

BAY-DELTA CONSERVATION PLAN
Science Advisors Draft Report on BDCP Goals and Objectives
for Covered Fish Species

Prepared for:

BDCP Work Group on Goals and Objectives

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Summary of General Conclusions and Recommended Objectives

General Conclusions

1. *The goals and objectives already articulated as part of the BDCP process for some species provide a good starting point for further refinement.*
2. *Goals and objectives must use clearly defined, and agreed upon, terms (i.e., a glossary). To the extent possible they must be clear, concise, obtainable, and measurable.*
3. *Quantitative objectives may not be possible for many of the listed fish species.*
4. *There are presently a few situations where quantitative objectives can be determined. This will change in the future as improved understanding and predictive tools are available.*
5. *Quantitative objectives can be expressed in various ways including the reduction of stressors, responses of fish abundance, spatial distribution, or key population dynamic processes (growth, survival, reproduction, and migration).*
6. *Determining the objectives that address some of the stressors for a few of the listed species (e.g., delta smelt) will be controversial and developing objectives for these may be dependent on more focused discussion and/or the development of additional analyses.*
7. *The approaches to the development of quantitative objectives included here are for illustrative purposes and require review and refinement before becoming the basis for a conservation plan.*
8. *Extending and applying the illustrative approaches to developing quantitative objectives is best achieved by BDCP experts working closely with a team of independent advisors; for the plan to be successful BDCP stakeholders must 'own' the objectives.*
9. *Establishing baseline reference conditions that can be used as a foundation for the future refinement of objectives and the plan as a whole is essential.*
10. *Development of conservation measures to achieve objectives developed for individual species must consider effects on other species, both positive and negative.*

Recommended BDCP Objectives

The objectives presented focus on stressors that we considered important in contributing to the recovery of the three species considered. There was no attempt to be comprehensive in our approach and have not considered every possible stressor affecting these species. The objectives presented here can and should be refined as the planning process proceeds. Additional analyses are needed to finalize a full suite of objectives for these three species, as well as the remaining eight covered fish species.

Winter-run Chinook salmon

1. Juvenile Growth - Increase the growth rate of juvenile winter-run Chinook salmon migrating through the Delta to 85% of their temperature adjusted physiological maximum rate.
2. Juvenile Survival - Increase winter-run Chinook fitness by doubling juvenile survival (relative to current survival rates) during freshwater migration.
3. Upstream Adult Passage - Maintain median passage delays at weirs less than 1.5 days

Sacramento splittail

1. Dry-year Floodplain Inundation – The amount of inundated floodplain (acre-days) in the Delta during dry years should be no less than 10% of that in wet years during January-May.
2. Growth - Mean growth rates of larval/early juvenile splittail should be 0.3 to 0.5 mm/d so that they can begin emigrating from inundated floodplain and commence a downriver migration to shallow brackish tidal sloughs marshes around Suisun and San Pablo Bays within 60-80 days post-hatch.

Delta smelt

1. Growth - Increase fall mean body length of juvenile delta smelt to about 65 mm in December rather than 60 mm by increasing summer growth rates.
2. Adult Entrainment - Maintain the proportion of the adult delta smelt population that is entrained in the CVP and SWP facilities during December to March below a level that is consistent with values estimated for years with historically low entrainment and relatively high delta smelt population growth.
3. Juvenile Entrainment - Maintain the proportion of delta smelt juveniles lost to entrainment at the project diversions (during the spring and early summer) below a value based on historical entrainment relative to the FMWT or Kodiak population indices.

1.0 Introduction

This report presents the findings and recommendations of a group of independent science advisors convened to assist with the development of covered fish species goals and objectives for BDCP. Example objectives are provided for three of eleven covered fish species which represent three different life history strategies; winter-run Chinook salmon, Sacramento splittail, and delta smelt.

We have identified and amplified objectives which are, in our opinion are: (a) achievable by some combination of conservation measures; (b) measureable, for the most part, in terms of key processes (growth, reproduction, survival, migration) which relate to population effects; and (c) likely to promote the continued survival of the species in the Delta.

The objectives presented focus on stressors that we considered important in contributing to the recovery of the three species considered. We did not attempt to be comprehensive in our approach and have not considered every possible stressor affecting these species. Additional objectives will likely be needed for these species, and the objectives presented here can and should be refined as the planning process proceeds. We present quantified objectives based on a set of assumptions and an approach which are outlined. Different assumptions or approaches would yield different values for the objectives. Additional analyses are needed to finalize a full suite of objectives for these three species, as well as the remaining eight covered fish species.

