**Sacramento Splittail - DRAFT**

**BDCP Logic Chains for Covered Fish Species**

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Updated by KH on 11/12/10

***Note to Reviewers:***

*The following presents a draft set of BDCP biological objectives for a Sacramento splittail. 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. *Some of the objectives presented herein are hypothetical. These objectives are introduced to stimulate further discussion.*
2. *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

# Maintain self-sustaining populations of Sacramento splittail that will persist indefinitely.

# Global Objective

Implement actions known to benefit splittail, to minimize threats to their existence, and improve understanding of them in order to maintain their abundance and distribution. (reference: logic chain workshop October 2010)

# Stressors/Limiting Factors

The following stressors/limiting factors were adapted from Kratville (2008). Not all of the stressors listed below are proposed to be addressed by BDCP.

|  |  |  |
| --- | --- | --- |
| ***ID*** | ***Stressor*** | ***Summary Description*** |
| **Stressors Addressed by BDCP** | | |
| **1** | Habitat Loss and Modification | Changes in the extent, access to, and or quality of key natural habitats for specific life history stages. |
| **2** | Predation by Non-native Species | Population effects from predation by introduced species. (Note: this is a low impact stressor – little information available for splittail) |
| **3** | Entrainment | Direct mortality due to project and non-project diversions. |
| **4** | Food Limitation | Food quality, availability, and food web disruptions. |
| **5** | Toxins and Contaminants | Effects of contaminants and toxic compounds on all life stages. |
| **6** | Stranding | Effects on productivity and abundance from incidences of stranding associated with water management activities. [No grading, etc. on Yolo Bypass planned?]. Splittail are floodplain spawners. Design of the restored floodplain may influence potential for stranding. |
| **7** | Harvest | Population effects from illegal harvest. |
| **8** | Barriers | Barriers to migration (upstream and downstream). |
| **9** | Altered flows | Altered distribution due to diversions and gate operations. Directionality of flows thru the Delta (Note: It is not known altered flows are a stressor for splittail) |

### Stressor #1. Habitat Loss and Modification

The substantial loss of floodplain and channel margin habitat is probably the key limiting factor for splittail populations (Moyle et al. 2004). Splittail rely on floodplain habitat for spawning and rearing of larvae and young juveniles. The population shows a remarkable response to floodplain inundation as indicted by salvage during wet years following extensive floodplain inundation (Moyle et al. 2004). In addition, the extensive application of riprap to the rivers for flood protection has reduced channel margin habitat used by juvenile splittail during migration to the Delta and Suisun Marsh from spawning areas upstream (Kratville 2008).

**BDCP Objective #1**

Increase access to, and availability of suitable spawning, rearing and foraging habitat for splittail.

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| --- | --- |
| **Relation to Global Objectives** | Increasing the extent of, access to, and availability of suitable spawning and rearing habitats will improve the productivity of splittail. |
| **Indicator** | Floodplain habitat, tidal marsh habitat, channel margin habitat |
| **Location** | * Yolo Bypass * Sutter Bypass * San Joaquin Floodplains * Cache Slough ROA * Suisun Marsh ROA * West Delta ROA |
| **Attributes** | * Extent, duration, and frequency of, and access to, activated floodplain habitat. * Extent of and access to tidal marsh habitat. * Extent and quality of riparian and channel margin habitat |
| **Quantity or State** | * Increase by \_\_% the total surface area of floodplain habitat that will be inundated when Delta inflow is \_\_ cfs to enhance splittail spawning and rearing of larvae and early juveniles. Increase to the maximum operable extent. Look at the flow curve relationship. Flow, depth, duration, timing. Duration is the known & understood variable. Change shape of landscape and maintain flow into the area. * Operate so that at least (6,000 cfs thru the notch to get x acres – look at acreage to flow curve) x acres of floodplain will be continuously inundated inundated for at least 30 days every 2 to 4 years . (maximum operable flooding). * Look for opportunities to maximize the flooding for 30 days. * Restore and/or enhance tidal marsh within:   + Cache Slough ROA by \_\_ acres,   + Suisun Marsh ROA by \_\_ acres,   + West Delta ROA by \_\_ acres,   + Consumnes/Mokelumne ROA by \_\_ acres,   + East Delta ROA by \_\_ acres, and   + South Delta ROA by \_\_ acres.   + (Note, this is for foraging and rearing habitat. Quantify deep intertidal habitat. It is not known exactly how many acres this species would benefit from) * Create or enhance channel margin and/or floodplain terrace habitat along the Sacramento River and other migratory corridors to increase by \_\_% the total length of such habitat. |
| **Time Frame** | Restoration and enhancement targets achieved 20 years after permit issuance. |

Note: See Attachment 2 for details regarding the relationship between flow and splittail abundance.

