**Fall-Run Chinook Salmon –DRAFT**

**BDCP Logic Chains for Covered Fish Species**

***Note to Reviewer:***

*The following presents a draft set of BDCP biological objectives for fall-run Chinook salmon. Per the recommendations of the independent science review panel, the objectives have been structured to address specific stressors as identified in existing documents such as existing recovery plans, biological opinions, and/or DRERIP life history conceptual models. A standardized table is used for each objective to provide specificity regarding the objective. Terms used in the table such as “Indicator” and “Attribute” are defined in Attachment 1. Additional components of the logic chain such as expected outcomes, conservation measures, and monitoring metrics are not presented herein. However, portions of the objective table are specifically intended to provide information relevant for these additional components. Efforts to link specific species objectives to broader natural community objectives and ecosystem objectives will be conducted once the species objectives have been reviewed and finalized.*

***Disclaimers:***

1. *The Global Goals and Global Objectives presented below are not BDCP goals and objectives. BDCP will contribute to the achievement of these global goals and objectives.*

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# Global Goal

1. Adequate protection for replacement of losses due to natural mortality (disease and stochastic events);
2. Sufficient genetic robustness to avoid inbreeding depression and allow for adaptation;
3. Sufficient habitat (type, amount, and quality) for long-term population maintenance, and;
4. Elimination or control of threats.

# Global Objectives

1. increase abundance;
2. increase spatial extent of key life stages;
3. restore life history/genetic diversity to historic/natural levels; and
4. increase productivity (population growth rate = births-deaths).

# Stressors/Limiting Factors

The following stressors/limiting factors were adapted from Williams (2009) and the National Marine Fisheries Service (NMFS) Draft Recovery Plan for Chinook salmon and Steelhead (2009). Not all of the stressors listed below are proposed to be addressed by BDCP.

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| ***ID*** | ***Stressor*** | ***Summary Description*** |
| **Stressors Addressed by BDCP** |
| **1** | Habitat loss and modification  | Changes in the extent, access to, and or quality of habitat including habitat variability and food. |
| **2** | Predation | Predation losses, including effects of structures and habitat alterations that promote predators.  |
| **3** | Altered flows  | Modifications to Delta inflow and outflow rates and hydrodynamics resulting in deviations from migration pathways, delays, reduced survival and adult straying. |
| **4** | Impingement and entrainment. | Impingement and entrainment at project and non-project facilities  |
| **5** | Water quality (toxics, DO, temperature) | Water quality conditions affecting migration, growth rate, and reproductive success. |
| **6** | Passage impediments | Barriers to migration (upstream and downstream). |
| **7** | Hatchery effects  | Interbreeding of hatchery and wild-type species can reduce genetic fitness with long-term effects, and affect straying. |
| **8** | Illegal harvest  | Direct mortality due to illegal harvest |
| **Stressors Not Addressed by BDCP** |
| **9** | Access to historic spawning habitat. | Barriers to historic spawning habitat are predominately located outside of the BDCP planning area. In-delta migration and barriers addressed in Stressor #3 and 6 above. |
| **10** | Climate Change | Increases in ambient air temperatures resulting in increased water temperatures with negative effects on habitat suitability. |

### Stressor #1: Habitat Loss and Modification

Habitat modification created by levees and other landscape modifications is a major stress on juvenile Chinook by blocking their access to rearing areas and confining them to habitat in the channels (Williams 2009). The loss of floodplain and tidal marsh habitat has greatly reduced the availability and quality of juvenile rearing habitat, including reduced input of organic and inorganic material and food resources.

Limited information on the feeding and growth of juvenile Chinook salmon as they migrate through the Delta and bays, suggest that these fish may be food limited (Kjelson *et al.* 1982; MacFarlane and Norton 2002). Substantial food web alterations in the Bays and Delta that have occurred over the last few decades may have reduced the availability of preferred prey for juvenile Chinook salmon (and steelhead) rearing and migrating through those locations (NMFS 2009). These food web changes were primarily caused by unintentional introductions of non-native species (Carlton *et al.* 1990; Kimmerer *et al.* 1994). Additionally, high concentrations of ammonium can inhibit primary and secondary production with cascading trophic effects (NMFS 2009).