A major issue was to determine the extent to which objectives could be quantified. Quantified objectives add a degree of specificity that can ensure common expectations for all parties, guide the development and scaling of conservation measures, and inform the performance metrics used to evaluate success of conservation measures in achieving the objective (Reed, et.al. 2010). However, if the available information does not support quantitative objectives or assessment of specified objectives is infeasible (e.g., sampling limitations), then more generally expressed objectives (e.g., expressed in terms of historical benchmarks) can be used to effectively direct conservation planning and provide a level of accountability. The objectives presented here thus vary based on the type and level of information available. Refinement of these and development of additional objectives is necessarily constrained by information and tools. We used tools which were available to us – this report should not be taken as rigid guidance on developing quantitative objectives.

Ultimately, setting appropriate goals and objectives for the BDCP, or any other planning process, is the responsibility of policy-makers and stakeholders. While goals and objectives can, and should be informed by science, they should reflect a mutually agreed upon vision for the future that can not necessarily be defined by technical analyses.

1.1 The Role of Goals and Objectives

It appears that there are very different understandings and expectations among the different BDCP participants regarding what the purpose and role of goals and objectives are, or should be, relative to the Plan. It will be impossible to arrive at mutually agreed upon goals and objectives if there are different definitions of what purpose they serve.

Biological goals are generally expressed as broad principles that provide the rationale for the conservation measures set out in the plan.¹ For complex conservation plans, biological objectives are used to step down the biological goals into measurable components. Objectives are more detailed statements of species-/stage-specific focal indicators, quantities or states at particular locations. They provide a link between conservation actions and how they contribute to meeting the broader goals of the program. These measurable objectives may be either environment or species based, and are generally described with as much specificity as possible.²

Goals and objectives serve a particular purpose within the Plan; to articulate an overall vision of what the Plan is intended to achieve. They should realistically reflect the expected outcomes of the Plan, based on current understanding of system dynamics. The goals and objectives are achieved through the implementation of conservation measures (or actions) which reflect how the goals and objectives will be achieved. Biological goals and objectives inform the development of conservation measures, and conservation measures also inform the development of goals and objectives. Planning is an essentially iterative process. The goals and objectives presented here are proposed as a starting point for such a process; the Advisors recognize that additional information, e.g., the Effects Analysis, may lead to their revision and refinement as both planning and implementation proceed

The achievement of goals and objectives are further supported by performance measures (measured using specific metrics) which reflect change in particular attributes of the system that will be monitored to assess progress toward achieving the goals and objectives. These three components of the Plan architecture can be illustrated as a simple hierarchical relationship as shown below:

¹ Although the NCCPA provides little specific guidance regarding the role of biological goals and objectives in conservation plans, the California Department of Fish and Game has embraced the inclusion of goals and objectives in conservation plans consistent with the approaches set out in this paper.

² According to the federal Five Point HCP Policy, “the Services and the applicants must determine the appropriate unit of measure such as numbers of individuals at a particular life stage, all life stages, or quantity or quality of habitat.” 65 Fed. Reg. 35242, 35244 (June 1, 2000).

- Goals and Objectives (what the plan intends to achieve)
 - Conservation Strategy and Measures (how goals and objectives will be met)
 - Performance Measures (how progress will be monitored and assessed)

While this reflects an overly simplistic structure, it illustrates: (1) the role of goals and objectives relative to other key Plan components; and (2) the importance of integrating across these components so that they function together. It is useful to have specific objectives, including quantified objectives where such objectives can be supported as relevant and attainable, but the objectives should not be confused with actions or performance measures, which serve a different, but related purpose.

Biological goals and objectives do not constitute permit conditions. Rather, the purpose of biological goals and objectives is to help guide the development of conservation measures, which the permit holder is then obligated to implement. Provided the actions committed to under a plan are being properly implemented a permittee is considered to be in compliance with the section 10 and section 2835 permits.³

1.2 Establishing a Planning Framework

As noted above, goals and objectives are part of a larger planning and implementation framework that includes proposed actions and performance measures. At the planning stage, this framework should also include an analysis of the likely effects, or outcomes of proposed measures. Predicted outcomes based on modeling or other analytical techniques can be used to refine the conservation measures. They can also be used to refine the objectives, including realistic quantification. This is inherently an iterative process where analytical work leads to increased knowledge and understanding that can then be used to establish more specific and attainable objectives.