### Stressor #2. Predation by Non-native Species

Major introduced fish predators such as striped bass and largemouth bass have been in the Delta for over a century (Dill and Cordone 1997), during which time splittail have persisted; however, reduced turbidity in the delta combined with increased largemouth bass habitat provided by Egeria densa have enhanced both the bass numbers and their ability to sight feed (Kratville 2008). (Note this is a low impact stressor. Predation likely does not contribute population declines)

**BDCP Objective #2**

Reduce predation of splittail by centrachids and other predators.

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| **Relation to Global Objectives** | Reducing predation rate will increase the abundance and productivity of splittail. [Are these objectives to be treated as hypotheses? There is currently no evidence that predation, entrainment or contaminants have any effect on the abundance and productivity of splittail.] |
| **Indicator** | Predation by centrachids and other predators. |
| **Location** | Sacramento to Rio Vista and San Joaquin River |
| **Attribute** | Predation rate. |
| **Quantity or State** | Reduce predation rate by \_\_% from pre-permit levels.[This is unachievable because we have no idea what current predation rate is.] |
| **Time Frame** | Within 10 years of permit issuance. |

### Stressor #3. Entrainment

Power plants within the planning area have the ability to entrain large numbers of fish. Large volumes of water are pumped through the facilities which are located within splittail rearing habitat (Matica and Nobriga 2005). The State Water Project and the Central Valley Project show high rates of salvage when splittail populations are at high levels; YOY have critical swimming velocities that are near the water velocities of the large pumps and are entrained at these facilities (Young and Cech 1996). When these fish are salvaged, mortalities can be quite high from over crowding within transport tanks and predation at drop off points within the Delta (Moyle et al. 2004). (Note: It is not known whether entrainment is a stressor for splittail)

**BDCP Objective #3**

Reduce the effects (direct and indirect mortality) of entrainment on juvenile and adult splittail.

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| --- | --- |
| **Relation to Global Objective** | Reducing direct and indirect mortality associated with entrainment and salvage will have positive effects on abundance and productivity |
| **Indicator** | Entrainment numbers and mortality rates. |
| **Location** | Power plants and water diversions within BDCP planning area. |
| **Attribute** | Entrainment rates   * Mortality * Occurrence [Not sure what this refers to] |
| **Quantity or State** | Normal (or wetter) water year type:   * Entrainment rate ≤ \_\_% of total splittail population.   Below normal (or drier) water year type:   * Entrainment mortality rate ≤ \_\_% of total splittail population. [These are unachievable because we currently have no estimates of splittail population abundance.] |
| **Time Frame** | Within 10 years of permit issuance and maintained annually thereafter. |

### Stressor #4: Food Limitation

Growth rates, especially in the first year or two of life, may be strongly dependent on availability of high quality food, as suggested by changes in growth rate following the invasion of the overbite clam into the marsh in the 1980s (Moyle et al. 2004, Kratville 2008). This invasion was followed by the collapse of Neomysis populations upon which splittail historically specialized (Feyrer and others 2003).

**BDCP Objective #4**

Increase food availability for all life stages of splittail.

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| **Relation to Global Objectives** | Increased food availability will affect abundance and productivity |
| **Indicator** | * Abundance of larval/juvenile prey items such as rotifers, cladocerans (mostly *Daphnia* and *Bosmina*), copepods, and chironomid larvae. (Note this might be difficult to measure) . * Historical prey of adult splittail such as mysid shrimp. * Nutrients, * Phytoplankton * Measure splittail response to the maximum operable flooding extent in Yolo. |
| **Location** | BDCP Planning Area |
| **Attribute** | * Abundance of prey items * Growth rates of splittail |
| **Quantity or State** | * Increase abundance of suitable prey items by \_\_% |
| **Time Frame** | Within x years of permit issuance. |

### Stressor #5: Toxins and Contaminants

Tissues of wild caught splittail in Suisun Bay were sufficiently high in selenium to cause physiological problems, in particular reproductive abnormalities (Stewart et al. 2004). Adult splittail feed on the overbite clam (*Corbula amurensis*), which accumulates and transfers selenium at high concentrations (Kratville 2008).

*Combinations of low concentration toxic chemicals (Pyrethroids, Organophosphates, Organochlorines, etc.) which may have low effects on fish directly can have significant negative impacts on important food source for splittail on the floodplain where these chemicals occur (Kratville 2008). A loss of food resources at this early life stage coupled with sub-lethal toxic effects could have a substantial impact on the population, but this is unknown (Kratville 2008).*

**BDCP Objective #5**

Reduce tissue concentrations of contaminants in adult splittail below threshold effects levels.

