling tool, called PCD Risk, accepts user-generated inputs of up to 45 variables, such as species, number, and size of hatchery and wild fish, residence time, habitat complexity and segregation, and daily encounter rates and simulates individual interactions up to a user-specified daily limit. Running comparative simulations is a helpful strategy to assess the sensitivity of outcomes to different metrics and to evaluate alternative hatchery practices that can be used to reduce risks.

PCD Risk Model Simulations
<u>Spring-run Chinook Salmon</u>
Two PCD Risk Model scenarios were used in this assessment, and each assumed a total of three million hatchery SRFCS released and an estimated three hundred thousand natural-origin SCS juveniles. For the first scenario, the hatchery groups consisted of one million fed fry for each release, including Battle Creek (day 1), downstream Sacramento River (day 7), and Surrogate Floodplain rearing near the lower Sacramento River (day 60; after extended rearing on agriculture fields). Natural origin SCS consisted of estimated three hundred thousand juvenile SCS emigrating from the upper Sacramento River (above Red Bluff, CA) with a mean fork length of 51mm on January 8th. Total population count and fork lengths of SCS emigrating from the upper Sacramento River were estimated from Red Bluff Diversion Dam rotary-screw trap data (5-year mean, 2018–2022; pers. comm. Scott Voss, U.S. Fish and Wildlife Service). The intent of this scenario is to model risks associated with releasing hatchery-origin groups to integrate with the natural-origin fish already present in the Sacramento River. In the second scenario, the three hatchery groups of SRFCS fry from scenario 1 were considered as one group, having already been released into the river, and now having three hundred thousand juvenile SCS emigrate into the Sacramento River (produced from spawning occurring in tributaries to the middle and lower Sacramento River). Due to limited data on SCS emigrating from tributaries directly into the mainstem Sacramento River, count and size data of SCS produced in tributaries was assumed to be of similar size to SRFCS reared on Surrogate Floodplains and of similar count to SCS emigrating from the Upper Sacramento River.

The values used for each model parameter, and their source, are described in Appendix C. Under scenario 1, no direct mortality from predation or competition was predicted for natural-origin SCS after release of hatchery-origin SRFCS. However, delayed mortality did occur and was associated with reduced feeding resulting from interactions with hatchery-origin SRFCS (such as nipping or chasing). Mean mortality of SCS under scenario 1 was 2,086 fish, or 0.70% of the estimated 300,000 initial abundance (estimated from rotary-screw trap 5-year mean, 2017–2021). Similarly, in scenario 2 the only mortality of natural-origin fish was predicted due to delayed negative effects of interactions with hatchery-origin fish, and amounted to a mean of 1,060 deaths, or 0.35% of the initial 300,000 natural-origin population (unknown total tributary contribution. Assumed the same as in-river estimate).

Winter-run Chinook Salmon

The effect of hatchery-origin SRFCS released on natural-origin winter-run Chinook Salmon was assessed with one PCD Risk Model scenario using the same three hatchery SRFCS groups as described above (one million each from releases into Battle Creek, the Sacramento River, and Surrogate Floodplain habitats). The natural-origin winter-run Chinook Salmon juvenile total population size was estimated at 1.5 million, with a mean fork length of 76mm on January 8th, from Red Bluff Diversion Dam rotary-screw trap data (5-year mean, 2018–2022; pers. comm. Scott Voss, U.S. Fish and Wildlife Service). The intent of this scenario was to model risks associated with releasing the hatchery-origin groups on the natural-origin fish already present in the Sacramento River.

The values used for each model parameter, and their source, are described in Appendix C. Under the winter-run Chinook Salmon simulation, no direct mortality from predation or competition was predicted to occur for to natural-origin fish after release of hatchery-origin SRFCS. However, delayed mortality was predicted and was associated with reduced feeding resulting from negative interactions with hatchery-origin SRFCS (such as nipping or chasing). The simulation mean mortality of winter-run Chinook Salmon was 9,507 fish, or 0.60% of the estimated 1,500,000 initial abundance.

Summary of Effects at Juvenile Life Stage

Both qualitative and quantitative assessments of ecological effects suggest proposed study actions are likely to affect ESA-listed winter-run Chinook Salmon and SCS through competitive interactions (competition and displacement) at juvenile life stages. Modeled effects predict greater effects to SCS than those to winter-run Chinook Salmon as a result of their smaller body size, which is more similar to that of SRFCS. Study actions proposed in this biological assessment are unlikely to increase predation on ESA-listed anadromous fishes because of gape limitations of hatchery SRFCS. Qualitative assessment of inter-specific (e.g., fish, birds, mammals) predation indicates predation of ESA-listed anadromous fishes may be either increased by the proposed actions; increased inter-specific predation may occur if predators are attracted by large congregations of hatchery fish, whereas decreased inter-specific predation may occur if hatchery SRFCS provide an abundant alternative prey source.

Genetic and Ecological Effects at the Adult Life Stage

The potential for genetic and ecological interactions between SRFCS and wild populations of SCS increase if proposed actions increase overlap of spawning distributions. The primary genetic risk at the adult life stage is hybridization. If hybridization between SRFCS and important natural spawning populations of SCS occurs it would reduce between-population genetic diversity, potentially causing a reduction of productivity and greater vulnerability to environmental change (Waples 1991). The primary ecological risk at the adult life stage is redd superimposition. Superimposition of SCS redds by similar-timed or later SRFCS spawners could disturb previously deposited eggs from the gravel, reducing their survival. Redd superimposition has been identified as an important source of mortality for naturally produced salmon in some areas (Bakkala 1970).

The increased potential for impacts to SCS that may result from releasing SRFCS hatchery fish outside of their natal stream result mostly from an increased proclivity for straying. Substantial research has shown that transporting juvenile salmon from their rearing location and releasing them at distant locations increases straying when those fish return to spawn as adults (reviewed in Lister et al. 1981). Transporting juvenile salmonids is thought to disrupt homing abilities of adults by eliminating the environmental cues normally obtained by juvenile fish during their downstream migration. Transported salmon are thereby deprived of the imprinting sequences necessary for them to locate their natal rearing locations when they return to spawn as adults (reviewed in Dittman and Quinn 1996; and Keefer and Caudill 2014). A previous investigation conducted at the Coleman NFH confirms that straying tendencies of SRFCS increase when juveniles are transported to off-site release locations (Niemela 1996). During the five-year study conducted during the late-1980's through early 1990's, it was estimated that a minimum of 75% of fall Chinook Salmon transported and released at Benicia, downstream of the Delta, that returned as adults strayed to locations other than Battle Creek. More recently, straying of Coleman NFH smolts released at San Pablo Bay has approached 100% (Service, unpublished data).

Fall Chinook Salmon originating at the Coleman NFH and returning to locations other than Coleman NFH-Battle Creek would not pose a genetic risk to ESA-listed winter-run Chinook Salmon because winter-run spawn at a different time (summer months); however, adult SRFCS straying would pose a genetic risk to ESA-listed SCS if either hybridization or redd superimposition occurs as SCS and SRFCS spawn timing can overlap temporally. To assess these risks to SCS resulting from the planned transportation and release of Coleman NFH SRFCS outside of the Battle Creek, we examined coded-wire tag recovery data for previous off-site releases of fall Chinook Salmon from the Coleman NFH. Releasing SRFCS at an off-site location is a strategy that has been utilized by Coleman NFH for a variety of reasons including experimental releases for various studies or as an emergency action to mitigate for severely degraded in-river conditions associated with drought.

Since 2000, approximately 27.4 million fall Chinook Salmon (10.7% of all SRFCS released) were transported and released outside of Battle Creek. Most of these releases (73.8% of all off-site releases) occurring since 2000 were due to deterioration of environmental conditions in the emigration corridor. Experimental releases of fish at different locations, sizes, or release methods account for approximately 3% of all Coleman NFH SRFCS since 2000 (Table 1).

To assess the risks of hybridization and redd superimposition, we examined the CWT recovery locations of off-site released SRFCS relative to recognized spawning habitats of ESA-listed SCS. We assumed that strays resulting from Bay releases were not imprinted to specific areas and were drawn to spawning areas by factors other than imprinting, and that SRFCS fry released through this study would behave similarly. Furthermore, we assumed that overlap in space and time of the spawning of SRFCS and SCS was indicative of a probable impact of hybridization. Overlap in spawning areas but later timing of fall Chinook Salmon was assumed to indicate a possible impact of redd superimposition. We used October 1 to demark the end of SCS spawning and the beginning of fall Chinook Salmon spawning. Based on this date, and assuming a period of 14-days from spawning to senescence, we assumed that coded-wire tagged carcasses of SRFCS observed on or before October 15 may have potentially hybridized populations of SCS present in the same area. We examined the incidence of coded-wire tag recovery for these groups within natural spawning areas used by SCS, including Mill Creek, Deer Creek, Butte Creek, Clear Creek, the Upper Sacramento River, Feather River, and Yuba River.

Table 1. Summary of numbers of fall Chinook Salmon released from Coleman National Fish Hatchery for brood years 2000-2020. Fish released at any location other than Battle Creek are considered “off-site”. Release types are categorized as “standard” for typical releases associated with fall Chinook Salmon from Coleman National Fish Hatchery, “Experiment” for releases that sought to evaluate the contribution of an alternate release strategy on an experimental basis, or “Emergency” for releases that were made in response to detrimental environmental conditions. Also provided is the yearly percent of total release occurring at off-site locations (%).