The BDCP Logic Chain is an example of a planning framework that is designed to link goals and objectives to actions and outcomes (Figure 1). The DRERIP Scientific Evaluation Process is an example of an analytical structure that could operate within a planning framework that relies on conceptual models and expert opinion to evaluate not only the magnitude of expected outcomes, but the certainty of those outcomes.

³ As the federal fish and wildlife agencies have stated, “[w]hether the HCP is based on prescriptions, results, or both, the permittee’s obligation for meeting the biological goals and objectives is proper implementation of the operating conservation program. In other words, under the No Surprises assurances, a permittee is required only to implement the HCP, IA, if any, and terms and conditions of the permit.” 65 Fed. Reg. at 35251.

Future work on the BDCP Effects Analysis should be designed to inform refinements to both the conservation measures and the objectives. A specific process for integrating the findings of the Effects Analysis into decision-making regarding actions and objectives should be considered. In many cases, findings from the Effects Analysis can provide valuable information regarding what is achievable in terms of objectives as well as what can be accomplished through implementation of particular conservation measures. Information from the Effects Analysis can inform adjustments to conservation measures, objectives, or both.

Beyond planning, establishment of a well-articulated decision-making framework is also critical for implementation and management (Bisbal, 2001). An example of such a framework is the adaptive management framework recommended for BDCP by an earlier group of independent science advisors convened to offer advice on adaptive management that includes synthesis and communication of monitoring and evaluations of plan actions to inform decisions regarding further implementation.

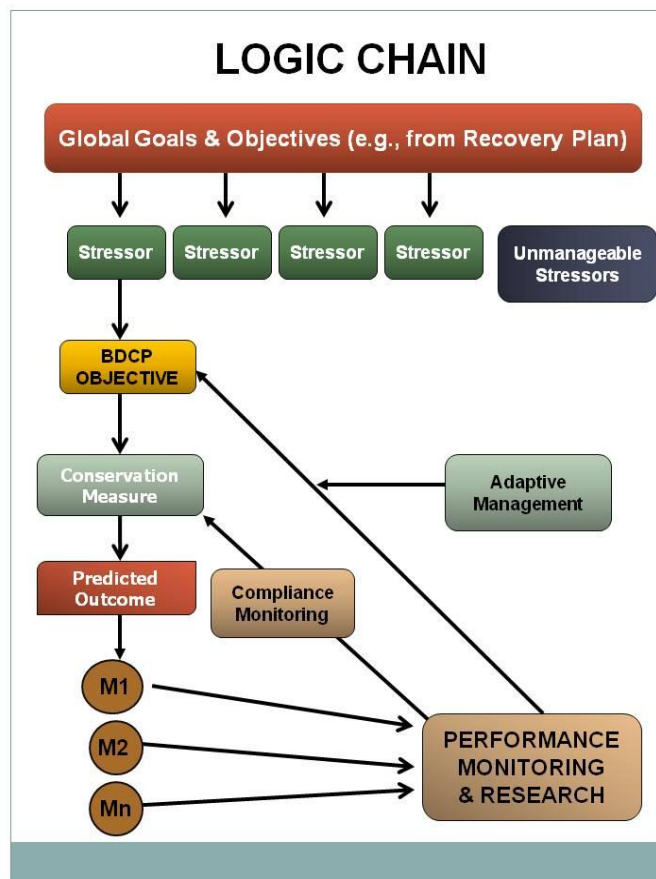


Figure 1. BDCP Logic Chain Framework

2.0 Recommended BDCP Objectives

The following outlines recommended BDCP objectives for three covered fish species:

- Winter-run Chinook salmon
- Sacramento splittail
- Delta smelt

For each species, recommended objectives are presented in summary tables followed by rationale that provide context for each recommended objective. For winter-run Chinook salmon and delta smelt, we also describe specific stepwise methods for how the objectives could be quantified, where we believe there are sufficient data and tools to do so. The tables below are not intended to be complete representations of the BDCP Logic Chain (Reed, et.al. 2010; Dahm, et. al. 2010). We have included some elements from the upper part of the Logic Chain to be clear about where this work fits with previous discussions. The remaining portions of the logic chain can be completed by BDCP stakeholders.

