BUREAU OF RECLAMATION

Long-Term Operation – Initial Alternatives

Appendix D – Seasonal Operation Stressors on Aquatic Species

Central Valley Project, California

Interior Region 10 – California-Great Basin

U.S. Department of the Interior September 2022

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Bay-Delta Office

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1. Introduction

This seasonal operations deconstruction appendix analyzes potential stressors on aquatic species and their critical habitats from Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) actions to store, release, divert, and route flows during the Long-Term Operation (LTO) of the Central Valley Project (CVP) and State Water Project (SWP). Where stressors may change in manner with potential adverse effects to listed species, those stressors are identified for consideration of conservation measures to limit operations and/or compensate for potential adverse effects.

Appendix A of this Initial Alternatives Report provides a description of the facilities and the requirements for the CVP and SWP under each respective authorization. Appendix B describes the water available for operation of the CVP and SWP with three scenarios: (1) The impaired inflow to reservoirs and releases for flood control; (2) Operations under Water Right Decision 1641 and other water right requirements; and (3) The 2020 Record of Decision implementing the 2019 Biological Opinions for the CVP and SWP and the 2020 California Incidental Take Statement for the operation of the SWP under the California ESA. Appendix C analyzes historical monitoring to describe observations of listed fish species within the Central Valley. This appendix applies consideration for the direction and magnitude of changes to flows and water quality from the operation of the CVP and SWP. While the Proposed Action and alternatives may result in different magnitudes of flows, the direction of changes are likely to remain similar.

Reclamation considered commonly used published conceptual models where available and made adaption for species where such models were absent. Conceptual models described hypothesized linkages between the landscape, environmental drivers, habitat, and fish response for different life stages. The conceptual models provide a list of potential stressors. Management actions can change the landscape and environmental drivers to influence these stressors when species may be present.

The timing of water operations may vary in any specific year but generally follows patterns that align with fall, winter, spring, and summer seasonal periods. These months are generally December through February for winter, March through May for spring, June through August for summer, or September through November for fall. Life stages were identified in the dominant season(s) rather than repeated if the leading and trailing months fell within similar operations. Low presence indicates that species have been seen at that time, in some years, but in small numbers. Medium presence indicates observations of species in some years at numbers that warrant potential detailed consideration of the effects of actions. High presence indicates that species are likely present. Thresholds were based on professional opinion and generally represent approximately <1%, <5%, and >5% of the population. For each species, each watershed, each season, and each lifestage, Reclamation evaluated each stressor to determine how changes in flows as a result of storing, releasing, diverting, or routing water may increase or reduce each stressor. The evaluation also determined where operations have no effect on the stressor, may affect but are not likely to adversely affect the stressor through minimal and/or discountable changes, or where operations may affect and are likely to adversely affect the stressor and warrant more detailed analysis.

The next stage of formulating a Proposed Action and one or more alternatives use modeling to explore potential ranges of water operations, develop conservation measures to address adverse impacts, incorporate conservation measures planned to contribute to recovery of species, and evaluate those measures.

2. Winter-Run Chinook Salmon

The federally listed evolutionarily significant unit (ESU) of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) (winter-run) and designated critical habitat occurs in the action area and may be affected by the seasonal operations. Winter-run exhibit a life-history strategy found nowhere else in the world. Adult winter-run return to their natal tributary in the winter and spawn during the summer months when air temperatures usually approach their warmest. The last remaining natural spawning area for winter-run is located on the upper Sacramento River, downstream of Keswick Dam. As a result, the natural population of winter-run depend entirely upon cold-water releases from Shasta Dam to protect incubating eggs from warm ambient conditions.

2.1 Conceptual Lifecycle Models

An action may affect fish when the change in conditions overlap with the location and timing of fish and/or their habitats. The Salmon and Sturgeon Assessment of Indicators by Life stage (SAIL) conceptual model (Windell et al. 2017) describes life stages and geographic locations for winter-run (Figure).

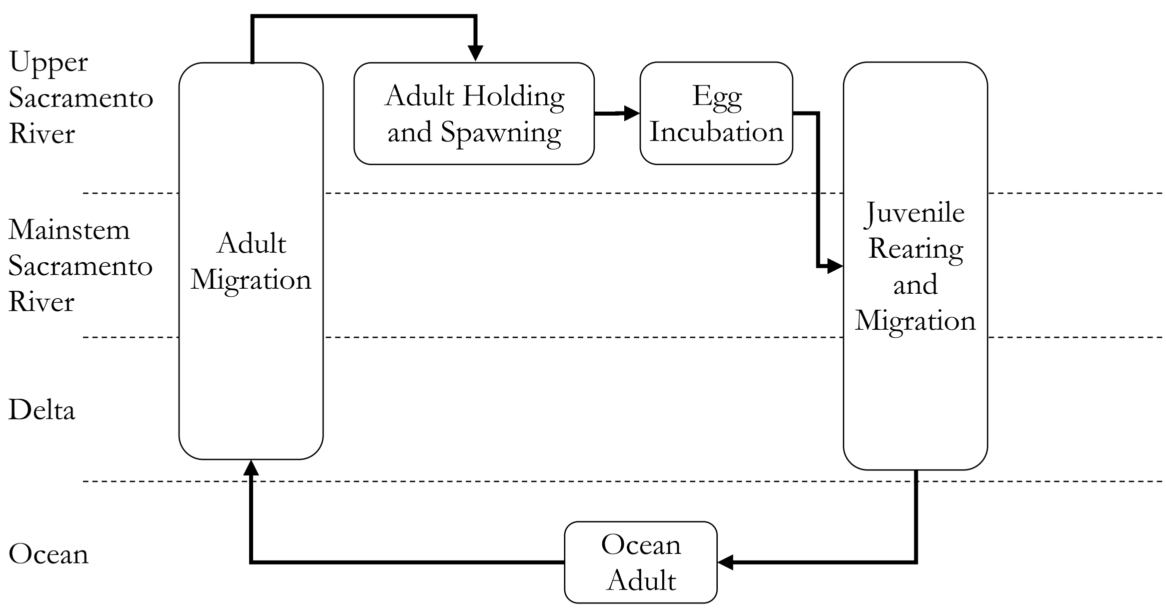

Figure 1. Geographic Life Stage Domains for Winter-Run Chinook Salmon (adapted from Windell et al. 2017, Figure 2)

SAIL models describe linkages between landscape attributes and environmental drivers to habitat attributes that may affect fish (stressors) based on life stage. The SAIL models provide life stages and stressors of:

- Adult Migration
    - H1: In-river fishery and poaching
    - H2: Toxicity from contaminants
    - H3: Stranding risk
    - H6: Water temperature
    - H4: Dissolved oxygen
    - H5: Pathogens
- Adult Holding and Spawning
    - H3: In-river fishery or poaching
    - H1: Toxicity from contaminants
    - H6: Water temperature
    - H7: Pathogens and disease
    - H5: Dissolved oxygen
    - H4: Spawning habitat
    - H2: Competition, introgression, and broodstock removal
- Eggs Incubation to Fry Emergence
    - H1: In-river fishery and trampling
    - H2: Toxicity and contaminants
    - H4: Stranding and dewatering
    - H7: Water temperature
    - H5: Dissolved oxygen
    - H6: Pathogens
    - H8: Sedimentation and gravel quantity
    - H3: Redd quality
    - H9: Predation risk
- Juvenile Rearing to Outmigration

- H1: Toxicity and contaminants
- H6: Stranding risk
- H5: Outmigration cues
- H7: Water temperature and DO
- H8: Pathogens and disease
- H9: Entrainment risk
- H3: Refuge habitat
- H4: Food availability and quality
- H2: Predation and competition

Each deconstruction of the action considers the 31 stressors for the four life stages listed above. Additional and/or alternative conceptual models (e.g., Central Valley Project Improvement Act [CVPIA] Science Integration Team, South Delta Salmonid Research Collaborative) may be incorporated as applicable.

Monitoring data from snorkeling, carcass surveys, redd surveys, rotary screw traps, trawls, and beach seines describe the timing of winter-run presence (Figure 2) (Appendix C).

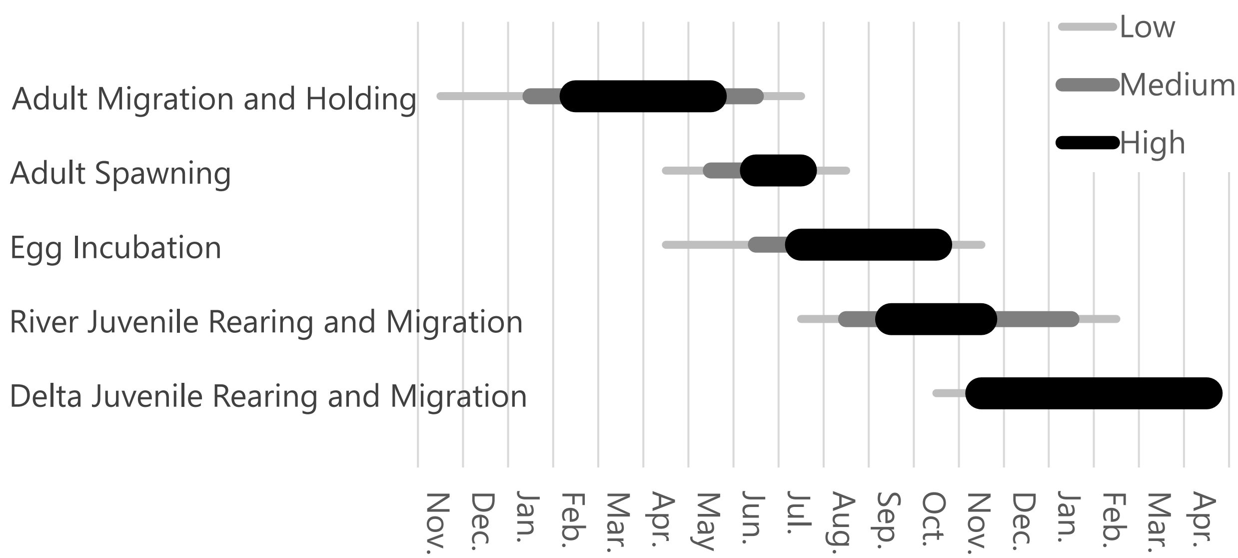

Figure 2. Temporal Life Stage Domains for Winter-Run Chinook Salmon from Appendix C

The two spatial domains defined for winter-run are the Sacramento River and Bay-Delta. Presence of several life-stages in the Central Valley and Bay-Delta (adult migration and holding, juvenile migration) occur over multiple calendar years. The ocean life stage is outside the critical habitat action area determined by the National Marine Fisheries Service (NMFS) and therefore is not shown.

2.2 Species Effects Deconstruction

Winter-run are anticipated in the Sacramento River and Delta and may experience effects from seasonal operations, as described below. The Sacramento River includes migrating, holding, and spawning adults; egg incubation below Keswick Dam; and rearing and migrating juveniles. The Delta includes migrating adults and rearing and migrating juveniles.

2.2.1 Sacramento River

In the winter, Reclamation and DWR's proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flow in the upper Sacramento River may change stressors on winter-run.

Adults are migrating in the Sacramento River in the winter, undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery and poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the upper Sacramento River during the winter. Poaching may impact adult survival during migration.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change for adults from decreased flows causing low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the winter has not been observed in the upper Sacramento River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogen stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased salmon have not been observed in the upper Sacramento River during the winter.

Eggs are not present in the Sacramento River during the winter.

Juveniles are rearing and migrating downstream in the Sacramento River in the winter. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Winter-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen (DO) stressors are not anticipated to change with decreased flows. Passing of flows through Shasta Reservoir results in warmer water temperatures in the winter; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogen and disease stressors may or may not increase due to decreased flows. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. This stressor has not been observed in juvenile Chinook in the winter in the Sacramento River.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]) are screened.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the upper Sacramento River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors. Seasonal operation of the CVP is not anticipated to change predation and competition.

In the spring, Reclamation and DWR's proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flow in the upper Sacramento River may change stressors on winter-run.

Adults are migrating, holding, and spawning in the upper Sacramento River in the spring. Adults move into the upper watershed where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery or poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the upper Sacramento River during the spring. Poaching may impact adult survival during migration.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors may or may not increase. The passing of flows through Shasta Reservoir may result in warmer water temperatures in the spring; however, water temperatures are colder than adult migration, holding, and spawning needs. Warmer water temperatures generally decrease DO and increase physiological stress and metabolic rates for adults. Reclamation and NMFS tested a warm-water bypass in 2021 that resulted in elevated temperatures near thresholds.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally decreases with an increase in water temperatures. This decrease can increase physiological stress and metabolic rates for adults.

Pathogens and disease stressors may or may not increase with decreased flows. Decreased flows may cause crowding or competition in smaller holding habitat areas. An increase in density of adults may increase the potential for lateral transmission of disease and may affect pre-spawn mortality. Decreased flows may increase coldwater pool reserves, decreasing later water temperatures, which may reduce pathogen infectibility among holding and spawning adult winter-run. This stressor has not been observed in juvenile Chinook in the spring in the Sacramento River.

Spawning habitat stressors may or may not change. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality. A decrease in flows may increase spawning habitat stressors; however, the majority of winter-run do not spawn until the summer.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult winter-run using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. These competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. Competition for spawning habitats may lead to genetic introgression due to spawning between hatchery and natural origin winter-run. The Livingston Stone National Fish Hatchery is operated as a conservation hatchery to minimize genetic divergence between the hatchery and natural population and precautionarily manage broodstock removal.

Eggs are not present in the Sacramento River in the spring.

Juveniles are not present in the Sacramento River in the spring.

In the summer, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Keswick Dam. Increased flow in the upper Sacramento River may change stressors on winter-run.

Adults are migrating, holding, and spawning in the upper Sacramento River in the summer. Adults move into the upper watershed where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery or poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the upper Sacramento River during the summer. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on the Sacramento River.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the Sacramento River, reducing their spawning success. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogens and disease stressors may or may not decrease with increased flows. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult winter-run. Water temperature-related effects are addressed in the water temperature stressor section.

Spawning habitat stressors are not anticipated to change. Increased flows may decrease stressors by increasing spawning habitat quantity and quality. An increase in flows may improve spawning habitat; however, no known habitat would be additionally inundated.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit winter-run in the summer.

Eggs are incubating in the Sacramento River streambed in the summer. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, development rate, and condition.

In-river fishery and trampling stressors may or may not change due to higher flows increasing depths over channel-edge spawning and incubation habitat. Recreational trout fishing and other human activity may cause trampling, which can negatively impact eggs in the redd. An increase in flows may increase or decrease trampling stressors depending on changes in channel-edge spawning and incubation habitat. In the Sacramento River, higher flows generally result in deeper winter-run redds.

Toxicity and contaminants stressors may decrease due to increased flows to dilute contaminants. Contaminants are one variable that influences the survival of eggs. An increase of flows may decrease stress caused by compounding effects of toxicity and increased water temperature if increased flows cool in-river temperatures.

Stranding and dewatering stressors may decrease due to increased flows in low-flow habitat channels where spawning may occur. Since eggs may be at risk of dewatering when releases from Keswick Dam decrease after adult spawning has occurred, an increase of flows may decrease dewatering stressors. Redd dewatering is low at flows greater than 6,000 cfs; therefore, the typical flow schedules avoid summer dewatering.

Water temperature stressors may or may not be increased due to increased flows. Water temperature affects egg and alevin development rates and physiological stress. Increased flows may deplete coldwater pool reserves, increasing development rates and physiological stress, pathogen susceptibility, and the water temperature stressor. Increased flows may also cool in-river temperatures. Additionally, water temperature affects stream saturation concentration of DO.

Dissolved oxygen stressors may decrease due to increased flows. Egg and alevin emergence is affected by dissolved oxygen, which is one habitat attribute in the redds. Increased flows may increase velocities, which may increase dissolved oxygen concentrations, positively impacting egg and alevin emergence.

Pathogen stressors may decrease due to increased flows. Increased flows may improve flow circulation in the redd and maintain egg condition and reduce pathogen transmission. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility of eggs. Water temperature-related effects are addressed in the water temperature stressor section.

Predation risk stressors are not anticipated to change.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Increased flow may reduce aquatic vegetation and may improve hydrologic and biological connectivity within the streambed that improve egg survival and alevin emergence. Increased flow does not affect gravel size.

Sedimentation and gravel quantity stressors may decrease due to increased flow. Egg and alevin emergence is affected by sedimentation and gravel quantity. Increased flows may remove fine sediment, which may compromise egg and alevin essential functions, stunting development. Flows in the summer are less than channel-forming flows with little, if any, scour.

Juveniles are rearing and outmigrating in the middle Sacramento River. The amount of time spent rearing in the upper Sacramento River varies before juveniles migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a migration corridor to the Bay-Delta. Time spent within and size distribution both entering and exiting the middle Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may decrease due to increased flows in marginal habitat channels. Rearing and/or migrating juveniles' survival can decrease when fish become stranded in disconnected off-channel habitats. An increase in flows may increase habitat availability and decreased juvenile stranding risk during the summer.

Outmigration cues stressors may or may not decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not decrease due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section. The seasonal operation of the CVP to increase flows is not anticipated to change refuge habitat stressors.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the middle Sacramento River. The seasonal operation of the CVP to increase flows is not anticipated to change food availability stressors.

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

In the fall, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Keswick Dam. Increased flow in the upper Sacramento River may change stressors on winter-run.

Adults are not present in the Sacramento River in the fall.

Eggs are incubating and alevin are emerging in the Sacramento River. Egg and alevin survival is dependent on a few habitat attributes. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors may decrease due to higher flows creating more available habitat. Recreational fishing and other human activity such as trampling can reduce eggs and alevin survival in the redd.

Toxicity and contaminants stressors may decrease due to increased flows to dilute contaminants effects on this sensitive life stage. Contaminants are one habitat attribute that influences the survival of eggs. An increase of flows may decrease stress caused by compounding effects of toxicity and increased water temperature if increased flows cool in-river temperatures.

Stranding and dewatering stressors may or may not decrease due to increased seasonal releases. Since redds may be at risk of dewatering when releases from Keswick Dam decrease after adult spawning has occurred, an increase of flows may decrease redd dewatering stressors. Potential redd dewatering increases at flows less than 6,000 cfs; and redd dewatering stressors may increase due to seasonal flow fluctuations.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, and warmer water temperature affects egg and alevin development rates, physiological stress, and survival. Additionally, water temperature affects stream saturation concentration of DO. DO related effects are addressed in the DO stressor section. Increased flows may also cool in-river temperatures. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors may decrease due to increased flows. Egg and alevin emergence is affected by dissolved oxygen, which is one habitat attribute in the redds. Increased flows may increase velocities, which may increase dissolved oxygen concentrations, positively impacting egg and alevin emergence. The seasonal operation of the CVP to increase flows is not anticipated to change DO stressors.

Pathogens stressors may or may not decrease due to increased flows. Increased flows may improve flow circulation in the redd and maintain egg condition and reduce pathogen transmission. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility of eggs. Water temperature-related effects are addressed in the water temperature stressor section.

Sedimentation and gravel quantity stressors may decrease due to increased flow. Egg and alevin emergence is affected by sedimentation and gravel quantity. Increased flows may remove fine sediment that may compromise egg and alevin essential functions, stunting development. Flows in the summer are less than channel-forming flows with little, if any, scour.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Increased flow may reduce aquatic vegetation and may improve hydrologic and biological connectivity within the streambed that improve egg survival and alevin emergence. Increased flow does not affect gravel size but may affect quantity. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section.

Predation risk stressors are not anticipated to change.

Juveniles are rearing and outmigrating in the middle Sacramento River. The amount of time spent rearing in the upper Sacramento River varies before juveniles migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting the middle Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may or may not decrease due to increased flows in marginal habitat channels. Rearing and/or migrating juveniles' survival can decrease when fish become stranded in disconnected off-channel habitats. An increase in flows may increase habitat availability and decrease juvenile stranding risk during the fall. Potential juvenile stranding increases at flows less than 6,000 cfs; and stranding risk stressors may increase due to seasonal flow fluctuations.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the middle Sacramento River.

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

2.2.2 Bay-Delta

In the winter, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on winter-run.

Adults are migrating in the Delta. Adults are undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified to possibly delay adult migration, decrease adult survival during migration, or increase energy necessary to undergo the transition.

In-river fishery and poaching stressors are not anticipated to change. No Chinook fishing is allowed in the Delta in the winter. Poaching may impact adult survival during migration and can cause migration delays.

Toxicity from contaminants stressors are not anticipated to change.

Stranding risk stressors are not anticipated to change. Flows from the upper and middle Sacramento River into the Bay-Delta can be routed through agricultural lands, creating false cues for migrating adults. These false cues can divert adults, causing stranding, which may delay migration.

Water temperature stressors are not anticipated to change.

Dissolved oxygen stressors are not anticipated to change.

Pathogens stressors are not anticipated to change.

Eggs are not present in the Delta.

Juveniles are migrating, foraging, and sheltering in the Delta. Juvenile use of the Bay-Delta varies both within and among years. During the winter months, some early migrants can leave the Delta, though migration can occur through May. A large storm pulse during the winter may cue juveniles rearing in the middle Sacramento to migrate into the Bay-Delta, but in years without a storm pulse or pulses, juveniles historically migrate in a single pulse during late winter. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juvenile rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors are not anticipated to change from decreased Delta outflow.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate and reducing travel rates in the Delta, which may reduce outmigration survival. Juveniles may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants. That is addressed in the toxicity and contaminants stressors section.

Water temperature and DO stressors are not anticipated to change.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence juveniles' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta are not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors are not anticipated to increase due to lower releases. Lower releases may cause less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

In the spring, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on winter-run.

Adults are migrating in the Delta. Adults move through the Bay-Delta into reaches of the Middle and upper Sacramento River, where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery and poaching stressors are not anticipated to change. There is no Chinook salmon fishing permitted in the Delta in the spring.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change.

Water temperature stressors are not anticipated to change.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally decreases with an increase in water temperatures. This decrease can increase physiological stress and metabolic rates for adults.

Pathogens stressors are not anticipated to change. Decreased flows in the Delta do not affect crowding or the density of winter-run Chinook salmon, which may increase transmission of disease or pathogens.

Eggs and alevin are not present in the Delta.

Juveniles are rearing and migrating in the Delta. Juvenile use of the Bay-Delta varies both within and among years. During the spring months, some early migrants can leave the Delta, though migration can occur through May. A large storm pulse during the winter may cue juveniles rearing in the middle Sacramento River to migrate into the Bay-Delta, with a second pulse between February and March. The majority of the population is present within the Bay-Delta during the spring. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change.

Stranding risk stressor are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate. Juveniles may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants.

Water temperature and DO stressors are not anticipated to change.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR reverse flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may increase entrainment risk stressors for juveniles within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence juveniles' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta are not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors are not anticipated to increase due to lower releases. Lower releases may cause less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

In the summer, Reclamation and DWR's proposed water operations will decrease Delta outflow on average through CVP and SWP diversions.

Adults are not present in the Delta in the summer.

Eggs are not present in the Delta.

Juveniles are not present in the Delta in the summer.

In the fall, Reclamation and DWR's proposed water operations will decrease Delta outflow on average through CVP and SWP diversions. Decreased outflow in the Bay-Delta may change stressors on winter-run.

Adults are not present in the Delta.

Eggs are not present in the Delta.

Juveniles are rearing and outmigrating from the Sacramento River to the Delta. Juvenile use of the Bay-Delta varies both within and among years. Historic distribution of juveniles present in the Bay-Delta in the fall is low. Several stressors have been identified to possibly affect survival, residence time and migration, and condition.

Toxicity and contaminants stressors are not anticipated to change.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate. Juveniles may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants. Historic distribution of juveniles present in the Bay-Delta in the fall is low.

Water temperature and DO stressors are not anticipated to change.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may increase entrainment risk stressors for juveniles within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence juveniles' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta are not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors are not anticipated to increase due to lower releases. Lower releases may cause less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. An influx of striped bass subadults that prey on juveniles occurs in the fall. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

2.3 Species Effect Determination

The seasonal operation of the CVP and SWP may affect and is likely to adversely affect Sacramento River winter-run Chinook salmon ESU. The seasonal operation of the CVP is also likely to have beneficial effects. Deconstruction of the seasonal operations systematically evaluated each stressor identified by conceptual models. Stressors not linked to the operation of the CVP and SWP were identified as "are not anticipated to change." Stressors that were insignificant or discountable were documented. Stressors with a material effect on the fitness of species were identified, and the Proposed Action will consider minimization and/or compensation through conservation measures.

Stressors on **adults** influenced by the seasonal operations include:

- Water temperatures: In the summer, increased flow can have mixed effects on water temperatures to create conditions that may or may not be suitable for adults. A conservation measure for Sacramento River origin water temperature that considers flows may benefit water temperatures for some adults and adversely affect others. Managing water temperatures for egg incubation provides colder waters than needed for adults, but that management action may start later in the year, depending on seasonal operations.

- Pathogen and disease: Lower flows may cause crowding that increases the potential for disease transmission in adults. A conservation measure for minimum instream flows may minimize the potential for pathogens and disease.

Stressors on **eggs and alevins** influenced by the seasonal operations include:

- Water temperatures: The management of cold water in Shasta Reservoir is necessary to maintain suitable water temperatures for egg incubation. Management actions for Sacramento River water temperature management that consider seasonal operations may benefit some eggs and alevins and adversely affect others.
- Redd dewatering: The transition from summer releases below Keswick Dam to fall and winter flows rebuilds storage in Shasta Reservoir but may dewater late-spawning winter-run redds. A conservation measure for fall and winter instream flows may minimize potential stranding.

Stressors on **juveniles** influenced by the seasonal operations include:

- Juvenile stranding: The transition from summer releases below Keswick Dam to fall and winter flows rebuilds storage in Shasta Reservoir but may result in stranding of juvenile winter-run. A conservation measure for ramping rates may avoid or minimize the potential for juvenile stranding.
- Outmigration cues: The change in timing of flows in the Sacramento River and the Bay-Delta during the juvenile winter-run outmigration period may disrupt outmigration cues and reduce survival. A conservation measure for minimum instream flows may avoid or minimize juvenile outmigration stressors.
- Water temperatures: Increased flow in the summer can have mixed effects on water temperatures to create conditions that could be suitable or unsuitable for juveniles. A conservation measure for Sacramento River water temperature management that considers flows may benefit some juveniles and adversely affect others. Management for egg incubation provides colder waters than needed for juveniles but may end earlier in the juvenile rearing period.
- Entrainment risk: All CVP and SWP facilities have fish screens. However, juveniles may be entrained at the Delta Cross Channel and routed into areas of the Delta with poor survival by the export facilities or entrained at the salvage facilities for the CVP and SWP. Several actions may avoid, minimize, or benefit the potential for Bay-Delta juvenile entrainment, including a conservation measure for the Delta Cross Channel, a conservation measure for routing at Georgiana Slough, a conservation measure for Old and Middle River flow management, and a conservation measure for salvage before the export facilities.

- Refuge habitat: Decreased flows may provide decreased habitat availability. A conservation measure for the construction of rearing habitat may minimize or benefit potential refuge habitat.
- Food availability and quality: Decreased flows may provide less food availability through a reduction in suitable feeding areas. A conservation measure for the construction of additional tributary and tidal rearing habitat may minimize or benefit food availability and quality.

2.4 Critical Habitat Physical and Biological Features

The critical habitat designation for winter-run Chinook salmon includes: The Sacramento River from Keswick Dam; Shasta County (River Mile 302) to Chipps Island (River Mile 0) at the westward margin of the Sacramento-San Joaquin Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge.[1]

Within the Sacramento River, the designation includes the river water, river bottom (including those areas and associated gravel used by winter-run Chinook salmon as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing. Also, in the areas westward from Sherman Island to Chipps Island, it includes Kimball Island, Winter Island, and Browns Island. In the areas westward from Chipps Island, including San Francisco Bay to the Golden Gate Bridge, it includes the estuarine water column and essential foraging habitat and food resources used by winter-run as part of their juvenile outmigration or adult spawning migration. Critical habitat does not include the open ocean habitat used by winter-run because NMFS determined this area does not appear to be in need of special management consideration, and degradation of this portion of the species' habitat, and other factors associated with the open ocean such as commercial and recreational fishing, do not appear to be significant factors in the decline of the species. NMFS determined existing laws appeared adequate to protect these areas, and special management of this habitat was not considered necessary. The designation does not include any estuarine sloughs within San Francisco Bay or San Pablo Bay. NMFS concluded that proper management of the existing habitat is sufficient to provide for the survival and recovery of this species.