Brood	Total	Battle Creek		Off-site		
Year	Release	Standard	Emergency	Experiment	Emergency	%
2000	12,664,580	12,463,905	0	200,675	0	1.6
2001	11,318,028	11,117,019	0	201,009	0	1.8
2002	14,018,806	13,817,974	0	200,832	0	1.4
2003	13,101,565	12,900,936	0	200,629	0	1.5
2004	11,854,153	11,706,886	0	147,267	0	1.2
2005	13,355,345	13,157,164	0	198,181	0	1.5
2006	12,316,193	12,113,601	0	202,592	0	1.6
2007	12,699,100	11,230,794	0	1,468,306	0	11.6
2008	14,021,126	12,529,458	0	1,491,668	0	10.6
2009	11,569,461	10,210,449	0	1,359,012	0	11.7
2010	12,709,391	11,369,732	0	1,339,659	0	10.5
2011	12,508,161	12,508,161	0	0	0	0.0
2012	11,873,864	11,873,864	0	0	0	0.0
2013	11,780,007	4,506,160	0	0	7,273,847	61.7
2014	11,846,951	0	0	0	11,846,951	100.0
2015	12,160,858	12,160,858	0	0	0	0.0
2016	12,184,997	12,184,997	0	0	0	0.0
2017	5,498,252	5,498,252	0	0	0	0.0
2018	12,835,143	7,705,716	4,953,456	175,971	0	1.4
2019	12,392,944	5,662,900	6,730,044	0	0	0.0
2020	12,931,177	5,571,070	6,284,776	186,450	888,881	8.3

Mill and Deer Creeks

The Department has conducted annual snorkel surveys of SCS spawning areas of Mill and Deer Creeks since the late 1990's to estimate the abundance of spawners, with additional video weir monitoring stations in more recent years (Table 2; Killam 2022). Salmon carcasses observed during the survey are examined for an adipose fin clip, and fish with a missing adipose fin are examined for the presence of a coded-wire tag. Due to the difficulty of locating salmon carcasses, only a small proportion of the salmon carcasses are typically examined for a coded wire tag. Based on many years of observations it is believed that fall Chinook Salmon spawning occurs downstream of SCS spawning areas in Mill and Deer Creeks. Fall Chinook Salmon are rarely observed above 1,200-foot elevation whereas SCS spawning generally occurs above this elevation (pers. comm. Colleen Harvey-Arrison, California Department of Fish and Wildlife-retired, and Matt Johnson, California Department of Fish and Wildlife).

Few off-site releases of Coleman NFH SRFCS have been recovered in Mill and Deer Creeks, even after large portions (75-100%) of annual Coleman NFH SRFCS production was trucked to the West Delta and San Pablo Bay during the 2014-2015 drought years. None of the Coleman NFH SRFCS recoveries have been found before October 15, supporting observations that there may be some temporal separation of SRFCS and SCS spawning in these creeks. Deer Creek typically has lower escapement of SRFCS than SCS in most years; additionally, water management within the drainage tends to limit the ability of SRFCS to migrate into upstream SCS areas during the fall period, outside of large rain events (pers. comm. Matt Johnson, California Department of Fish and Wildlife).

Table 2. Total Escapement of Spring and Fall Chinook Salmon observed in Deer and Mill Creeks from 2002-2021. Expanded recoveries of Coleman National Fish Hatchery fall Chinook Salmon are shown, as well as the number of these coded wire tags that were recovered before October 15 annually, and the number of CWTs recovered from off-site releases.

Deer Creek	Return Year																			
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total SCS Escapement	2,195	2,759	804	2,239	2,432	644	140	213	262	271	734	708	830	268	331	219	159	585	90	619
Total FCS Escapement			300	963	1,905	563	194	58	166	662	873	1,026	849	612	253	106	124	584	60	210
Total CNFH FCS Recovered	**-**	**7**	**27**	**-**	**-**	**-**	**-**	**-**	**-**	**4**	**-**	**-**	**142**	**96**	**-**	**-**	**-**	**-**	**-**	**-**
# Released Off-site	-	-	-	-	-	-	-	-	-	-	-	-	142	96	-	-	-	-	-	-
# Before Oct 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Mill Creek	Return Year																			
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total SCS Escapement	1,594	1,426	998	1,150	1,002	920	381	237	482	366	768	644	679	127	175	258	152	180	80	718
Total FCS Escapement	2,611	2,426	1,192	2,426	1,403	851	218	102	144	1,231	890	2,197	2,488	1,033	602	342	611	2,523	382	589
Total CNFH FCS	**19**	**358**	**94**	**30**	**2**	**-**	**-**	**-**	**-**	**104**	**12**	**32**	**590**	**133**	**8**	**-**	**12**	**1,017**	**-**	**4**
# Released Off-site	-	3	-	2	2	-	-	-	-	12	4	8	107	67	-	-	-	-	-	-
# Before Oct 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Butte Creek

The Department monitors SCS in Butte Creek in a variety of methods including a Vaki Riverwatcher (Vaki Aquaculture Systems, Iceland), snorkel survey, and a carcass mark-recapture that began in 2001 (Nichols 2022). All fish with a missing adipose fin are examined for a coded-wire tag. While SRFCS spawning in Butte Creek previously utilized habitat downstream of SCS, this spatial separation has lessened in recent years, and SRFCS have been observed migrating upstream of the barrier in Parrot-Phelan Dam (pers. comm. Tracy McReynolds, California Dept. of Fish and Wildlife).

Few Coleman NFH-origin SRFCS have been recovered in Butte Creek, even after large portions (75-100%) of annual production was trucked to the West Delta and San Pablo Bay during the 2014-2015 drought years (Table 3). In 2011 only, Coleman NFH SRFCS carcasses were found before October 15, indicative of a possible risk of hybridization with SCS, but during most years there was likely temporal separation of SRFCS and SCS spawning in Butte Creek, reducing risk of hybridization. However, monitoring of SRFCS spawning in Butte Creek in recent years has been limited (pers. comm. Colin Purdy, California Dept. of Fish and Wildlife).

Table 3. Total Escapement of Spring and Fall Chinook Salmon observed in Butte Creek from 2002-2021. Expanded recoveries of Coleman National Fish Hatchery fall Chinook Salmon are shown, as well as the number of these coded wire tags that were recovered before October 15 annually, and the number of CWTs recovered from off-site releases.

Butte Creek	**Return Year**																			
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total SCS Escapement	16,409	17,404	10,558	17,592	6,537	6,871	11,046	2,687	1,991	4,871	16,317	16,782	5,083	569	5,731	515	2,404	15,047	1,333	21,580
Total FCS Escapement	3,665	3,492	2,516	4,255	1,920	1,225	275	306	370	416	813	2,200	1,412	82	626	105		1,481		
Total CNFH FCS	**-**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**19**	**-**	**17**	**16**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
# Released Off-site	-	-	2	-	-	-	-	-	-	19	-	17	16	-	-	-	-	-	-	-
# Before Oct 15	-	-	-	-	-	-	-	-	-	19	-	-	-	-	-	-	-	-	-	-

<u>Clear Creek</u>

Migrations of salmon in Clear Creek have been blocked since the construction of Whiskeytown Dam in the early 1960's. Since 2003, the U.S. Fish and Wildlife Service have installed a temporary picket weir in Clear Creek to spatially separate spawning SRFCS and SCS. Video monitoring, and snorkel, kayak, and redd surveys are conducted to estimate the abundance of SRFCS and SCS (Table 4). Salmon carcasses observed during the survey are examined for an adipose fin clip, and fish with a missing adipose fin are examined for the presence of a coded-wire tag. Additionally, salmon carcasses that wash up onto the temporary picket weir are assessed for the presence of a coded-wire tag.

A majority of Coleman NFH SRFCS that are recovered in Clear Creek are strays from fish released into Battle Creek. While many of the carcasses are also recovered prior to October 15, a temporary barrier weir is installed to prevent hybridization and redd superimposition between spring and fall Chinook Salmon (Schaefer et al. 2023).

Table 4. Total Escapement of Spring and Fall Chinook Salmon observed in Clear Creek from 2002-2021. Expanded recoveries of Coleman National Fish Hatchery fall Chinook Salmon are shown, as well as the number of these coded wire tags that were recovered before October 15 annually, and the number of CWTs recovered from off-site releases.

Clear Creek	**Return Year**																			
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total SCS Escapement	66	25	98	69	77	194	200	120	21	8	68	659	95	45	29	25	49	62	172	2,252
Total FCS Escapement	16,071	9,475	6,365	14,824	8,422	4,157	7,677	3,228	7,192	4,841	7,631	13,337	15,794	8,809	2,481	2,353	8,547	5,712	6,631	19,867
Total CNFH FCS	**20**	**79**	**219**	**70**	**-**	**16**	**-**	**70**	**159**	**120**	**1,089**	**2,864**	**3,655**	**1,034**	**311**	**-**	**1,435**	**831**	**2,362**	**6,410**
# Released Off-site	-	5	15	21	-	8	-	5	63	4	346	258	195	368	234	-	-	-	-	157
# Before Oct 15	-	-	3	3	-	10	-	20	38	-	272	438	718	-	-	-	260	81	2,362	1,096

<u>Feather River</u>

Fall and Spring Chinook Salmon in the Feather River are widely recognized as having a history of hybridization (Yoshiyama et al. 2001). Annual surveys of spawner escapement in the Feather

River do not differentiate between fall and spring Chinook Salmon when reporting season totals, instead include all SCS within SRFCS spawner estimates (Table 5). The lack of spatial or temporal separation between the two stocks makes it probable that these impacts occur at some level on an annual basis. Spatial segregation is not maintained between natural spawning fall and spring Chinook Salmon in the Feather River, and hybridization likely occurs at some unknown level, and Coleman NFH SRFCS from both on-site and off-site releases are recovered in the Feather River in most years. Recoveries occur before October 15 in several years, indicate potential for hybridization in this intermingled population.

Table 5. Total Escapement of Spring and Fall Chinook Salmon observed in Feather River from 2002-2021. Expanded recoveries of Coleman National Fish Hatchery fall Chinook Salmon are shown, as well as the number of these coded wire tags that were recovered before October 15 annually, and the number of CWTs recovered from off-site releases. Spring and Fall Chinook escapement estimates are not separated and shown in the fall Chinook Salmon escapement numbers.