To the extent practicable, we have recommended specific, measurable, and time- and space - bound objectives. Where we did not feel there was enough existing knowledge, or tools to establish numeric objectives, we recommend a benchmarking approach that looks to establish a first order of approximation for objectives based on historic or existing conditions. In many cases, the best that could be done was to state the objectives in the context of intended qualitative improvements. At the very least, such objectives can show how the conservation measures are intended to mitigate the intensity of the identified stressors on life stages that use the BDCP area; this is in keeping with the intention of the Logic Chain process. While qualitative, such objectives are measurable through trend analyses.

Developing quantitative objectives for specific stressors is complicated by the fact that no stressor functions independently to impact the population. For example, juvenile smelt might grow best at 20°C, but require a great deal of food to do so. That means at least two stressors (drivers) have to be coordinated or balanced to produce a favorable result (i.e. max growth). Altering temperature alone or food alone (if that is even possible) will not give the intended result, nor will measuring one or the other necessarily allow an accurate prediction of growth. Then, there has to be a known relationship between growth and survival, and while one is expected ('bigger is better' hypothesis), it is not necessarily demonstrated, so as we move toward the ultimate goal of producing more spawners, the uncertainty keeps compounding and so confidence in any prediction goes down.

2.1 Winter-run Chinook Salmon

Winter-run spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period. Shasta Dam now blocks access to all of these waters except Battle Creek, which has its own impediments to upstream migration (i.e., the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir). Adults (usually 3 years old) enter freshwater in winter or early spring (peak run March), and spawn between Keswick Dam and Red Bluff Diversion Dam (RBDD) in the spring or early summer (peak spawning May and June). Juveniles migrate to sea after only 4 to 7 months of river life. The timing of migration varies with river flows, dam operations, and water year type (NMFS 2009).

We recommend three objectives for winter-run Chinook salmon as follows:

1. Juvenile Growth - Increase the growth rate of juvenile winter-run Chinook salmon migrating through the Delta to 85% of their temperature adjusted physiological maximum rate.
2. Juvenile Survival - Increase winter-run Chinook fitness by doubling juvenile survival (relative to current survival rates) during freshwater migration.
3. Upstream Adult Passage - Maintain median passage delays at weirs less than 1.5 days

** Note that these objectives are based on a set of assumptions and an approach which are outlined below. Different assumptions or approaches would yield different values for the objectives. We did not attempt to be comprehensive in our approach and have not considered every possible stressor affecting winter-run Chinook. Additional objectives will likely be needed for this species.*

Winter-run Chinook Juvenile Growth Objective

<i>Species life stage and process</i>	Juvenile winter-run Chinook salmon Growth
<i>Relevant Global Goals (as provided)⁴</i>	GG1. Attainment of the winter-run Chinook salmon global abundance goal will occur by 2060 with achievement of 6-year geometric mean escapement levels of: 20,000 in the mainstem Sacramento River with no year below 5,000; 3,000 in the Battle Creek watershed with no year below 500; and 500 in a third dependent population with no year below 200.
<i>Relevant Global Objectives (as provided)⁴</i>	VSP1. Increase abundance. VSP4. Increase productivity (population growth rate = births-deaths) CH6. Provide riparian (including floodplain) habitat for successful juvenile development and survival. CH7. Provide adequate downstream migration corridors for successful emigration of juveniles.
<i>Stressor(s)</i>	Limited growth during juvenile passage associated with loss of floodplain and tidal marsh habitat has reduced the availability and quality of juvenile rearing habitat, including reduced input of organic and inorganic material and food resources. The introduction of the overbite clam has also impacted food availability.
<i>Recommended BDCP Objective</i>	<i>Increase the growth rate of juvenile winter-run Chinook salmon migrating through the Delta to 85% of their temperature adjusted physiological maximum rate.</i>

Rationale

Limited growth during juvenile passage associated with historical loss of floodplain and tidal marsh habitat has reduced the availability and quality of juvenile rearing habitat, including reduced input of organic and inorganic material and food resources. The introduction of the overbite clam has also impacted food availability.