The action area encompasses the entire range-wide riverine and estuarine critical habitat physical and biological features for Sacramento River winter-run Chinook salmon. Physical and biological features that are essential for the conservation of winter-run, based on the best available information, are discussed below.

[1] NMFS designated critical habitat for Sacramento River winter-run Chinook salmon on June 16, 1993 (58 FR 33212).

2.4.1 Adult Passage

Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River is essential for the conservation of winter-run.

The species effect determination found related potential stressors of:

- Stranding that may be minimized through a conservation measure of minimum instream flows.

There are no additional operations effects on adult passage when species are not present.

2.4.2 Spawning Substrate

The availability of clean gravel for spawning substrate is essential for the conservation of winter-run and is necessary for the population to successfully spawn and produce offspring.

The species effect determination found related potential stressors of:

- Spawning habitat quality that may be compensated for and enhanced by the maintenance and construction of spawning habitat.

There are no additional operations effects on spawning substrate when species are not present.

2.4.3 Adequate Flows

Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles are essential for the conservation of winter-run.

The species effect determination found related potential stressors of:

- Stranding that may be minimized through a conservation measure for ramping rates.
- Juvenile outmigration cues that may be minimized through a conservation measure for minimum instream flows.
- Pathogens and disease that may be minimized through a conservation measure for minimum instream flows.

There are no additional operations effects on adequate flows when species are not present.

2.4.4 Water Temperatures

Water temperatures between 42.5°F and 57.5°F (5.8°C and 14.1°C) for successful spawning, egg incubation, and fry development are essential for the conservation of winter-run.

The species effect determination found related potential stressors of:

- Adult holding that may be minimized or enhanced through a conservation measure for water temperature management.

- Egg incubation that may be minimized or enhanced through a conservation measure for water temperature management.
- Juvenile rearing that may be minimized or enhanced through a conservation measure for water temperature management.

There are no additional operation effects on water temperatures when species are not present.

2.4.5 Uncontaminated Habitat Areas and Prey

Habitat areas and adequate prey that are not contaminated are essential for the conservation of winter-run.

The species effect determination found related potential stressors of:

- Food availability and quality that may be compensated or enhanced through rearing habitat construction.

There are no additional operation effects on uncontaminated habitat areas and prey when species are not present.

2.4.6 Juvenile Riparian Habitat

Riparian habitat that provides for successful juvenile development and survival are essential for the conservation of winter-run.

The species effect determination found related potential stressors of:

- Refuge habitat that may be compensated or enhanced through construction of rearing habitat.
- Food availability and quality that may be compensated or enhanced through construction of rearing habitat.

There are no additional operation effects on juvenile riparian habitat when species are not present.

2.4.7 Juvenile Passage

Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean.

The species effect determination found related stressors of:

- Entrainment risk that may be minimized or compensated by several conservation measures that may include Delta Cross Channel Gate closures, a Georgiana Slough Barrier, Old and Middle River flow management, and salvage before the export facilities.

There are no additional operation effects on juvenile passage when species are not present.

2.5 Critical Habitat Effect Determination

The seasonal operation is likely to adversely affect critical habitat for Sacramento River winter-run Chinook salmon ESU.

- Degraded spawning substrate is reintroduced in the action area through gravel augmentation projects.
- Degraded water temperatures for egg incubation are actively managed through Cold Water Pool Management.
- Impacts to juvenile rearing habitat and prey availability are compensated through the construction of additional habitat and implementing recommendations based on new research.
- Impacts to juvenile passage from the Sacramento River to the Pacific Ocean are actively managed through Old and Middle River flow management.

3. Spring-Run Chinook Salmon

The federally listed evolutionarily significant unit (ESU) of Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*) (spring-run) and designated critical habitat occurs in the action area and may be affected by the seasonal operations. Adult spring-run return to their natal tributary in the spring and spawn during the summer and fall months. Juvenile spring-run uniquely exhibit two life history strategies whereby some juveniles migrate to the ocean after spawning as "young of year," and some over-summer in their natal tributary and migrate the following year as "yearlings." Spring-run primarily spawn on the mainstem Sacramento River and Butte, Mill, Clear, and Deer Creeks with a reintroduction program on the San Joaquin River downstream of Friant Dam.

3.1 Conceptual Lifecycle Models

An action may affect fish when the change in conditions overlap with the location and timing of fish and/or their habitats. The SAIL winter-run Chinook salmon conceptual model (Windell et al. 2017) has been adapted for spring-run Chinook salmon by generalizing to natal tributaries and with the addition of yearling life history diversity to describe life stages and geographic locations for this effects analyses (Figure).

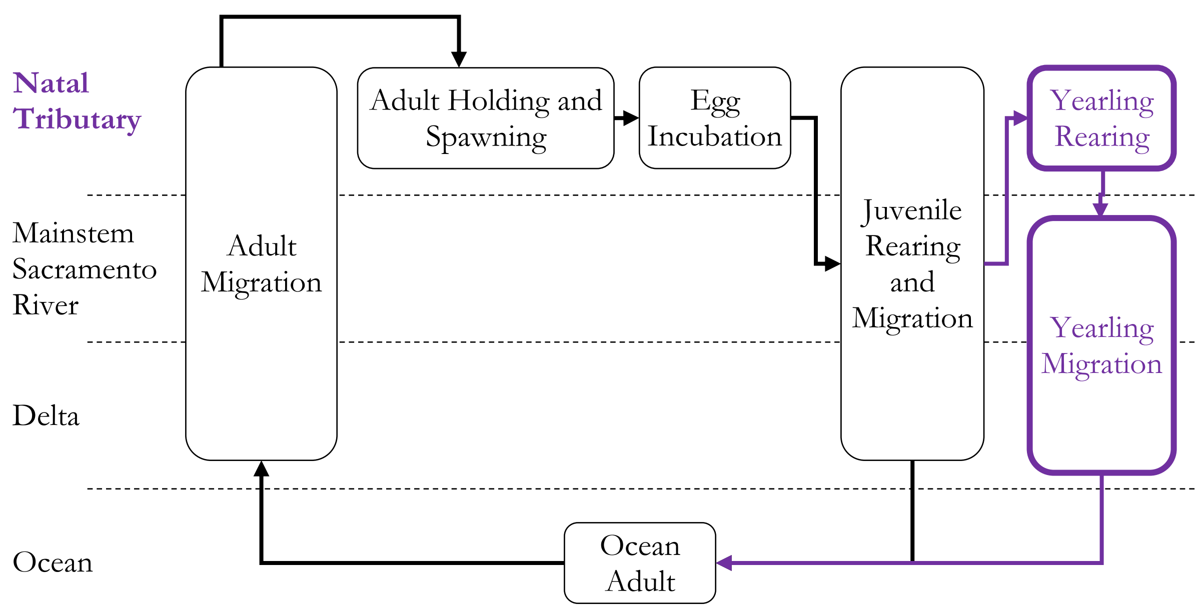

Figure 3. Geographic Life Stage Domains for Spring-Run Chinook Salmon (adapted from Windell et al. 2017, Figure 2)

In addition to the winter-run Chinook salmon life stages and stressors, the proposed conceptual lifecycle framework for spring-run considers two additional life stages that include stressors from the winter-run Chinook salmon Juvenile Rearing to Outmigration hypotheses:

- Yearling Rearing
    - H1: Toxicity and contaminants
    - H6: Stranding risk
    - H5: Outmigration cues
    - H7: Water temperature and DO
    - H8: Pathogens and disease
    - H9: Entrainment risk
    - H3: Refuge habitat
    - H4: Food availability and quality
    - H2: Predation and competition
- Yearling Migration
    - H1: Toxicity and contaminants
    - H6: Stranding risk
    - H5: Outmigration cues
    - H7: Water temperature and DO
    - H8: Pathogens and disease
    - H9: Entrainment risk
    - H3: Refuge habitat
    - H4: Food availability and quality
    - H2: Predation and competition

Each deconstruction of the action considers the stressors for the winter-run life stages and the additional two spring-run life stages. Additional and/or alternative conceptual models (e.g., CVPIA Science Integration Team, South Delta Salmonid Research Collaborative) may be incorporated as applicable.

Monitoring data from snorkeling, carcass surveys, redd surveys, rotary screw traps, trawls, and beach seines describe the timing of spring-run Chinook salmon presence (Figure 4) (Appendix C).

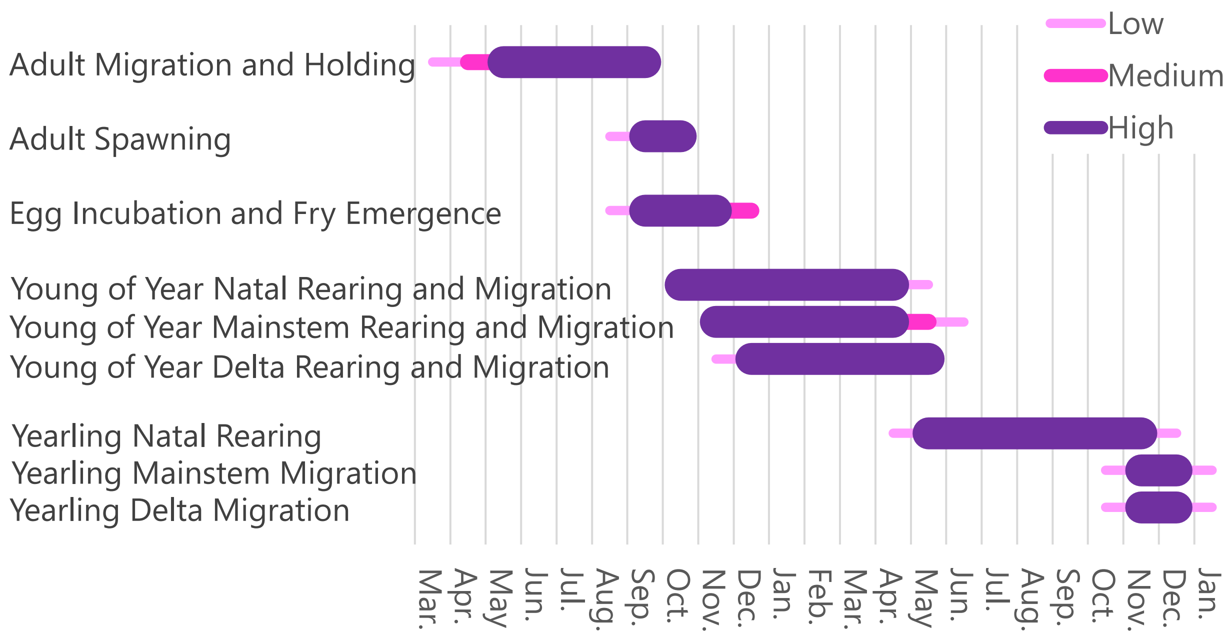

Figure 4. Temporal Life Stage Domains for Spring-Run Chinook Salmon from Appendix C

The three spatial domains defined for spring-run are the Sacramento River, Clear Creek, and the Bay-Delta Central Valley and Bay-Delta presence for young of year and yearling rearing span more than one year. The ocean life stage is outside the action area determined by NMFS and therefore is not shown.

3.2 Species Effects Deconstruction

Spring-run are primarily anticipated in the Sacramento River, Clear Creek, and the Delta and may experience effects from components of seasonal operations as described below. The Sacramento River includes migrating, holding, and spawning adults; egg incubation below Keswick Dam; and rearing and migrating juveniles and yearlings. Clear Creek includes migrating, holding, and spawning adults; egg incubation; and rearing and migrating juveniles and yearlings. The Bay-Delta includes migrating adults, rearing and migrating juveniles, and migrating yearlings.

3.2.1 Sacramento River

In the winter, Reclamation and DWR’s proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flows in the upper Sacramento River may change stressors on spring-run.

Adults are not present in the upper Sacramento River in the winter.

Yearlings are rearing and migrating in the upper Sacramento River. The amount of time spent rearing in the upper Sacramento River varies before yearlings migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting the upper Sacramento River varies among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, yearlings rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, yearlings can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen (DO) stressors are not anticipated to change with decreased flows. Passing of flows through Shasta Reservoir results in warmer water temperatures in the winter; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors may or may not increase due to crowding in smaller habitat areas. Yearling survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin yearlings. This has not been observed in juvenile monitoring during the winter.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may increase due to decreased flow causing less suitable margin and off-channel habitats to be available for yearlings.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the upper Sacramento River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating yearlings. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of yearlings.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating yearlings. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

Juveniles are rearing and migrating in the upper Sacramento River in the winter. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and DO stressors are not anticipated to change. Passing of flows through Shasta Reservoir results in warmer water temperatures in the winter; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors may or may not increase due to crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. This has not been observed in juvenile monitoring during the winter.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may increase due to decreased flows causing less suitable margin and off-channel habitats to be available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the upper Sacramento River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

Eggs are not present in the upper Sacramento River.

In the spring, Reclamation and DWR's proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flows in the upper Sacramento River may change stressors on spring-run.

Adults are migrating and holding in the upper Sacramento River in the spring. Adults move into the upper watershed where they hold until ready for spawning, undergoing an energetically taxing salt-to-freshwater transition. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery and poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the upper Sacramento River during the spring. Poaching may impact adult survival during migration.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding has many possible effects on migrating adults, several of which may be linked to other stressors including exposure to higher water temperatures and low dissolved oxygen levels.

Water temperature stressors are not anticipated change. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding. The decrease in flows results in warmer water temperatures in the winter; however, spring temperatures are colder than adult migration and holding temperature needs.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogen stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult spring-run Chinook using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. These competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. There is no spring-run Chinook hatchery in the upper Sacramento River, so genetic introgression is not a stressor.

Juveniles are rearing and migrating in the upper Sacramento River in the spring After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual’s physiological stage and condition and hydrologic conditions. Historically peak juvenile abundance occurs in the winter; however, migration can occur through May, especially during dry water years. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring late-season precipitation events.

Outmigration cues stressors may increase due to lower flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and DO stressors are not anticipated to change. Passing of flows through Shasta Reservoir results in warmer water temperatures in the spring; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors may or may not increase due to decreased flows and potential crowding in smaller habitat areas and less flushing flows. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. This has not been observed in juvenile monitoring during the spring.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may increase due to decreased flows causing less suitable margin and off-channel habitats to be available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the upper Sacramento River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

Yearlings are rearing in the upper Sacramento River in the spring. The amount of time spent rearing in the upper Sacramento River varies before yearlings migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting the upper Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. During rearing, prior to outmigration, yearlings rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, yearlings can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring late-season precipitation events.

Outmigration cues stressors may increase due to lower flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and DO stressors are not anticipated to change. Passing of flows through Shasta Reservoir results in warmer water temperatures in the spring; however, water temperatures are colder than yearling rearing needs.

Pathogens and disease stressors may or may not increase due to decreased flows that cause crowding in smaller habitat areas and less flushing flows. Yearling survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin fish. This has not been observed in juvenile monitoring during the spring.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may increase due to decreased flows causing less suitable margin and off-channel habitats to be available for rearing yearlings.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the upper Sacramento River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for rearing yearlings. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of yearlings.

Predation and competition are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for rearing yearlings. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

Eggs are not present in the upper Sacramento River in the spring.

In the summer, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Keswick Dam. Increased flows in the upper Sacramento River may change stressors on spring-run.

Adults are migrating and holding in the upper Sacramento River. Adults move into the upper watershed where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery and poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the upper Sacramento River during the summer. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on the Sacramento River.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may decrease from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the summer has not been observed in the upper Sacramento River due to seasonal operations.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the Sacramento River, reducing their spawning success. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures (Appendix H).

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogen stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult spring-run Chinook. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon.

Spawning habitat stressors are not anticipated to change. Increased flows may decrease stressors by increasing spawning habitat quantity and quality. An increase in flows may improve spawning habitat; however, no known habitat would be additionally inundated.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit spring-run in the summer. Broodstock removal stressors are not anticipated to change.

Juveniles are not present in the upper Sacramento River in the summer.

Yearlings are rearing in the upper Sacramento River in the summer. The amount of time spent rearing in the upper Sacramento River varies before yearlings migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting the upper Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Yearling growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance.

Stranding risk stressors may decrease due to increased flows in marginal habitat channels and decreases yearling stranding risk during the summer.

Outmigration cues stressors may or may not decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range, which may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures or DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of yearlings. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due to increased flows causing more suitable margin and off-channel habitats to be available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease yearlings' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue yearlings to rear longer and grow larger in the middle Sacramento River

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento are highly channelized with low complexity and little cover from predators for rearing yearlings. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on rearing and outmigrating yearlings. Increased flows increase travel rates of rearing yearlings, which change behavior to outmigrating yearlings, exposing them to less predator pressure.

Eggs are not present in the upper Sacramento River in the summer.

In the fall, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Keswick Dam. Increased flows in the upper Sacramento River may change stressors on spring-run.

Adults are migrating, holding, and spawning in the upper Sacramento River in the fall. Adults move into the upper watershed where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery or poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the upper Sacramento River during the fall. Increased flows may make them more vulnerable to poaching; however, this effect has not been observed on the Sacramento River.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the Sacramento River, reducing their spawning success. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogen and disease stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult spring-run Chinook. Water temperature-related effects are section the water temperature stressor.

Spawning habitat stressors are not anticipated to change. Increased flows may decrease stressors by increasing spawning habitat quantity and quality. An increase in flows may improve spawning habitat; however, no known habitat would be additionally inundated.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit spring-run in the fall. Broodstock removal stressors are not anticipated to change.

Juveniles are rearing and migrating in the middle Sacramento River. The amount of time spent rearing in the upper Sacramento River varies before juveniles migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting the middle Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may or may not increase from increased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during fall month seasonal operations and/or precipitation events.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due to increased flows causing more suitable margin and off-channel habitats to be available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the middle Sacramento River

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

Yearlings are rearing and migrating in the middle Sacramento River. The amount of time spent rearing in the upper Sacramento River varies before yearlings migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting the middle Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and yearling condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Yearling growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may or may not increase from increased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during fall month seasonal operations and/or precipitation events.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range, which may affect growth rate and result in direct mortality if yearlings experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of yearlings. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due increased flows causing more suitable margin and off-channel habitats to be available for yearlings. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease yearlings' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue yearlings to rear longer and grow larger in the middle Sacramento River

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento are highly channelized with low complexity and little cover from predators for outmigrating yearlings. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating yearlings. Increased flows increase travel rates of outmigrating yearlings exposing them to less predator pressure.

Eggs are present in the upper Sacramento River in the fall. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors may decrease due to higher flows creating more available habitat. Recreational fishing and other human activity such as trampling can reduce eggs and alevin survival in the redd.

Toxicity and contaminants stressors may decrease due to increased flows to dilute contaminants effects on this sensitive life stage. Contaminants are one habitat attribute that influences the survival of eggs. An increase of flows may decrease stress caused by compounding effects of toxicity and increased water temperature if increased flows cool in-river temperatures.

Stranding and dewater stressors may or may not decrease due to increased flows and seasonal flow fluctuations. Since redds may be at risk of dewatering when releases from Keswick Dam decrease after adult spawning has occurred, an increase of flows may decrease redd dewatering stressors. Potential redd dewatering increases at flows less than 6,000 cfs; and redd dewatering stressors may increase due to seasonal flow fluctuations.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, and warmer water temperature affects egg and alevin development rates, physiological stress, and survival. Additionally, water temperature affects stream saturation concentration of DO. DO related effects are addressed in the DO stressor section. Increased flows may also cool in-river temperatures. Water temperature will be addressed further in coldwater pool conservation measures.

DO stressors may decrease due to increased flows. Egg and alevin emergence is affected by dissolved oxygen, which is one habitat attribute in the redds. Increased flows may increase velocities, which may increase dissolved oxygen concentrations, positively impacting egg and alevin emergence.

Pathogens and disease stressors may or may not decrease due to increased flows. Increased flows may improve flow circulation in the redd and maintain egg condition and reduce pathogen transmission. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility of eggs. Water temperature-related effects are addressed in the water temperature stressor section.

Sedimentation and gravel quantity stressors may decrease due to increased flow. Egg and alevin emergence is affected by sedimentation and gravel quantity. Increased flows may remove fine sediment, which may compromise egg and alevin essential functions, stunting development. Flows in the summer are less than channel-forming flows with little, if any, scour.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Increased flow may reduce aquatic vegetation and may improve hydrologic and biological connectivity within the streambed that improve egg survival and alevin emergence. Increased flow does not affect gravel size but may affect quantity. Gravel quantity-related effects are addressed in sedimentation and gravel quantity section. The seasonal operation of the CVP to increase flows is not anticipated to change redd quality stressors.

Predation risk stressors are not anticipated to change.

3.2.2 Clear Creek

In the winter, Reclamation and DWR’s proposed storage of water will decrease flows on average in Clear Creek below Whiskeytown. Decreased flows in Clear Creek may change stressors on spring-run.

Adults are not present in Clear Creek in the winter.

Yearlings are rearing and migrating in Clear Creek. The amount of time spent rearing in Clear Creek varies before yearlings migrate into the upper and middle reaches of the Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years, although yearling presence in low. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration. Yearling juveniles are not observed in measurable numbers in the winter in Clear Creek.

Toxicity and contaminants stressors are not anticipated to change. During outmigration yearlings rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering in marginal habitat channels. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may occur with stranding risk stressors decreasing from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to decreased flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and DO stressors are not anticipated to change. The passing of flows through Whiskeytown reservoir results in warmer water temperatures in the winter; however, water temperatures are colder than yearling rearing and migration needs.

Pathogens and disease stressors are not anticipated to change. Yearling survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River and its tributaries. This has not been observed in juvenile monitoring during the winter.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may increase due to decreased flows causing less suitable margin and off-channel habitats to be available for juveniles.

Food availability and quality stressors may or may not increase due to decreased flows causing less inundated habitats in some areas. As yearlings migrate through Clear Creek into the reaches of the upper Sacramento, they encounter a highly channelized habitat with low complexity and a low abundance of prey for outmigrating yearlings. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of yearlings.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors’ sections.

Juveniles are rearing and migrating in Clear Creek. The amount of time spent rearing in Clear Creek varies before yearlings migrate into the upper and middle reaches of the Sacramento River. This habitat is primarily used for rearing and as a through-way to the Sacramento River and Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and DO stressors are not anticipated to change. Passing of flows through Shasta Reservoir results in warmer water temperatures in the winter; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors may or may not increase due to crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. This has not been observed in juvenile monitoring during the winter.

Entrainment risk stressors are not expected to change on Clear Creek in the winter due to seasonal operations.

Refuge habitat stressors may increase due to less suitable habitat being activated in some areas.

Food availability and quality stressors may increase due to decreased flow causing less inundated acres in some areas. A juveniles migrate through Clear Creek into the reaches of the upper Sacramento River, they encounter a highly channelized habitat with low complexity and a low abundance of prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors sections.

Eggs are not present in Clear Creek in the winter

In the spring, Reclamation and DWR's proposed release of water will decrease flows on average in Clear Creek below Whiskeytown. Decreased flows in Clear Creek may change stressors on spring-run.

Adults are migrating and holding in Clear Creek.

In-river fishery and poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the Clear Creek during the spring. Poaching may impact adult survival during migration.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases. Stranding has many possible effects on migrating adults, several of which may be linked to other stressors including exposure to higher water temperatures and low dissolved oxygen levels. Stranding of adults has not been observed in Clear Creek.

Water temperature stressors are not anticipated change. The decrease in flows results in warmer water temperatures in the winter; however, spring temperatures are colder than adult migration and holding temperature needs.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogen stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult spring-run Chinook using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. These competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. There is no spring-run Chinook hatchery in the upper Sacramento River, so genetic introgression is not a stressor. Broodstock removal stressors are not anticipated to change.

Juveniles are rearing and migrating in Clear Creek. The amount of time spent rearing in Clear Creek varies before yearlings migrate into the upper and middle reaches of the Sacramento River. This habitat is primarily used for rearing and as a through-way to the Sacramento River and Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years, although presence in low. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring late-season precipitation events.

Outmigration cues stressors may increase due to lower flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and DO stressors are not anticipated to change. Passing of flows through Whiskeytown in the spring results in warmer water temperatures in the spring; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors are not anticipated to change during the spring in Clear Creek.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to decreased flows causing less inundated areas. As juveniles migrate through Clear Creek into the reaches of the upper Sacramento, they encounter a highly channelized habitat with low complexity and a low abundance of prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the Clear Creek are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

Yearlings are rearing in Clear Creek. The amount of time spent rearing in Clear Creek varies before yearlings migrate into the upper and middle reaches of the Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration. Yearling juveniles are not observed in measurable numbers in the spring in Clear Creek.

Toxicity and contaminants stressors are not anticipated to change. During rearing, prior to outmigration, yearlings rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, yearlings can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring late-season precipitation events.

Outmigration cues stressors may increase due to lower flows. Spring-run use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and DO stressors are not anticipated to change. Passing of flows through Whiskeytown in the spring results in warmer water temperatures in the spring; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors are not anticipated to change during the spring in Clear Creek.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to decreased flows causing less inundated areas. As juveniles migrate through Clear Creek into the reaches of the upper Sacramento, they encounter a highly channelized habitat with low complexity and a low abundance of prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the Clear Creek are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors’ sections.

Eggs are not present in Clear Creek between in the spring.

In the summer, Reclamation and DWR's release of water will increase flows on average in Clear Creek below Whiskeytown. Decreased flows in Clear Creek may change stressors on spring-run.

Adults are migrating and holding in Clear Creek.

In-river fishery and poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the Clear Creek River during the fall. Increased flows may make them more vulnerable to poaching; however, this effect has not been observed on the Sacramento River.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Increased flows may reduce contaminant loading of toxins from sources like stormwater runoff and mines, which may reduce spawning success or cause adult mortality.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the Sacramento River, reducing their spawning success. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogen stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult spring-run Chinook. Water temperature-related effects are addressed in the water temperature stressor section.

Spawning habitat stressors are not anticipated to change. Increased flows may decrease stressors by increasing spawning habitat quantity and quality. An increase in flows may improve spawning habitat; however, no known habitat would be additionally inundated.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit spring-run in the fall. Broodstock removal stressors would not change due to decreased flows.

Juveniles are not present in Clear Creek in the summer.

Yearlings are rearing in Clear Creek. The amount of time spent rearing in Clear Creek varies before yearlings migrate into the upper and middle reaches of the Sacramento River. This habitat is primarily used for rearing and as a through-way to the Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration. Yearling juveniles are not observed in measurable numbers in the summer in Clear Creek.

Toxicity and contaminants stressors are not anticipated to change. Yearling growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may or may not increase from increased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during fall month seasonal operations and/or precipitation events.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range, which may affect growth rate and result in direct mortality if yearlings experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not increase due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of yearlings. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility. Pathogen and disease stressor effects, such as reduced growth and mortality, have not been observed in yearlings in Clear Creek in the summer.

Entrainment risk stressors are not anticipated to change in the summer on Clear Creek due to increased flows.

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for yearlings. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease yearlings' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue yearlings to rear longer and grow larger in the middle Sacramento River

Predation and competition stressors are not anticipated to change. Reaches of the Clear Creek are highly channelized with low complexity and little cover from predators for rearing yearlings. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources.

Eggs are not present in Clear Creek in the summer.

In the fall, Reclamation and DWR's proposed release of water will increase flows on average in Clear Creek below Whiskeytown. Release of water is an absolute action. Increased flows in Clear Creek may change stressors on spring-run.