	Return Year																			
Feather River	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total SCS Escapement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total FCS Escapement	105,163	89,946	54,171	49,160	76,414	21,909	5,939	4,847	44,914	47,289	63,649	151,209	61,200	20,566	38,775	10,534	45,826	51,967	42,724	9,652
Total CNFH FCS	**-**	**-**	**44**	**26**	**18**	**14**	**13**	**-**	**360**	**1,561**	**2,487**	**3,640**	**792**	**477**	**4,535**	**533**	**-**	**245**	**-**	**-**
# Released Off-site	-	-	44	26	18	14	13	-	360	1,561	2,451	3,577	644	453	4,535	533	-	-	-	-
# Before Oct 15	-	-	17	-	-	-	-	-	-	38	108	692	248	-	202	-	-	-	-	-

Yuba River

Similar to the Feather River, spring and fall Chinook Salmon in the Yuba River have been hybridized (Yoshiyama et al. 2001). Annual surveys of spawner escapement in the Yuba River do not differentiate between fall and spring Chinook Salmon when reporting season totals, instead including all SCS within SRFCS spawner estimates (Table 6). The lack of spatial or temporal separation between the two stocks makes it probable that these impacts occur at some level on an annual basis. Spatial segregation is not maintained between natural spawning fall and spring Chinook Salmon in the Yuba River, and hybridization likely occurs at some unknown level, and Coleman NFH SRFCS from both on-site and off-site releases are recovered in the Yuba River in most years. Recoveries occur before October 15 in several years, indicating a potential for hybridization in this intermingled population.

Table 6. Total Escapement of Spring and Fall Chinook Salmon observed in Yuba River from 2002-2021. Expanded recoveries of Coleman National Fish Hatchery fall Chinook Salmon are shown, as well as the number of these coded wire tags that were recovered before October 15 annually, and the number of CWTs recovered from off-site releases. Spring and Fall Chinook escapement estimates are not separated and shown in the fall Chinook Salmon escapement numbers.

	Return Year																			
Yuba River	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total SCS Escapement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total FCS Escapement	24,051	28,316	15,269	17,630	8,121	2,604	3,508	4,635	14,375	8,928	7,668	14,880	11,615	6,507	4,057	1,634	3,455	3,446	4,194	3,719
Total CNFH FCS	**-**	**17**	**-**	**34**	**2**	**-**	**6**	**6**	**434**	**145**	**680**	**614**	**266**	**1,111**	**817**	**993**	**-**	**-**	**-**	**-**
# Released Off-site	-	17	-	34	2	-	6	6	434	145	680	587	266	1,111	817	993	-	-	-	-
# Before Oct 15	-	-	-	-	-	-	-	-	17	24	-	104	-	-	21	-	-	-	-	-

Upper Sacramento River

Data are not available to conclusively indicate the level of hybridization and redd superimposition to SCS resulting from SRFCS spawning naturally in the Upper Sacramento

River. Carcass surveys have not been successful at identifying spatial or temporal separation between the two stocks and it is probable that these impacts occur at some level on an annual basis (Killam 2022).

Coleman NFH SRFCS from both onsite and offsite releases are frequently recovered on the carcass survey, representing 4 – 31% of all SRFCS spawning in the Upper Sacramento River since 2010, but most are typically recovered after October 15, indicating higher risk of redd superimposition that hybridization (Table 7).

Table 7. Total Escapement of Spring and Fall Chinook Salmon observed in the Upper Sacramento River from 2002-2021. Expanded recoveries of Coleman National Fish Hatchery fall Chinook Salmon are shown, as well as the number of these coded wire tags that were recovered before October 15 annually, and the number of CWTs recovered from off-site releases. Spring and Fall Chinook escapement estimates are not separated and shown in the fall Chinook Salmon escapement numbers.

Upper Sacramento River	Return Year																			
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total SCS Escapement	195	0	370	0	0	248	0	0	0	0	0	114	8	414	21	4	0	30	16	190
Total FCS Escapement	45,552	66,485	34,050	44,950	46,568	14,097	23,134	5,311	13,824	10,299	22,435	32,515	29,885	21,766	4,263	1,822	8,982	23,482	12,952	14,913
Total CNFH FCS	**7**	**610**	**2,291**	**226**	**-**	**74**	**-**	**85**	**879**	**1,530**	**6,911**	**4,365**	**5,710**	**2,834**	**1,042**	**256**	**1,812**	**900**	**3,129**	**3,814**
# Released Off-site	-	38	105	60	-	74	-	7	272	171	1,225	978	1,068	453	361	128	-	-	-	198
# Before Oct 15	-	122	207	7	-	-	-	26	59	49	360	163	359	193	40	-	85	50	3,129	1,243

<u>Summary of Adult Impacts</u>

Coded-wire tag data of SRFCS released from Coleman NFH at off-site locations was used to assess the risks of spatial and temporal overlap of SRFCS and SCS. Spatial and temporal overlap of spawning distributions was interpreted as conferring a risk of hybridization and redd superimposition resulting from study actions. In the recent 20-year period, SRFCS from both on-site and off-site release groups from Coleman NFH were observed in the SCS 'strongholds' of Mill Creek, Deer Creek, and Butte Creek. Whereas Coleman-origin SRFCS from on-site releases were more likely to be observed in Mill Creek, data suggests that Deer Creek showed an increased proclivity to be affected by off-site releases from the Coleman NFH. In each of these watersheds, opportunities for hybridization and redd superimposition were somewhat limited by selection of different spawning areas, prevailing environmental conditions, flow management, or intentional segregation of spawning populations. However, the perspective of local biologists is that existing management actions do not provide absolute protection against hybridization and redd superimposition, and these risks would be increased if an October rainfall event coincides with adult migrations or if the numbers of SRFCS entering those watersheds is substantially increased. In Clear and Battle Creeks, genetic and ecological risks are reduced by management actions that limit SRFCS to downstream spawning habitats, however, these risks could also increase if passage barriers fail to obstruct passage of SRFCS.

Non-salmonid ESA-listed Species

<u>Southern Distinct Population Segment of Green Sturgeon</u>

Impacts to juvenile green sturgeon are unlikely since they occupy a different ecological niche than SRFCS and do not directly competing for the same resources. Substantive differences of life history and habitats between green sturgeon and salmonids propagated at the Coleman NFH Complex make interactions between these species unlikely to occur.

Southern Resident Killer Whale

The proposed fish propagation activities at the Coleman NFH Complex are not expected to result in direct or incidental take of the DPS of Southern Resident killer whale, nor are they expected to destroy or alter the species' critical habitat. Conversely, implementation of the proposed project would be expected to benefit killer whale if it results in increased abundance of salmonids, a primary food resource for Southern Resident killer whale. Any additional salmon available in the ocean for prey by killer whale populations would have potential benefits for the population. Recent efforts have been undertaken in Oregon and Washington to increase hatchery salmon production with a goal to increase prey availability for Southern Resident killer whale by 4-5 percent in subsequent years (NMFS 2021).

Cumulative Effects

The study actions described and assessed in this biological assessment pertain specifically to the operational changes being proposed for SRFCS produced at the Coleman NFH. It is noted, however, that the proposed study is a cooperative effort across hatcheries operated by both the Service and the State. Thus, increases of fry production at the Coleman NFH are to be accompanied by increased fry production at the Department's Feather River Fish Hatchery and Nimbus Fish Hatchery. For the 2023 spawning season, production increases at these State-operated facilities will total 3 million SRFCS. All fry released from the Feather River Fish Hatchery and Nimbus Fish Hatchery will be liberated into the Feather and American Rivers, respectively, downstream of each hatchery facility. Thus, proposed releases of fed SRFCS fry associated with this study, including increased production at all three facilities, will total 6 million. We did not assess the effects of fry releases from the Feather River Fish Hatchery and Nimbus Fish Hatchery, nor did we assess cumulative effects of all fry releases planned through this combined study effort. However, we present the following information about inter-annual variation of natural production of SRFCS to add some context around a common perception about the perceived large scale of actions being proposed in this study.

High levels of inter-annual variability are observed within natural production of SRFCS in Central Valley. The number of naturally produced SRFCS emigrating from the Upper Sacramento River has varied more than 8-fold since 2016 (Voss 2023). For example, in 2017, an estimated 18.6 million SRFCS emigrated past the Red Bluff Diversion Dam (RBDD), whereas only one year later the estimated number was only 2.2 million. These large differences in natural production of SRFCS demonstrate substantial annual variation in reproductive output. The total increases of fed fry production from all hatcheries associated with this proposed study fall within the range of annual variability of naturally produced SRFCS fry observed emigrating from the Upper Sacramento River. If competitive interactions with hatchery SRFCS fry are a primary factor limiting growth and survival of ESA-listed species of anadromous fishes, then similar levels of competition are also likely limiting during years of high natural production.

Critical Habitats and Essential Fish Habitat

Critical habitats of spring-run Chinook Salmon, Central Valley Steelhead, and Southern Distinct Population Segment of North American Green Sturgeon will be affected by proposed study actions. Extended rearing of SRFCS fry will occur in the Yolo Bypass; this area is used for rearing of these stocks and is part of their freshwater emigration corridor.

Under the Magnuson-Stevens Fishery Conservation and Management Act, EFH is considered "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

Effects to EFH resulting from implementation of this proposal are likely similar to those previously assessed by NMFS in a biological opinion for the Ricelands Juvenile Salmonid Rearing Technical Guidelines and Management Activities Research Project conducted by the California Rice Commission, in collaboration with the Natural Resources Conservation Service and may include the following impacts summarized by NMFS (2022b).