**BDCP Objective #1**

Increase extent, access to, and availability of, suitable habitat for juvenile fall-run Chinook salmon, including presence of suitable food resources.

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| **Relation to Global Objective** | Increasing the extent, access to, availability and quality of rearing habitat will improve juvenile survival in the Delta and growth (~increased survival of smolts in the Bay and nearshore ocean). This objective will also improve life history diversity. |
| **Indicator** | Floodplain, tidal, and channel margin riparian habitat |
| **Locations** | * Yolo Bypass, Cache Slough, Suisun Marsh, West Delta, Cosumnes/Mokelumne, South Delta
* Sacramento River, Steamboat and Sutter sloughs
* San Joaquin River (between Vernalis and Mossdale)
 |
| **Attribute** | * Extent, duration, and frequency, of access to activated floodplain habitat.
* Extent, quality, and access to tidal marsh habitat.
* Extent and quality of riparian and channel margin habitat
* Food quality and quantity
 |
| **Quantity or State** | AchieveYolo Bypass inundation frequency of 75 to 90% of years for a minimum of \_\_ days that inundate \_\_ acres (specify spatial extent) – see currently proposed actionIncrease spatial extent of tidal habitat (up to 65,000 acres).Create and/or enhance 20 miles of channel margin habitat. Increase presence of preferred prey.Need to explore spatial extent questionFurther calibrate flow rate needed to get a significant fraction of the fish into Yolo bypass (telemetry study) |
| **Time Frame** | Floodplain Habitat: * within 10 years?

Tidal Habitat:* 14,000 acres developed within 10 years
* 25,000 acres (cumulative) developed by year 15
* 65,000 acres (cumulative) developed by year 40

Channel Margin Habitat:* at least 5 miles by year 10
* at least 10 miles by year 20
* at least 15 miles by year 25
* at least 20 miles by year 30
 |

### Stressor #2: Predation

Predation is a threat in the Delta where there are high densities of non-native fish that prey on outmigrating salmon (NMFS 2009). Modification of natural channel margins and riparian habitats, colonization of non-native SAV and FAV, as well as artificial instream structures may change the natural predator-prey dynamics favoring predators (NMFS 2009). High predation rates of salmon by centrachids and striped bass have been observed near project diversions (NMFS 2009).

**BDCP Objective #2**

Reduce susceptibility to, and impact of predation by non-native predatory fish on juvenile outmigrants.

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| **Relation to Global Objectives** | Reducing predation of steelhead will reduce mortality and increase survival of juveniles through the Delta. |
| **Indicator** | Juvenile survival and predator abundance in a given area |
| **Location** | Sacramento to Rio Vista and San Joaquin River |
| **Attribute** | SurvivorshipNumber of predators in a given area  |
| **Quantity or State** | We have established an ambitious objective of reducing predation related mortality by 5%, recognizing our ability to detect and measure the effects of predation is limited, more research is needed, and that the value of reduced predation to salmonid populations is uncertain. |
| **Time Frame** | Within 10 years of permit issuance |

### Stressor #3: Altered Flows

Delta exports and diversions have modified historic Delta flow rates and hydrodynamics resulting in the diversion of juveniles from the mainstem Sacramento River into the central and southern Delta where environmental conditions are poor (NMFS 1997). The channel complexity and reverse flow conditions in the central Delta likely delay migration to the ocean thereby increasing the length of time that fish may be exposed to adverse conditions where survival is substantially lower than through northern routes (NMFS 2009). Altered flow conditions can also contribute to straying of upstream migrating adults and delays in upstream migration.

In the southern Delta, juvenile San Joaquin River salmon must thread their way through complex channels and face problems of poor water quality, exposure to unscreened water diversions, increased vulnerability to predation mortality, entrainment in the large pumps of the State Water Project and Central Valley Project, lack of shallow water habitat, and other health and mortality factors (San Joaquin River Restoration Program Technical Advisory Committee [SJR TAC] 2008).