Survival of juvenile salmon during freshwater migration and ocean entrance is correlated with fish size and is believed to involve gape limited predation in which larger fish are unavailable to smaller predators which reduces the effective predator population of larger migrating juveniles. In addition, larger fish have greater energy reserves which provide a buffer prior to the fish reaching the ocean. The objective is to increase the growth rate of fish migrating through the Delta to 85% of their temperature adjusted physiological maximum rate. To evaluate the

⁴ Global goals and global objectives presented in the tables are as provided by the National Marine Fisheries Service (see Appendix C). These do not represent work products of the science advisors and are provided here for reference.

potential for increasing growth by improvements in the habitat first consider the current levels of growth observed in habitats (Table 1).

The length of winter-run Chinook juveniles passing through the lower Sacramento River (Figure 2) increases over the migration season from about 70 to 110 mm, an apparent growth rate of ~ 0.33 mm/day (Figure 2). Thus, fish size measured at any location and date depends on both growth rate and age and is highly variable but exhibits a trend over the migration season. Williams (2006) commented that winter Chinook travel time to the pumps is shorter than it is to Chipps Island however the fish arriving at the pumps tend to be larger than fish arriving at Chipps Island. This anomaly suggests that, on average, fish destined for the pumps experience a faster growth rate than fish destined for Chipps Island. In the estuary, growth rate is insignificant (MacFarlane and Norton 2002). Studies suggest that juvenile salmonids foraging on floodplains grow at a faster rate than fish foraging in the main river channel (Jeffres et al. 2008). Part of the increased growth rate on floodplains is the result of warmer temperatures on floodplains (Myrick and Cech 2004). Finally, growth in hatchery studies are typically about 1 mm/day which equates to about 3% body wt./day (Williams 2006). Thus, 1 mm/day for fish in the river is nearing the maximum possible growth rate under a full ration.

As a caveat to the importance of fish size on fitness a recent study illustrated that of the adult Chinook salmon returning to the Central Valley only 32% emigrated as smolts (> 75 mm). The majority of returning adults emigrate as smaller fish: 20% as fry (< 55 mm) and 48% as parr (56 to 75 mm) (Miller et al. 2010). Thus, while large size of fish is in principle advantageous, the diversity of juvenile migration strategies is important and actions should avoid the elimination of any life history strategy.

Growth rate is a function of temperature as well as ration. Using data from Williams (2006) the maximum growth rate can be expressed to a first order as a function of temperature for $T < 20^{\circ}\text{C}$

$$\text{Maximum.growth.rate (\% body wt./day)} = T / 4 \quad (1a)$$

or

$$\text{Maximum.growth.rate (\%FL/day)} = T / 12 \quad (1b)$$

Above 20°C , growth rates decline to zero at $T = 25^{\circ}\text{C}$. From these equations, the maximum growth rate at 20°C is 5% body wt./day or 1.7% FL/day. For a 70mm fish this equates to 1.2 mm/day.

Table 1. Representative estimates of growth rate observed for Central Valley fish

location	Comments on study	Run	Growth mm/day	Time	Reference
Butte Creek	Capture-recapture	Fall Chinook	0.3 – 0.8		(Williams 2006)
Yolo Bypass	Capture-recapture	Fall Chinook	0.5 – 0.8	Feb-March	(Sommer et al. 2001b)
Sacramento R.	Capture-recapture	Fall Chinook	0.4 – 0.5	Feb-March	(Sommer et al. 2001b)
Lower Sac R.	Captures over season	Winter Chinook	0.4	Jan-April	(Williams 2006)
Consumnes Floodplain	Enclosure study	Fall Chinook	0.8 – 1.2	March-April	(Jeffres et al. 2008)
Consumnes R.	Enclosure study	Fall Chinook	0.3 – 0.6	March-April	(Jeffres et al. 2008)
Estuary	Captures over season	Chinook	0.2	May-June	(MacFarlane and Norton 2002)
Ocean	Captures over season	Chinook	0.6	May-June	(MacFarlane and Norton 2002)
laboratory	Fed 60-80% ration	Fall Chinook	1	March-May	(Williams 2006)