<u>Migration Delays, Stranding and Entrainment</u>

Juvenile Fishes

There is very little known about rearing, migratory behavior, and general emigration patterns of juvenile green sturgeon within the Lower Sacramento River region and may have potential to become entrained into the Yolo Bypass and onto study fields with high flows during a natural overtopping event, in addition out-migrating juvenile spring- and winter-run Chinook Salmon. Studies on managed floodplains within the Yolo Bypass have monitored the potential for fish to become stranded and have documented some juvenile fish stranding, including relatively small numbers of salmonids, occurring during the descending flows, and mostly in isolated earthen ponds or near engineered water control structures in the bypass (Sommer et al. 2005). Any juvenile fishes entrained in the study may have potential to experience elevated water temperatures, low dissolved oxygen, predation risk, maximum impacts for competition and displacement described in PCD Risk Assessment (Appendix C) and stranding during receding water.

Adult Fishes

During high water events when flows from the Sacramento overtop weirs and flood the Yolo Bypass, there is potential for entrainment of migrating adult fish within the study area, including spring- and winter-run Chinook Salmon, Central Valley steelhead and green sturgeon, resulting in migratory delays or stranding. Shallow water depths associated with surrogate floodplain rearing may make adult fish vulnerable to some predators and may expose fish to any sub-optimal rearing conditions described below.

<u>Water Quality and Environmental Impacts</u>

Anthropogenic actions within the study area may could numerous negative impacts to water quality and environment, including increased sedimentation, high water temperatures, low dissolved oxygen (which would negate benefits from increased macroinvertebrate production), and noise associated with fish release, large machinery necessary to maintain levels, remove large debris or otherwise manage the surrogate floodplain habitat.

Potential Benefits

This project may result in some short term and small-scale benefits to rearing habitats and food resources. Previous studies in Knaggs Ranch have shown increased plankton production after inundation (Katz et al. 2017, Sommer et al. 2020). This increase may lead to increase in macroinvertebrate production, and potential discharge of food-enriched effluent water flowing into downstream areas of the Yolo Bypass, habitat that may be used by emigrating and rearing listed salmonids and green sturgeon.

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Appendix A. Changes to Standard Operations in the Coleman NFH SRFCS Program

Implementation of the proposed study will bring about substantial changes to the existing SRFCS program at Coleman NFH, including a new program goal, an increased annual production target, and modification of rearing and release strategies. Appendix A provides an overview of the changes to the Coleman NFH SRFCS program that will result from implementation of the proposed actions. This information is provided to contrast specific changes to standard hatchery protocols that will result from implementation of the proposed study. Aspects of program operations that are not addressed (e.g., hatchery facilities) in Appendix A or assessed in this biological assessment will remain unchanged from the those described in the 2011 biological assessment and the Coleman SRFCS Hatchery and Genetic Management Plan (HGMP). A more complete description of standard operations in the Coleman SRFCS propagation program is provided in the 2011 biological assessment (Service 2011) with amendments and the HGMP (Service 2014).

Type of Program

Existing - The SRFCS propagation program at Coleman NFH is an *integrated-harvest* type program. The level of integration in hatchery spawning is not actively managed, because only 25% of Coleman-origin SRFCS receive a fin clip and coded wire tag as juveniles, so unmarked hatchery and natural origin SRFCS adults cannot be completely differentiated during spawning operations.

Proposed – The proposed study will bring about a new goal for the SRFCS propagation program at Coleman NFH. The SRFCS program will be operated as an *integrated-harvest and supplementation program*. The smolt production program will remain largely unchanged, with on-site releases intended to promote the availability of hatchery brood during future years. In addition, hatchery produced fry will be released at various locations of the Sacramento River watershed with the intent that they return and spawn naturally in underutilized habitats throughout lower elevations of the Sacramento River system. The level of integration in hatchery spawning will continue to be passively managed, because unmarked hatchery and natural origin SRFCS adults cannot be completely differentiated during spawning operations.

Purpose (Goal) of Program

Existing - The primary goal for the SRFCS propagation program at the Coleman NFH is to mitigate for losses of spawning and rearing habitats resulting from the construction of Shasta and Keswick dams, key features of the Central Valley Project (CVP). The SRFCS program at Coleman NFH targets the production of 12 million SRFCS smolts annually. Coleman NFH SRFCS contribute to harvest in the Sacramento River sport fishery and the ocean sport and commercial fisheries and benefit the region’s social, cultural, and economic well-being. The Service’s overall goal of total contribution (i.e., harvest plus escapement) of adult SRFCS is 1.0% of the number of juveniles released, equivalent to an average annual yield of approximately 120,000 SRFCS contributing to harvest and spawner escapement.

Natural spawning of Coleman-origin SRFCS is promoted in Battle Creek downstream of the hatchery but not in other areas of the Sacramento River watershed. The number of natural spawning SRFCS in lower Battle Creek is managed to a maximum of 20,000 spawners through the broodstock collection process, contingent upon the availability of sufficient spawners. This is the number of natural spawners agreed upon by the fishery management agencies to promote maximum spawning success and production in Battle Creek. In contrast to the management strategy for lower Battle Creek, the Coleman SRFCS program is operated to discourage natural spawning in other areas of the Central Valley; this objective is intended to reduce the potential for reduced fitness of natural spawning SRFCS through domestication. To accomplish this objective, Coleman SRFCS are released onsite to promote a strong imprint to Battle Creek. Despite efforts to encourage a strong imprint to Battle Creek, a relatively small proportion of Coleman SRFCS adults stray and spawn naturally in other areas of the Central Valley, particularly the upper Sacramento River.

Proposed – With implementation of the proposed study, the primary goal for the SRFCS propagation program at the Coleman NFH will continue to be *mitigation* for losses of salmonid spawning and rearing habitats resulting from the construction and operation of Shasta and Keswick dams. On-site releases of SRFCS smolts will promote a high level of spawning fidelity to Battle Creek, thereby encouraging a sufficient return of adults to satisfy the hatchery's future broodstock needs. Additionally, the hatchery's existing goal of supplementing natural spawning in Battle Creek will be expanded, with an intent to supplement natural spawning in lower elevation spawning habitats throughout the Sacramento River system. Off-site releases of SRFCS fry will encourage imprinting to natural spawning habitats throughout the Sacramento River that are considered by some to be underutilized. Releases of SRFCS fry will increase the diversity of juvenile life history strategies expressed by hatchery releases, thereby promoting improved population diversity and resiliency to unpredictable and changing environmental conditions. Together, the smolt and fry production programs will contribute to harvest in the Sacramento River sport fishery and the ocean sport and commercial fisheries and benefit the region's social, cultural, and economic well-being. The Service's overall goal with respect to total (i.e., harvest plus escapement) contribution of Coleman SRFCS will continue to be 1.0% of the number of juveniles released, equivalent to an average annual yield of approximately 120,000 adult SRFCS contributing to harvest and spawner escapement.

Size of Program

Existing - The Coleman NFH targets an annual release target of 12 million SRFCS smolts (90 fpp/75mm). Actual production levels may differ from this release target by up to 15% (≤13.8 million) due to annual variations in fecundity and survival.

Proposed – Through implementation of the proposed study, the Coleman NFH will target an annual release target of approximately 13 million SRFCS smolts (90 fpp/75mm) and 3 million SRFCS fed fry (500 fpp/45 mm). Actual production levels may differ from these release targets due to annual variations in broodstock availability, fecundity, and survival during incubation and rearing. However, production of SRFCS smolts will not exceed the production limit of 13.8 million imposed by term and condition of the existing biological assessment.

Spawning

Existing - The current minimum spawning target for Coleman SRFCS is 2,600 females, spawned using pairwise matings. This spawning target is derived from back calculation based on a release target of 12 million smolts, the annually estimated fecundity of female spawners (eggs/female) and expected survival from egg to release. Spawning of SRFCS in excess of the hatchery's annual production target serves several purposes, including providing increased surety that the annual production target will be achieved, facilitating post-hoc management of egg takes to improve the temporal distribution of spawners contributing to juvenile releases, providing opportunity to optimize the ponding of SRFCS juveniles within existing raceways at the Coleman NFH, and decreasing the biomass of SRFCS spawners in lower Battle Creek to encourage successful natural production. Eggs of SRFCS exceeding the number needed to meet the hatchery's annual production target are culled prior to reaching the eyed stage. A target of 20,000 adults are left in Battle Creek to spawn naturally, contingent upon the abundance of salmon returning to the creek.

Proposed – Through implementation of the proposed study, the minimum spawning target for Coleman SRFCS will be approximately 3,250 females, spawned using pairwise matings. This spawning target is back calculated based on a release target of 13 million SRFCS smolts and 3 million SRFCS fed fry, and accounts for the estimated fecundity of female spawners (eggs/female) and expected rates of survival to the time of release. Culling of SRFCS is expected to be reduced. Number of SRFCS spawning naturally in Battle Creek may be reduced from the current target of 20,000, if limited by the abundance of spawners returning to Battle Creek.

Incubation and Rearing

<u>Marks and Tags Applied</u>

Current – Marking and tagging of hatchery SRFCS is essential to assess their contributions to program goals. Since brood year 2006, general production SRFCS at Coleman NFH have been adipose fin-clipped and coded-wire tagged at a rate of 25%, consistent with the target rate of the Constant Fractional Marking (CFM) Program and the same as all other SRFCS hatchery programs in the Central Valley. Total contribution of hatchery origin SRFCS are estimated based on the number of marked and tagged salmon observed in monitoring programs and the annual rate of marking and tagging.