Adults are holding and spawning in Clear Creek. Adults move into the upper watershed where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery or poaching stressors may decrease due to increased flows. Chinook fishing is closed in Clear Creek during the fall. Seasonal operation of the CVP is not anticipated to change poaching stressors.

Toxicity from contaminants stressors may decrease from increased flows to dilute contaminants. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality. Seasonal operation of the CVP is anticipated to decrease toxicity from contaminant stressors.

Stranding risk stressors are not anticipated to change for adults in the fall.

Water temperature stressors may decrease due to increased flows. Increased flows may provide cooler water temperatures that generally increase DO and reduce physiological stress and metabolic rates for adults. Seasonal operation of the CVP to increase flows is anticipated to decrease water temperature stressors.

Dissolved oxygen stressors may decrease due to increased flows. Dissolved oxygen generally decreases with an increase in water temperatures. This decrease can increase physiological stress and metabolic rates for adults. The seasonal operation of the CVP to increase flows is anticipated to decrease DO stressors.

Pathogen and disease stressors may or may not decrease due to increased flows. Crowding may be reduced due to increased flows. Decreased density of adults may decrease the potential for lateral transmission of disease; however, lateral transmission is not known to be a limiting factor. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility. Water temperature-related effects are addressed in the water temperature stressor section.

Spawning habitat stressors may decrease due to more habitat availability. Increased flows may decrease stressors by increasing spawning habitat availability.

Competition, introgression, and broodstock removal stressors may decrease due to more available habitat and food availability. Crowding of adults may be reduced due to increased flow. An increase in flows may decrease competition; however, crowding is not known to limit spring-run adults in the fall in Clear Creek.

Juveniles are rearing and migrating in Clear Creek. The amount of time spent rearing in Clear Creek is limited before migrating into the upper and middle reaches of the Sacramento River, and juveniles' presence is very high in the fall. This habitat is primarily used for rearing and migrating and as a through-way to the Sacramento River and Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may or may not increase from increased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during fall month seasonal operations and/or precipitation events.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility. Pathogen and disease stressor effects, such as reduced growth and mortality, have not been observed in juveniles in Clear Creek in the fall.

Entrainment risk stressors are not anticipated to change in the fall in Clear Creek due to increased flows.

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the middle Sacramento River

Predation and competition stressors are not anticipated to change. Reaches of Clear Creek are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

Yearlings are rearing and migrating in Clear Creek. The amount of time spent rearing in Clear Creek varies before yearlings migrate into the upper and middle reaches of the Sacramento River. This habitat is primarily used for rearing and as a through-way to the Sacramento River and Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and condition (some affecting several parameters) during the migration. Yearling juveniles are not observed in measurable numbers in the fall in Clear Creek.

Toxicity and contaminants stressors are not anticipated to change. Yearling growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may or may not increase from increased flows in areas prone to dewatering when flows are reduced. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during fall month seasonal operations and/or precipitation events.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range, which may affect growth rate and result in direct mortality if yearlings experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of yearlings. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility. Pathogen and disease stressor effects, such as reduced growth and mortality, have not been observed in yearlings in Clear Creek in the fall.

Entrainment risk stressors are not anticipated to change in the fall in Clear Creek due to increased flows.

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for yearlings. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease yearlings' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor.

Food availability and quality stressors may decrease due to more inundated acres in some areas. As yearlings rear and migrate through Clear Creek, they encounter a highly channelized habitat with low complexity and a low abundance of prey for outmigrating yearlings. Access to quality food may cue yearlings to rear longer and grow larger in the middle Sacramento River

Predation and competition stressors are not anticipated to change. Reaches of Clear Creek are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

Eggs are present in Clear Creek. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors may decrease due to higher flows creating more available habitat. Recreational fishing and other human activity such as trampling can reduce eggs and alevin survival in the redd.

Toxicity and contaminants stressors may decrease due to increased flows to dilute contaminants effects on this sensitive life stage. Contaminants are one habitat attribute that influences the survival of eggs. An increase of flows may decrease stress caused by compounding effects of toxicity and increased water temperature if increased flows cool in-river temperatures.

Stranding and dewater stressors may or may not decrease due to increased flows and seasonal flow fluctuations. Spring-run Chinook salmon redd dewatering has not been observed in Clear Creek due to increased flows in the fall.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, and warmer water temperature affects egg and alevin development rates, physiological stress, and survival. Additionally, water temperature affects stream saturation concentration of DO. DO related effects are addressed in the DO stressor section. Increased flows may also cool in-river temperatures. Water temperature will be addressed further in coldwater pool conservation measures.

DO stressors may decrease due to increased flows. Egg and alevin emergence is affected by dissolved oxygen, which is one habitat attribute in the redds. Increased flows may increase velocities, which may increase dissolved oxygen concentrations, positively impacting egg and alevin emergence.

Pathogens and disease stressors may or may not decrease due to increased flows. Increased flows may improve flow circulation in the redd and maintain egg condition and reduce pathogen transmission. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility of eggs. Water temperature-related effects are addressed in the water temperature stressor section.

Sedimentation and gravel quantity stressors may decrease due to increased flow. Egg and alevin emergence is affected by sedimentation and gravel quantity. Increased flows may remove fine sediment, which may compromise egg and alevin essential functions, stunting development. Flows in the summer are less than channel-forming flows with little, if any, scour.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Increased flow may reduce aquatic vegetation and may improve hydrologic and biological connectivity within the streambed that improve egg survival and alevin emergence. Increased flow does not affect gravel size but may affect quantity. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section. The seasonal operation of the CVP to increase flows is not anticipated to change redd quality stressors.

3.2.3 Bay-Delta

In the winter, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on spring-run.

Adults are migrating in the Delta. Adults are undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified to possibly delay adult migration, decrease adult survival during migration, or increase energy necessary to undergo the transition.

In-river fishery and poaching stressors are not anticipated to change. No Chinook fishing is allowed in the Delta in the winter. Poaching may impact adult survival during migration and can cause migration delays.

Toxicity and contaminants stressors are not anticipated to change.

Stranding risk stressors are not anticipated to change. Flows from the upper and middle Sacramento River into the Bay-Delta can be routed through agricultural lands, creating false cues for migrating adults. These false cues can divert adults, causing stranding, which may delay migration.

Water temperature stressors are not anticipated to change.

Dissolved oxygen stressors are not anticipated to change.

Pathogens stressors are not anticipated to change.

Eggs are not present.

Juveniles are rearing and migrating in the Delta. Juvenile use of the Bay-Delta varies both within and among years. During the winter months, some early migrants can leave the Delta, though migration can occur through May. A large storm pulse during the winter may cue juveniles rearing in the middle Sacramento River to migrate into the Bay-Delta, but in years without a storm pulse or pulses, juveniles historically migrate in a single pulse during late winter. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate and reducing travel rates in the Delta, which may reduce outmigration survival. Juveniles may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants. That is addressed in the toxicity and contaminants stressors section.

Water temperature and DO stressors are not anticipated to change.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence juveniles' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta is not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors may or may not increase due to less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

Yearlings are migrating in the Delta. Yearling use of the Bay-Delta varies both within and among years. During the winter months, some early migrants can leave the Delta, though migration can occur through May. A large storm pulse during the winter may cue yearlings rearing in the middle Sacramento River to migrate into the Bay-Delta, but in years without a storm pulse or pulses, yearlings historically migrate in a single pulse during late winter. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change. During outmigration yearlings rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate and reducing travel rates in the Delta, which may reduce outmigration survival. Yearlings may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants. That is addressed in the toxicity and contaminants stressors section.

Water temperature and DO stressors are not anticipated to change.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence yearlings' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta is not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors may increase due to decreased flows. Decreased flow may cause less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

In the spring, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on spring-run.

Adults are migrating in the Delta. Adults move through the Bay-Delta into reaches of the Middle and upper Sacramento River, where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery and poaching stressors are not anticipated to change. There is no Chinook salmon fishing permitted in the Delta in the spring.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change.

Water temperature stressors are not anticipated to change.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally decreases with an increase in water temperatures. This decrease can increase physiological stress and metabolic rates for adults.

Pathogen stressors are not anticipated to change. Decreased flows in the Delta do not affect crowding or the density of winter-run Chinook salmon, which may increase transmission of disease or pathogens.

Eggs are not present in the Delta.

Juveniles are rearing and migrating in the Delta. Juvenile use of the Bay-Delta varies both within and among years. During the spring months, some early migrants can leave the Delta, though migration can occur through May. A large storm pulse during the winter may cue juveniles rearing in the middle Sacramento River to migrate into the Bay-Delta, with a second pulse between February and March. The majority of the population is present within the Bay-Delta during the spring. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate. Juveniles may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants.

Water temperature and DO stressors are not anticipated to change.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR reverse flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may increase entrainment risk stressors for juveniles within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence juveniles' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta are not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors may increase due to decreased flows. Decreased flow may create less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

Yearlings are not present in the Delta in the spring.

In the summer, Reclamation and DWR's proposed water operation will decrease Delta outflow on average.

Adults are not present in the Delta in the summer.

Eggs are not present in the Delta in the summer.

Juveniles are not present in the Delta in the summer.

Yearlings are not present in the Delta in the summer.

In the fall, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on spring-run.

Adults are not present in the fall.

Juveniles are not present in the fall.

Eggs are not present in the fall.

Yearlings are migrating in the Delta. Yearling use of the Bay-Delta varies both within and among years. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate. Yearlings may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants.

Water temperature and DO stressors are not anticipated to change.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR reverse flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may increase entrainment risk stressors for yearlings within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence yearlings' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta are not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors are not anticipated to change due to decreased outflow. Decreased flow may cause less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence yearling salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating yearlings.

3.3 Species Effects Determination

The seasonal operation of the CVP and SWP may affect, and is likely to adversely affect, Central Valley spring-run Chinook salmon. The seasonal operation of the CVP is also likely to have beneficial effects. Deconstruction of the seasonal operations systematically evaluated each stressor identified by conceptual models. Stressors not linked to the operation of the CVP and SWP were identified as "are not anticipated to change." Stressors that were insignificant or discountable were documented. Stressors with a material effect on the fitness of species were identified, and seasonal operations will consider minimization and/or compensation through conservation measures.

Stressors on **adults** influenced by the seasonal operations include:

- Water temperatures: Increased flows are anticipated to increase water temperature stressors in the Sacramento River and Clear Creek. A conservation measure for Sacramento River and Clear Creek water temperature that considers flows may benefit water temperatures for some adults and adversely affect others. Managing water temperatures for egg incubation provides colder waters than needed for adults, but that management action may start later in the year, depending on seasonal operations.
- Spawning habitat: Decreased flows may provide less habitat availability and may increase crowding. A conservation measure for maintenance and construction of spawning habitat may minimize or benefit potential spawning habitat.
- Redd Dewatering: The transition between seasonal summer and fall releases below Keswick Dam may increase spring-run Chinook redd dewatering in the Sacramento River. A conservation measure for fall instream flows may minimize potential dewatering.

Stressors on **yearlings** influenced by the seasonal operations include:

- Stranding risk: Reduced releases below Keswick Dam and Whiskeytown Dam during the yearling rearing period (November through April) pose a stranding risk to yearlings. A conservation measure for ramping rates may avoid or minimize the potential for yearling stranding.

- Outmigration cues: The change in timing of flows in the Sacramento River, Clear Creek and Bay-Delta during the yearling outmigration period may disrupt outmigration cures and reduce survival. Conservation measures for minimum instream flows and pulse flows may avoid or minimize outmigration cue stressors.
- Entrainment risk: All CVP and SWP facilities have fish screens. However, juveniles may be entrained at the Delta Cross Channel and routed into areas of the Delta with poor survival by the export facilities or entrained at the salvage facilities for the CVP and SWP. Several actions may avoid, minimize, or benefit the potential for Bay-Delta juvenile entrainment including a conservation measure for the Delta Cross Channel, a conservation measure for routing at Georgiana Slough, a conservation measure for Old and Middle River flow management, and a conservation measure for salvage before the export facilities.
- Refuge habitat: Decreased flows may provide decreased habitat availability. A conservation measure for the construction of additional rearing habitat on the Sacramento River and Clear Creek may minimize or benefit potential refuge habitat.
- Food availability and quality: Decreased flows may provide less food availability through a reduction in suitable feeding areas. A conservation measure for the construction of additional tributary and tidal rearing habitat may minimize or benefit food availability and quality.

Stressors on **juveniles** influenced by the seasonal operations include:

- Stranding risk: Reduced releases below Keswick Dam and Whiskeytown Dam during the juvenile rearing period (November through April) pose a stranding risk to yearlings. A conservation measure for instream minimum flows and ramping rates may avoid or minimize the potential for yearling stranding.
- Outmigration cues: The change in timing of flows in the Sacramento River, Clear Creek and Bay-Delta during the yearling outmigration period may disrupt outmigration cures and reduce survival. Conservation measures for minimum instream flows and spring pulse flows may avoid or minimize outmigration cue stressors.
- Entrainment risk: All CVP and SWP facilities have fish screens. However, juveniles may be entrained at the Delta Cross Channel and routed into areas of the Delta with poor survival by the export facilities or entrained at the salvage facilities for the CVP and SWP. Several actions may avoid, minimize, or benefit the potential for Bay-Delta juvenile entrainment including a conservation measure for the Delta Cross Channel, a conservation measure for routing at Georgiana Slough, a conservation measure for Old and Middle River flow management, and a conservation measure for salvage before the export facilities.
- Refuge habitat: Decreased flows may provide decreased habitat availability. A conservation measure for the construction of additional rearing habitat on the Sacramento River and Clear Creek may minimize or benefit potential refuge habitat.

- Food availability and quality: Decreased flows may provide less food availability through a reduction in suitable feeding areas. A conservation measure for the construction of additional tributary and tidal rearing habitat may minimize or benefit food availability and quality

Stressors on **eggs and alevins** influenced by the seasonal operations include:

- Stranding: The transition between seasonal summer and fall releases below Keswick Dam may increase spring-run Chinook stranding in the Sacramento River. A conservation measure for fall instream flows may minimize potential dewatering.
- Water temperatures and dissolved oxygen: The management of cold water in Whiskeytown Reservoir and Shasta Reservoir is necessary to maintain suitable water temperature for egg incubation. Management actions for Sacramento River and Clear Creek water temperature management that considers seasonal operations may benefit some eggs and alevin and adversely affect others.

3.4 Critical Habitat Physical and Biological Features

Critical habitat has been designated for spring-run (70 FR 52488, September 2, 2005) and includes all river reaches accessible to listed spring-run in the Sacramento River and its tributaries in California. Also included were river reaches and estuarine areas of the Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge.

The critical habitat for spring-run lists the essential physical and biological features, which include:

3.4.1 Spawning Sites

Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development is essential for the conservation of spring-run. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.

The species effects determination found related potential stressors of:

- Spawning habitat
- Water temperatures
- Dewatering

There are no additional operation effects on spawning sites when species are not present.

3.4.2 Rearing Sites

Freshwater rearing sites with the following criteria are essential for the conservation of spring-run: water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them juveniles cannot access and utilize areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) for survival.

The species effects determination found related potential stressors of:

- Water temperature
- Juvenile stranding
- Refuge habitat
- Food availability and quality

There are no additional operation effects on rearing sites when species are not present.

3.4.3 Migration Corridors

Freshwater migration corridors with the following criteria are essential for the conservation of spring-run: habitat free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.

The species effects determination found related potential stressors of:

- Outmigration cues
- Refuge habitat
- Food availability and quality
- Entrainment Risk

There are no additional operation effects on migration corridors when species are not present

3.4.4 Estuarine Areas

Estuarine areas with the following criteria are essential for the conservation of spring-run: habitat free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh-and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.

The species effects determination found related potential stressors of:

- Outmigration cues
- Refuge habitat
- Food availability and quality

There are no operation effects on estuarine areas when species are not present.

3.5 Critical Habitat Effect Determination

The seasonal operation is likely to adversely affect critical habitat for Central Valley spring-run Chinook salmon.

- Degraded spawning substrate is reintroduced in the action area through gravel augmentation projects.
- Impacts to juvenile rearing habitat and migration corridors are compensated through the construction of additional habitat and implementing recommendations based on new research.
- Impacts to juvenile passage from the Sacramento River to the Pacific Ocean are actively managed through spring pulse flows, minimum instream flows, fall and winter instream flows, Old and Middle River flow management.

4. Steelhead

The federally listed ESU of California Central Valley steelhead distinct population segment (*Oncorhynchus mykiss*) (steelhead) and designated critical habitat occurs in the action area and may be affected by the seasonal operations of the CVP. Steelhead exhibit the most complex suite of life history traits of any species of Pacific salmonid. *O. mykiss* may migrate to the ocean as listed anadromous steelhead or remain a freshwater resident as non-listed rainbow trout. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death; however, iteroparity in California steelhead populations is considered relatively rare (Moyle 2002), and it is rare for steelhead to spawn more than twice before dying. Anadromous adults migrating downstream after spawning are termed "kelts." Steelhead and rainbow trout are present in nearly every Central Valley tributary.

4.1 Conceptual Lifecycle Models

An action may affect fish when the change in conditions overlap with the location and timing of fish and/or their habitats. The SAIL winter-run Chinook salmon conceptual model (Windell et al. 2017) has been adapted for steelhead by generalizing to natal tributaries and with the addition of an adult emigration element of life history as well as the consideration of resident rainbow trout to describe life stages and geographic locations for this effects analyses (Figure).

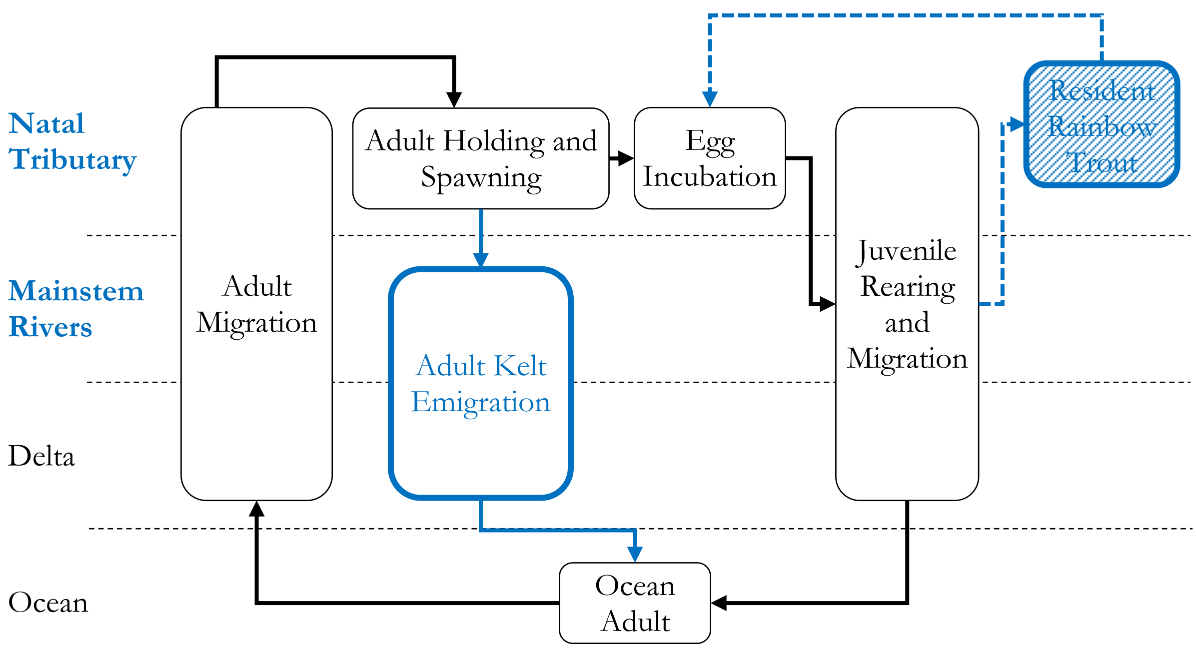

Figure 5. Geographic Life Stage Domains for Steelhead (adapted from Windell et al. 2017, Figure 2)

In addition to the winter-run Chinook salmon life stages and stressors, the proposed conceptual lifecycle framework for steelhead considers two additional life stages, resident rainbow trout and kelts.

The stressors are deconstructed as follows:

- Resident Rainbow Trout
    - Water Temperature
    - Food availability and quality
    - Streamflow
- Adult Kelt Emigration
    - Freshwater entry and post-spawning (kelt) emigration
    - Residual Lipid Content of White Muscle Post-Spawning
    - Pathogens
    - Predation risk

Each deconstruction of the action considers the 38 stressors for the winter-run life stages and the additional two steelhead life stages. Additional and/or alternative conceptual models (e.g., CVPIA Science Integration Team, South Delta Salmonid Research Collaborative) may be incorporated as applicable.

Environmental conditions such as food availability, water temperature, and stream flow can influence the expression of anadromy in *O. mykiss* (Beakes and Phillis 2021). For example, low and variable summer stream flows produce warmer temperatures and greater competition for food as suitable habitat contracts. When conditions limit growth due to density-dependent competition or increasing metabolic demands of the individual anadromy becomes more common (Pearsons et al. 2008; Courter et al. 2009; Berejikian et al. 2013). In contrast, cooler temperatures and lower individual metabolic rates produce higher rates of freshwater maturation for equivalent somatic growth, particularly in females (McMillan et al. 2012; Sloat and Reeves 2014). The propensity of individuals to adopt the anadromous life history (i.e., steelhead) is the product of interactions between genetic and environmental factors. Recent research has shown some gene complexes associated with anadromy (e.g., Omy5) indirectly impact life-history expression through mediation of early somatic growth rates (Kelson et al. 2020). Further, past research has shown the expression of anadromy is related to an individual's state during their juvenile rearing phase and a genetically controlled size threshold required to initiate smolt transformation and anadromy (Tomkins and Hazel 2007; Hutchings 2011; Pulido 2011; Dodson et al. 2013). Growth rate and body-size thresholds above which anadromy is adopted have been described theoretically (Thorpe et al. 1998; Rikardsen et al. 2004; Mangel and Satterthwaite 2008) and documented empirically for steelhead (Thrower et al. 2004; Satterthwaite et al. 2010; Beakes et al. 2010; Phillis et al. 2016). The outcome of these genetic-environment interactions will vary within populations (e.g., males vs. females) and between populations according to the costs and benefits of alternative life history pathways.

For kelts, much of the available information on repeat spawning for steelhead comes from the Pacific Northwest (e.g., Mayer et al. 2008; Narum et al. 2008) because iteroparity in California steelhead populations is considered relatively rare (Moyle 2002). In Pacific Northwest populations, the rate of downstream migration post-spawning reach 54% (Mayer et al. 2008), but the rate of survival for kelts is often low (Narum et al. 2008). Factors that affect kelt survival include, but are not limited to, freshwater entry and post-spawning (kelt) emigration, residual lipid content of white muscle post-spawning, pathogens, and predation.

Monitoring data from snorkeling, carcass surveys, redd surveys, rotary screw traps, trawls, and beach seines describe the timing of steelhead presence (Figure 6) (Appendix C).

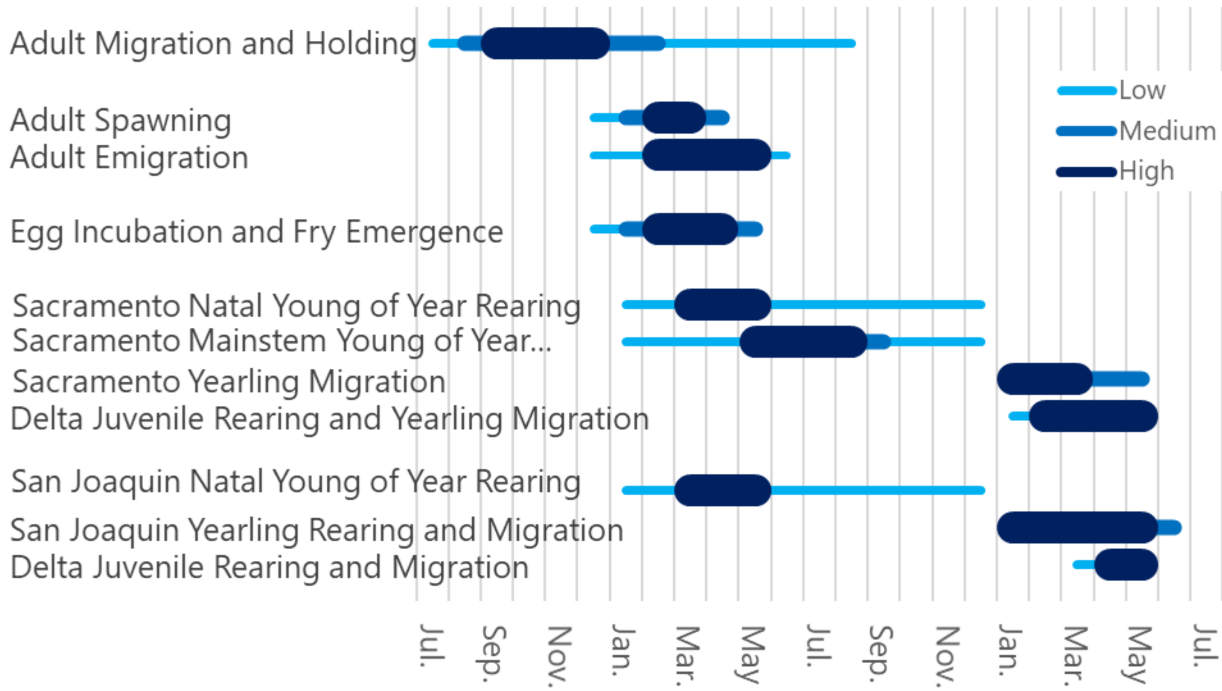

Figure 6. Temporal Life Stage Domains for Steelhead from Appendix C

The six spatial domains defined for steelhead are the Sacramento River, Clear Creek, the American River, the Stanislaus River, the Bay-Delta, and the San Joaquin River. Unique timing is provided for San Joaquin origin steelhead based on Mossdale trawl. Presence of a life-stage in the Central Valley and Bay-Delta (adult migration and holding) occurs over multiple calendar years. The ocean life stage is outside the action area determined by NMFS and therefore is not shown.

4.2 Species Effects Deconstruction

Steelhead are anticipated in Clear Creek: the Sacramento, American, Stanislaus, and San Joaquin Rivers; and in the Bay-Delta and may experience effects from the seasonal operations as described below. Although not listed, mature resident *O. mykiss* are also present and potentially produce offspring that adopt the anadromous life history. The Sacramento River, Clear Creek, American River, Stanislaus River, and San Joaquin River include adult migration and holding, adult spawning and emigration, egg incubation and fry emergence, and juvenile rearing and outmigration. The Bay-Delta includes adult migration and holding, and juvenile rearing.

4.2.1 Sacramento River

In the winter, Reclamation and DWR's proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flow in the upper Sacramento River may change stressors on steelhead.

Adults and resident *O. mykiss* are migrating, holding, spawning, and rearing in the Sacramento River in the winter, undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery and poaching stressors are not anticipated to change due to decreased flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding of steelhead in the winter has not been observed in the upper Sacramento River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogen stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the upper Sacramento River during the winter.

Spawning habitat stressors may or may not change. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality. A decrease in flows may increase spawning habitat stressors; however, the majority of steelhead do not spawn until the spring.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. These competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. Competition for spawning habitats may lead to genetic introgression due to spawning between hatchery and natural origin steelhead.

Eggs are incubating and fry are emerging in the Sacramento River. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors are not anticipated to change in the winter on the Sacramento River. Fisher wading in spawning beds can cause redd trampling. In the Sacramento River, decreased flows generally result in shallower redds.

Toxicity and contaminants stressors are not anticipated to change due to decreased winter flows. Decreased flows may increase contaminant stressors. Contaminants are one habitat attribute that influences the survival of eggs.