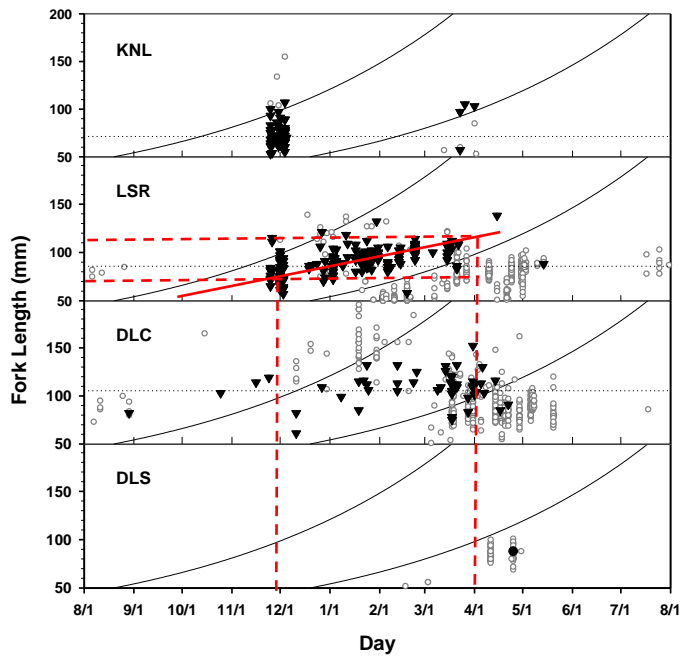


Figure 2. Fork length and day of capture for juvenile Chinook assigned to runs by Hedgecock et al. (2002) for four areas from the IEP monitoring: Knights Landing (KNL), the lower Sacramento River (LSR), the central Delta (DLC), and southern Delta (DLS). Winter Chinook are shown by black triangles, other Chinook by open circles; dotted lines show mean lengths for winter-run at the site. The curved lines show length at date criteria for winter-run. Extracted from Williams (2006) as copied from Hedgecock (2002). The red line illustrates the trend in increasing growth rate over the migration season.

We suggest setting the target growth rate as 85% of the temperature adjusted maximum rate defined by eqs. (1 a,b) or through a more extensive analysis of maximum growth rate analysis when available (see Williams (2006) p 67) . The target is set below the maximum rate to account for across study variations in maximum growth rate.

Increasing growth rate can be achieved by routing fish onto available floodplains. Increasing inundation of the Yolo Bypass during the winter Chinook migration would likely achieve the growth rate target for the species. Note, increasing growth rate of fish migrating through the Sacramento River is less effective because the maximum growth rate is less because temperatures are less in the channeled river.

Growth rates can be determined four ways: (1) with rearing enclosures for juvenile salmon placed in selected river reaches (Jeffres et al. 2008); (2) by measuring fish length over the season at a selected site and estimating growth rate by the slope of a size vs. day regression (Fig. 2); (3) by inferring juvenile size via otolith widths (e.g. Miller et al. 2010); or (4) through a mark-recapture program where fish are tagged with passive integrated transponders upstream and detected and re-measured downstream using collect-by-code technology.

2.1.2 Winter-run Chinook Survival Objective

<i>Species life stage and Process</i>	Juvenile winter-run Chinook salmon Survival
<i>Relevant Global Goals (as provided)</i>	GG1. Attainment of the winter-run Chinook salmon global abundance goal will occur by 2060 with achievement of 6-year geometric mean escapement levels of: 20,000 in the mainstem Sacramento River with no year below 5,000; 3,000 in the Battle Creek watershed with no year below 500; and 500 in a third dependent population with no year below 200.
<i>Relevant Global Objectives (as provided)</i>	VSP1. Increase abundance. VSP3. Protect and increase life history and genetic diversity. VSP4. Increase productivity (population growth rate = births-deaths) CH6. Provide riparian (including floodplain) habitat for successful juvenile development and survival. CH7. Provide adequate downstream migration corridors for successful emigration of juveniles.
<i>Stressors</i>	Survival of juvenile salmon during freshwater migration is affected by multiple stressors, including, but not limited to predation, water diversion facilities, and entrainment.
<i>Recommended BDCP Objective</i>	<i>Increase winter-run Chinook fitness by increasing juvenile survival during freshwater migration to twice its current level (2000-2008)</i>

Rationale

Survival of juvenile salmon during freshwater migration is a major factor limiting fitness of all Central Valley Chinook salmon and moderate improvements in survival will have significant beneficial impacts on populations. Survival depends on a number of factors including: (1) predator density, water clarity and temperature, which increase predator encounters; (2) smolt size, which affects the predators ability to capture a prey; (3) juvenile fish travel time and; (4) migration distance (Anderson et al. 2005). In particular, survival depends on distance traveled in the river when water velocity is dominated by the river flow and survival depends on travel time through the Delta when water velocity is dominated by the tides. The idea being that in the river salmon run a gauntlet of predators, which depends on distance traveled, while in the Delta the tidal oscillation allows for multiple encounters with a predator and survival depends on passage time of the fish through the Delta.