Proposed – With implementation of the proposed study, SRFCS smolts produced at the Coleman NFH will continue to receive an adipose fin-clip and coded-wire tag at a rate of 25%, consistent with the constant fractional marking program of all SRFCS smolt production programs in the Central Valley. In addition, releases of SRFCS fry associated with this study will be genetically "tagged" using parental-based tagging (PBT). Parental-based tagging will be conducted by amplifying a panel of genetic markers (presumed single nucleotide polymorphisms) that have been selected by geneticists based on their ability to accurately associate parents with their offspring (Anderson and Garza 2005, Beachham et al. 2021). The target rate of PBT sampling of hatchery broodstock associated with releases of fed fry from the Coleman NFH will be 100%; however, it is possible that a small percentage of total fry releases will not be represented in parental genotyping, if necessary to facilitate achieving program goals or due to errors in the ponding process. If these situations occur, they will be documented and the percentage of releases that are not represented by parental sampling will be estimated.

The use of PBT is required to accommodate fry releases because they must be liberated before achieving a size suitable for marking and tagging in the automated trailers. Parental-based tagging is a robust monitoring tool that can provide data sufficient to assess the contributions of fry releases associated with this proposed study. In addition to its utility for evaluating fry releases associated with the proposed study, development and implementation of a robust monitoring program using PBT will provide a wealth of information that can be used to assess and improve many aspects of salmon management, including hatchery practices (e.g., spawning and release strategies), quantifying estimates of incidental take of ESA-listed species associated with ocean fisheries, and improving ocean abundance forecast and harvest models used by the Pacific Fisheries Management Council (PFMC) by providing both origin and age of all salmon released from hatcheries.

<u>Fish health certification procedures applied pre-release.</u>
Existing - Fish health inspections at the Coleman NFH Complex are conducted by the Service's California-Nevada Fish Health. A pre-release examination of SRFCS smolts is conducted for viral, bacterial, and parasitic fish pathogens ≥30 days prior to the scheduled release date. The pre-release examination is conducted following methods of the AFS Blue book and U.S. Fish and Wildlife Service Aquatic Animal Health Handbook. The hatchery receives an inspection report that lists pathogens tested for and observed.

Proposed - A complete panel of pre-liberation sampling of fry may be precluded by their small size and early stages of development. Sampling of SRFCS fry will be determined through consultation with the Department.

Juvenile Release

Existing – Coleman NFH SRFCS smolts (90 fpp, ~75mm) are liberated into Battle Creek, downstream of the hatchery's barrier weir, during April. On-site releases promote a strong imprint to Battle Creek and reduce the proclivity for straying, which is associated with releases at distant locations, or "off-site" releases. At times when the emigration corridor is deemed to be inhospitable to emigrating salmon and likely to result in the near-complete loss of Coleman SRFCS release groups, such as during periods of severe drought, alternative emergency release strategies (e.g., early releases of undersized fish and trucking to San Pablo Bay) may be employed. Decisions to use these emergency release strategies are made in real-time, based on observed and forecast conditions in the migratory corridor.

Proposed – Releases of Coleman SRFCS smolts will be unchanged from current operations. To promote a strong imprint to Battle Creek and increase the likelihood of meeting future broodstock needs, priority will be given to on-site releases of smolts.

Releases of SRFCS fed fry from the Coleman NFH will occur when they reach a size of approximately 500 fpp (40-50 mm), but may occur earlier or later, depending on multiple factors, including environmental conditions and constraints at the Coleman NFH or release sites. Fry releases will occur at both on-site and off-site locations, including direct releases into Battle

Creek, direct releases into the Sacramento River between Battle Creek and Colusa, and releases into inundated agricultural fields and off-channel wetlands where fry will be afforded the opportunity for extended rearing.

Table A.1. Summary of existing operations and proposed changes resulting from implementation of the proposed study actions.

Target/Activity	Existing Operations	Proposed Operations
Program purpose (geographic scope)	Fishery augmentation (Pacific Ocean and Sacramento River upstream to Redding) and supplementation of natural spawning (Battle Creek)	Fishery augmentation (Pacific Ocean and Sacramento River upstream to Redding) and supplementation of natural spawning (Sacramento River watershed upstream to Redding)
Program type	Integrated (passively)	Integrated (passively)
Annual production target	12M ± 15%	12M ± 15% Smolt 3M Fed fry
Target life stage (approx. size) at release	Smolt (90/lb, ~75mm)	Smolt (~90/lb, 75mm) 3M Fed fry (~500/lb, 40-50mm)
Release Location	Smolt - Battle Creek; releases into the San Pablo Bay may be considered if the emigration corridor is unsuitable	Smolt - Battle Creek; releases into the San Pablo Bay may be considered during years the emigration corridor is unsuitable. Fed fry – 1M Battle Creek, 1M Sacramento River and 1M Surrogate Floodplain Habitats

Appendix B. Critical Habitats

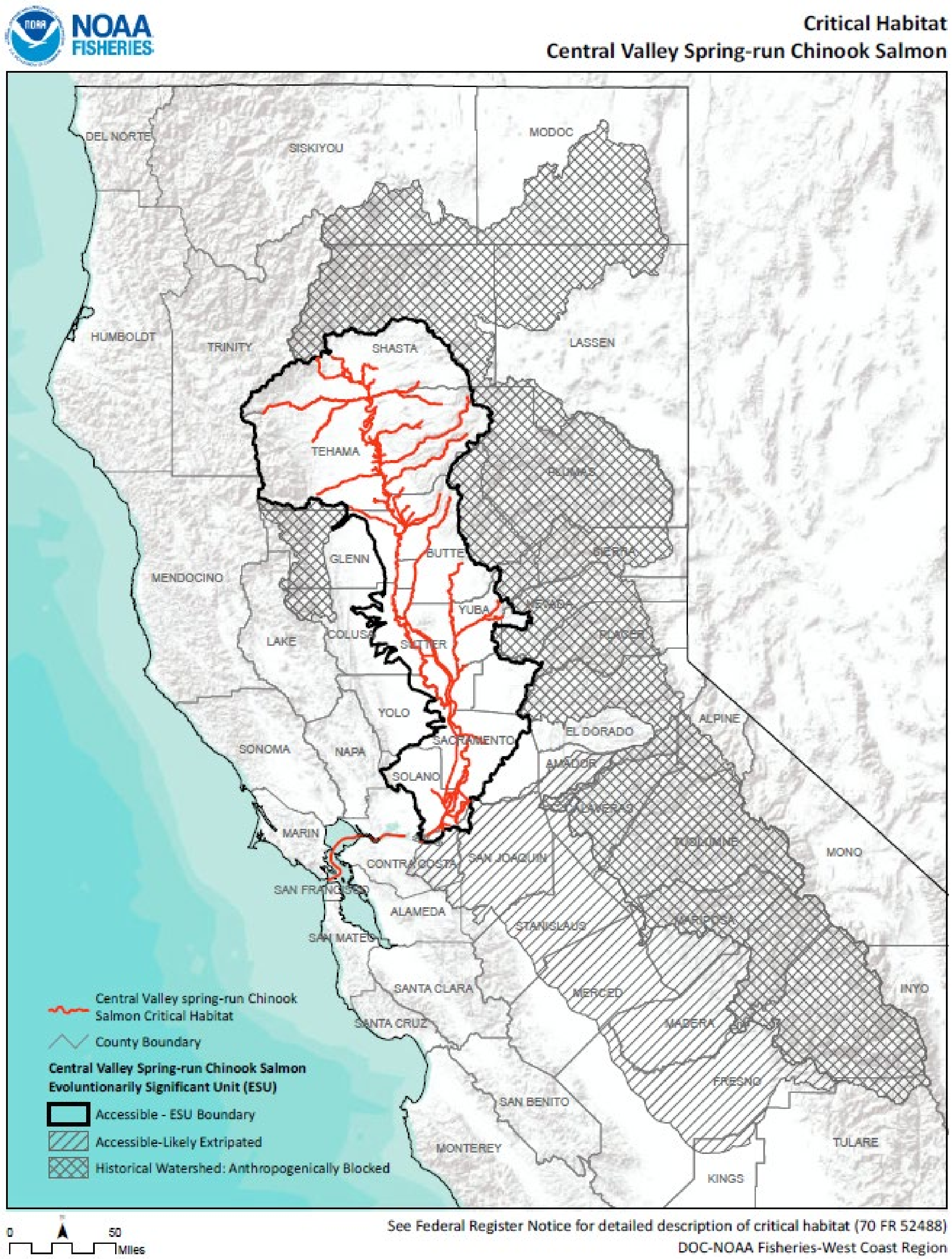

Figure B.1. Critical Habitat for Central Valley Spring Chinook Salmon (Source: NMFS 2014b; Figure 3)