**BDCP Objective #3**

Maintain through Delta hydrodynamics necessary to facilitate migration success of juvenile and adult Sacramento and San Joaquin River fall-run Chinook salmon.

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| **Relation to Global Objectives** | Improving outmigration success will: * Increase productivity (more return spawners);
* Promote maintenance of life history/genetic diversity (by increasing the window of migration opportunity).

Improved upstream migration will:* Increase productivity (more return spawners);
* Promote maintenance of life history/genetic diversity (by increasing the window of migration opportunity).
 |
| **Indicator** | In Delta hydrodynamicsJuvenile survivalAdult straying (?) |
| **Location** | Sacramento and San Joaquin River |
| **Attribute** | River flows at Knights Landing, Freeport, Rio Vista and Vernalis.Net tidal flowsGate operationsBetween basin adult straying of SJR fish (?)Outmigration success (eg. JPI) - Survival Knights Landing to Chips Island (using telemetry) and Vernalis to Chips Island. |
| **Quantity or State** | Positive trajectory in the survival indices of downstream migrating fish.  Sustainable population level after recovery goal is achieved.   |
| **Time Frame** | Within 10 years of permit issuance |

### Stressor #4: Impingement and Entrainment

Unscreened water diversions and CVP and SWP pumping plants entrain juvenile salmon, leading to fish mortality (NMFS 2009). The cumulative effect of entrainment at these diversions and delays in outmigration of smolts caused by reduced flow may affect fall-run Chinook salmon fitness (NMFS 2009). Additionally, cooling water intakes at power plants in Antioch and Pittsburgh entrain and kill juvenile fish from mechanical and heat stress (CALFED 2000).

**BDCP Objective #4**

Reduce impingement and entrainment of juvenile fall-run Chinook salmon

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| **Relation to Global Objective** | Reducing direct and indirect mortality associated with entrainment and salvage will have positive effects on:* Productivity
* Life history/genetic diversity maintenance (restoration)
 |
| **Indicator** | Impingement and Entrainment  |
| **Location** | Power plants and water diversions within BDCP planning area. |
| **Attribute** | Impingement Entrainment Salvage |
| **Quantity or State** | Reduce impingement and entrainment by \_\_\_% of JPE (JPE to be determined)* Need to look at data by water year type to scale the target reduction
 |
| **Time Frame** | Within 10 years of permit issuance and maintained annually thereafter. |

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### Stressor #5: Water Quality

The main potential toxicity components for salmon are ammonia, pyrethroid pesticides, and copper (Williams 2009). The effects of these contaminants include the suppression of immune competence, reduced growth and damage to the olfactory system (NMFS 1997, Williams 2009).

High water temperature is a major stressor for Chinook in the Delta causing delays in or obstructing migration (NMFS 2009, Williams 2009). Additionally, dissolved oxygen concentrations on the San Joaquin River near Stockton can be low enough to block migration of adult salmon (Hallock et al. 1970; Alabaster 1989). Usually this problem eases in late October.

**BDCP Objective #5**

1. Toxics - Reduce levels of ammonia, organophosphate, pyrethroid pesticides and copper in the Delta to levels below chronic and acute effect threshold for salmon and their food
2. Dissolved Oxygen - Maintain adequate dissolved oxygen levels in the SJR near Stockton to avoid blocking migration of adult salmon.
3. Temperature - Maintain in water temperatures in the upper Sacramento River and tributaries (Yuba, Feather, American)(?) and San Joaquin River that will not inhibit spawning and rearing.

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| **Relation to Global Objective** | Improvements in key water quality parameters will positively effect:* Spatial extent of key life stages through the elimination of water quality barriers to migration.
* Productivity
* Life history/genetic diversity maintenance (restoration)
 |
| **Indicator** | Water quality parameters. |
| **Location** | Key migratory corridors |
| **Attribute** | * Concentration (µg/L) of;
	+ ammonia,
	+ pyrethroids,
	+ copper,
	+ organophosphates
* Dissolved oxygen levels (mg/L)
* Water temperature (°C)
 |
| **Quantity or State** | TBD |
| **Time Frame** | TBD |

### Stressor #6: Passage Impediments/Barriers

Passage impediments block access to historic staging and spawning habitats and eliminate the spatial segregation of spawning habitat that historically existed for spring-run and fall-run Chinook salmon (NMFS 2009). These barriers exist primarily at low flows and likely impede upstream migration of fall-run Chinook salmon and potentially early migrating adult steelhead (Vanicek 1993).