Stranding and dewatering stressors may or may not increase with decreased flows. Since redds may be at risk of dewatering when releases from Keswick Dam decrease after adult spawning has occurred, a decrease of flows may increase redd dewatering stressors. Potential redd dewatering increases at flows less than 6,000 cfs; and redd dewatering stressors may increase due to seasonal flow fluctuations. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the winter.

Pathogens stressors are not anticipated to change during the winter. Decreased flows may decrease flow circulation in the redd, increase pathogen transmission, and diminish egg condition. Flow circulation related effects are addressed in the redd quality stressor section.

Dissolved oxygen stressors are not anticipated to change during the winter.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment, which may compromise egg and alevin essential functions, stunting development.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Decrease flows do not affect gravel size but may increase aquatic vegetation. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section.

Predation stressors are not anticipated to change in the winter of eggs.

Juveniles are rearing and outmigrating in the Sacramento River. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen (DO) stressors are not anticipated to change with decreased flows. Passing of flows through Shasta Reservoir results in warmer water temperatures in the winter; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogen and disease stressors may or may not increase due to decrease flows. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. This stressor has not been observed in *O. mykiss* in the winter in the Sacramento River.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the upper Sacramento River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles.

Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

In the spring, Reclamation and DWR's proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flow in the upper Sacramento River may change stressors on steelhead.

Adults and resident *O. mykiss* are spawning, undertaking kelt emigration, and rearing in the Sacramento River in the spring, undergoing an energetically taxing freshwater-to-salt transition to forage. Several stressors have been identified that may delay spawning or effect kelt emigration.

In-river fishery and poaching stressors are not anticipated to change due to decrease flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the spring has not been observed in the upper Sacramento River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the spring; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogen stressors are not anticipated to change. Migrating adults and post-spawn kelts may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased O. mykiss have not been observed in the Sacramento during the spring.

Spawning habitat stressors may or may not increase. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality. A decrease in flows may increase spawning habitat stressors.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. Competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. Competition for spawning habitats may lead to genetic introgression due to spawning between hatchery and natural origin steelhead.

Eggs are incubating and fry are emerging in the Sacramento River in the spring. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors are not anticipated to change in the spring on the Sacramento River. Fisher wading in spawning beds can cause redd trampling. In the Sacramento River, decreased flows generally result in shallower redds.

Toxicity and contaminants stressors are not anticipated to change in the spring on the Sacramento River. A decrease of flows may increase stress caused by compounding effects of toxicity. Contaminants are one habitat attribute that influences the survival of eggs.

Stranding and dewatering stressors may or may not increase with decreased flows. Since redds may be at risk of dewatering when releases from Keswick Dam decrease after adult spawning has occurred, a decrease of flows may increase redd dewatering stressors. Potential redd dewatering increases at flows less than 6,000 cfs; and redd dewatering stressors may increase due to in-season flow fluctuations. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the spring on the Sacramento River.

Pathogens stressors are not anticipated to change during the winter. Decreased flows may decrease flow circulation in the redd and diminish egg condition and increase pathogen transmission. Decreased flows may warm in-river temperatures, which may increase pathogen infectibility of eggs. Water temperature-related effects are addressed in the water temperature stressor section.

Dissolved oxygen stressors are not anticipated to change during the spring.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment, which may compromise egg and alevin essential functions, stunting development.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Decrease flows do not affect gravel size but may increase aquatic vegetation. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section.

Predation stressors are not anticipated to change.

Juveniles are rearing and outmigrating in the Sacramento River in the spring. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen (DO) stressors are not anticipated to change with decreased flows. Passing of flows through Shasta Reservoir results in warmer water temperatures in the spring; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogen and disease stressors may or may not increase. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. Diseased *O. mykiss* have not been observed in the Sacramento River in the spring.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the upper Sacramento River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles.

Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors sections. Seasonal operation of the CVP is not anticipated to change predation and competition.

In the summer, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Keswick Dam. Increased flow in the upper Sacramento River may change stressors on steelhead.

Adult and resident *O. mykiss* are migrating, holding, and rearing in the Sacramento River. Several stressors have been identified that may affect migration and rearing influencing maturation and migration.

In-river fishery or poaching stressors are not anticipated to change. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on the Sacramento River.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change in the summer due to increased flows.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the Sacramento River, reducing their spawning success. Increased flows increase velocities and may increase the extent of cool in-river temperatures, which would decrease water temperature stressors on adults and resident rainbow trout. Water temperatures are managed in the summer for winter-run Chinook egg incubation, which are cooler than necessary for adult and resident *O. mykiss* holding and rearing. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogens and disease stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult spring-run Chinook. Water temperature-related effects are addressed in the water temperature stressor section. Diseased *O. mykiss* have not been observed in the Sacramento in the summer.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit spring-run in the summer.

Eggs are not present in the upper Sacramento River in the summer.

Juveniles are rearing in the middle Sacramento River. The amount of time spent rearing in the upper Sacramento River varies before juveniles migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a migration corridor to the Bay-Delta. Time spent within and size distribution both entering and exiting the middle Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may decrease due to increased flows in marginal habitat channels. Rearing and/or migrating juveniles' survival can decrease when fish become stranded in disconnected off-channel habitats. An increase in flows may increase habitat availability and decreased juvenile stranding risk during the summer.

Outmigration cues stressors may or may not decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility. Diseased juvenile *O. mykiss* have not been observed in the Sacramento in summer at monitoring locations.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section. The seasonal operation of the CVP to increase flows is not anticipated to change refuge habitat stressors.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the middle Sacramento River. The seasonal operation of the CVP to increase flows is not anticipated to change food availability stressors.

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

In the fall, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Keswick Dam. Increased flow in the upper Sacramento River may change stressors on steelhead.

Adults and resident *O. mykiss* are migrating, holding, and rearing in the Sacramento River. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery or poaching stressors are not anticipated to change. There is no in-river fishery for salmon in the upper Sacramento River during the fall. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on the Sacramento River.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may decrease with increased flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the fall has not been observed in the upper Sacramento River due to seasonal operations.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the Sacramento River, reducing their spawning success. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogens and disease stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult spring-run Chinook. Water temperature-related effects are addressed in the water temperature stressor section.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit steelhead in the fall.

Eggs are not present in Sacramento River in the fall.

Juveniles are rearing and outmigrating in the middle Sacramento River. The amount of time spent rearing in the upper Sacramento River varies before juveniles migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a migration corridor to the Bay-Delta. Time spent within and size distribution both entering and exiting the middle Sacramento River vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may decrease due to increased flows in marginal habitat channels. Rearing and/or migrating juveniles' survival can decrease when fish become stranded in disconnected off-channel habitats. An increase in flows may increase habitat availability and decrease juvenile stranding risk during the fall.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the middle Sacramento River.

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

4.2.2 Clear Creek

In the winter, Reclamation and DWR's proposed storage of water will decrease flows on average.

Adults and resident *O. mykiss* are migrating, holding, and spawning in Clear Creek.

In-river fishery and poaching stressors are not anticipated to change due to decreased flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding of steelhead in the winter has not been observed in the upper Sacramento River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogens and disease stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the Clear Creek during the winter.

Spawning habitat stressors may or may not change. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality. A decrease in flows may increase spawning habitat stressors; however, the majority of steelhead do not spawn until the spring.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. These competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions.

Eggs are incubating and fry are emerging in Clear Creek. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors are not anticipated to change in the winter on Clear Creek.

Toxicity from contaminants stressors are not anticipated to change due to decreased winter flows. Decreased flows may increase contaminant stressors.

Stranding and dewatering may or may not increase with decreased flows. Redd dewatering stressors may increase due to seasonal flow fluctuations. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the winter.

Pathogens stressors are not anticipated to change during the winter. Decreased flows may decrease flow circulation in the redd, increase pathogen transmission, and diminish egg condition. Flow circulation related effects are addressed in the redd quality stressor section.

Dissolved oxygen stressors are not anticipated to change during the winter.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment, which may compromise egg and alevin essential functions, stunting development. Sedimentation has been observed in Clear Creek associated with recent significant forest fires.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Decrease flows do not affect gravel size but may increase aquatic vegetation. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section.

Predation stressors are not anticipated to change in the winter of eggs.

Juveniles are rearing and may start to outmigrate in Clear Creek. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity from contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use, although these land uses are limited in Clear Creek.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced from Whiskeytown Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen stressors are not anticipated to change with decreased flows in the winter. Passing of flows through Whiskeytown Reservoir may result in warmer water temperatures in the winter; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors may or may not increase due to decrease flows. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the Sacramento River. This stressor has not been observed in *O. mykiss* in the winter in the Clear Creek.

Entrainment risk stressors are not anticipated to change in the winter for juvenile.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of lower Clear Creek are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the Clear Creek are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

In the spring, Reclamation and DWR's proposed release of water will decrease flows on average.

Adults and resident *O. mykiss* are are spawning, rearing, and undertaking kelt emigration back to the Sacramento River in the spring, undergoing an energetically taxing freshwater-to-salt transition to forage. Several stressors have been identified that may delay spawning, affect kelt emigration, or refuge habitat.

In-river fishery and poaching stressors are not anticipated to change due to decrease flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating kelts or resident *O. mykiss* may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the spring has not been observed in Clear Creek.

Water temperature stressors are not anticipated to change. The decrease in flows may result in warmer water temperatures in the spring; however, water temperatures are colder than adult migration temperature needs. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. These stressor effects would be accounted for under stranding.

Pathogens stressors are not anticipated to change. Migrating adults and post-spawn kelts may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in Clear Creek during the spring.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for resident *O. mykiss*.

Spawning habitat stressors may or may not increase. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality. A decrease in flows may increase spawning habitat stressors.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. Competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions.

Eggs are incubating and fry are emerging in the Clear Creek in the spring. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors are not anticipated to change in the spring on the Sacramento River. Fisher wading in spawning beds can cause redd trampling. In Clear Creek, decreased flows generally result in shallower redds.

Toxicity and contaminants stressors are not anticipated to change in the spring on the Clear Creek. A decrease of flows may increase stress caused by compounding effects of toxicity. Contaminants are one habitat attribute that influences the survival of eggs.

Stranding and dewatering stressors may or may not increase with decreased flows. Since redds may be at risk of dewatering when releases from Whiskeytown Dam decrease after adult spawning has occurred, a decrease of flows may increase redd dewatering stressors. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the spring on Clear Creek.

Pathogens stressors are not anticipated to change during the winter. Decreased flows may decrease flow circulation in the redd and diminish egg condition and increase pathogen transmission. Decreased flows may warm in-river temperatures, which may increase pathogen infectibility of eggs. Water temperature-related effects are addressed in the water temperature stressor section.

Dissolved oxygen stressors are not anticipated to change during the spring.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment, which may compromise egg and alevin essential functions, stunting development.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Decrease flows do not affect gravel size but may increase aquatic vegetation. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section.

Predation stressors are not anticipated to change.

Juveniles are rearing and outmigrating in Clear Creek in the spring. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Whiskeytown Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen (DO) stressors are not anticipated to change with decreased flows. Passing of flows through Whiskeytown Reservoir may result in warmer water temperatures in the spring; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogen and disease stressors may or may not increase. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in Clear Creek. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. Diseased *O. mykiss* have not been observed in the Sacramento River in the spring.

Entrainment risk stressors are not anticipated to change on Clear Creek in the spring due to seasonal operations.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the lower Clear Creek are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the lower Clear Creek are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections. Seasonal operation of the CVP is not anticipated to change predation and competition.

In the summer, Reclamation's proposed release of water will increase flows on average in Clear Creek below Whiskeytown. Increased flow in Clear Creek may change stressors on steelhead.

Adults and resident *O. mykiss* are migration and holding in Clear Creek. Several stressors have been identified that may affect migration and rearing influencing maturation and migration.

In-river fishery or poaching stressors are not anticipated to change. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on Clear Creek.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change in the summer due to increased flows.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the Clear Creek, reducing their spawning success. Increased flows increase velocities and may increase the extent of cool in-river temperatures, which would decrease water temperature stressors on adults and resident rainbow trout. Water temperatures are managed in the summer for winter-run Chinook egg incubation, which are cooler than necessary for adult and resident *O. mykiss* holding and rearing. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogens and disease stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult spring-run Chinook. Water temperature-related effects are addressed in the water temperature stressor section. Diseased *O. mykiss* have not been observed in the Sacramento in the summer.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit spring-run in the summer.

Eggs are not present in Clear Creek in the summer.

Juveniles are rearing to outmigration in Clear Creek. The amount of time spent rearing in the Clear Creek varies before juveniles migrate into the middle Sacramento River. This habitat is primarily used for rearing and as a migration corridor to the Sacramento River and Bay-Delta. Time spent within and size distribution both entering and exiting Clear Creek vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may decrease due to increased flows in marginal habitat channels. Rearing and/or migrating juveniles' survival can decrease when fish become stranded in disconnected off-channel habitats. An increase in flows may increase habitat availability and decreased juvenile stranding risk during the summer.

Outmigration cues stressors may or may not decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility. Diseased juvenile *O. mykiss* have not been observed in the Sacramento in summer at monitoring locations.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section. The seasonal operation of the CVP to increase flows is not anticipated to change refuge habitat stressors.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the middle Sacramento River. The seasonal operation of the CVP to increase flows is not anticipated to change food availability stressors.

Predation and competition stressors are not anticipated to change. Reaches of the middle Sacramento are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

In the fall, Reclamation and DWR's proposed release of water on average will increase flows.

Adults are not present in Clear Creek in the fall.

Resident *O. mykiss* are present in Clear Creek in the fall.

In-river fishery or poaching stressors are not anticipated to change due to increased flows.

Toxicity from contaminants stressors are not anticipated to change.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit *O. mykiss* in the fall.

Eggs are not present in the fall in Clear Creek.

Juveniles are rearing in the fall in Clear Creek.

Toxicity from contaminants stressors are not anticipated to change.

Stranding risk stressors may or may not increase from increased flows in areas prone to dewatering when flows are reduced to maximize storage in Shasta Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during fall month seasonal operations and/or precipitation events.

Water temperature and dissolved oxygen stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease.

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for yearlings. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease yearlings’ need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue yearlings to rear longer and grow larger in the middle Sacramento River

Predation and competition stressors are not anticipated to change. Reaches of the Clear Creek are highly channelized with low complexity and little cover from predators for rearing yearlings. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources

4.2.3 American River

In the winter, Reclamation and DWR's proposed storage of water will decrease flows on average in the American River below Nimbus Dam. Decreased flow in the American River may change stressors on steelhead.

Resident *O. mykiss* are rearing in the American River. Several stressors have been identified that may affect rearing influencing maturation.

In-river fishery and poaching stressors are not anticipated to change due to decrease flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the winter has not been observed in the American River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult temperature needs.

Dissolved oxygen stressors are not anticipated to change.

Pathogens stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the American River during the winter.

Adults are holding, spawning, and emigrating in the American River in the winter, undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery or poaching stressors are not anticipated to change due to decreased flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult migration temperature needs.

Pathogens and disease stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the upper Sacramento during the winter.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Spawning habitat stressors may increase due to decreased flows. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. These competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. Competition for spawning habitats may lead to genetic introgression due to spawning between hatchery and natural origin steelhead.

Eggs are incubating to fry emergence in the American River. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors are not anticipated to change in the winter on the American River. Fisher wading in spawning beds can cause redd trampling. In the American River, decreased flows generally result in shallower redds.

Toxicity from contaminants stressors are not anticipated to change due to decreased winter flows. Decreased flows may increase contaminant stressors. Contaminants are one habitat attribute that influences the survival of eggs.

Stranding and dewatering stressors may or may not increase with decreased flows. Since redds may be at risk of dewatering when releases from Nimbus Dam decrease, a decrease of flows may increase redd dewatering stressors. Potential redd dewatering increases at flows less than 2,000 cfs; and redd dewatering stressors may increase due to seasonal flow fluctuations. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the winter.

Pathogens stressors are not anticipated to change during the winter. Decreased flows may decrease flow circulation in the redd, increase pathogen transmission, and diminish egg condition. Flow circulation related effects are addressed in the redd quality stressor section.

Dissolved oxygen stressors are not anticipated to change during the winter.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment, which may compromise egg and alevin essential functions, stunting development or causing mortality.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Decrease flows do not affect gravel size but may increase aquatic vegetation. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section.

Predation stressors are not anticipated to change in the winter for eggs.

Juveniles are rearing and outmigrating in the American River. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity from contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Folsom Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen stressors are not anticipated to change with decreased flows. Passing of flows through Folsom Reservoir results in warmer water temperatures in the winter; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors may or may not increase due to decrease flows. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the American River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. This stressor has not been observed in *O. mykiss* in the winter in the American River in the winter.

Entrainment risk stressors are not anticipated to change in the American River.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the American River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the American River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

In the spring, Reclamation and DWR's proposed storage of water will decrease flows on average in the American River below Nimbus Dam. Decreased flow in the American River may change stressors on steelhead.

Adults and resident *O. mykiss* are migrating, holding, and rearing in the American River in the spring, undergoing an energetically taxing freshwater-to-salt transition to forage. Several stressors have been identified that may delay spawning or effect kelt emigration.

In-river fishery and poaching stressors are not anticipated to change due to decrease flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult or resident *O. mykiss* stranding in the spring has not been observed in the American River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the spring; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogens stressors are not anticipated to change. Migrating adults and post-spawn kelts may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the American River during the spring.

Adults and kelts are spawning and emigrating in the American River, in the spring, undergoing an energetically taxing freshwater-to-salt transition to forage. Several stressors have been identified that may delay spawning or effect emigration.

In-river fishery or poaching stressors are not anticipated to change due to decrease flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the spring; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogens and disease stressors are not anticipated to change. Migrating adults and post-spawn kelts may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased O. mykiss have not been observed in the American River during the spring.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Spawning habitat stressors may increase. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality. A decrease in flows may increase spawning habitat stressors.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. Competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. Competition for spawning habitats may lead to genetic introgression due to spawning between hatchery and natural origin steelhead.

Eggs are incubating and fry emerging in the American River in the spring. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fisher and trampling stressors are not anticipated to change in the spring on the American River. Fisher wading in spawning beds can cause redd trampling. In the American River, decreased flows generally result in shallower redds.

Toxicity from contaminants stressors are not anticipated to change in the spring on the Sacramento River. A decrease of flows may increase stress caused by compounding effects of toxicity. Contaminants are one habitat attribute that influences the survival of eggs.

Stranding and dewatering stressors may or may not increase with decreased flows. Since redds may be at risk of dewatering when releases from Nimbus Dam decrease after adult spawning has occurred, a decrease of flows may increase redd dewatering stressors. Potential redd dewatering increases at flows less than 2,000 cfs; and redd dewatering stressors may increase due to in-season flow fluctuations. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the spring on the American River.

Pathogens stressors are not anticipated to change during the winter. Decreased flows may decrease flow circulation in the redd and diminish egg condition and increase pathogen transmission. Decreased flows may warm in-river temperatures, which may increase pathogen infectibility of eggs. Water temperature-related effects are addressed in the water temperature stressor section.

Dissolved oxygen stressors are not anticipated to change during the spring.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment, which may compromise egg and alevin essential functions, stunting development.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Decrease flows do not affect gravel size but may increase aquatic vegetation. Gravel quantity-related effects are addressed in the sedimentation and gravel quantity section.

Predation and competition stressors are not anticipated to change.

Juveniles are rearing and outmigrating in the American River in the spring. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity from contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in Nimbus Reservoir. When flows are reduced, juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen stressors are not anticipated to change with decreased flows. Passing of flows through Folsom Reservoir results in warmer water temperatures in the spring; however, water temperatures are colder than juvenile rearing and migration needs.

Pathogens and disease stressors may or may not increase. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the American River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. Diseased juvenile *O. mykiss* have not been observed in the American River in the spring.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the American River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the lower American River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

In the summer, Reclamation and DWR's proposed release of water will increase flows on average in the American River below Nimbus Dam. Increased flow in the American River may change stressors on steelhead.

Resident *O. mykiss* are rearing in the American River. Several stressors have been identified that may affect migration.

In-river fishery or poaching stressors are not anticipated to change. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on the American River.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates. Increased flows increase velocities and may increase the extent of cool in-river temperatures, which would decrease water temperature stressors on resident rainbow trout. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not change due to increased flows. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult steelhead. Water temperature-related effects are addressed in the water temperature stressor section. Diseased *O. mykiss* have been observed in the American River in the summer.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Competition, introgression, and broodstock removal stressors are not anticipated to change. An increase in flows may decrease competition; however, crowding is not known to limit steelhead in the summer.

Eggs are not present in the American River in the summer.

Juveniles are outmigrating in the American River. The amount of time spent rearing in the American River varies before juveniles migrate. Time spent within and size distribution vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity from contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may decrease due to increased flows in marginal habitat channels. Rearing and/or migrating juvenile survival can decrease when fish become stranded in disconnected off-channel habitats. An increase in flows may increase habitat availability and decreased juvenile stranding risk during the summer.

Outmigration cues stressors may or may not decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and dissolved oxygen stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not increase due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility. Diseased juvenile *O. mykiss* have been observed in the American River in summer at monitoring locations.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section. The seasonal operation of the CVP to increase flows is not anticipated to change refuge habitat stressors.

Food availability and quality stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the American River. The seasonal operation of the CVP to increase flows is not anticipated to change food availability stressors.

Predation and competition stressors are not anticipated to change. Reaches of the lower American River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

In the fall, Reclamation and DWR's proposed release of water will increase flows on average in the American River below Nimbus Dam. Increased flow in the American River may change stressors on steelhead.

Resident *O. mykiss* are migrating, holding, and rearing in the American River in the fall. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery and poaching stressors are not anticipated to change. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on the American River.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may decrease with increased flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the fall has not been observed in the American River due to seasonal operations.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates, and weakened adults may be moved downstream out of temperature-controlled sections of the American River, reducing their spawning success. Increased flows increase velocities and may increase DO and the extent of cool in-river temperatures, which would decrease water temperature stressors on adults. Water temperature will be addressed further in coldwater pool conservation measures.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogens stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon.

Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among resident *O. mykiss*. Water temperature-related effects are addressed in the water temperature stressor section.

Adults are not present in the American River in the fall.

Eggs are not present in the American River in the fall.

Juveniles are rearing and outmigrating in the American River in the fall. The amount of time spent rearing in the American River varies before juveniles migrate. Time spent within and size distribution vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity from contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Stranding risk stressors may decrease due to increased flows in marginal habitat channels. Rearing and/or migrating juveniles' survival can decrease when fish become stranded in disconnected off-channel habitats. An increase in flows may increase habitat availability and decrease juvenile stranding risk during the fall.

Outmigration cues stressors may decrease due to higher flows. An increase in flows may change fish behavior to end rearing behavior and begin migrating downstream. Unoccupied downstream habitats may improve growth and survival, while occupied downstream habitat or lack of habitat may reduce growth and survival.

Water temperature and DO stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the American River.

Predation and competition stressors are not anticipated to change. Reaches of the lower American River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

4.2.4 Stanislaus River

In the winter, Reclamation and DWR's proposed storage of water diversion of water will decrease flows in the Stanislaus River below Goodwine Dam. Decreased flow in the Stanislaus River may change stressors on steelhead.

Adults and resident *O. mykiss* are migrating, holding, and rearing in the Stanislaus River in the winter, undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery and poaching stressors are not anticipated to change due to decrease flows.

Toxicity and contaminants stressors not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors may increase from fluctuations in releases and low flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the winter has not been observed in the Stanislaus River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogens and disease stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the Stanislaus River during the winter.

Adults are spawning and emigrating in the Stanislaus River in the winter, undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery or poaching stressors are not anticipated to change due to decreased flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogens and disease stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the Stanislaus River during the winter.

Dissolved oxygen stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Spawning habitat stressors may or may not change. Decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality. A decrease in flows may increase spawning habitat stressors; however, the majority of steelhead do not spawn until the spring.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. These competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions.

Eggs are incubating and fry emerging in the Stanislaus River. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors are not anticipated to change in the winter on the Stanislaus River. Fisher wading in spawning beds can cause redd trampling. In the Stanislaus River, decreased flows generally result in shallower redds.

Toxicity and contaminants stressors are not anticipated to change due to decreased winter flows. Decreased flows may increase contaminant stressors. Contaminants are one habitat attribute that influences the survival of eggs.

Stranding and dewatering stressors may or may not increase with decreased flows. Since redds may be at risk of dewatering when releases from Goodwin Dam decrease, a decrease of flows may increase redd dewatering stressors. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the winter.

DO stressors are not anticipated to change during the winter.

Pathogens and disease stressors are not anticipated to change during the winter. Decreased flows may decrease flow circulation in the redd, increase pathogen transmission, and diminish egg condition. Flow circulation related effects are addressed in the redd quality stressor section.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment, which may compromise egg and alevin essential functions, stunting development.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristics describing redd quality. Decrease flows do not affect gravel size but may increase aquatic vegetation. Gravel quantity-related effects are addressed in sedimentation and gravel quantity section.

Predation stressors are not anticipated to change in the winter for eggs.

Juveniles are rearing and outmigrating in the Stanislas River in the winter. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual’s physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in New Melones Reservoir. When flows are reduced juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration and outmigration cues may be changed due to a decrease in flows.

Entrainment risk stressors are not anticipated to change.

Water temperature and dissolved oxygen stressors are not anticipated to change with decreased flows.

Pathogens and disease stressors may increase due to increased proximity from other fish and decreased habitat availability.

Refuge habitat stressors may increase due to less suitable margin and off channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the lower Stanislaus River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation decreasing food availability and quality impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the lower Stanislaus River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors.

In the spring, Reclamation and DWR's proposed diversion of water will decrease flows in the Stanislaus River below Goodwin Dam. Decreased flow in the Stanislaus River may change stressors on steelhead.

Adults and resident *O. mykiss* are spawning and emigrating in the Stanislaus River in the spring, undergoing an energetically taxing freshwater-to-salt transition to forage. Several stressors have been identified that may delay spawning or effect emigration.

In-river fishery or poaching stressors are not anticipated to change due to decrease flows.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the spring; however, water temperatures are colder than adult migration temperature needs. Migrating adults stranded in bypasses may be exposed to high water temperatures, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

DO stressor are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen which can affect, which can influence body condition. Poor body condition may decrease migration success. These stressor effects would be accounted for under stranding.

Pathogens and disease stressors are not anticipated to change. Migrating and spawning adults may be more susceptible to disease if they are in poor body condition although salmonids are exposed throughout their lifecycle to pathogens. Diseased O. mykiss have not been observed in the Stanislaus River during the spring.

Spawning habitat stressors may increase as decreased flows may reduce the quantity and quality of spawning habitats. Competition by spawners for limited habitat may lead to redd superimposition. A decrease in flows may cause a deficit in spawning habitat or reduce its quality.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. Competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions. Competition for spawning habitats may lead to genetic introgression due to spawning between hatchery and natural origin steelhead.

Eggs are present in the Stanislaus River in the spring. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

In-river fishery and trampling stressors are not anticipated to change in the winter on the American River. Fisher wading in spawning beds can cause redd trampling. In the American River, decreased flows generally result in shallower redds.

Toxicity and contaminants stressors are not anticipated to change due to decreased winter flows. Decreased flows may increase contaminant stressors. Contaminants are one habitat attribute which influences the survival of eggs.

Stranding and dewatering stressors may or may not increase with decreased flows. Since redds may be at risk of dewatering when releases from Goodwin Dam decrease, a decrease of flows may increase redd dewatering stressors. However, the opposite effect may also occur, and dewatering risk stressors may decrease from the dampening of flow fluctuations during winter month precipitation events.

Water temperature stressors are not anticipated to change during the spring.

Pathogens stressors are not anticipated to change during the spring. Decreased flows may decrease flow circulation in the redd, increase pathogen transmission, and diminish egg condition. Flow circulation related effects are addressed in the redd quality stressor.

Dissolved oxygen stressors are not anticipated to change during the spring.