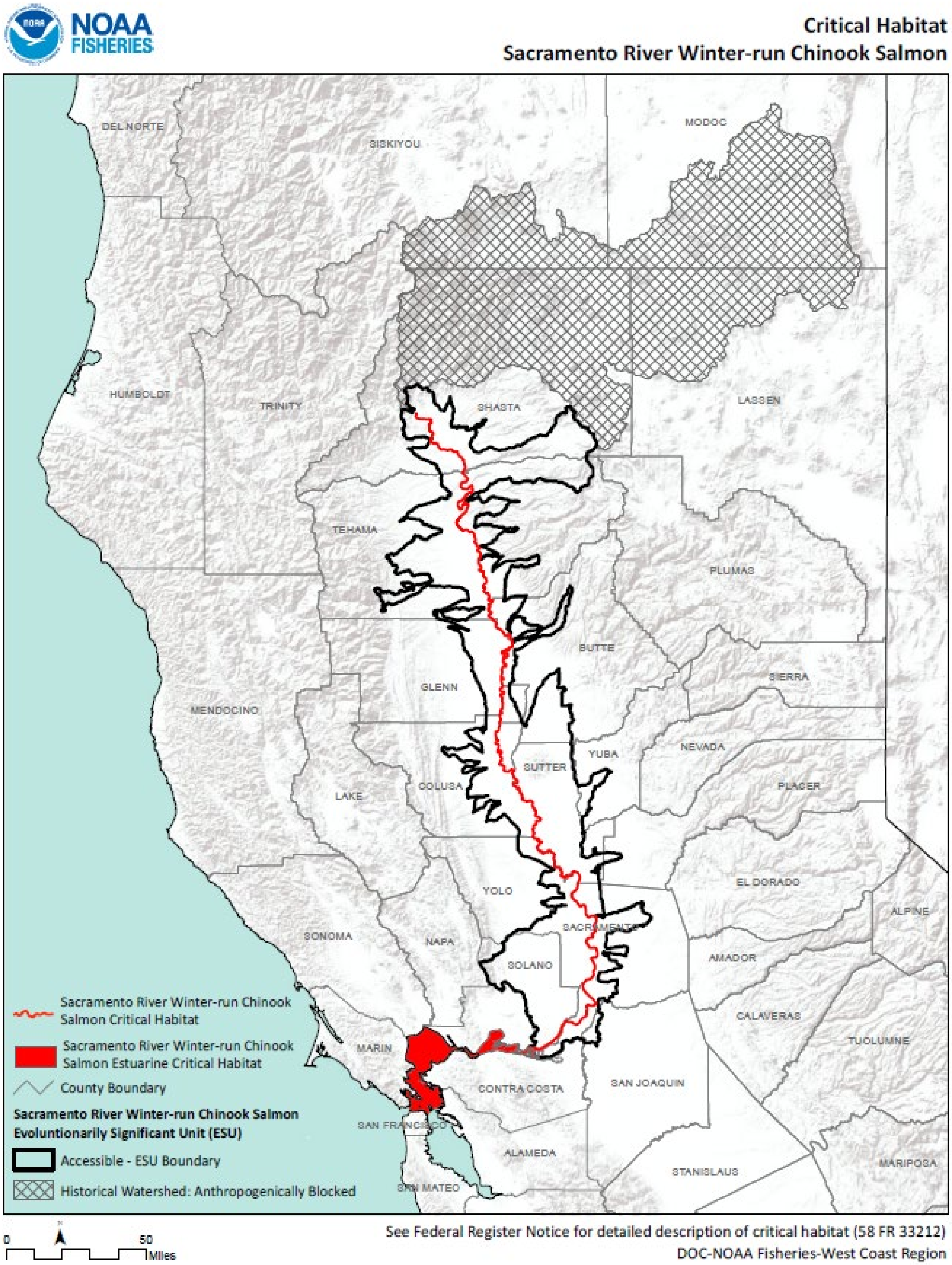

Figure B.2. Critical Habitat for Sacramento River Winter-run Chinook Salmon (Source: NFMS 2014; Figure 4)

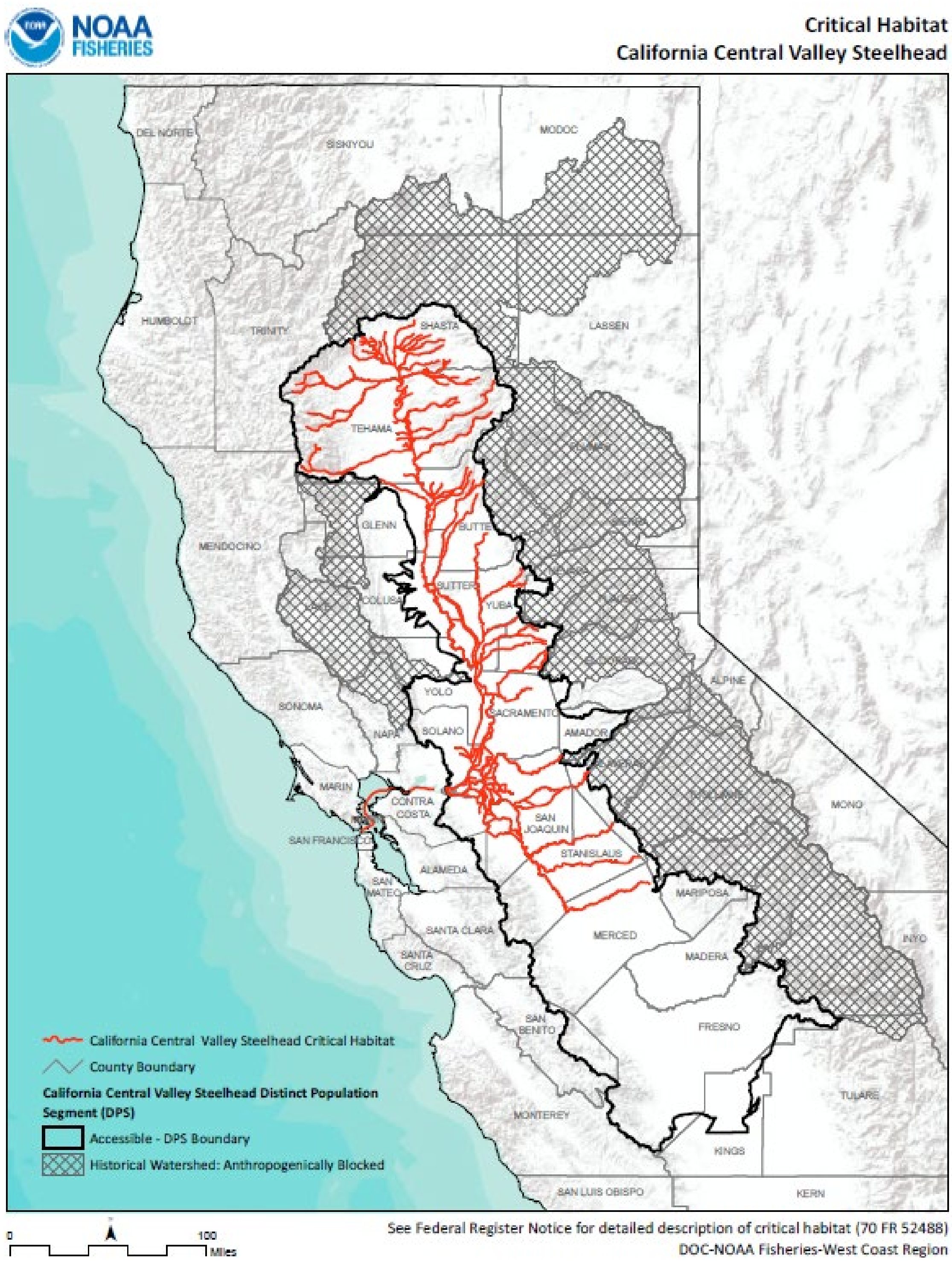

Figure B.3. Critical Habitat for California Central Valley Steelhead (Source: NMFS 2014b; Figure 5)

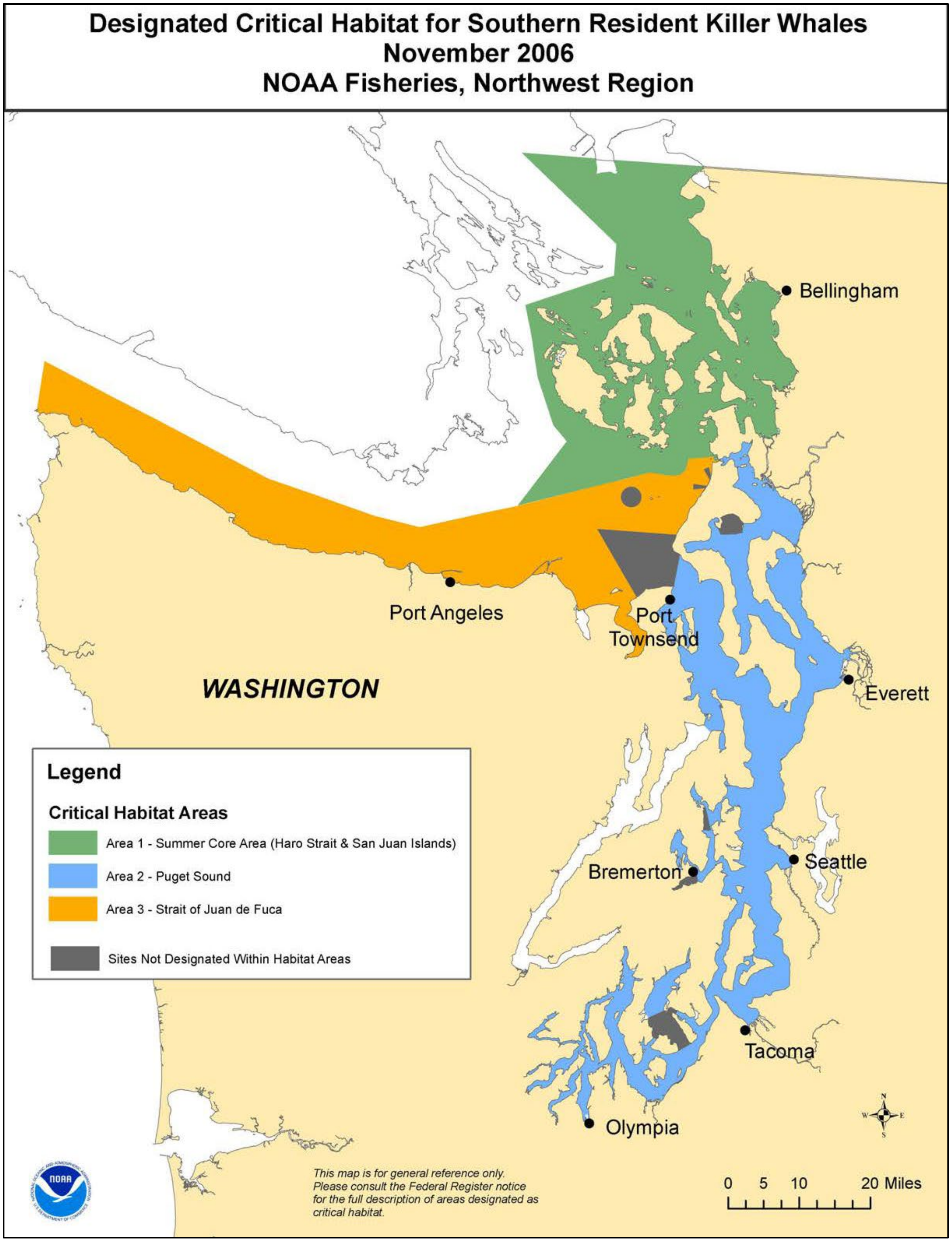

Figure B.4. Critical Habitat for Southern Resident Killer Whale (Source: NMFS 2008, Figure 7).