Hydrodynamic conditions created by operation of the Delta Cross Channel (DCC) can delay or block juvenile salmon that outmigrate through the central Delta (NMFS 2009). Additionally, dissolved oxygen concentrations on the San Joaquin River near Stockton can be low enough to block migration of adult salmon (Hallock et al. 1970; Alabaster 1989). Usually this problem eases in late October.

**BDCP Objective #6**

Improve upstream and downstream passage for fall-run Chinook salmon.

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| **Relation to Global Objective** | Elimination of passage barriers will have positive effects on:* Productivity
* Life history/genetic diversity maintenance (restoration)
 |
| **Indicator** | Upstream passage |
| **Location** | Yolo Bypass, SDWSC, and Stockton Ship Channel |
| **Attribute** | * Dissolved oxygen levels (mg/L)
* Immigration rate and success
 |
| **Quantity or State** | Increase immigration success by \_\_%.Reduce migratory delays by \_\_\_% |
| **Time Frame** | Within 10 years of permit issuance. |

### Stressor #7: Hatchery Effects

Coded-wire tag information from hatchery returns indicates that substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices (NMFS 2009). The Central Valley hatchery practice of trucking fall-run production for out-of-basin release, and the use of large numbers of hatchery fall-run juveniles for monitoring studies, has resulted in high straying rates of returning adults, and threatening the genetic integrity of all extant spring-run populations as well as natural fall-run populations (Williamson and May 2003).

**BDCP Objective #7**

Manage hatchery to minimize genetic affects on natural producing fall-run.

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| **Relation to Global Objective** | Reduced effects of hatcheries will help maintain life history/genetic diversity.  |
| **Indicator** | Fall-run Chinook salmon genetics |
| **Location** | BDCP Planning Area |
| **Attribute** | * Develop and implement a genetic management program to assess winter-run Chinook salmon population genetic variability.
* Adjust and maintain management program as needed.
 |
| **Quantity or State** | TBD |
| **Time Frame** | Within \_\_\_ years of permit issuance. |

### Stressor #8: Illegal Harvest

Beginning in August, early spawning fall-run Chinook salmon begin to arrive in the Sacramento River and they likely make up the majority of the sportfishing harvest through the end of the year (NMFS 2009). Deliberate poaching activity is not likely heavy until later in the year when fall-run have arrived (NMFS 2009).

**BDCP Objective #8**

Discourage illegal harvest of adult fall-run Chinook salmon.

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| **Relation to Global Objective** | Reductions in illegal harvest will reduce adult mortality and increase productivity.  |
| **Indicator** | Illegal Harvest |
| **Location** | Upstream spawning areas |
| **Attribute** | Enforcement |
| **Quantity or State** | Increase number of patrol hours by 100% during migration and holding period (September-December) |
| **Time Frame** | Within \_\_\_ years of permit issuance. |

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San Joaquin River Restoration Program Technical Advisory Committee [SJR TAC]. (2008). Recommendations on Restoring Fall-run Chinook Salmon to the Upper San Joaquin River. 42 pp. February 2008.Attachment 1: Objective Worksheet

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| **Relation to Global Objective** | How will the stressor-level objective contribute to achieving the global objective? |
| **Indicator** | What will be measured? Species, habitat, ecological process, physical condition… |
| **Location** | Where will it be achieved? |
| **Attribute** | What aspect of the indicator will be measured?Population size, density, cover, presence/absence, reproductive rate… |
| **Quantity or State** | What measurable condition or change is expected?Increase, decrease, maintain or limit negative impact?*Quantity*: 500 individuals, 20% cover, 30% increase …*Quality*: Weed-free, all life stages present, cover class 4… |
| **Time Frame** | When will this be achieved? |