Sedimentation and gravel quantity stressors may increase due to decreased flow and affect egg survival and alevin emergence. Decreased flows may reduce velocities and reduce removal of fine sediment which may compromise egg and alevin essential functions stunting development.

Redd quality stressors are not anticipated to change. Egg and alevin emergence is affected by gravel size and aquatic vegetation, which are the physical characteristic describing redd quality. Decrease flows do not affect gravel size, but may increase aquatic vegetation. Gravel quantity related effects are addressed in sedimentation and gravel quantity.

Predation stressors are not anticipated to change in the spring for eggs.

Juveniles are rearing and migrating in the Stanislas River in the spring. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration juveniles rely on prey for growth and survival which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Water temperature and dissolved oxygen stressors are not anticipated to change with decreased flows.

Stranding risk stressors may or may not increase from decreased flows in areas prone to dewatering when flows are reduced to maximize storage in New Melones Reservoir. When flows are reduced juveniles can become stranded in habitat disconnected from the main channel where habitats are desiccated and fish cannot survive, or they may be exposed to higher levels of predation. Clear water can allow visual predators a higher success rate on stranded fish. However, the opposite effect may also occur, and stranding risk stressors may decrease from the dampening of flow fluctuations during spring month precipitation events.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration and outmigration cues may be changed due to a decrease in flows.

Pathogens and disease stressors may or may not increase. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the American River. A decrease in flows may influence pathogen and disease exposure including increased transfer from hatchery fish to natural-origin juveniles. Diseased *O. mykiss* have not been observed in the Stanislaus River in the spring.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the lower Stanislaus River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the lower Stanislaus River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

In the summer, Reclamation and DWR proposed water operations will increase flows in the Stanislaus River below Goodwin Dam. Increased flow in the Stanislaus River may change stressors on steelhead.

Resident *O. mykiss* are rearing and emigrating in the Stanislaus River in the summer. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

In-river fishery or poaching stressors are not anticipated to change. Increased flows may make them more vulnerable to poaching. An increase in flows may change poaching stressors; however, this effect has not been observed on the Stanislaus River.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may result in depletion of coldwater pool and increase water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates. Increased flows increase velocities and may increase the extent of cool in-river temperatures, which would decrease water temperature stressors on adults and resident rainbow trout. Water temperature will be addressed further in coldwater pool conservation measures.

DO stressors are not anticipated to change. Dissolved oxygen generally increases with increased flows. High levels of DO can reduce physiological stress and metabolic rates for adults. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may reduce levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogens and disease stressors are not anticipated to change. Crowding may be reduced due to increased flows and more holding habitat. Lower densities of holding adults may decrease the potential for lateral transmission of disease. Increased flows have been used in the Klamath and

Trinity River as a management strategy to reduce pathogen transmission among holding adult salmon. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility among adult steelhead. Water temperature-related effects are addressed in the water temperature stressor section. Diseased *O. mykiss* have not been observed in the Stanislaus River in the summer.

Stranding stressors may decrease with increased flow in areas prone to dewatering. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding in the summer has not been observed in the Stanislaus River due to seasonal operations.

Eggs are not present in the Stanislaus River in the summer.

Juveniles are rearing in the Stanislaus River in the summer. The amount of time spent rearing in the American River varies before juveniles migrate. Time spent within and size distribution vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. An increase in flows may not change toxicity and contaminants stressors.

Water temperature stressors may or may not be increased due to increased flows. Increased flows may deplete coldwater pool reserves, creating conditions outside an optimal water temperature range that may affect growth rate and result in direct mortality if juveniles experience lethal water temperatures of low DO. Increased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section. Water temperature will be addressed further in coldwater pool conservation measures.

Pathogens and disease stressors may or may not be increased due to increased flow. Increased flows may deplete coldwater pool reserves, increasing water temperatures, which may increase pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Increased flows may reduce crowding in smaller habitat areas and reduce infectibility. Diseased juvenile *O. mykiss* have not been observed in the Stanislaus River in summer at monitoring locations.

Entrainment risk stressors are not anticipated to change.

Refuge habitat stressors may decrease due to more suitable margin and off-channel habitats being available for juveniles. An increase in flows may increase access to high quality refuge in areas with lower velocity and may decrease juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability stressors may decrease due to more foraging habitat area to produce food. Access to quality food may cue juveniles to rear longer and grow larger in the Stanislaus River.

Predation stressors are not anticipated to change. Reaches of the lower Stanislaus River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

In the fall, Reclamation and DWR's proposed storage release of water will decrease flows in the Stanislaus River below Goodwin Dam. Decreased flow in the Stanislaus River may change stressors on steelhead.

Adults are not present in the fall.

Resident *O. mykiss* are present in the Stanislaus River in the fall.

In-river fishery or poaching stressors are not anticipated to change. Decreased flows may make them more vulnerable to poaching. A decrease in flows may change poaching stressors; however, this effect has not been observed on the Stanislaus River.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause mortality.

Water temperature stressors may or may not be increased due to decreased flows. Decreased flows may result in slower depletion of coldwater pool and maintain water temperatures. Warmer water temperatures generally decrease DO, which increases physiological stress and metabolic rates. Decreased flows decrease velocities and may decrease the extent of cool in-river temperatures, which would increase water temperature stressors on adults and resident rainbow trout. Water temperature will be addressed further in coldwater pool conservation measures.

DO stressors are not anticipated to change. Dissolved oxygen generally decreases with decreased flows. Low levels of DO can increase physiological stress and metabolic rates for adults. Decreased flows may maintain coldwater pool reserves, decreasing water temperatures, which may maintain levels of DO. Water temperature-related effects to DO are addressed in the water temperature stressor section.

Pathogens and disease stressors are not anticipated to change. Crowding may be increased due to decreased flows and less holding habitat. Higher densities of residents may increase the potential for lateral transmission of disease. Decreased flows may reduce depletion of coldwater pool reserves, maintaining water temperatures, which may decrease pathogen infectibility among adult steelhead. Water temperature-related effects are addressed in the water temperature stressor section. Diseased *O. mykiss* have not been observed in the Stanislaus River in the fall.

Stranding stressors may increase with decreased flow in areas prone to dewatering. Stranding of resident *O. mykiss* may cause physiological stress, due to low DO or warm water temperatures, and mortality. Resident *O. mykiss* in the fall have not been observed in the Stanislaus River due to seasonal operations.

Eggs are not present in the Stanislaus River in the fall.

Juveniles are rearing and outmigrating in the Stanislaus River in the fall. The amount of time spent rearing in the Stanislaus River varies before juveniles migrate. Time spent within and size distribution vary among years. Several stressors have been identified, each possibly affecting survival, residence time and migration, and juvenile condition (some affecting several parameters) during the migration.

Toxicity and contaminants stressors are not anticipated to change. Juvenile growth rate, condition, and survival may be affected by exposure to contaminants by suppressing appetite and affecting hormone balance. A decrease in flows may increase toxicity and contaminants stressors.

Water temperature and DO stressors may or may not be increased due to decreased flows. Decreased flows may maintain coldwater pool reserves creating conditions of optimal water temperature range for longer duration. Decreased flows may also cool in-river temperatures. Changes in water temperature and DO may cue fish outmigration. Outmigration-related effects are addressed in the outmigration cue stressor section.

Pathogens and disease stressors may or may not be increased due to decreased flow. Decreased flows may maintain coldwater pool reserves longer, decreasing water temperatures, which may decrease pathogen infectibility, reduce growth, increase metabolic demand, and increase mortality of juveniles. Decreased flows may increase crowding in smaller habitat areas and reduce infectibility.

Outmigration cues stressors may increase due to lower flows. A decrease in flows may change fish behavior to maintain rearing behavior and not migrate downstream.

Stranding stressors may increase due to decreased flows in marginal habitat channels. Rearing and/or migrating juveniles' survival can decrease when fish become stranded in disconnected off-channel habitats. A decrease in flows may decrease habitat availability and increase juvenile stranding risk during the fall.

Refuge habitat stressors may increase due to more suitable margin and off-channel habitats being unavailable for juveniles. A decrease in flows may decrease access to high quality refuge in areas with lower velocity and may increase juveniles' need to expend energy while foraging and decrease predation risk. Predation risk-related effects are addressed in the predation and competition stressor section.

Food availability and quality stressors may increase due to more foraging habitat area to produce food. Lack of access to quality food may cue juveniles to rear for shorter and not grow in the Stanislaus River.

Predation and competition stressors are not anticipated to change. Reaches of the lower Stanislaus River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Increased flows increase refuge habitat and may decrease fish density, decreasing competition for resources. Predation is a high source of mortality on outmigrating juveniles. Increased flows increase travel rates of outmigrating juveniles, exposing them to less predator pressure.

4.2.5 Bay-Delta

In the winter, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on steelhead.

Adults are migrating in the Delta. Adults are undergoing an energetically taxing salt-to-freshwater transition to spawn. Several stressors have been identified to possibly delay adult migration, decrease adult survival during migration, or increase energy necessary to undergo the transition.

In-river fishery and poaching stressors are not anticipated to change. No steelhead fishing is allowed in the Delta in the winter. Poaching may impact adult survival during migration and can cause migration delays.

Toxicity from contaminants stressors are not anticipated to change.

Stranding risk stressors are not anticipated to change. Flows from the upper and middle Sacramento River into the Bay-Delta can be routed through agricultural lands, creating false cues for migrating adults. These false cues can divert adults, causing stranding, which may delay migration.

Water temperature stressors are not anticipated to change.

Dissolved oxygen stressors are not anticipated to change.

Pathogens stressors are not anticipated to change.

Eggs are not present in the Delta.

Juveniles are rearing and migrating in the Delta. Juvenile use of the Bay-Delta varies both within and among years. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate and reducing travel rates in the Delta, which may reduce outmigration survival. Juveniles may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants. That is addressed in the toxicity and contaminants stressors section.

Water temperature and DO stressors are not anticipated to change in the winter.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence juveniles' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta is not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors may or may not increase due to less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

In the spring, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on steelhead.

Adults are migrating in the Delta. Adults move through the Bay-Delta into reaches of the middle and upper Sacramento River, where they hold until ready for spawning. This life-history strategy may leave adults vulnerable to multiple factors that affect survival, timing, and distribution. Additionally, adult body condition upon return to spawning areas can influence effects of stressors on pre-spawn mortality or fecundity. Several stressors have been identified for habitat attributes that affect spawning and holding.

In-river fishery and poaching stressors are not anticipated to change. There is steelhead fishing permitted in the Delta in the spring due to seasonal operations.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change.

Water temperature stressors are not anticipated to change.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally decreases with an increase in water temperatures. This decrease can increase physiological stress and metabolic rates for adults.

Pathogens stressors are not anticipated to change. Decreased flows in the Delta do not affect crowding or the density of steelhead, which may increase transmission of disease or pathogens.

Eggs are not present in the Delta.

Juveniles are rearing and migrating in the Delta. Juvenile use of the Bay-Delta varies both within and among years. Several stressors have been identified to possibly affect survival, residence time and migration, and condition. Habitat attributes may have compounding effects; it is important to not consider a single stressor alone.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to decreased Delta outflow. Decreased Delta outflow may increase outmigration cues stressors by masking the cue to migrate and reducing travel rates in the Delta, which may reduce outmigration survival. Juveniles may use olfactory systems to cue to migrate, which may be influenced by toxicity and contaminants. That is addressed in the toxicity and contaminants stressors section.

Water temperature and DO stressors are not anticipated to change in the winter.

Pathogens and disease stressors are not anticipated to change.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Refuge habitat stressors may increase due to less habitat availability. A decrease in Delta outflow may increase refuge habitat stressors, reducing both opportunities to avoid predators and foraging opportunities in a productive environment. Habitat capacity may also influence juveniles' choice to switch from rearing and foraging to migrating behavior.

Food availability and quality stressors in the north Delta is not anticipated to change but may increase in the south Delta due to the export of primary and secondary productivity. A decrease in Delta outflow may increase food availability and quality stressors, particularly within the hydraulic footprint of the Delta export facilities where available zooplankton and invertebrates may be exported.

Predation and competition stressors may or may not increase due to less available habitat area, creating high predator densities. Rearing and foraging areas with high predator density may influence juvenile salmon survival. Inter- and intra-species competition may affect individuals' body condition, which influences survival rates for outmigrating juveniles.

In the summer, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on steelhead.

Adults are migrating in the Delta.

Toxicity and contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change.

Water temperature stressors are not anticipated to change.

Dissolved oxygen stressors are not anticipated to change. Dissolved oxygen generally decreases with an increase in water temperatures. This decrease can increase physiological stress and metabolic rates for adults.

Pathogen stressors are not anticipated to change. Decreased flows in the Delta do not affect crowding or the density of winter-run Chinook salmon, which may increase transmission of disease or pathogens.

Eggs are not present in the Delta.

Juveniles are not present in the Delta.

In the fall, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on steelhead.

Adults are not present in the Delta.

Eggs are not present in the Delta.

Juveniles are not present in the Delta.

4.2.6 San Joaquin River

In the winter, Reclamation and DWR's operations on average decrease flows on the San Joaquin River. Decreased flow on the San Joaquin River may change stressors on steelhead.

Adults are migrating and holding in the San Joaquin River.

In-river fishery and poaching stressors are not anticipated to change due to decreased flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease.

Stranding risk stressors are not anticipated to change. Stranding of migrating adults may cause physiological stress, due to low DO or warm water temperatures, and mortality. Adult stranding of steelhead in the winter has not been observed in the San Joaquin River due to seasonal operations.

Water temperature stressors are not anticipated to change. The decrease in flows results in warmer water temperatures in the winter; however, water temperatures are colder than adult migration temperature needs.

Dissolved oxygen stressors are not anticipated to change

Pathogens and disease stressors are not anticipated to change. Migrating adults may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the San Joaquin River during the winter.

Spawning habitat stressors are not anticipated to change.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding habitats.

Eggs are not present in the winter in the San Joaquin River

Juveniles are rearing and outmigrating in the San Joaquin River in the winter After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual’s physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity from contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use, although these land uses are limited in Clear Creek.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen stressors are not anticipated to change with decreased flows in the winter.

Pathogens and disease stressors may or may not increase due to decrease flows. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the San Joaquin. This stressor has not been observed in *O. mykiss* in the winter in the San Joaquin River.

Entrainment risk stressors are not anticipated to change in the winter for juvenile in the San Joaquin River.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the lower San Joaquin River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the lower San Joaquin River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors' sections.

In the spring, Reclamation and DWR's operations on average will decrease flows on the San Joaquin River. Decreased flow on the San Joaquin River may change stressors on steelhead.

Adults and kelts are emigrating in the San Joaquin River.

In-river fishery and poaching stressors are not anticipated to change due to decrease flows.

Toxicity from contaminants stressors are not anticipated to change. Toxins can increase physiological stress, which may affect gamete maturation and viability and susceptibility to disease. Contaminant loading of toxins from sources like stormwater runoff and mines can reduce spawning success or cause adult mortality.

Stranding risk stressors are not anticipated to change. Adult stranding in the spring has not been observed in the San Joaquin River.

Water temperature stressors are not anticipated to change. The decrease in flows may result in warmer water temperatures in the spring; however, water temperatures are colder than adult migration temperature needs. These stressor effects would be accounted for under stranding.

Dissolved oxygen stressors are not anticipated to change. These stressor effects would be accounted for under stranding.

Pathogens stressors are not anticipated to change. Migrating adults and post-spawn kelts may be more susceptible to disease if they are in poor body condition, although salmonids are exposed throughout their lifecycle to pathogens. Diseased *O. mykiss* have not been observed in the lower San Joaquin River during the spring.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the lower San Joaquin River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for adults and kelts. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Competition, introgression, and broodstock removal stressors are not anticipated to change. Decreased flows may increase the density of adult steelhead using holding and spawning habitats. Crowding and redd superimposition may occur due to decreased flows. Competition stressor effects are addressed in the pathogen and disease and spawning habitat stressor descriptions.

Eggs are not present in the spring in the San Joaquin River

Juveniles are rearing and outmigrating in the San Joaquin River in the spring. After emergence, fry either swim or are passively advected downstream. Juveniles can exhibit a range of migration rates dependent on an individual's physiological stage and condition and flow conditions. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during the migration.

Toxicity and contaminants stressors are not anticipated to change. During outmigration, juveniles rely on prey for growth and survival, which may be negatively impacted by presence of toxicity caused by urban and agricultural land use.

Stranding risk stressors are not anticipated to change.

Outmigration cues stressors may increase due to lower flows. Steelhead use flows for cues to begin and continue migration, and outmigration cues may be changed due to a decrease in flows.

Water temperature and dissolved oxygen (DO) stressors are not anticipated to change. The decrease in flows may result in warmer water temperatures in the spring; however, water temperatures are colder than adult migration temperature needs. These stressor effects would be accounted for under stranding.

Pathogen and disease stressors may or may not increase. Decreased flows may cause crowding in smaller habitat areas. Juvenile survival is influenced by specific diseases (e.g., C-shasta, furunculosis) present in the San Joaquin River. A decrease in flows may influence pathogen and disease exposure, including increased transfer from hatchery fish to natural-origin juveniles. Diseased *O. mykiss* have not been observed in the San Joaquin River in the spring.

Entrainment risk stressors are not anticipated to change on the San Joaquin River in the spring due to seasonal operations.

Refuge habitat stressors may increase due to less suitable margin and off-channel habitats being available for juveniles.

Food availability and quality stressors may or may not increase due to less inundated habitats in some areas. Reaches of the lower San Joaquin River are highly channelized with low complexity, although the reservoir may provide phytoplankton and zooplankton-rich water as prey for outmigrating juveniles. A decrease in flows can alter food web processes and riparian vegetation, decreasing food availability and quality, impacting the successful growth and survival of juveniles.

Predation and competition stressors are not anticipated to change. A decrease in flows can increase predation and competition stressors. Reaches of the lower San Joaquin River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. A decrease in flow may reduce carrying capacity and lead to competition for limited refuge habitats and resources. Effects from refuge habitat stressors and food availability are addressed in those stressors sections.

In the summer, Reclamation and DWR operations will decrease flows on average on the San Joaquin River.

Adults are not present in the summer in the San Joaquin River.

Eggs are not present in the San Joaquin River in the summer.

Juveniles are not present in the summer in the San Joaquin River

In the fall, Reclamation and DWR's proposed storage and release of water will decrease on average.

Adults are present in the San Joaquin River in the fall.

Eggs are not present in the San Joaquin River in the fall.

Juveniles are not present in the San Joaquin River in the fall.

4.3 Species Effects Determination

The seasonal operation of the CVP and SWP may affect and is likely to adversely affect California Central Valley steelhead. The seasonal operation of the CVP is also likely to have beneficial effects. Deconstruction of the seasonal operations systematically evaluated each stressor identified by conceptual models. Stressors not linked to the operation of the CVP and SWP were identified as "are not anticipated to change." Stressors that were insignificant or discountable were documented. Stressors with a material effect on the fitness of species were identified, and seasonal operations will consider minimization and/or compensation through conservation measures.

Stressors on **adults and resident *O. mykiss*** influenced by seasonal operations include:

- Water Temperatures: Increased flows may affect water temperature stressors in the Sacramento River and Clear Creek. A conservation measure for Sacramento River and Clear Creek water temperature that considers flows may benefit water temperatures for some adults and adversely affect others. Managing water temperatures for egg incubation provides colder waters than needed for adults, but that management action may start later in the year, depending on seasonal operations
- Stranding Risk: Seasonal flows may affect stranding risks for adult steelhead in CVP streams. Conservation measures for ramping rates and minimum instream flows may avoid or minimize the potential for adult stranding.
- Spawning Habitat: Decreased flows may provide less habitat availability and may increase crowding. A conservation measure for maintenance and construction of spawning habitat may minimize or benefit potential spawning habitat.

Stressors on **eggs and alevins** influenced by seasonal operations include:

- Dewatering: The transition between seasonal winter and spring flows on the American River may increase steelhead redd dewatering. A conservation measure for ramping rates and instream flows may minimize potential dewatering.
- Sedimentation and gravel quantity: Fine sediment deposition and quantity of spawning gravel available decreases with reduced flows. The construction of spawning habitat is anticipated to improve redd quality.

Stressors on **juveniles** influenced by seasonal operations include:

- Stranding: Reduced releases below CVP reservoirs during the juvenile rearing period pose a stranding risk to juveniles. A conservation measure for ramping rates may avoid or minimize the potential for yearling stranding.
- Outmigration: The change in timing of flows for seasonal operations below CVP reservoirs and in the Bay-Delta may disrupt outmigration cures and reduce survival. Conservation measures for minimum instream flows and pulse flows may avoid or minimize outmigration cue stressors.
- Refuge Habitat: Decreased flows may provide decreased habitat availability. A conservation measure for the construction of additional rearing habitat on the Sacramento River, American River, Stanislaus River, and Clear Creek may minimize or benefit potential refuge habitat.
- Food Availability and Quality: Decreased flows may provide less food availability through a reduction in suitable feeding areas in the Bay-Delta and below CVP reservoirs. A conservation measure for the construction of additional tributary and tidal rearing habitat may minimize or benefit food availability and quality.
- Entrainment: Reduced flows affect routing and entrainment of steelhead in the Bay-Delta. Several actions may avoid, minimize, or benefit the potential for Bay-Delta juvenile entrainment including a conservation measure for the Delta Cross Channel, a

conservation measure for routing at Georgiana Slough, a conservation measure for Old and Middle River flow management, and a conservation measure for salvage before the export facilities.

4.4 Habitat Physical and Biological Features

Critical habitat has been designated for steelhead (70 FR 52488, September 2, 2005), and includes all river reaches accessible to listed steelhead in the Sacramento River and its tributaries in California.

The geographical extent of designated critical habitat includes, but is not limited to, the following: Sacramento, Feather, and Yuba Rivers; Clear, Deer, Mill, Battle, and Antelope Creeks in the Sacramento River basin; the San Joaquin River, including its tributaries; and the waterways of the Delta (Figure 24). With the exception of Clifton Court Forebay, the entirety of the Proposed Action area in the Central Valley is designated critical habitat for steelhead.

The critical habitat for steelhead lists the essential physical and biological features, which include:

4.4.1 Adult Passage

Freshwater spawning habitat for steelhead is in the reaches of the Sacramento River from Keswick Dam to Red Bluff Diversion Dam. Unobstructed access from the Pacific Ocean to the upper Sacramento River is essential for the conservation of steelhead. The availability of freshwater riparian habitat can support successful juvenile development and survival.

The species effect determination found related potential stressors of:

- Stranding

There are no additional operations effects on adult passage when species are not present.

4.4.2 Spawning and Rearing Substrate

The availability of good water quality and floodplain for spawning and rearing substrate are essential for the conservation of steelhead. Water flow fluctuations, water temperature, loss of floodplain habitat, loss of natural river morphology and alternation of physical habitat are stressors that can reduce the freshwater spawning habitat for steelhead. Without them the species cannot successfully spawn and produce offspring.

The species effect determination found related potential stressors of:

- Sedimentation and gravel quantity
- Refuge habitat

There are no additional operations effects on spawning substrate when species are not present.

4.4.3 Juvenile Riparian Habitat and Passage

Riparian habitat that provides for successful juvenile development and survival are essential for the conservation of steelhead. In the late summer and fall, due to the reduction in natural flow and habitat on coastal California streams, the survival conditions become stressful for steelhead. At low flows, critical riffles may become natural barriers to upstream and downstream passage for steelhead, which may prevent adult steelhead from moving to spawning areas or prevent smolts from migrating downstream to staging areas before entering the ocean. The low flows may prevent or delay rearing juvenile steelhead from moving between adequate summer freshwater rearing habitats, seeking productive feeding areas, and avoiding predation. Without adequate flows for juvenile to access passage downstream, the juveniles may not easily migrate from the spawning grounds to the Pacific Ocean.

The species effect determination found related potential stressors of:

- Outmigration cues
- Entrainment risk

There are no additional operations effects on juvenile riparian habitat and passage when species are not present.

4.4.4 Uncontaminated Habitat Areas and Prey

A functioning migration corridor for the emigration of juvenile steelhead from the upper Sacramento River to the Delta and its tributaries is dependent on the condition of flows, temperature, suitable habitat, and a lack of fish predators. Habitat areas that are not contaminated are essential for the conservation of steelhead.

The species effect determination found related potential stressors of:

- Food availability and quality

There are no additional operations effects on uncontaminated habitat areas and prey when species are not present.

4.4.5 Suitable Flows

Suitable river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles are essential for the conservation of steelhead. A suitable flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development. Successful migration of adult steelhead to and from spawning grounds is also dependent on sufficient water flow. Spawning success is associated with water flow and water temperature.

The species effect determination found related potential stressors of:

- Outmigration cues
- Refuge habitat

- Food availability and quality
- Stranding
- Entrainment risk

There are no additional operations effects on suitable flows when species are not present.

4.4.6 Water Temperature

Spawning success is associated with water flow and water temperature. Water temperatures between 40°F and 55°F (4.4°C and 12.8°C) are suitable for successful spawning, egg incubation, and fry development for steelhead (WDOE 2002).

The species effect determination found related potential stressors of:

- Egg incubation

There are no additional operation effects on water temperatures when species are not present.

4.5 Critical Habitat Effect Determination

The seasonal operation is likely to adversely affect critical habitat for steelhead.

- Degraded spawning and rearing substrate is reintroduced in the proposed action area through gravel augmentation projects.
- Degraded water temperatures for egg incubation and adult holding are actively managed through Cold Water Pool Management.
- Impacts to juvenile rearing and refuge habitat are compensated through the construction of additional habitat and implementing recommendations based on new research.
- Flow management is actively managed to reduce or avoid impacts to stressors on steelhead for all life stages.

5. Green Sturgeon

The southern distinct population segment of North American green sturgeon (Acipenser medirostris) (green sturgeon) and designated critical habitat occurs in the action area and may be affected by the seasonal operations. Green sturgeon are an anadromous fish species that can live 60 to 70 years and grow to a size of 9 feet. Green sturgeon spawn in the Sacramento River and spend most of their life in the nearshore marine environment and coastal bays and estuaries along the west coast of North America.

5.1 Conceptual Lifecycle Models

An action may affect fish when the change in conditions overlaps with the location and timing of fish and/or their habitats. The SAIL conceptual model (Heublein et al. 2017) describes life stages and geographic locations for green sturgeon (Figure).