Figure B.5. Critical habitat for southern DPS of green sturgeon (Source: NFMS 2018, Figure 9)

Appendix C. PCD Risk Model Assessment

Provided below are rationales of input parameters, and corresponding values, used in simulations for the PCD Risk Model assessments. All model parameters were derived from either data collected directly on Chinook Salmon within the study area (data), or when unknown, from recommended values provided in the PCD Risk Model v4.2.0 users guide (manual; Pearsons et al. 2023[1]). Known hatchery-origin parameter values were derived from data and analysis of Coleman NFH fall-run Chinook Salmon (SRFCS), whereas natural-origin spring- and winter-run Chinook Salmon (SCS and WCS, respectively) parameter values were developed using rotary-screw trap collection data provided by the Mainstem Juvenile Monitoring Program, Red Bluff, CA (Scott Voss, personal communication). The total SCS population size in the Upper Sacramento River was estimated to be approximately 300,000 (rotary-screw trap 5-year maximum, 2017–2021) and the total WCS population size in the Upper Sacramento River was expected to be approximately 1,500,000 (rotary-screw trap 5-year mean, 2018–2022). Migration period chosen for analysis was from the expected first release of hatchery-origin SRFCS (mid-January) through the expected emigration period out of the Sacramento River (end of May; forced out-migration due to water temperatures increasing to lethal limits). Lethal water temperatures are likely to occur near approximately day 150 after the first hatchery-origin release (mid-January release through mid-June), therefore the residence time of 150 was used in model scenarios.

<u>Main Model Parameters</u>

-Number of iterations (manual). The manual recommends a minimum of ten iterations as the average total mortality estimated by the model stabilizes at that point.

-Hat & Nat Pop Overlap (data): The actual overlap between modeled species is largely unknown. We estimated maximized interaction at 100% (proportion of overlap = 1.0) but acknowledge the likely in-river interaction would be some lower value.

<u>Hatchery-origin Fish Parameters</u>

-Minimum size (data): For WCS assessment and SCS scenario 1, minimum fork length was estimated for SRFCS as freshly hatched fry at Coleman NFH. For SCS scenario 2, we estimated minimum fork length of hatchery-origin SRFCS in March (estimated date of SCS emigrating from Sacramento River tributaries; outmigration sizes).

-Maximum encounters (manual): Manual states “In more recent analyses for ESA Section 7 consultations, the number of maximum encounters has generally been set to 3 encounters per model day.”

-Predation Critical Size Ratio (manual).

-Number of fish (data). Under WCS and SCS scenario 1, release of hatchery SRFCS is modeled from the first day of group 1 release and through the two subsequent hatchery releases (three total) and their emigration through the Sacramento River system. Thus, hatchery fish are

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[1] Pearsons, T., Busack, C., and Olson, A. 2023. PCD Risk Version 4.2.0 The Predation, Competition and Delayed Mortality Risk Model User’s Guide.

released into habitats already occupied by natural origin WCS or SCS. Under SCS scenario 2, all hatchery SRFCS have been released into the Sacramento River and then encounter natural-origin SCS emigration from tributaries.

-Mean Length (data). Mean fork lengths are derived from estimated size of hatchery-origin SRFCS as newly hatched button-up fry and an estimated size of hatchery-origin fish after approximately two months of rearing in agriculture field conditions.

-CV Length (data). Newly hatched fry are unlikely to vary in length due to the limited growth potential and time. Hatchery-origin SRFCS released from the Coleman NFH often have length CV of approximately 0.12-0.15 (average FL: 75-80 mm).

-Start Day (data). All scenarios begin at day 1; initial interaction between hatchery- and natural-origin fish. For scenario 1, additional releases of hatchery-origin fish occur and at later dates. The release of fish directly into the Sacramento River is estimated to occur approximately one week after the initial Battle Creek release, and the liberation from agriculture fields is expected approximately mid-March (60 days after the initial Battle Creek release).

-Residence Time (data). Residence time is based an expected 150 total days of Sacramento River residency by hatchery-origin fish, minus Start Day for individual hatchery-origin groups (adjustment for later release of some groups)

-Survival rate (data): This value is largely unknown for fry releases, but is likely highly variable, dependent on environmental conditions (e.g., low water year, unseasonably hotter temperatures, predator abundance). The true value may range from a low approaching 100% mortality to a high of less than 100% survival. Though somewhat arbitrary, a value of 75% survival was selected for our simulation to model high levels of hatchery and natural interactions and thereby provide an estimate of a stronger interaction/competition risk effect.

-Habitat segregation (manual): Amount of segregation to be expected between hatchery- and natural-origin fish. The manual suggests 0.3 for fish of the same species.

-Habitat segregation mode (manual): We used the recommended value based on fish of equal sizes. The mode=0 setting excludes fish randomly, as opposed to mode=1 which excludes fish of increases size differently based on the belief they will occupy different habitats or zones in the river (the latter is not expected given the similar fish sizes).

-Piscivory (manual): Piscivory is not expected due to the similar sizes of hatchery-origin and natural-origin fish at time of release, expected similar growth rates during coexistence, and reduced period of interaction prior to ocean entry. However, it is still possible and cannot be entirely rejected, especially as fish near the end of residence time and are of larger sizes (predation on smaller/slower growing fish possible). Piscivory by emigrating hatchery-origin SRFCS in the Sacramento River is expected to be low (see Predation Effects Analysis in main document, page 27). The PCD Risk manual suggested values of 0.0 to 0.02 based on data derived from peer-reviewed papers, and with suggested values for stream fishes between 0.0 and 1.0. Because our scenarios were designed to estimate maximum negative interactions, the largest suggested value of 0.02 was used.

Natural-origin Fish Parameters

-Number of fish (data): An in-river population estimate of juvenile SCS and WCS was derived from data collected from rotary-screw traps located at the Red Bluff Diversion Dam. The count of SCS emigrating from Sacramento River tributaries is largely unknown; however, we choose a large count to model possible interactions during years of near estimated normal outmigration counts (count equal to mainstem Sacramento River SCS production.

-Minimum size (data). Minimum sizes of natural-origin salmonids in the Sacramento River potentially interacting with hatchery SRFCS releases. Natural fish are assumed to be newly hatched button-up fry (SCS scenario 1), of similar size to hatchery-origin SRFCS (SCS scenario 2), or larger than hatchery-origin fish (WCS).

-Habitat protection (manual): This is largely unknown, but habitat complexity does exist and provides an area of refuge from interactions with hatchery-origin fish. As suggested by the manual, other researchers typically use 0.1.

-Competition Dominance Mode (data): This parameter defines what proportion of hatchery-origin will dominate natural-origin fish based on differing scenarios, ranging from hatchery-origin are likely larger and display complete dominance over natural-origin (100% dominance at all sizes) to no interactions between hatchery-origin and natural-origin due to such aspects as continuous migration and no residence time (0% dominance at all sizes). In our scenario, there is likely to be some dominance as fish will be residing for extended period (> 0%), but also less than 'complete hatchery-origin dominance due to hatchery-origin being larger and more aggressive due to hatchery environment rearing' (<100%). We assumed equal dominance displayed by both natural- and hatchery-origin fish because releasing hatchery-origin fish as fry limits rearing within the hatchery environment and assumes similar size and residence times of both groups.

-Critical Proportion for Death (manual): The suggested value reported in the manual was used for proportion of weight loss resulting from hatchery-origin/natural-origin interactions that will result in natural-origin death.

-Competition Probability of Weight Loss (manual): This is the probability that a dominated natural-origin fish will have a reduced daily ration (reduced growth or even death).

-Proportion of Daily Ration Lost (data): This parameter is the natural-origin food ration lost due to interactions with hatchery-origin fish. The PCD Risk model generally assumes hatchery-origin fish are larger and more dominant and that natural-origin will stop eating for some time after interacting with hatchery-origin fish, but also acknowledges limited data exists on this subject. Even based on this hatchery-origin dominance, the manual suggests this parameter likely is limited to no greater than 0.5. However, given that the hatchery-origin fish will be released as unfed fry, they are more likely to behave as natural-origin fish and not confer some hatchery influenced dominance over natural-origin fish (suggests setting parameter to 0, or at least lower than typical). Any negative interaction (regardless of which origin is dominant) is likely to confer some level of ration lost due to stress and hesitancy to eat. The true value of this parameter is unknown but not expected to be large. For this reason, this parameter was set at 0.1 (greater than the unlikely 0.0 but much less than when hatchery-origin fish are larger and more dominant than natural-origin fish; manual suggested maximum value of 0.5).

-Delated Mortality Curve (manual): The delayed mortality curve parameter affects how sensitive fish are to delayed mortality. No suggested value is provided by the manual. Also, no evidence is known to suggest this parameter should be adjusted.

<u>Diet and Temperature Parameters</u>

-Diet (manual). Values provided in the manual are species specific for Chinook Salmon and as defined in the Wisconsin Fish Bioenergetics Model (v4.0).

-Temperature (data). Sacramento River temperatures are hard to predict based on high variability seen annually based on numerous factors (e.g. water year type, managed flows, runoff, water diversions, air temperature); however historical values are available (https://cdec.water.ca.gov/). These historical data provide a reasonable estimate of early season water temperatures (less likely to be variable), with end of migration temperatures being influenced by the thermal maximum tolerance of Chinook Salmon (chronically lethal = 25 °C in the Central Valley; Myrick and Cech 2001[2]).