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| --- | --- |
| **Relation to Global Objective** | Reducing concentrations of contaminants in splittail will increase abundance and productivity. |
| **Indicator** | Se, Hg, pyrethroids, and EDC concentrations |
| **Location** | BDCP Planning Area |
| **Attribute** | Splittail tissue concentrations of Se, Hg, pyrethroids, and EDCs |
| **Quantity or State** | Using pre-permit concentration levels as baseline, reduce adult tissue concentrations of:   * Selenium by \_\_% * Mercury by \_\_% (Note: the threshold for mercury or EDC’s are not known)   Reduce juvenile tissue concentrations of:   * EDCs by \_\_\_%(Note: the threshold for mercury or EDC’s are not known)   Reduce inputs of pyrethoids to the water column via public outreach. (Note: Pyrethoids do not bioaccumulate in the tissue). |
| **Time Frame** | Within 20 years of permit issuance. |

### Stressor #6: Stranding

Stranding is addressed via the Yolo Conservation Measure ( Fremont Wier and Lisbon etc.)

### Stressor #7: Harvest

Stranding is addressed via increased wardens thru BDCP CM.

### Stressor #8: Barriers

Barriers are addressed via the Yolo Conservation Measure ( Fremont Wier and Lisbon etc.)

### Stressor #9: Altered Flows

(Note: It is not known altered flows are a stressor for splittail)

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# References

Dill, W. A., and A. J. Cordone. (1997). History and status of introduced fishes in California, 1871-1996, volume 178. State of California, Department of Fish and Game.

Feyrer, F., B. Herbold, S. A. Matern, and P. B. Moyle. (2003). Dietary shifts in a stressed fish assemblage: Consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67(3):277-288.

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Matica, Zoltan, and Matt Nobriga. (2005). Modifications to an agricultural water diversion to permit fish entrainment sampling. California Fish and Game 91, no. 1:53-56.

Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. (2004). Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science 2(2):1-47.

Stewart, A. R., S. N. Luoma, C. E. Schlekat, M. A. Doblin, and K. A. Hieb. (2004). Food web pathway determines how selenium affects aquatic ecosystems: A San Francisco Bay case study. Environmental Science & Technology 38(17):4519-4526.

Young, P. S., and J. J. Cech Jr. (1996). Environmental tolerances and requirements of splittail. Transactions of the American Fisheries Society 125:664-678.

# 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? |

Attachment 2: Flow/Floodplain Inundation – Splittail Abundance Relationships

Timing: Sommer (pers. comm. w/S.Unger Nov2010) considers that February – June is the critical period for floodplain inundation. Feyrer et al. 2006 concluded that the closer inundation occurs to March 21 (vernal equinox) the more YOY are produced.

Depth and Flow Velocity: Depth and flow velocity are important flow-related habitat attributes for splittail on floodplains, but preliminary model simulations indicated that flow velocities are consistently suitable for splittail over a wide range of flows. Depth is the most important quantifiable habitat attribute for splittail on the floodplain. HSI values for depths for young splittail were estimated from results in Sommer et al. (2008) and discussions with Dr. Sommer (pers. comm.) as follows: 0 to 1.5 feet = 1.0, >1.5 to 4.5 feet = 0.5, >4.5 to 6.5 feet = 0.16 and >6.5 feet = 0.

Flow/Floodplain Inundation: Feyrer et al. 2006 found that YOY production on Yolo Bypass was most strongly correlated with mean January – June Yolo Bypass stage (which is a function of Sacramento River flow). However, the scatterplot they present of the relationship (Figure 4) suggests that stage has no effect on abundance until it reaches about 2.5 meters, which is approximately the stage at which the Bypass begins to flood (Figure 2). There is a great deal of variability in YOY production when mean stage is near 2.5 meters (probably because dates of inundation, which is a very important factor, varies among the years tested), but above this stage production increases (although this conclusion is based on one year only – 1998). Note that the BDCP will reduce the stage threshold for Bypass flooding. Sommer et al. 1997 also conclude YOY abundance is related to Yolo Bypass inundation, but that a step function incorporating a threshold of at least a month of continuous Bypass inundation best describes the relationship. These results indicate that the best metric to use to assess flow effects on abundance is not flow *per se*, but rather the cumulative surface area of Yolo Bypass inundation that persists for at least 30 days. A cumulative surface area metric combines two metrics, duration of and surface area of floodplain inundation.

Feyrer, F., T. Sommer, and W. Harrell. 2006. Managing floodplain inundation for native fish: production dynamics of age-0 splittail (*Pogonichthys macrolepidotus*) in California’s Yolo Bypass. Hydrobiologia 573:213-226.

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Sommer, T. R.; W. C. Harrell; Z. Matica; and F. Feyrer. 2008. Habitat associations and behavior of adult and juvenile splittail (Cyprinidae: *Pogonichthys macrolepidotus*) in a managed seasonal floodplain wetland. San Francisco Estuary and Watershed Science. Vol. 6, Issue 2 (June), Article 3.