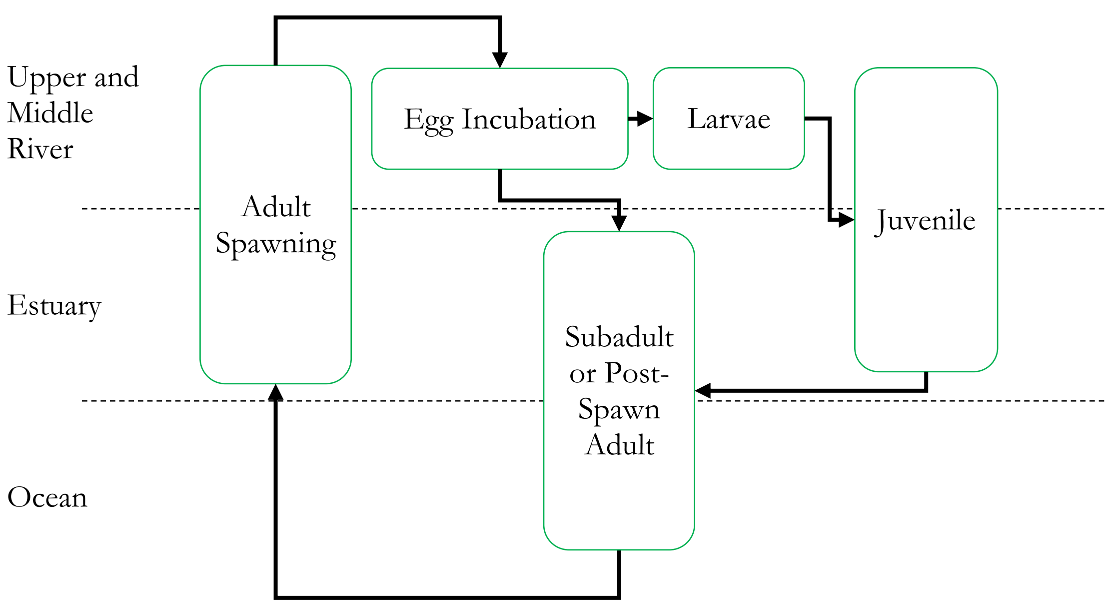

Figure 7. Geographic Life Stage Domains for Green Sturgeon (developed from Heublein et al. 2017)

SAIL models describe linkages between landscape attributes and environmental drivers to habitat attributes that may affect fish (stressors) based on life stage. The green sturgeon SAIL model provides life stages and stressors of:

- Adult to Spawning Adult

    - H25: Harvest
    - H29: Food
    - H26, H27: Water Temperature & Salinity
    - H30: Toxicity & DO
    - H28: Migration & Foraging Habitat
    - H31: Predation Risk
- Egg to Larvae
    - H3: Flow
    - H2: Water Temperature
    - H5: Toxicity & DO
    - H4: Incubation Habitat
    - H6: Predation Risk
- Larvae to Juvenile
    - H8: Flow
    - H9: Water Temperature
    - H13: Toxicity & DO
    - H12: Entrainment Risk
    - H10: Rearing Habitat
    - H14: Food
    - H11: Predation Risk
- Juvenile to Subadult/Adult
    - H16: Flow
    - H17, H20: Water Temperature & Salinity
    - H21: Toxicity & DO
    - H22: Entrainment Risk
    - H18: Rearing Habitat
    - H19: Food
    - H23: Predation Risk

- Spawning Adult to Egg & Post-Spawn Adult
    - H37: Harvest
    - H34, H39: Flow
    - H35, H38, H40: Water Temperature
    - H41: Toxicity & DO
    - H33: Barriers
    - H36: Spawning Habitat

Each deconstruction of the action considers the 31 stressors for the five life stages listed above. Additional and/or alternative conceptual models (e.g., CVPIA Science Integration Team) may be incorporated as applicable.

The temporal occurrence of green sturgeon (Figure 8) (Appendix C) was informed from Heublein et al 2017 and updated with information from Red Bluff monitoring (Poytress pers. comm.) and information on telemetered green sturgeon (Colborne pers. comm.).

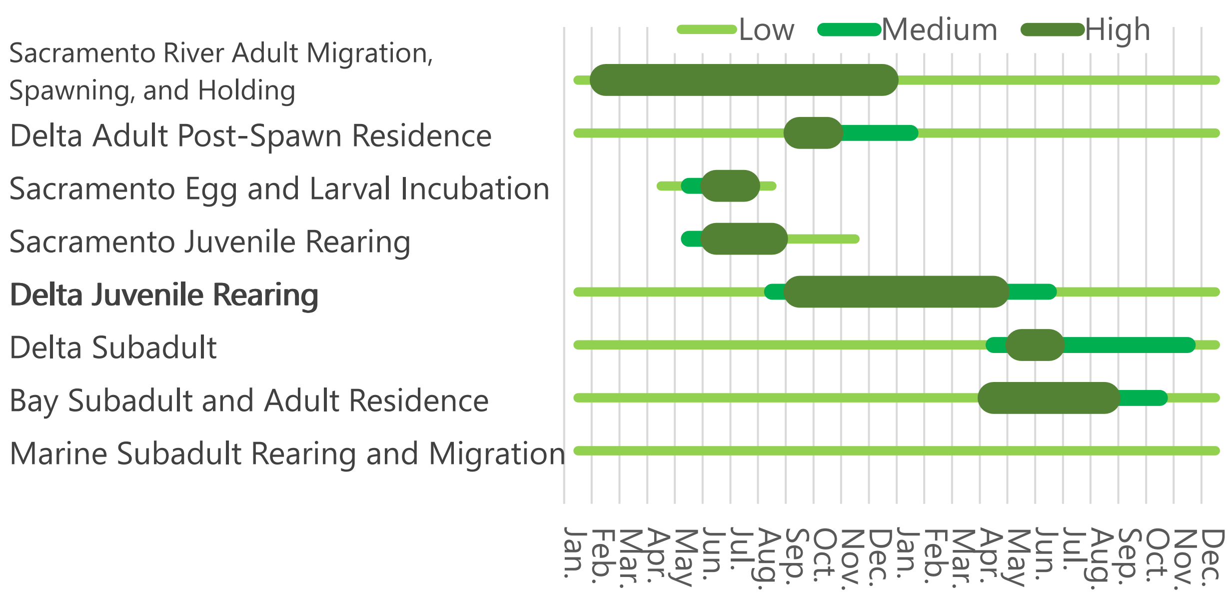

Figure 8. Temporal Life Stage Domains for Green Sturgeon from Appendix C

The two spatial domains defined for green sturgeon are the Sacramento River and Bay-Delta. The presence for Sacramento spawning and Bay-Delta subadult stages span more than one year. Green sturgeon remain subadults for multiple years and likely rear at least a portion of that multi-year time in bays and estuaries adjacent to the Sacramento River (*i.e.*, the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco Bays). The ocean life stage is a critical habitat action area determined by NMFS and is shown but not evaluated in the species effects deconstruction.

5.2 Species Effects Deconstruction

Green sturgeon are anticipated in the Sacramento River and Bay-Delta and may experience effects from components of the seasonal operations as described below. The Sacramento River includes adult migration and holding, adult spawning and emigration, egg incubation and larvae presence, and juvenile rearing and outmigration. The Bay-Delta includes migrating adults and post-spawn adults and migrating juveniles.

5.2.1 Sacramento River

In the winter, Reclamation and DWR's proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flow in the upper Sacramento River may change stressors on green sturgeon.

Adults are outmigrating in the upper Sacramento River in the winter. Adults present and outmigrating in the winter represent the tail end of the life stage exhibiting that behavior. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

Harvest stressors are not anticipated to change. Harvest from sturgeon fisheries may adversely affect current and subsequent green sturgeon abundance. This impact should be considered in population recovery efforts.

Flow stressors are not anticipated to change. Freshwater flow plays an important role in green sturgeon habitat, especially in estuaries. Decreased flows in the upper Sacramento River are less likely to impact adult migrating green sturgeon until they enter the lower reaches of the Sacramento River.

Water temperature stressors are not anticipated to change. A decrease in flows results in warmer water temperature in the winter. However, water temperatures are colder than adult migration temperature needs. Migrating adults may be exposed to high water temperatures if they become stranded in bypasses, which can influence body condition. Poor body condition may decrease migration success.

Toxicity and DO stressors are not anticipated to change. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease migration success. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries). Adults that do not outmigrate may stay in the Sacramento River for another year, possibly exposing them to increased levels of contaminants.

Barriers stressors are not anticipated to change. Migrating adult green sturgeon are unlikely to encounter barriers in the Sacramento River that would impede outmigration.

Spawning habitat stressors are not anticipated to change. Spawning does not occur during the winter months between December and February in the Sacramento River.

Eggs are not present in the upper Sacramento River in the winter.

Larvae are not present in the upper Sacramento River in the winter.

Juveniles are not present in the upper Sacramento River in the winter.

In the spring, Reclamation and DWR's proposed storage of water will decrease flows on average in the Sacramento River below Keswick Dam. Decreased flow in the upper Sacramento River may change stressors on green sturgeon.

Adults are migrating, spawning, and holding in the upper Sacramento River in the spring. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration. Green sturgeon spawning and holding in the Sacramento River are undergoing an energetically taxing transition to spawn.

Harvest stressors are not anticipated to change. No legal harvest of green sturgeon is allowed in the Bay-Delta.

Flow stressors may or may not increase due to lower flows. Decreased flows in the upper Sacramento River may impact adult migration cues, but delayed migration has not been observed in the Sacramento River.

Water temperature stressors are not anticipated to change. A decrease in flows results in warmer water temperature in the winter. However, water temperatures are colder than adult migration temperature needs. Migrating adults may be exposed to high water temperatures if they become stranded in bypasses, which can influence body condition. Poor body condition may decrease migration success.

Toxicity and dissolved oxygen stressors are not anticipated to change due to decreased spring flows. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease migration success. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries). Adults that do not outmigrate may stay in the Sacramento River for another year, possibly exposing them to increased levels of contaminants.

Barriers stressors may increase due to decreased flows. Migrating adult green sturgeon may encounter barriers in the Sacramento River that would impede outmigration, particularly during periods when spring pulse flows are occurring.

Spawning habitat stressors may increase due to decreased flows. Green sturgeon spawning occurs in the spring and decreased flows may cause decrease availability of spawning habitat. Decreased flows may alter spawning cues changing green sturgeon spawning patterns in the Sacramento River. Effects of flows on spawning cues is addressed in flow stressors section.

Eggs are present in the upper Sacramento River in the spring. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

Flow stressors may increase due to decreased flows. Flows directly and indirectly influence habitat attributes important for green sturgeon eggs including egg incubation habitat quality. Effects of flow on incubation habitat is addressed in the incubation habitat stressor section for eggs.

Water temperature stressors may or may not increase due to decreased flows. Decreases in flows results in warmer water temperatures in the spring. Green sturgeon egg incubation temperature requirement are different than other species temperature is managed for in the spring, and temperatures where eggs incubate is likely a function of spawning habitat availability and spawner habitat selection.

Toxicity and DO stressors are not anticipated to change for eggs.

Incubation habitat stressors may increase due to decreased flows. Flows directly and indirectly influence habitat attributes important for green sturgeon eggs incubation and are described in flow stressors for eggs. Attributes such as sedimentation, substrate, and turbidity in spawning grounds may be affected, which can impact egg incubation survival.

Predation risk stressors are not anticipated to change. Flow directly and indirectly affects larvae survival. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Sacramento River.

Larvae are present in the upper Sacramento River. Several stressors have been identified for habitat attributes that affect larvae development, relative abundance, and distribution.

Flow stressors may increase due to decreased flow. Flows directly and indirectly influence habitat attributes important for green sturgeon larval abundance such as rearing habitat and food availability. Effects of flow on rearing habitat and food availability are addressed in the rearing habitat and food stressors section for larvae.

Water Temperature stressors may or may not increase due to decreased flows in the spring. Water temperatures affect larval development, and a decrease in flows may result in warmer water temperatures in the spring or may extend cooler waters in the summer across the larval development period.

Toxicity and DO stressors are not anticipated to change. Contaminants may directly influence larvae survival through consumption of contaminated food resources. Larvae may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease survival success.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Rearing Habitat stressors may or may not increase due to decreased flows. Decreased flows may reduce rearing and slow-moving refuge habitat for larvae since there may be less edge habitat. Alternately, decreased flows may reduce velocities and increase larval rearing habitat. There is limited information on rearing habitat requirements for green sturgeon larvae.

Food stressors are not anticipated to change. Habitat attributes including availability of periphyton and zooplankton are not likely to change due to flow.

Predation risk stressors are not anticipated to change from decreased flows. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Sacramento River.

Juveniles are present in the upper Sacramento River. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during migration.

Flow stressors may increase due to decreased flows. Flows may affect residency and migration of juvenile green sturgeon in the Sacramento River.

Water Temperature and salinity stressors may or may not increase due to decreased flows. Water temperatures affect larval development and a decrease in flows may result in warmer water temperatures in the spring or may extend cooler waters in the summer across the larval development period. Salinity stressors are not anticipated in the Sacramento River.

Toxicity and DO stressors are not anticipated to change. Contaminants may directly influence juvenile survival through consumption of contaminated food resources. Juveniles may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease survival success.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Rearing habitat stressors may or may not increase due to decreased flows. Decreased flows may reduce rearing and slow-moving refuge habitat for juveniles since there may be less edge habitat. Alternately, decreased flows may reduce velocities and increase larval rearing habitat. There is limited information on rearing habitat requirements for green sturgeon larvae.

Food stressors are not anticipated to change. Habitat attributes including availability of periphyton and zooplankton are not likely to change due to flow.

Predation risk stressors are not anticipated to change. Flow directly and indirectly affects larvae survival. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Sacramento River.

In the summer, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Kewsick Dam. Increased flow in the upper Sacramento River may change stressors on green sturgeon.

Adults are migrating, spawning, and holding in the upper Sacramento River. Several stressors have been identified that may impact adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration. Green sturgeon spawning and holding in the Sacramento River are undergoing an energetically taxing transition to spawn.

Harvest stressors are not anticipated to change. No legal harvest of green sturgeon is allowed in the Bay-Delta.

Flow stressors may decrease due to increased flows. Increased flows in the upper Sacramento River are less likely to impact adult migrating green sturgeon until they enter the lower reaches of the Sacramento River. An increase in flow may cue adults to outmigrate towards the Bay-Delta.

Water temperature stressors may decrease due to increased flows. Migrating adults may be exposed to high water temperatures if they become stranded in bypasses, which can influence body condition. Poor body condition may decrease migration success. Sacramento River summer water temperatures are managed for cold water requirements of other species, which are less than the temperature preferences for adult green sturgeon.

Toxicity and DO stressors may decrease due to increased flows. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease migration success. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries). Adults that do not outmigrate may stay in the Sacramento River for another year, possibly exposing them to increased levels of contaminants. Increased flows may increase velocities and maintain DO.

Barriers stressors may decrease due to increased flows. Migrating adult green sturgeon may encounter barriers in the Sacramento River that would impede outmigration, particularly during periods when spring pulse flows are occurring. This has not been observed in the summer.

Spawning habitat stressors may decrease due to increased flows. Green sturgeon spawning occurs in the summer and increased flows may cause increased availability of spawning habitat. Increased flows may alter spawning cues changing green sturgeon spawning patterns in the Sacramento River.

Eggs are present in the upper Sacramento River in the summer. Egg to fry survival is highly dependent on a few parameters. Several stressors have been identified for habitat attributes that affect egg survival, timing, and condition.

Flow stressors may decrease due to increased flows. Flows directly and indirectly influence habitat attributes important for green sturgeon eggs including egg incubation habitat quality. Effects of flow on incubation habitat is addressed in the incubation habitat stressor section for eggs.

Water temperature stressors may or may not decrease due to increased flows. Increases in flows results in cooler water temperatures in the summer. Green sturgeon egg incubation temperature requirement are different than other species temperature is managed for in the summer, and temperatures where eggs incubate is likely a function of spawning habitat availability and spawner habitat selection.

Toxicity and DO stressors are not anticipated to change.

Incubation habitat stressors may decrease due to increased flows. Flows directly and indirectly influence habitat attributes important for green sturgeon eggs including egg distribution, larval abundance, and egg incubation habitat availability and quality.

Predation risk stressors are not anticipated to change for eggs.

Larvae are present in the upper Sacramento River. Several stressors have been identified for habitat attributes that affect larvae development, relative abundance, and distribution.

Flow stressors may decrease due to increased flows. Increased flows may be a primary driver of successful transitions between early life stages. Flows directly and indirectly influence habitat attributes important for green sturgeon larval abundance.

Water Temperature stressors may or may not decrease due to increased flows. Larval growth and distribution may be influenced by water temperature and an increase in flows may result in cooler water temperatures in the summer, which may reduce growth but expand distribution.

Toxicity and DO stressors are not anticipated to change for juveniles.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Rearing habitat stressors may decrease due to increased flows. Increased flows may expand rearing and slow-moving refuge habitats for juveniles since there may be more edge habitat. Alternatively increased flows may increase velocities and reduce juvenile rearing habitat. There is limited information on rearing habitat requirements and availability for green sturgeon juveniles.

Food stressors are not anticipated to change. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Predation risk stressors are not anticipated to change. Flow directly and indirectly affects larvae survival. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Sacramento River.

Juveniles are present in the upper Sacramento River. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during migration.

Flow stressors may decrease due to increased flows. Flows may influence juvenile green sturgeon residency and migration in the Sacramento River.

Water Temperature and salinity stressors may decrease due to increased flows. Water temperatures affect juvenile development and an increase in flows may result in cooler water temperatures in the spring or may extend cooler waters in the summer across the larval development period. Salinity stressors are not anticipated in the Sacramento River.

Toxicity and DO stressors are not anticipated to change.

Entrainment risk stressors are not anticipated to change. CVP facilities on the Sacramento River (Red Bluff Pumping Plant) and facilities used to divert water for CVPIA refuges are screened (e.g., Glenn-Colusa Irrigation District [GCID], Reclamation District 108 [RD 108]).

Rearing habitat stressors may decrease due to increased flows. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Food stressors are not anticipated to change. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Predation risk stressors are not anticipated to change. Flow directly and indirectly affects larvae survival. Reaches of the upper Sacramento River are highly channelized with low complexity and little cover from predators for outmigrating juveniles. Historical data shows that turbidity is generally low. Turbidity can occasionally spike when releases increase; however, the spikes are short-lived. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Sacramento River.

In the fall, Reclamation and DWR's proposed release of water will increase flows on average in the Sacramento River below Kewsick Dam. Increased flow in the upper Sacramento River may change stressors on green sturgeon.

Adults are migrating and holding in the upper Sacramento River. Several stressors have been identified that may impact adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration.

Harvest stressors are not anticipated to change. No legal harvest of green sturgeon is allowed in the Bay-Delta.

Flow stressors may decrease due to increased flows. An increase in flow may cue adults to migrate towards the Bay-Delta.

Water temperature stressors may decrease due to increased flows. An increase in flows results in warmer water temperature in the fall. However, water temperatures are colder than adult migration temperature needs.

Toxicity and DO stressors may decrease due to increased flows. Migrating adults stranded in bypasses may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease migration success. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries). Adults that do not outmigrate may stay in the Sacramento River for another year, possibly exposing them to increased levels of contaminants.

Barriers stressors may decrease due to increased flows.

Spawning habitat stressors are not anticipated to change.

Eggs are not present in the upper Sacramento River in the fall.

Larvae are not present in the upper Sacramento River in the fall.

Juveniles are not present in the upper Sacramento River in the fall.

5.2.2 Bay-Delta

In the winter, Reclamation and DWR's proposed storage and diversion of water will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on green sturgeon.

Adults are migrating and holding in the Delta in the winter. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration. Green sturgeon holding in the Sacramento River are preparing to undergo an energetically taxing transition to spawn.

Harvest stressors are not anticipated to change. No legal harvest of green sturgeon is allowed in the Bay-Delta.

Food stressors are not anticipated to change.

Water temperature and salinity stressors are not anticipated to change. Water temperatures are colder than adult temperature needs.

Toxicity and DO stressors are not anticipated to change. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries). Adults do not spend a substantial portion of their life in Bay-Delta.

Migration and foraging habitat stressors are not anticipated to change. Outmigration cues may be changed due to a decrease in flows. Habitat attributes including availability of quality food supply and localized areas to forage are primarily subtidal and tidal, which are not influenced by seasonal operations.

Predation risk stressors are not anticipated to change in the Delta for adults due to decreased outflow.

Larvae are not present in the Delta in the winter.

Eggs are not present in the Delta.

Juveniles are rearing in the Delta in the winter. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during migration.

Flow stressors may increase due to decreased outflow. Decreased flows may change juveniles' cues to begin outmigrate and duration of Delta residency.

Water temperature and salinity stressors are not anticipated to change. Juvenile survival and distribution may be influenced by habitat attributes like water temperature and salinity.

Toxicity and DO stressors are not anticipated to change. Contaminants may directly influence juvenile survival through consumption of contaminated food resources. Juveniles may be exposed to low dissolved oxygen, which can affect and influence body condition and survival.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce juveniles' travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities. Historic salvage of green sturgeon at the Delta export facilities is low and highly variable.

Rearing habitat stressors are not anticipated to change. Subtidal habitats used for refuge are affected by tidal flows, not seasonal decreased due to operations.

Food stressors are not anticipated to change. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Predation risk stressors are not anticipated to change. Water temperatures influence the metabolic rates of predators, although winter temperatures are cool.

In the spring, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on green sturgeon.

Adults are residing in the Delta in the spring. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration. Green sturgeon holding in the Sacramento River are preparing to undergo an energetically taxing transition to spawn.

Harvest stressors are not anticipated to change. No legal harvest of green sturgeon is allowed in the Bay-Delta.

Food stressors are not anticipated to change. Habitat attributes including quantity of available food for adults are not affected by flow.

Water temperature and salinity stressors are not anticipated to change.

Toxicity and DO stressors are not anticipated to change. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries).

Migration and foraging habitat stressors are not anticipated to change. Outmigration cues may be changed due to a decrease in flows, but adults show very varied duration of outmigration through the spring. Habitat attributes including availability of quality food supply and localized areas to forage successfully may be influenced by flows.

Predation risk stressors are not anticipated to change for adults.

Larvae are not present in the Delta.

Eggs are not present in the Delta.

Juveniles are rearing in the Delta in the spring. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during migration.

Flow stressors may or may not increase due to decreased flows. Decreased flows may change juveniles' cues to begin outmigration or may extend residency in the Delta while fish prepare for marine migration.

Water temperature and salinity stressors are not anticipated to change. Juvenile survival and distribution may be influenced by habitat attributes like water temperature and salinity. A decrease in flows results in warmer water temperatures in the winter. Understanding of temperature effects in situ on juveniles from telemetry studies is limited.

Toxicity and DO stressors are not anticipated to change. Contaminants may influence juvenile survival through consumption of contaminated food resources. Juveniles may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease survival success.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce juveniles' travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities. Historic salvage of green sturgeon at the Delta export facilities is low.

Rearing Habitat stressors are not anticipated to change. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Food stressors are not anticipated to change. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Predation risk stressors are not anticipated to change. Flow directly and indirectly affects predation on adult green sturgeon. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Bay-Delta.

In the summer, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on green sturgeon.

Adults are residing in the Delta in the summer. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration. Green sturgeon holding in the Sacramento River are preparing to undergo an energetically taxing transition to spawn.

Harvest stressors are not anticipated to change. No legal harvest of green sturgeon is allowed in the Bay-Delta.

Food stressors are not anticipated to change. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Water temperature and salinity stressors are not anticipated to change. Migrating adults may be exposed to high water temperatures if they become stranded in bypasses, which can influence body condition. Poor body condition may decrease migration success.

Toxicity and DO stressors are not anticipated to change. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries).

Migration and foraging habitat stressors may or may not change. Adult outmigration cues are not anticipated may be changed due to a decrease in flows during the summer. Foraging habitat attributes including availability of quality food supply and localized areas to forage are primarily subtidal and tidal, which are not influenced by seasonal operations.

Predation risk stressors are not anticipated to change for adults due to decreased flows

Larvae are not present in the Delta.

Eggs are not present in the Delta.

Juveniles are rearing in the Delta in the summer. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during migration.

Flow stressors may increase due to decreased flows. Flows may influence juvenile green sturgeon abundance in the Bay-Delta. Flows may also affect outmigration cues. Decreased flows may change juveniles' cues to begin outmigration. Limited data suggest flows influence freshwater residency.

Water temperature and salinity stressors are not anticipated to change. Juvenile survival and distribution may be influenced by habitat attributes like water temperature and salinity.

Toxicity and DO stressors are not anticipated to change. Contaminants may directly influence juvenile survival through consumption of contaminated food resources. Juveniles may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease survival success.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce juveniles' travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities. Historic salvage of green sturgeon at the Delta export facilities is low.

Rearing habitat stressors are not anticipated to change. Rearing habitat attributes including availability of quality food supply and localized areas to forage are primarily subtidal and tidal, which are not influenced by seasonal operations.

Food stressors are not anticipated to change. The quantity and quality of prey resources for juveniles are not affected by flow in the summer.

Predation risk stressors are not anticipated to change. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Bay-Delta.

In the fall, Reclamation and DWR's proposed water operations will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on green sturgeon.

Adults are residing in the Delta in the fall. Several stressors have been identified that may delay adult migration, increase energy necessary to undergo the transition, or decrease adult survival during migration. Green sturgeon holding in the Sacramento River are preparing to undergo an energetically taxing transition to spawn.

Harvest stressors are not anticipated to change. No legal harvest of green sturgeon is allowed in the Bay-Delta.

Food stressors are not anticipated to change. Habitat attributes including availability of quality food supply and localized areas to seek refuge may be influenced by flows.

Water temperature and salinity stressors are not anticipated to change. Migrating adults may be exposed to high water temperatures if they become stranded in bypasses, which can influence body condition. Poor body condition may decrease migration success.

Toxicity and DO stressors are not anticipated to change. Bioaccumulation of toxic contaminants in adults may negatively impact the following generation (e.g., contaminant accumulation in ovaries).

Migration and foraging habitat stressors are not anticipated to change. Outmigration cues may be changed due to a decrease in flows. Foraging habitat attributes including availability of quality food supply and localized areas to forage are primarily subtidal and tidal, which are not influenced by seasonal operations.

Predation risk stressors are not anticipated to change. Flow directly and indirectly affects predation on adult green sturgeon. Water temperatures may have an influence on the metabolic rates of predators, and flows can mediate the abundance and distribution of the fish community in the Bay-Delta.

Larvae are not present in the Delta.

Eggs are not present in the Delta.

Juveniles are rearing in the Delta in the fall. Several stressors have been identified to possibly affect survival, residence time and migration, and juvenile growth during migration.

Flow stressors may increase due to decreased flows. Flows may influence juvenile outmigration cues and duration of residency.

Water temperature and salinity stressors are not anticipated to change. Juvenile survival and distribution may be influenced by habitat attributes like water temperature and salinity. A decrease in flows results in warmer water temperatures in the winter. Understanding of temperature effects in situ on juveniles from telemetry studies is limited.

Toxicity and DO stressors are not anticipated to change. Contaminants may directly influence juvenile survival through consumption of contaminated food resources. Juveniles may be exposed to low dissolved oxygen, which can affect and influence body condition. Poor body condition may decrease survival success.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may reduce juveniles' travel rates and route fish into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities. Historic salvage of green sturgeon at the Delta export facilities is low.

Rearing habitat stressors are not anticipated to change. Rearing habitat attributes including availability of quality food supply and localized areas to forage are primarily subtidal and tidal, which are not influenced by seasonal operations.

Food stressors are not anticipated to change. The quantity and quality of prey resources for juveniles are not affected by flow in the summer.

Predation risk stressors are not anticipated to change in the fall due to decreased flows.

5.3 Species Effects Determination

The seasonal operation of the CVP and SWP may affect and is likely to adversely affect the southern distinct population segment of Norther American Green Sturgeon. The seasonal operation of the CVP is also likely to have beneficial effects. Deconstruction of the seasonal operations systematically evaluated each stressor identified by conceptual models. Stressors not linked to the operation of the CVP and SWP were identified as "not anticipated to change." Stressors that were insignificant or discountable were documented. Stressors with a material effect on the fitness of species were identified, and the seasonal operation incorporates minimization and/or compensation through conservation measures.

Stressors on **adults** influenced by the seasonal operations include:

- Spawning habitat: Reduced released below Keswick may increase spawning habitat stressors in the Sacramento River in the spring. Adverse effects are minimized through seasonal flow management.
- Barriers: Decreased flows during the spring in the Sacramento River may increase barriers stressors. Adverse effects are minimized through operation and maintenance at structures that are known barriers (e.g., Fremont Weir).

Stressors on **eggs** influenced by the seasonal operations include:

- Water Temperatures: Decreased flows in the spring and lower temperatures from coldwater pool management in the summer may impact egg incubation conditions and survival. Adverse effects are minimized through allowing uninterrupted migratory corridor so adults may select habitats that provide temperatures that are suitable for spawning, egg incubation, and juvenile growth.
- Incubation habitat: Decreased flows in the spring may provide less habitat quality. Adverse effects are minimized through seasonal flow operations.

Stressors on **larvae** influenced by the seasonal operations include:

- Flow: Lower spring flows could reduce larval abundance. Adverse effects are minimized by seasonal flow operations.
- Water Temperatures: Actions to preserve cold water for use later in the year modify summer river temperatures (e.g., operation of the TCD, warm-water power bypass). Colder water temperature may have an adverse effect, which are minimized by allowing adults to select habitats that provide temperatures that are suitable for spawning, egg incubation, and juvenile growth.
- Rearing habitat: Decreased flows in the spring may provide less habitat quality. Adverse effects are minimized through seasonal operations.