[2] Myrick, C. and Cech, J. 2001. Bay-Delta Modeling Forum Technical Publication 01-1. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations.

Main Model Parameters	
Description	Value
User Name	Kevin Offill
Model Run Title	BC_SacR
Diagnostics Level	0
Diagnostics File Name	BC_SacR.txt
Number of Iterations	12
Hat & Nat Pop Overlap	1

Hatchery-origin Fish Parameters					
Species Code	2				
Minimum Size (mm)	32				
Maximum Encounters	3				
Predation Critical Size Ratio	0.25				
	Hatchery Release Group Demographics				
	Group 1	Group 2	Group 3	Group 4	Group 5
Number of Fish	1000000	1000000	1000000		
Mean Length	42	42	80		
CV Length	0.07	0.07	0.15		
Start Day	1	7	60		
Residence Time	150	143	90		
Survival Rate	0.75	0.75	0.75		
Habitat Segregation	0.3	0.3	0.3		
Habitat Segregation Mode	0	0	0		
Piscivory	0.3	0.3	0.3		

Natural-origin Fish Parameters							
Number of Fish	300000						
Species Code	2						
Minimum Size (mm)	44						
Habitat Protection	0.1						
Competition Dominance Mode	6						
Critical Proportion for Death	0.5						
Competition Probability of Weight Loss	0.05						
Proportion of daily ration lost	0.1						
Delayed Mortality Curve	0						
	Natural-origin Fish Demographics						
	Group 1	Group 2	Group 3	Group 4	Group 5	Total	
Age Proportion	1					1.0	
Mean Length	51						
CV Length	0.10						
	User Defined Competition Dominance (Mode=6)						
	<----- Hat is smaller than Nat					Hat is larger than Nat ----->	
Hat:Nat Length Percentage	< 25%	25% to 15%	15% to 5%	5% to 5%	5% to 15%	15% to 25%	> 25%
Percent Dominance	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Diet and temperature parameters					
	Prey Energy Density		Proportion of Cmax		
Day	HO	NO	HO	NO	Temp
1	3000	3000	0.6	0.6	8.5
7	3000	3000	0.6	0.6	8.0
30	3000	3000	0.6	0.6	9.1
50	3000	3000	0.6	0.6	10.6
60	3000	3000	0.6	0.6	11.3
90	3000	3000	0.6	0.6	15.4
120	3000	3000	0.6	0.6	17.0
150	3000	3000	0.6	0.6	20.3
NA					
NA					

Model Results			
PCDRisk Model Version:	4.2.0	Run Time:	02:09:00
Run Date and Time:	Thu, October 19, 2023 14:15		

Diagnostics	
Proportion of natural fish subject to predation	0.000000
Competition hit summary, averaged over replicates	
Mean number of non-lethal competitive interactions sustained	1002824.9
Mean number interactions sustained per surviving fish	3.3757
Mean number sustained per surviving fish, excluding fish with no hits	3.84

Mortality Summary for BC_SacR Scenario								
	Absolute				Rate (%)			
Total	Mean	SD	Min	Max	Mean	SD	Min	Max
Predation	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Competition	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Delayed	2086.0	35.3	2025.0	2170.0	0.6953	0.0118	0.6750	0.7233
Total	2086.0	35.3	2025.0	2170.0	0.6953	0.0118	0.6750	0.7233

Figure. C. 1. The PCD Risk Model parameters and values used in the assessment of risk associated with releasing three groups of hatchery-origin SRFCS on Sacramento River natural-origin SCS.

Main Model Parameters	
Description	Value
User Name	Kevin Offill
Model Run Title	SCS_SCSU
Diagnostics Level	0
Diagnostics File Name	SCS_SCSU.txt
Number of Iterations	12
Hat & Nat Pop Overlap	1

Hatchery-origin Fish Parameters	
Species Code	2
Minimum Size (mm)	60
Maximum Encounters	3
Predation Critical Size Ratio	0.25

Hatchery Release Group Demographics	Group 1	Group 2	Group 3	Group 4	Group 5
Number of Fish	3000000				
Mean Length	80				
CV Length	0.15				
Start Day	1				
Residence Time	60				
Survival Rate	0.75				
Habitat Segregation	0.3				
Habitat Segregation Mode	0				
Piscivory	0.02				

Natural-origin Fish Parameters	
Number of Fish	300000
Species Code	2
Minimum Size (mm)	60
Habitat Protection	0.1
Competition Dominance Mode	6
Critical Proportion for Death	0.5
Competition Probability of Weight Loss	0.05
Proportion of daily ration lost	0.1
Delayed Mortality Curve	0

Natural-origin Fish Demographics	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Age Proportion	1					1.0
Mean Length	80					
CV Length	0.15					

User Defined Competition Dominance (Mode=6)

	<------ Hat is smaller than Nat					Hat is larger than Nat ------>	
Hat:Nat Length Percentage	< 25%	25% to 15%	15% to 5%	5% to 5%	5% to 15%	15% to 25%	> 25%
Percent Dominance	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Diet and temperature parameters

	Prey Energy Density		Proportion of Cmax		
Day	HO	NO	HO	NO	Temp
1	3000	3000	0.6	0.6	15.4
30	3000	3000	0.6	0.6	17.0
60	3000	3000	0.6	0.6	20.3
NA					
NA					
NA					
NA					
NA					
NA					
NA					

Model Results

PCDRisk Model Version:	4.2.0	Run Time:	00:50:18
Run Date and Time:	Sun, October 15, 2023 18:53		

Diagnostics	
Proportion of natural fish subject to predation	0.000000
Competition hit summary, averaged over replicates	
Mean number of non-lethal competitive interactions sustained	402650.4
Mean number interactions sustained per surviving fish	1.3509
Mean number sustained per surviving fish, excluding fish with no hits	1.92

Mortality Summary for SCS_SCSU Scenario

	Absolute				Rate (%)			
Total	Mean	SD	Min	Max	Mean	SD	Min	Max
Predation	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Competition	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Delayed	1060.1	38.8	993.0	1112.0	0.3534	0.0129	0.3310	0.3707
Total	1060.1	38.8	993.0	1112.0	0.3534	0.0129	0.3310	0.3707

Figure. C. 2. The PCD Risk Model parameters and values used in the assessment of risk associated with out-migrating natural-origin SCS encountering previously released hatchery-origin SRFCS in the Sacramento River.

Main Model Parameters	
Description	Value
User Name	Kevin Offill
Model Run Title	BC_WCS
Diagnostics Level	0
Diagnostics File Name	BC_WCS.txt
Number of Iterations	12
Hat & Nat Pop Overlap	1

Hatchery-origin Fish Parameters					
Species Code	2				
Minimum Size (mm)	32				
Maximum Encounters	3				
Predation Critical Size Ratio	0.25				
	Hatchery Release Group Demographics				
	Group 1	Group 2	Group 3	Group 4	Group 5
Number of Fish	1000000	1000000	1000000		
Mean Length	42	42	80		
CV Length	0.07	0.07	0.15		
Start Day	1	7	60		
Residence Time	150	143	90		
Survival Rate	0.75	0.75	0.75		
Habitat Segregation	0.3	0.3	0.3		
Habitat Segregation Mode	0	0	0		
Piscivory	0.02	0.02	0.02		

Natural-origin Fish Parameters							
Number of Fish	1500000						
Species Code	2						
Minimum Size (mm)	60						
Habitat Protection	0.1						
Competition Dominance Mode	6						
Critical Proportion for Death	0.5						
Competition Probability of Weight Loss	0.05						
Proportion of daily ration lost	0.1						
Delayed Mortality Curve	0						
	Natural-origin Fish Demographics						
	Group 1	Group 2	Group 3	Group 4	Group 5	Total	
Age Proportion	1					1.0	
Mean Length	76						
CV Length	0.15						
	User Defined Competition Dominance (Mode=6)						
	<----- Hat is smaller than Nat					Hat is larger than Nat ----->	
Hat:Nat Length Percentage	< 25%	25% to 15%	15% to 5%	5% to 5%	5% to 15%	15% to 25%	> 25%
Percent Dominance	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Diet and temperature parameters					
	Prey Energy Density		Proportion of Cmax		
Day	HO	NO	HO	NO	Temp
1	3000	3000	0.6	0.6	8.5
7	3000	3000	0.6	0.6	8.0
30	3000	3000	0.6	0.6	9.1
50	3000	3000	0.6	0.6	10.6
60	3000	3000	0.6	0.6	11.3
90	3000	3000	0.6	0.6	15.4
120	3000	3000	0.6	0.6	17.0
150	3000	3000	0.6	0.6	20.3
NA					
NA					

Model Results			
PCDRisk Model Version:	4.2.0	Run Time:	05:37:46
Run Date and Time:	Mon, October 16, 2023 23:09		

Diagnostics	
Proportion of natural fish subject to predation	0.000000
Competition hit summary, averaged over replicates	
Mean number of non-lethal competitive interactions sustained	5020167.4
Mean number interactions sustained per surviving fish	3.3752
Mean number sustained per surviving fish, excluding fish with no hits	3.84

Mortality Summary for BC_WCS Scenario								
	Absolute				Rate (%)			
Total	Mean	SD	Min	Max	Mean	SD	Min	Max
Predation	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Competition	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Delayed	9057.1	109.4	8920.0	9318.0	0.6038	0.0073	0.5947	0.6212
Total	9057.1	109.4	8920.0	9318.0	0.6038	0.0073	0.5947	0.6212

Figure. C. 3. The PCD Risk Model parameters and values used in the assessment of risk associated with releasing three groups of hatchery-origin SRFCS on Sacramento River natural-origin WCS.