Stressors on **juveniles** influenced by the seasonal operations include:

- Flow: Reduced releases below Keswick may increase flow stressors. Adverse effects are minimized by seasonal flow operations.
- Water temperature: Actions to preserve cold water for use later in the year may warm river temperatures (e.g., operation of the TCD, warm-water power bypass). Adverse effects are minimized by allowing adults to select habitats that provide temperatures that are suitable for spawning, egg incubation, and juvenile growth.

- Rearing habitat: Decreased flows may provide less habitat quality. Adverse effects are minimized through seasonal operations.
- Entrainment: Reduced outflow in the Delta during multiple seasons may increase entrainment stressors. Adverse effects are minimized by OMR management.

5.4 Critical Habitat Physical and Biological Features

Critical habitat for green sturgeon was designated on October 9, 2009 (70 FR 52299).

The geographical extent of designated critical habitat includes: coastal U.S. marine waters within 60 fathoms (fm) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco Bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor). This rule designates approximately 515 kilometer (km) (320 miles (mi)) of freshwater river habitat, 2,323 km^2 (897 mi^2) of estuarine habitat, 29,581 km^2(11,421 mi^2) of marine habitat, 784 km^2 (487 mi^2) of habitat in the Sacramento-San Joaquin Delta, and 350 km^2 (135 mi^2) of habitat within the Yolo and Sutter bypasses (Sacramento River, CA).

The critical habitat for green sturgeon lists the essential physical and biological features, which include:

5.4.1 Food Resources

Green sturgeon need abundant prey items for larval, juvenile, subadult, and adult life stages. Although specific data on food resources for green sturgeon within freshwater riverine systems is very limited, juvenile green sturgeon most likely feed on fly larvae, amphipods, and bivalves, based on nutritional studies on the closely-related white sturgeon (Schreiber 1962; Radtke 1966). Food resources are important for juvenile foraging, growth, and development during their downstream migration to the Delta and bays. In addition, subadult and adult green sturgeon may forage during their downstream post-spawning migration, while holding within deep pools (Erickson et al. 2002), or on non-spawning migrations within freshwater rivers. Subadult and adult green sturgeon in freshwater rivers most likely feed on benthic prey species similar to those fed on in bays and estuaries, including shrimp, clams, and benthic fishes (Moyle et al. 1995; Erickson et al. 2002; Moser and Lindley 2007; Dumbauld et al. 2008).

The species effect determination found related potential stressors of:

- Rearing habitat

There are no additional operations effects on food resources when species are not present.

5.4.2 Spawning Substrate

Green sturgeon need substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adults (e.g., substrates for holding and spawning). For example, spawning is believed to occur over substrates ranging from clean sand to bedrock (Emmett et al. 1991; Moyle et al. 1995), with preferences for gravel, cobble, and boulder (Poytress et al. 2009; Erickson pers. Comm.). Eggs likely adhere to substrates or settle into crevices between substrates (Deng 2000; Van Eenennaam et al. 2001; Deng et al. 2002). Both embryos and larvae exhibited a strong affinity for benthic structure during laboratory studies (Van Eenennaam et al. 2001; Deng et al. 2002; Kynard et al. 2005) and may seek refuge within crevices but use flat-surfaced substrates for foraging (Nguyen and Crocker 2007).

The species effect determination found related potential stressors of:

- Incubation habitat

There are no additional operations effects on spawning substrate when species are not present.

5.4.3 Flow for Behavior, Growth, and Survival

A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) is necessary for normal behavior, growth, and survival of all life stages. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11°C -19°C) (COSEWIC 2004; Mayfield and Cech 2004; Van Eenennaam et al. 2005; Allen et al. 2006). Sufficient flow is needed to reduce the incidence of fungal infestations of the eggs (Deng et al. 2002; Parsley et al. 2002). In addition, sufficient flow is needed to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in (and potentially suffocating the eggs; Deng et al. 2002) and to maintain surfaces for feeding (Nguyen and Crocker 2007). Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning success is associated with water flow and water temperature. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 400 m^3/s (average daily water flow during spawning months: 198-306 m^3/s) (Brown 2007). Post-spawning downstream migrations are triggered by increased flows, ranging from 174-417 m^3/s in the late summer (Vogel 2005) and greater than 100 m^3/s in the winter (Erickson et al. 2002; Benson et al. 2007; Corwin pers. comm.).

The species effect determination found related potential stressors of:

- Flow
- Barriers
- Water Temperatures

There are no additional operations effects on flow for behavior, growth, and survival when species are not present.

5.4.4 Water Quality

Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures would include relatively stable water temperatures within spawning reaches (wide fluctuations could increase egg mortality or deformities in developing embryos); temperatures within 11°C -17°C (optimal range = 14°C -16°C) in spawning reaches for egg incubation (March–August) (Van Eenennaam et al. 2005); temperatures below 20°C for larval development (Werner et al. 2007); and temperatures below 24°C for juveniles (Mayfield and Cech 2004; Allen et al. 2006). Suitable salinity levels range from fresh water (<3 parts per thousand [ppt]) for larvae and early juveniles (about 100 dph) to brackish water (10 ppt) for juveniles prior to their transition to salt water. Exposure to higher salinities may affect the temperature tolerances of juvenile green sturgeon (Sardella et al. 2008), and prolonged exposure to higher salinities may result in decreased growth and activity levels and even mortality (Allen and Cech 2007). Adequate levels of dissolved oxygen are needed to support oxygen consumption by fish in their early life stages (ranging from 61.78 mg to 76.06 mg O_2 hr^{-1} kg^{-1} for juveniles) (Allen and Cech 2007). Suitable water quality would also include water containing acceptably low levels of contaminants (e.g., pesticides, polyaromatic hydrocarbons [PAHs], elevated levels of heavy metals) that may disrupt normal development of embryonic, larval, and juvenile stages of green sturgeon. Water with acceptably low levels of such contaminants would protect green sturgeon from adverse impacts on growth, reproductive development, and reproductive success (e.g., reduced egg size and abnormal gonadal development) likely to result from exposure to contaminants (Fairey et al. 1997; Foster et al. 2001a; Foster et al. 2001b; Kruse and Scarnecchia 2002; Feist et al. 2005; Greenfield et al. 2005).

The species effect determination found related potential stressors of:

- Water Temperatures

There are no additional operations effects on water quality when species are not present.

5.4.5 Migratory Corridor

A migratory is pathway necessary for the safe and timely passage of southern distinct population segment (DPS) fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage). We define safe and timely passage to mean that human-induced impediments (either physical, chemical, or biological) do not alter the migratory behavior of the fish such that its survival or the overall viability of the species is compromised (e.g., an impediment that compromises the ability of fish to reach their spawning habitat in time to encounter con-specifics and reproduce). Unimpeded migratory corridors are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries.

The species effect determination found related potential stressors of:

- Barriers

There are no additional operations effects on migratory corridor when species are not present.

5.4.6 Water Depth

Deep (≥5 m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow are needed to maintain the physiological needs of the holding adult or subadult fish. Deep pools of ≥5 m depth with high associated turbulence and upwelling are critical for adult green sturgeon spawning and for summer holding within the Sacramento River (Poytress et al. 2009). Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson et al. 2002; Benson et al. 2007).

The species effect determination found related potential stressors of:

- Flow

There are no additional operations effects on water depth when species are not present.

5.4.7 Sediment Quality

Sediment quality (i.e., chemical characteristics) is necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of elevated levels of contaminants (e.g., selenium, PAHs, and pesticides) that may adversely affect green sturgeon. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may adversely affect the growth, reproductive development, and reproductive success of green sturgeon.

The species effect determination did not find stressors associated with sediment quality.

There are no operations effects on sediment quality when species are not present.

5.5 Critical Habitat Effect Determination

The seasonal operation is likely to adversely affect critical habitat for the southern distinct population segment of North American green sturgeon.

- Degraded spawning substrate is reintroduced in the action area through gravel augmentation projects.
- Impacts to juvenile rearing habitat and migration corridors are compensated through the construction of additional habitat and implementing recommendations based on new research.
- Impacts associated with flow, water depth, and quality, are compensated through seasonal flow management.

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6. Delta Smelt

The Delta smelt was one of the most common and abundant pelagic fish caught by California Department of Fish and Game trawl surveys in the Delta during the early 1970s (Stevens and Miller 1983; Moyle et al. 1989; Stevens et al. 1990). A euryhaline, "semi-anadromous" species, as initially coined by Moyle et al. (1992), its distribution once ranged from western Suisun Bay upstream to Sacramento on the Sacramento River and to Mossdale on the San Joaquin River (Radtke 1966; Moyle 1976; Moyle et al. 1992), with 90% of fish caught at salinities <6 psu and a majority of both adults and juveniles caught at salinities <2 psu (Bennet 2005). The current juvenile and adult distribution, however, is mostly restricted to the "North Delta Arc" from the Cache Slough and Lindsay Slough Complex in the north Delta to the Sacramento River and Suisun Marsh (Merz et al. 2011). Larvae and juveniles are present in the central and south Delta, and increased incidental entrainment risk is possible under certain hydraulic conditions (reverse Old and Middle river flow) (Kimmerer 2008; Grimaldo et al. 2009). Once plentiful in the Delta ecosystem, this annual fish species is now a rare sight in monitoring surveys that provide data on fish abundance, leading to its status being listed as threatened (1993) under the California Endangered Species Act (CESA) and Federal Endangered Species Act (ESA), further elevated to endangered (2009) under CESA.

The Delta smelt is adapted for life in the mixing zone (brackish water/freshwater interface) of the Sacramento-San Joaquin estuary.

6.1 Conceptual Lifecycle Models

An action may affect fish when the change in conditions overlap with the location and timing of fish and/or their habitats. Conceptual models from the Delta Smelt Management Analysis, and Synthesis Team (IEP MAST 2015) describes life stages and geographic locations for Delta smelt (Figure); however, the subadult lifestage was omitted due to similar geographic locations, operational conditions, and stressors.

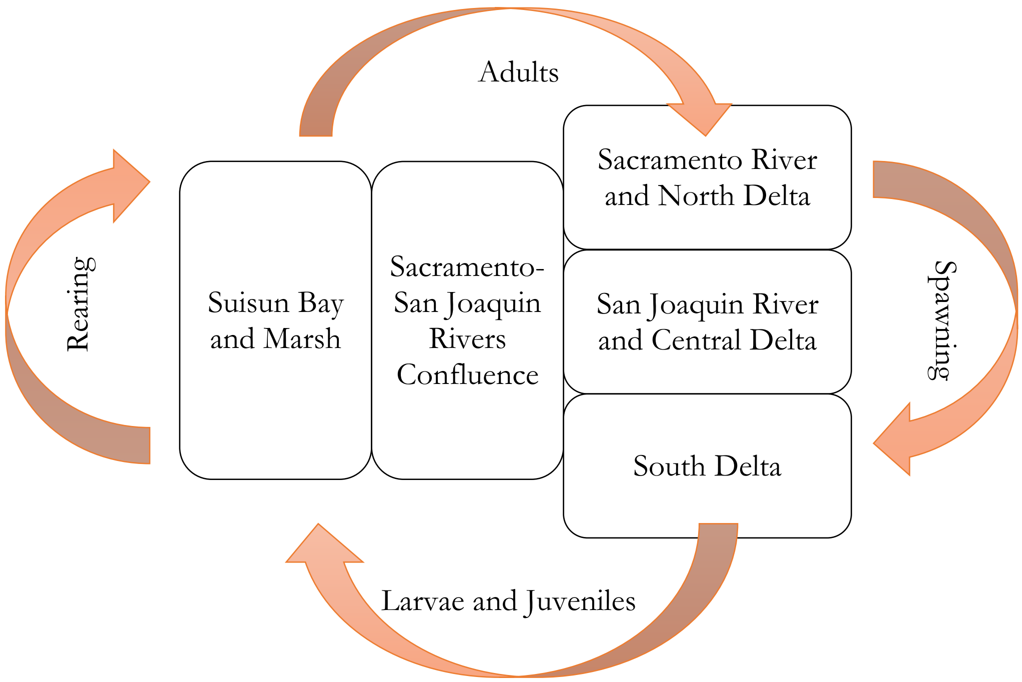

Figure 9. Geographic Life Stage Domains for Delta Smelt (developed from IEP MAST, 2015)

The Delta smelt MAST describes linkages between landscape attributes and environmental drivers to habitat attributes that may affect fish (stressors) based on life stage. The MAST model provides life stages and stressors of:

- Adults
  - H_{na}: Toxicity
  - H_{na}: Water Temperature
  - H4: Food Availability/Visibility
  - H3, H2: Predation Risk
  - H1: Entrainment Risk
- Eggs & Larvae
  - H1: Water Temperature
  - H2: Food Availability/Visibility
  - H3: Predation Risk
  - H4: Entrainment Risk & Transport Direction
- Juveniles

- H4a: Toxicity from Harmful Algal Blooms
- H1: Water Temperature
- H3, H4b: Food Availability & Quality
- H2: Predation Risk
- H4: Entrainment Risk & Transport Direction
- H3a: Harmful Algal Blooms
- H4: Size and Location of LSZ

Each deconstruction of the action considers the 13 stressors for the four life stages listed above. Additional and/or alternative conceptual models (e.g., Rose, Delta Smelt Structured Decision Making) may be incorporated as applicable.

Monitoring from trawls describes the timing of Delta smelt presence (Figure 10) (Appendix C).

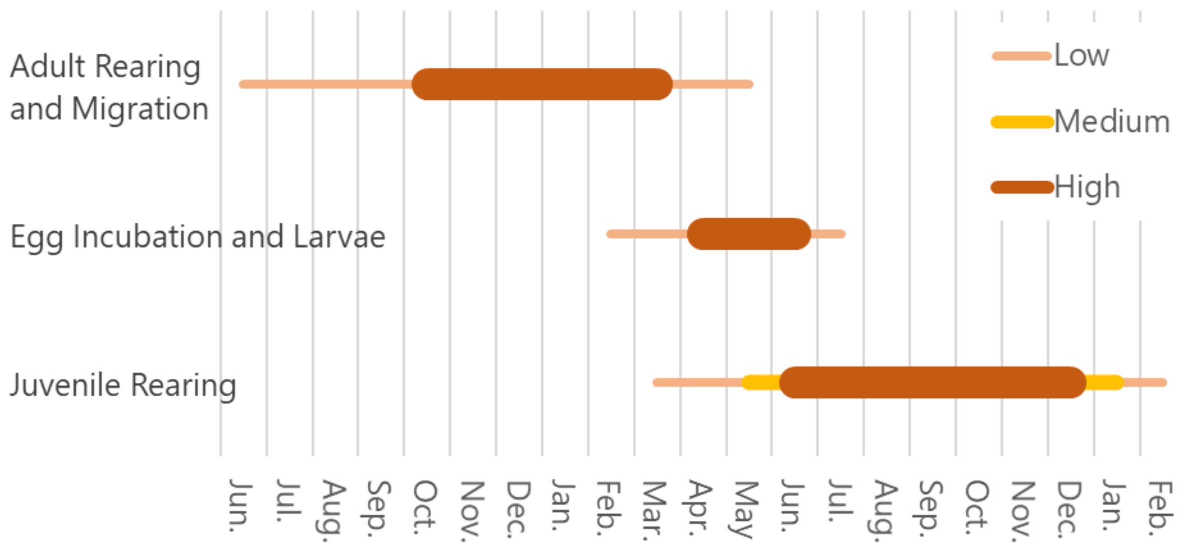

Figure 10. Temporal Life Stage Domains for Delta Smelt (developed from IEP MAST, 2015) from Appendix C.

6.2 Species Effects Deconstruction

Delta smelt complete their entire lifecycle within the Bay-Delta and Suisun Marsh. While most individuals follow a semi-anadromous life history, migrating to freshwater in winter to spawn, hatching mostly in the spring and dispersing back to the low-salinity zone in the summer and fall to rear, Hobbs has documented small resident portions of the population entirely completing their life cycle in either fresh or brackish areas (Hobbs et al. 2019). As such, the different Delta smelt life stages may experience different effects from components of the seasonal operations.

In the winter, Reclamation and DWR's proposed storage and diversion of water will decrease Bay-Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on Delta smelt.

Eggs and Larvae are not present in the winter.

Juveniles are not present in the winter.

Adults are migrating from rearing habitats in Suisun Bay and Marsh to spawning grounds in the lower Sacramento River, North Delta including the Cache Slough Complex, Sacramento Deep Water Ship Channel, and the lower San Joaquin River.

Toxicity stressors may or may not increase. Decreased Delta outflow may limit the potential for dilution of contaminants mobilized from the watershed, agricultural lands, and urban effluents. Toxicity from contaminants can affect Delta smelt both directly (lethal or sub lethally leading to growth or fecundity impairments) or indirectly (altering the lower food web).

Water temperature stressors are not anticipated to change. At temperatures above a threshold, adults' ability to grow and mature becomes impaired. A decrease in flows may result in slightly warmer water temperature in winter but those effects are anticipated to be minimal as even in the Delta water temperature is mainly driven by air temperature. Winter water temperatures are unlikely to reach levels unsuitable for Delta smelt.

Food availability stressors may increase from decreased net Delta outflows. It is hypothesized from model simulations that fall and winter food availability affects growth and egg production, but field data are currently insufficient to confirm it.

Food Visibility stressors may or may not change due to decreased flows. Lower flows may result in less suspended sediment being transported into the freshwater Delta. Portions of the populations in the LSZ and Suisun Bay and Marsh (rearing adults pre-migration or year-round residents) are unlikely to be affected as turbidity there is mostly tide- and wind-driven.

Predation risk stressors may increase from decreased outflow. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Direct effects of water temperature stressors are addressed in the water temperature stressor section. Increased water temperature may increase predator energetic requirements, although during the winter these remain low.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Harmful Algal Blooms stressors are not anticipated to change. Water temperature may increase frequency and magnitude of harmful algal blooms (HABS); however, this is unlikely to occur in the winter.

Size of LSZ stressors may increase from decreased net Delta outflows on average, and location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. For example, position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects Delta smelt.

In the spring, Reclamation and DWR's proposed storage and diversion of water will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on Delta smelt.

Eggs and Larvae are present. Eggs and larvae are involuntarily transported (advected) by Sacramento River and tidal flows. Several stressors have been identified for these more sensitive life stages.

Water temperature stressors are not anticipated to change. Water temperature influences egg development and hatching success. Larvae that hatch later in the season may experience warmer water temperatures as a result of reduced outflow slowing their timely dispersal toward cooler downstream rearing areas. However, air temperature is considered the main driver of water temperature in Delta smelt habitats, with freshwater inflow only thought to minimally contribute.

Food availability stressors may increase due to entrainment of food and decreased net Delta outflows on average. While higher residence time and turbulent mixing could theoretically stimulate primary and secondary productivity in shallow areas, abundances of historically important Delta smelt zooplankton prey taxa including *Eurytemora affinis* in the LSZ generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval Delta smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to Delta smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Food Visibility stressors may increase in the freshwater Delta due to lower turbidity with lower flows, while portions of the populations in the LSZ, and Suisun Bay and Marsh are unlikely to be affected as turbidity there is mostly tide- and wind-driven.

Predation risk stressors upon eggs is unknown. Predation risk stressors on larvae may increase from the decreased turbidity resulting from decreased outflow (Schreier et al 2016). Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements.

Entrainment risk and transport direction stressors. Eggs are not impacted. Stressors on larvae may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities.

A decrease in Delta outflow may route larvae into corridors towards the Delta export facilities within the hydraulic footprint of the facilities.

Juveniles are present. Juveniles are rearing in the estuary, and their growth and survival is hypothesized to largely depend on quality, quantity, and availability of resources. Several stressors have been identified for the juvenile life stage as fish transition into subadults.

Toxicity from Harmful Algal Blooms stressors are not anticipated to change. HABs, including *Microcystis*, can degrade habitat quality through toxicity to both Delta smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. However, this is more likely to occur in the summer and early fall.

Water temperature stressors are not anticipated to change. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements and potential HABs. However, air temperature is considered the main driver of water temperature in Delta smelt habitats, with freshwater inflow only thought to minimally contribute.

Food availability and Quality stressors may increase from decreased net Delta outflow on average. Abundances of historically important Delta smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis,* generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval Delta smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to Delta smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Predation risk stressors may increase due to decreased outflow and higher water clarity as a result of reduced sediment supply. Increases in water temperature may also increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Predation stressors caused by water temperature are addressed in the water temperature stressor section.

Entrainment risk and transport direction stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route juveniles into corridors towards the Delta export facilities within the hydraulic footprint of the facilities.

Adults are present.

Toxicity stressors may or may not increase. Toxicity from contaminants can affect Delta smelt both directly (lethal or sub lethally leading to growth or fecundity impairments) or indirectly (altering the lower food web). Decreased Delta outflow may limit the potential for dilution of contaminants mobilized from the watershed, agricultural lands, and urban effluents.

Water temperature stressors are not anticipated to change. At temperatures above a threshold, adults' ability to grow and mature becomes impaired. A decrease in flows may result in warmer water temperature in the spring. Increased water temperature also increases predator energetic requirements and the potential for HABs. However, spring water temperatures are unlikely to reach levels unsuitable for Delta smelt and air temperature is considered the main driver of water temperature in Delta smelt habitats, with freshwater inflow only thought to minimally contribute.

Food availability stressors may increase from decreased net Delta outflow. Abundances of historically important Delta smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis,* generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval Delta smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to Delta smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Food Visibility stressors may by increased in the freshwater Delta due to lower turbidity with lower flows, while portions of the populations in the LSZ and Suisun Bay and Marsh are unlikely to be affected as turbidity there is mostly tide- and wind-driven.

Predation risk stressors may increase from decreased outflow and higher water clarity as a result of reduced sediment supply. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing visibility to predators. Increased water temperature also increases predator energetic requirements.

Entrainment risk stressors may increase due to increased OMR flows their towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Harmful Algal Blooms stressors are not anticipated to change. HABs, including *Microcystis,* can degrade habitat quality through toxicity to both Delta smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. However, this is a more likely occurrence in the summer and early fall.

Size of LSZ stressors may increase from decreased net Delta outflows on average, and location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. For instance, the abundance of Delta smelt-favored preys like *Eurytemora affinis* is negatively correlated to X2 (smaller LSZ located eastward of productive habitat in Suisun Bay and Marsh).

In addition, LSZ position may affect recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects Delta smelt.

In the summer Reclamation and DWR's proposed release of water will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on Delta smelt.

Eggs and larvae are not present.

Juveniles are present. Juveniles are rearing in the estuary, and their growth and survival is hypothesized to largely depend on quality, quantity, and availability of resources. Several stressors have been identified for the juvenile life stage as fish transition into subadults.

Toxicity from harmful algal blooms stressors are not anticipated to change. HABs, including *Microcystis,* can degrade habitat quality through toxicity to both Delta smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. This is likely to occur in the summer and early fall. HAB stressors affected by water temperature are addressed in the water temperature stressor section.

Water temperature stressors are not anticipated to change due to summer seasonal operations. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements and potential HABs. However, air temperature is considered the main driver of water temperature in Delta smelt habitats, and the effect of reduced Delta outflow due to summer seasonal operations is anticipated to be comparatively minimal.

Food availability and Quality stressors may increase from decreased inflows to the Delta on average. Abundances of historically important Delta smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis*, generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate juvenile Delta smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to Delta smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams.

Predation risk stressors may increase from decreased outflow and higher water clarity as a result of reduced sediment supply. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Direct effects of water temperature stressors are addressed in the water temperature stressor section. Increased water temperature may increase predator energetic requirements.

Adults are not present.

In the fall, Reclamation and DWR's proposed storage and release of water will decrease Delta outflow on average. Decreased outflow in the Bay-Delta may change stressors on Delta smelt.

Eggs and Larvae are not present in the fall.

Juveniles are present. Juveniles are rearing in the estuary, and their growth and survival is hypothesized to largely depend on quality, quantity, and availability of resources. Several stressors have been identified for the juvenile life stage as fish transition into subadults then adults.

Toxicity from harmful algal blooms stressors are not anticipated to change. HABs, including *Microcystis,* can degrade habitat quality through toxicity to both Delta smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. This is likely to occur in the summer and early fall. HAB stressors affected by water temperature are addressed in the water temperature stressor section.

Water temperature stressors may increase with decreased outflow due to summer seasonal operations. Summer water temperatures have recently started to reach levels less than optimal or unsuitable for Delta smelt in some areas, which may have direct effects on growth and survival or trigger dispersal. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements and potential HABs. However, air temperature is considered the main driver of water temperature in Delta smelt habitats, and the effect of reduced Delta outflow due to summer seasonal operations is anticipated to be comparatively minimal.

Food availability and quality stressors may increase from decreased inflows to the Delta on average. Abundances of historically important Delta smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis,* generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate juvenile Delta smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to Delta smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams.

Predation risk stressors may increase from decreased outflow and higher water clarity as a result of reduced sediment supply. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Direct effects of water temperature stressors are addressed in the water temperature stressor section. Increased water temperature may increase predator energetic requirements.

Adults are present, rearing in the estuary. Their growth and survival is hypothesized to largely depend on quality, quantity, and availability of resources. Several stressors have been identified for the adult life stage as fish grow ahead in preparation for winter migration and spawning (larger healthy adults can produce multiple clutches of numerous higher quality eggs).

Toxicity stressors may or may not increase. Toxicity from contaminants can affect Delta smelt both directly (lethal or sub lethally leading to growth or fecundity impairments) or indirectly (altering the lower food web).

Water temperature stressors are not anticipated to change notably from decreased outflow due to fall seasonal actions as air temperature is considered the main driver of water temperature across the range of Delta smelt habitats. At sub-optimal temperatures, adults' ability to grow and mature becomes impaired. Water temperature also affects predation risk and potential HABs.

Food availability stressors may increase from decreased net Delta outflow. Abundances of historically important Delta smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis*, generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval Delta smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to Delta smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams.

Food Visibility stressors may increase in the freshwater Delta due to lower turbidity with lower flows, while portions of the populations in the LSZ and Suisun Bay and Marsh are unlikely to be affected as turbidity there is mostly tide- and wind-driven.

Predation risk stressors may increase from decreased outflow and higher water clarity as a result of reduced sediment supply. Increases in water temperature may increase Delta smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Direct effects of water temperature stressors are addressed in the water temperature stressor section.

Entrainment risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Harmful Algal Blooms stressors are not anticipated to change. HABs, including *Microcystis*, can degrade habitat quality through toxicity to both Delta smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. This is likely to occur in the summer and early fall. HAB stressors affected by water temperature are addressed in the water temperature stressor section.

Size of LSZ stressors may increase from decreased net Delta outflows on average, and location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. For instance, the abundance of Delta smelt-favored preys like *Eurytemora affinis* is negatively correlated to X2 (smaller LSZ located eastward of productive habitat in Suisun Bay and Marsh). In addition, LSZ position may affect recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects Delta smelt.

6.3 Species Effect Determination

The seasonal operations of the CVP and SWP may affect and is likely to adversely affect Delta smelt. The seasonal operations of the CVP is also likely to have beneficial effects. Deconstruction of the seasonal operations systematically evaluated each stressor identified by conceptual models. Stressors not linked to the operation of the CVP and SWP were identified as "are not anticipated to change." Stressors that were insignificant or discountable were documented above. Stressors with a material effect on the fitness of species were identified, and the seasonal operations incorporates minimization and/or compensation through conservation measures.

Stressors on **adults** influenced by the seasonal operations include:

- Food availability and visibility: May be reduced from decreased net Delta outflows on average resulting from seasonal operations. Adverse effects are minimized by increasing food availability through tidal habitat restoration and Summer Fall Habitat Action.
- Entrainment: Risk may increase from export operations because of migratory patterns. Adverse effects are minimized by implementing real time OMR management.
- Size of LSZ may be reduced from decreased net Delta outflows on average, and location of LSZ would be shifted eastward. Adverse effects are minimized by implementing the tidal restoration Summer Fall Habitat Action.

Stressors on **eggs and larvae** influenced by the seasonal operations include:

- Food availability and visibility may be reduced from decreased net Delta outflows on average. Adverse effects on larvae are minimized by increasing food availability through tidal habitat restoration, Summer Fall Habitat Action, and seasonal operations.
- Entrainment risk and transport direction risk may increase from decreased inflows to the Delta on average. Adverse effects are minimized by implementing real time OMR management.

Stressors on **juveniles** influenced by the seasonal operations include:

- Food availability and visibility may be reduced from decreased net Delta outflows on average. Adverse effects are minimized by increasing food availability through tidal habitat restoration and Summer Fall Habitat Action.
- Entrainment risk and transport direction: May increase from export operations. Adverse effects are minimized by implementing real time OMR management.
- Size and location of LSZ may be decreased due to decreased outflow. Adverse effects are minimized by seasonal operations and Summer Fall Habitat Action.

6.4 Critical Habitat Physical and Biological Features

The U.S. Fish and Wildlife Service designated critical habitat for the Delta smelt on December 19, 1994 (U.S. Fish and Wildlife Service 1994). The geographic area encompassed by the designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (U.S. Fish and Wildlife Service 1994). The entire designated critical habitat for Delta smelt is encompassed by the action area.

The 1994 critical habitat designation stated that “the primary constituent elements essential to the conservation of the Delta smelt are physical habitat, water, river flow, and salinity concentrations required to maintain Delta smelt habitat for spawning, larval and juvenile transport, rearing, and adult migration.” The 1994 critical habitat designation then organized the primary constituent elements by habitat conditions required for each life stage, noting the specific geographic areas and seasons identified for each habitat condition represent the maximum possible range of each of these conditions. Depending on the water-year type (i.e., wet, above normal, normal, below normal, dry, critically dry), each of the habitat conditions specified below requires fluctuation (within-year and between-year) in the placement of the 2 ppt isohaline (a line drawn to connect all points of equal salinity) around three historical reference points.

The U.S. Fish and Wildlife Service’s primary objective in designating critical habitat was to identify the key components of Delta smelt habitat that support successful completion of the life cycle, including spawning, larval and juvenile transport, rearing, and adult migration back to spawning sites (USFWS 2019).

The primary constituent elements for the Delta smelt are:

6.4.1 Spawning Habitat (“Shallow Water Habitat”)

Delta smelt adults seek shallow edge waters for spawning. Laboratory observations indicate that Delta smelt are broadcast spawners, discharging eggs and milt close to the bottom over substrates of sand or pebble (DWR and Reclamation 1994; Lindberg et al. 2003; Wang 2007). Rather than stick to immobile substrates, the adhesive eggs might adhere to sand particles, which keeps them negatively buoyant but not immobile (Hay 2007). Spawning occurs primarily during April through mid-May (Moyle 2002) in sloughs and shallow edge areas in the Bay-Delta. Spawning also has been recorded in Suisun Marsh and the Napa River (Hobbs et al. 2007). To ensure egg hatching and larval viability. spawning areas also must provide suitable water quality (i.e., low concentrations of pollutants).

Specific areas that have been identified as important Delta smelt spawning habitat include Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore Sloughs and the Sacramento River in the Delta, and tributaries of northern Suisun Bay. However, most adult fish have since been observed to aggregate around Grizzly Island, Sherman Island, and in the Cache Slough complex, including the subsequently flooded Liberty Island (USFWS 2019).

However, the U.S. Fish and Wildlife Service has noted that information on spawning habitat is incomplete, and because eggs are demersal and adhesive, they could attach to any number of substrates (USFWS 2019).

There are no additional operations effects on spawning habitat when species are not present.

6.4.2 Larval and Juvenile Transport

To ensure that Delta smelt larvae are transported from the area where they are hatched to shallow, productive rearing or nursery habitat, the Sacramento and San Joaquin rivers and their tributary channels must be protected from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversions that result in entrainment and in-channel barriers or tidal gates).

Adequate river flow is necessary to transport larvae from upstream spawning areas to rearing habitat in Suisun Bay. Additionally, river flow must be adequate to prevent interception of larval transport by the state and federal water projects and smaller agricultural diversions in the Bay-Delta. To ensure that suitable rearing habitat is available in Suisun Bay. The 2 ppt isohaline must be located westward of the Sacramento-San Joaquin River confluence during the period when larvae or juveniles are being transported, according to the historical salinity conditions that vary according to water-year type. Reverse flows that maintain larvae upstream in deep-channel regions of low productivity and expose them to entrainment interfere with those transport requirements. Suitable water quality must be provided so that maturation is not impaired by pollutant concentrations. The specific geographic area important for larval transport is confined to waters contained within the legal boundary of the Delta, Suisun Bay, and Montezuma Slough and its tributaries. The specific season when habitat conditions identified above are important for successful larval transport varies from year to year, depending on when peak spawning occurs and the water-year type.

The U.S. Fish and Wildlife Service identified situations in the biological opinion for the Delta smelt (1994) where additional flows might be required in the July through August period to protect Delta smelt that were present in the south and central Delta from being entrained in the state and federal project pumps, and to avoid jeopardy to the species.

The species effect determination found related potential stressors of:

- Entrainment risk
- Transport direction
- Size of LSZ

There are no additional operations effects on larval and juvenile transport when species are not present.

6.4.3 Rearing Habitat

Maintenance of the 2 ppt isohaline according to the historical salinity conditions described above and suitable water quality (low concentrations of pollutants) within the estuary is necessary to provide Delta smelt larvae and juveniles a shallow, protective, food-rich environment in which to mature to adulthood. This placement of the 2 ppt isohaline also serves to protect larval, juvenile, and adult Delta smelt from entrainment in the state and federal water projects. An area extending eastward from Carquinez Strait, including Suisun Bay, Grizzly Bay, Honker Bay, Montezuma Slough and its tributary sloughs, up the Sacramento River to its confluence with Three Mile Slough, and south along the San Joaquin River including Big Break, defines the specific geographic area critical to the maintenance of suitable rearing habitat. Three Mile Slough represents the approximate location of the most upstream extent of tidal excursion when the historical salinity conditions described above are implemented. Protection of rearing habitat conditions may be required from the beginning of February through the summer.

The species effect determination found related potential stressors of:

- Food availability and visibility
- Size and location of LSZ

There are no additional operations effects on rearing habitat when species are not present.

6.4.4 Adult Migration

Adult Delta smelt must be provided unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality may need to be maintained to attract migrating adults in the Sacramento River and San Joaquin River channels and their associated tributaries, including Cache and Montezuma Sloughs and their tributaries. These areas also should be protected from physical disturbance and flow disruption during migratory periods.

The species effect determination found related potential stressors of:

- Entrainment risk
- Food availability and visibility

There are no additional operations effects on adult migration when species are not present.

6.5 Critical Habitat Effect Determination

The seasonal operation is likely to adversely affect critical habitat for Delta smelt.

- Increased entrainment is minimized through seasonal operations in the action area.
- Impacts to food availability and visibility are compensated through the construction of additional habitat and seasonal operations and habitat actions.
- Size and location of LSZ are compensated through the construction of additional habitat and seasonal operations and habitat actions.

7. Longfin Smelt

Longfin smelt, *Spirinchus thaleichthys*, is an euryhaline smelt (family Osmeridae) found in California's bay, estuary, and nearshore coastal environments along the Pacific Coast of North America. The San Francisco Estuary, Sacramento-San Joaquin Delta, and nearshore ocean outside the Golden Gate Bridge supports the largest longfin smelt population in California, listed as a distinct population segment because of genetic isolation, with Humboldt Bay likely ranking second in longfin smelt abundance. Longfin smelt have a short lifespan of approximately 2 to 3 years. Most reach maturity at two years of age and can grow from 124 mm to 140 mm in length (standard length). They are anadromous and semelparous, spend their adult life in bays, estuaries, and nearshore coastal areas, and migrate to the low-salinity zone (LSZ) and freshwater tributaries to spawn between November and May, with peak spawning occurring from January through March, after which most adults die. Newly hatched larvae are 5 mm to 8 mm long and are thought to be buoyant until their air bladder develops at approximately 12 mm, leading to seaward advection to salinities of up to 12 Practical Salinity Units (PSU) despite their distribution appearing to be centered in the LSZ (2 to 4 PSU). Older larvae then appear to undergo reverse diel and tidal vertical migrations to follow preys and maintain their position in the productive parts of the salinity gradient. Longfin smelt's diet is mainly composed of calanoid copepods (*Eurytemora affinis* or *Pseudodiaptomus forbesi*), with larger adults switching to mysid. Densities of both prey categories have been documented as positively correlated with Delta outflow.

7.1 Conceptual Lifecycle Models

An action may affect fish when the change in conditions overlap with the location and timing of fish and/or their habitats. There are no commonly used published peer reviewed conceptual models; therefore, Reclamation analyses are based on the life stages and geographic locations shown in Figure 11.

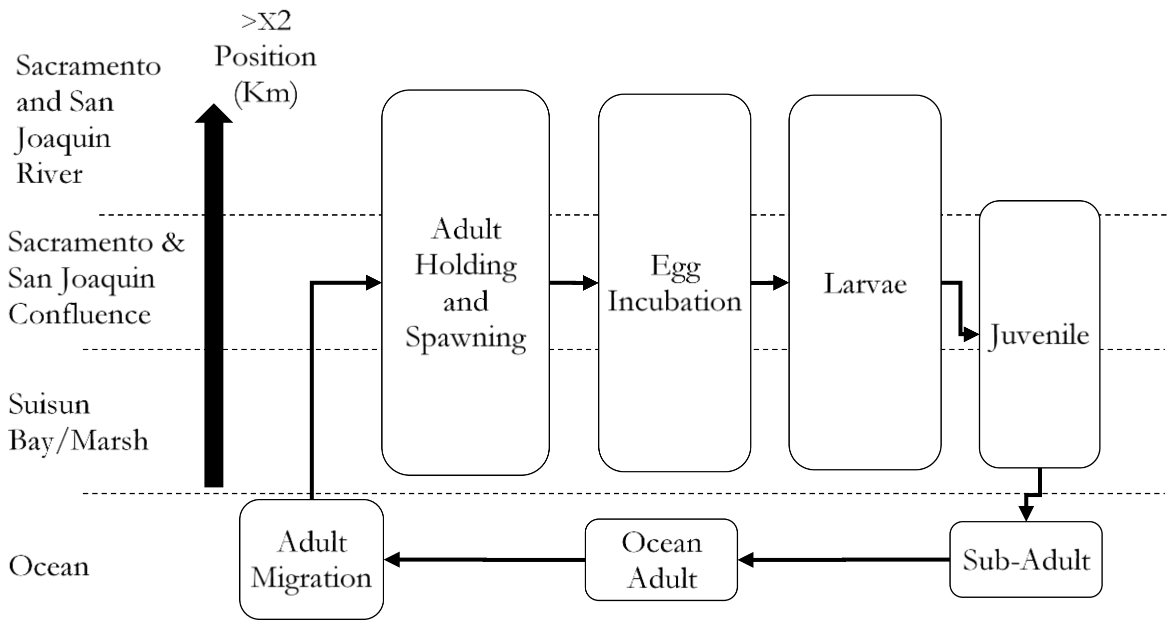

Figure 11. Proposed Geographic Life Stage Domains for Longfin Smelt

In the absence of a common model, Reclamation drew from SAIL and MAST conceptual models to identify the potential stressors on longfin smelt.

- Adults (little known about ocean life history)
    - Entrainment
    - Salinity
    - Water Temperature
    - Habitat Loss
    - Food Availability
    - Predation
    - Toxins
- Eggs & Larvae
    - Entrainment (only Larvae)
    - Salinity
    - Water Temperature

- Habitat Loss
- Predation
- Toxins

- Juveniles
  - Entrainment
  - Salinity
  - Water Temperature
  - Habitat Loss
  - Food Availability
  - Predation
  - Toxins

Each deconstruction of the action considers the 23 stressors for the four life stages listed above. Additional and/or alternative information may be incorporated as applicable (e.g., 2020 ITP).

Trawls provide the timing for longfin smelt presence (Figure 12) (Appendix C).

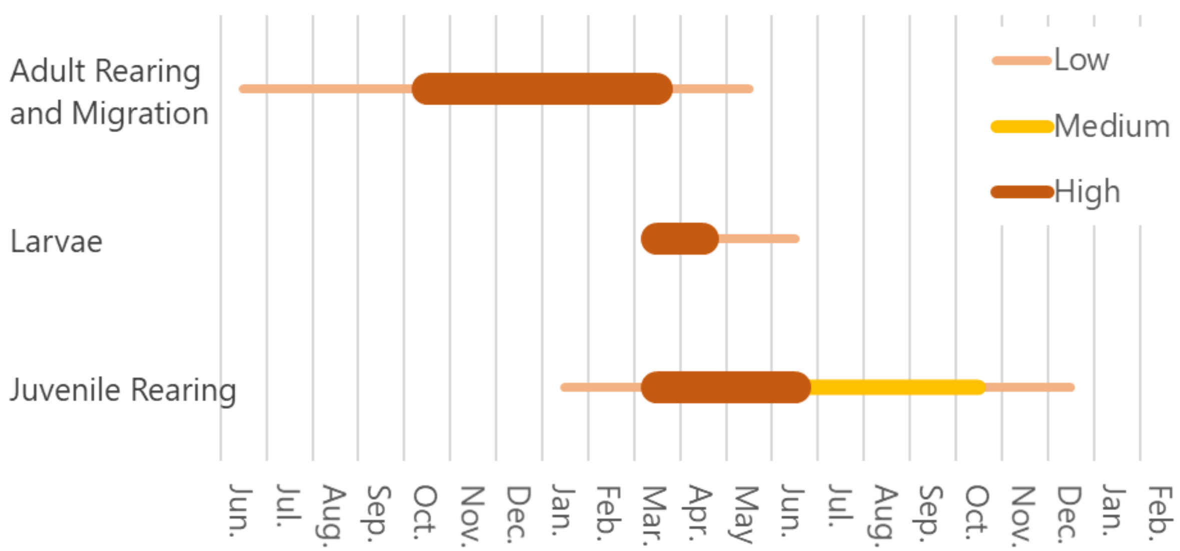

Figure 12. Temporal Life Stage Domains for Longfin Smelt from Appendix C.

7.2 Species Effects Deconstruction

Longfin smelt adults migrate into the Bay-Delta and Suisun Marsh to spawn, and larval and juvenile longfin migrate to the Bay-Delta to complete their lifecycle. The seasonal operations has little effect on conditions within the Bay-Delta.

In the winter, Reclamation and DWR's proposed storage, diversion, and export of water will decrease Delta outflow on average. Decreased flows in the Delta may change stressors on longfin smelt.

Juveniles are present in the Bay-Delta. Juveniles are rearing in the estuary, and their growth and survival is hypothesized to largely depend on quality, quantity, and availability of resources. Several stressors have been identified for the juvenile life stage as fish transition into subadults.

Entrainment Risk stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Salinity stressors may increase from decreased net Delta outflows on average. The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. Increases in water temperature may increase longfin smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements and potential harmful algal blooms (HABs). However, air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors are not anticipated to change.

Food Availability stressors may increase from decreased net Delta outflows. Abundances of historically important longfin smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis*, generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval longfin smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to longfin smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Predation stressors are not anticipated to change due to decreased outflow. Increases in water temperature may also increase longfin smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators.

Predation stressors caused by water temperature are addressed in water temperature stressor section.

Toxins stressors are not anticipated to change in the winter.

Adults are present.

Entrainment stressors may increase from increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Salinity stressors may increase from decreased net Delta outflows on average. The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. At temperatures above a threshold, adults' ability to grow and mature becomes impaired. A decrease in flows may result in warmer water temperature in the spring. Increased water temperature also increases predator energetic requirements and the potential for HABs. However, winter water temperatures are unlikely to reach levels unsuitable for longfin smelt, and air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors are not anticipated to change.

Food Availability stressors may increase from decreased net Delta outflows. Abundances of historically important adult longfin smelt prey taxa in the LSZ, including the calanoid copepod *Eurytemora affinis* or mysid *Neomysis mercedis,* generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval longfin smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to longfin smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Predation stressors are not anticipated in change in the winter.

Toxins stressors are not anticipated to change in the winter. Decreased Delta outflow may limit the potential for dilution of contaminants mobilized from the watershed, agricultural lands, and urban effluents. Toxicity from contaminants can affect longfin smelt both directly (lethal or sub lethally leading to growth or fecundity impairments) or indirectly (altering the lower food web).

In the spring, Reclamation and DWR's proposed storage, diversion, and exports of water will decrease Delta outflow on average. Decreased flows in the Bay-Delta may change stressors on longfin smelt.

Eggs and Larvae are present.

Entrainment stressors may increase for larvae due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities. Entrainment stressors are not anticipated to change for eggs.

Salinity stressors are not anticipated to change from decreased net Delta outflows on average in the spring. Larvae that rear in salinities around 2 ppt have been shown to have the greatest recruitment success to later life stages. Experimental evidence indicates that osmotic balance is maintained at salinity from 0.4 ppt to 10 ppt and that survival and growth peaked at intermediate salinity conditions (5 ppt or 10 ppt).

The location of LSZ may increase from being shifted eastward to less productive areas. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. Spawning happens at temperatures between 5°C and 15°C and usually peaks in January and February. Water temperature influences egg development and hatching success. Larvae that hatch later in the season may experience warmer water temperatures as a result of reduced outflow slowing their timely dispersal toward cooler downstream rearing areas. However, air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors are not anticipated to change.

Predation stressors on eggs is unknown and predation risk stressors on larvae may or may not increase due to decreased outflow. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements.

Toxins stressors are not anticipated to change in the spring due to decreased Delta outflow.

Juveniles are present.

Entrainment stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route juveniles into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Salinity stressors may increase from decreased net Delta outflows on average. The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. Increases in water temperature may increase longfin smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements and potential HABs. However, air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors are not anticipated to change.

Food Availability stressors may increase from decreased net Delta outflows. Abundances of historically important longfin smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis*, generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval longfin smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to longfin smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Predation stressors may or may not increase due to decreased outflow and higher water clarity as a result of reduced sediment supply. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements. Water temperature effects on predation are addressed in water temperature stressor section.

Toxins stressors are not anticipated to change. Decreased Delta outflow may limit the potential for dilution of contaminants mobilized from the watershed, agricultural lands, and urban effluents. Toxicity from contaminants can affect longfin smelt both directly (lethal or sub lethally leading to growth or fecundity impairments) or indirectly (altering the lower food web).

Adults are present.

Entrainment stressors may increase from increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Salinity stressors may increase from decreased net Delta outflows on average. The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. At temperatures above a threshold, adults' ability to grow and mature becomes impaired. A decrease in flows may result in warmer water temperature in the spring. Increased water temperature also increases predator energetic requirements and the potential for HABs. However, spring water temperatures are unlikely to reach levels unsuitable for longfin smelt, and air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors are not anticipated to change.

Food Availability stressors may increase from decreased net Delta outflows. Abundances of historically important adult longfin smelt prey taxa in the LSZ, including the calanoid copepod *Eurytemora affinis* or mysid *Neomysis mercedis*, generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval longfin smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to longfin smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Predation stressors are not anticipated to change in the summer due to decreased outflow. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements. Water temperature effects on predation are addressed in water temperature stressor section.

Toxins stressors are not anticipated to change. HABs, including *Microcystis*, can degrade habitat quality through toxicity to both longfin smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. However, this is more likely to occur in the summer and early fall. Decreased Delta outflow may limit the potential for dilution of contaminants mobilized from the watershed, agricultural lands, and urban effluents.

In the summer, Reclamation and DWR’s proposed release and export of water will decrease Delta outflow on average. Decreased flows in the Bay-Delta may change stressors on longfin smelt.

Eggs and Larvae are present.

Entrainment stressors may increase for larvae due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities. Entrainment stressors are not anticipated to change for eggs.

Salinity stressors may increase for larvae from decreased net Delta outflows on average. Larvae that rear in salinities around 2 have been shown to have the greatest recruitment success to later life stages. Experimental evidence indicates that osmotic balance is maintained at salinity from 0.4 to 10 and that survival and growth peaked at intermediate salinity conditions (5 or 10). The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. Water temperature influences egg development and hatching success. Larvae that hatch later in the season may experience warmer water temperatures as a result of reduced outflow slowing their timely dispersal toward cooler downstream rearing areas. However, air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors are not anticipated to change.

Predation stressors on eggs is unknown. Predation risk stressors on larvae are not anticipated to change due to summer decreased outflow. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements. Water temperature effects on predation are addressed in water temperature stressor section.

Toxins stressors may or may not increase. HABs, including *Microcystis*, can degrade habitat quality through toxicity to both longfin smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those.

Juveniles are present.

Entrainment stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route juveniles into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Salinity stressors may increase from decreased net Delta outflows on average. The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. Summer water temperature is negatively correlated to survival and may limit the range of available habitat to the cooler brackish areas of the system. Increases in water temperature may increase longfin smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements and potential HABs. However, air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors may not change.

Food Availability stressors may increase from decreased net Delta outflows. Abundances of historically important longfin smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis*, generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval longfin smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to longfin smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability

Predation stressors are not anticipated to change in summer due to decreased outflow. Decreased outflow can result in higher water clarity as a result of reduced sediment supply. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements. Water temperature effects on predation are addressed in the water temperature stressor section.

Toxins stressors are not anticipated to change. HABs, including *Microcystis,* can degrade habitat quality through toxicity to both longfin smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. This is likely to occur in the summer and early fall. HAB stressors affected by water temperature are addressed in the water temperature stressor section.

Adults are present.

Entrainment stressors may increase from increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Salinity stressors may increase from decreased net Delta outflows on average. The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

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Habitat Loss stressors are not anticipated to change.

Food Availability stressors may increase from decreased Net Delta outflows. Abundances of historically important adult longfin smelt prey taxa in the LSZ, including the calanoid copepod *Eurytemora affinis* or mysid *Neomysis mercedis,* generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval longfin smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to longfin smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Predation stressors are not anticipated to change in the summer due to decreased outflow and higher water clarity as a result of reduced sediment supply. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements. Water temperature effects on predation are addressed in the water temperature stressor section.

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In the fall, Reclamation and DWR's proposed release and export of water will decrease Delta outflow on average. Decreased flows in the Bay-Delta may change stressors on longfin smelt.

Juveniles are present.

Entrainment stressors may increase due to increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route juveniles into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

Salinity stressors may increase from decreased net Delta outflows on average. The location of LSZ stressors may increase from being shifted eastward. LSZ location has cascading effects. Position affects recruitment of clam, which affects the plankton community (composition, abundance, size), which in turn affects longfin smelt.

Water Temperature stressors are not anticipated to change. Increases in water temperature may increase longfin smelt energetic requirements. An increased requirement may cause juveniles to forage more during daylight hours, increasing their visibility to predators. Increased water temperature also increases predator energetic requirements and potential HABs. However, air temperature is considered the main driver of water temperature in longfin smelt habitats, with freshwater inflow only thought to minimally contribute.

Habitat Loss stressors are not anticipated to change.

Food Availability stressors may increase from decreased net Delta outflows. Abundances of historically important longfin smelt zooplankton prey taxa in the LSZ, including *Eurytemora affinis*, generally exhibit a positive correlation with Delta outflow. Decreased Delta outflows may also limit critical allochthonous subsidies of alternate larval longfin smelt food resources (e.g., *Pseudodiaptomus forbesi*) through advection from more productive upstream areas to longfin smelt rearing habitats where local zooplankton productivity is severely impacted by competition with clams. Sustained high spring freshwater flow in wet years has been hypothesized to affect *Potamocorbula* recruitment and greatly reduce its grazing pressure on phytoplankton the following fall. Reduced spring Delta outflow in wet years could limit such potential benefits and opportunities to boost food availability.

Predation stressors may or may not increase due to decreased outflow and higher water clarity as a result of reduced sediment supply. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements. Water temperature effects on predation are addressed in the water temperature stressor section.

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Entrainment stressors may increase from increased OMR flows towards the Skinner and Tracy Delta export facilities. A decrease in Delta outflow may route adults into migratory corridors with lower survival within the hydraulic footprint of the Delta export facilities.

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Predation stressors may or may not increase due to decreased outflow and higher water clarity as a result of reduced sediment supply. Predation increased with less turbid waters, and this may be affected by decreased outflow (Schreier et al 2016). Water temperature also increases predator energetic requirements. Water temperature effects on predation are addressed in water temperature stressor section.

Toxins stressors are not anticipated to change. HABs, including *Microcystis,* can degrade habitat quality through toxicity to both longfin smelt and their prey and can also limit food availability through bottom-up effects (outcompeting phytoplankton of higher nutritional quality to zooplankton, affecting the strength of the microbial loop, etc.). Increased water temperature may increase the frequency and magnitude of HABs, and reduced flows may limit the ability to disrupt those. This is a more likely occurrence in the summer and early fall.

7.3 Species Effect Determination

The seasonal operations of the CVP and SWP may affect and is likely to adversely affect longfin smelt. The seasonal operations of the CVP is likely to have beneficial effects. Deconstruction of the seasonal operations systematically evaluated each stressor identified by conceptual models. Stressors not linked to the operation of the CVP and SWP were identified as “are not anticipate to change.” Stressors that were insignificant or discountable were documented above. Stressors with a material effect on the fitness of species were identified, and the seasonal operations incorporate minimization and/or compensation through conservation measures.

Stressors on **adults** influenced by the seasonal operations include:

- Entrainment risk may increase from export operations because of migratory patterns. Adverse effects are minimized by implementing real time OMR management.
- Salinity stressors will increase as the low-salinity zone is shifted eastward from decreased Delta outflow. Adverse effects are minimized by implementing Spring Delta Outflow and Summer Fall Habitat Action.
- Food availability: May be reduced from decreased net Delta outflows on average resulting from seasonal operations. Adverse effects are minimized by increasing food availability through tidal habitat restoration and Summer Fall Habitat Action.

Stressors on **eggs and larvae** influenced by the seasonal operations include:

- Entrainment (only Larvae) risk and transport direction risk may increase from decreased inflows to the Delta on average. Adverse effects are minimized by implementing real time OMR management.
- Salinity stressors will increase as the low-salinity zone is shifted eastward from decreased Delta outflow. Adverse effects are minimized by implementing Spring Delta Outflow and Summer Fall Habitat Action.

- Food availability: May be reduced from decreased net Delta outflows on average resulting from seasonal operations. Adverse effects are minimized by increasing food availability through tidal habitat restoration and Summer Fall Habitat Action

Stressors on **juveniles** influenced by the seasonal operations include:

- Entrainment risk and transport direction: May increase from export operations. Adverse effects are minimized by implementing real time OMR management.
- Salinity stressors will increase as the low-salinity zone is shifted eastward from decreased Delta outflow. Adverse effects are minimized by implementing Spring Delta Outflow and Summer Fall Habitat Action.
- Food availability: May be reduced from decreased net Delta outflows on average resulting from seasonal operations. Adverse effects are minimized by increasing food availability through tidal habitat restoration and Summer Fall Habitat Action.

8. Killer Whales

- No conceptual model for Killer Whale.
- A population viability analysis identified several risk factors to this population, including limitation of preferred Chinook salmon prey, anthropogenic noise and disturbance resulting in decreased foraging efficiency, and high levels of contaminants, including PCBs and DDT (Ebre 2002; Clark et al. 2009; Krahn et al. 2007, 2009; Lacy et al. 2017). [Excerpt taken from the NMFS' U.S. Pacific Marine Mammal Stock Assessments: 2021]
- A way to understand the CVP impacts on Killer Whale would be to estimate the number of fall-run Chinook salmon under the No Action scenario and the Proposed Action.
- Killer Whale diet consists, in part, of Chinook salmon within its range.
- Recent literature indicate CV Chinook salmon make up a smaller percentage of the diet of Southern Resident Killer Whale diet than previously thought.

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