Survival studies conducted in the last several years using radio and acoustic tags indicate that survival of juvenile salmonids is 5 - 10% for both the Sacramento releases (from upper Sacramento to Golden Gate Bridge) (S. Lindley personal communication) (MacFarlane 2007) and San Joaquin releases (from Mossdale to Chipps Island or Clifton Court Forebay (R. Buchanan personal communication) and San Joaquin River Group Authority (2010). Two years of survival estimates based on hydroacoustic tag studies (Perry et al. 2010) indicate survival from Sacramento to Chipps Island of fall-run juvenile Chinook was about 50% with a standard error (SE) of about 10%. Note, the survival in the San Joaquin over a comparable distance (Mossdale to Chipps Island) is a factor of 10 less. Relative survival of fall Chinook through Yolo Bypass to Chipps Island was about 50% higher than fish passing over the comparable section of the Sacramento River (Sommer et al. 2001b). Finally, water exports at the SWP and CWP have little impact on survival of Sacramento Chinook to Chipps Island (Newman and Rice 2002; Newman and Brandes 2010). However, survival of Sacramento fish through the interior of the Delta was lower than fish passing through the Sacramento River (mean ratio of survival probabilities, 0.35) (Newman and Brandes 2010). As a first order working reference the survival from the Sacramento River to the Chipps Island is approximately 25%.

In evaluating the survival improvement as an objective, several caveats need to be noted. Survival studies conducted in the Central Valley have focused on fall-run Chinook, many of which are of a larger size than winter-run Chinook. Also, the two runs have different migration behavior and so extrapolation of the measured survivals to winter run Chinook has some uncertainty. In particular, the smaller migrating fish, fry < 55 mm, make up a considerable portion of the adults returning to the Central Valley (Miller et al. 2010).

Our suggested objective of increasing survival from the upper Sacramento to the Bay Bridge by a factor of 2 would result in measurable improvements in population numbers. The recent 5-year moving average cohort replacement rate is 0.63 (NMFS 2009; Pacific Fishery Management

Council 2011) and the long term average is 1.54 (NMFS 2009). Thus, reducing predators by 50% should increase the winter-run Chinook population to above its replacement level of 1.

Survival can be increased through three categories of actions:

- Improving survival in individual reaches by decreasing predator density
- Routing fish into reaches with higher survival
- Reducing diversion to the South Delta where the fish are susceptible to entrainment at the SWP and CVP facilities.

We consider methods for evaluation of each approach. Survival may be directly measured or measured by surrogates, in particular by qualifying reductions in predator density or in terms of diversion fractions. Here we illustrate the approaches and tradeoffs of each measure.

Predator Removal

We consider predator removal from Keswick Dam to the North Delta above the tidal influence zone. Survival over this segment can be expressed by the equation (Anderson et al. 2005)

$$S = \exp(-ax) \quad (1)$$

where x is the river distance and a is a coefficient expressing the predation rate per river mile, which is proportional to predator density. To estimate the effects of reducing predators by 50% over this reach, first calculate the initial predation rate as $a = -\log(S)/x$. Using data on late fall Chinook survival from Red Bluff Diversion Dam to Chipps Island in 2007 (MacFarlane 2007) gives $a = -0.006$ and $S = 0.26$. By decreasing predator density over the 250 mile reach by 50% the resulting survival increases to $S = 0.56$, i.e. a doubling of survival (200%). In areas with higher predator density the effect of predator reductions per mile would be greater. For example, in the lower Sacramento if $S = 0.6$ and $x = 40$ miles then $a = -0.0128$ and reducing predation by 50% over the shorter reach increases survival to 0.77, an increase in survival of 30%.

Fish Routing

To illustrate the issues when increasing survival through water routing consider Figure 3 showing a conceptual model of fish and water routing through the Delta. The overall survival improvement that can be obtained by routing water and fish depends on survival in all routes and the complexity precludes setting any simple criteria for how much water should be routed. We illustrate these issues with the heuristic model below.

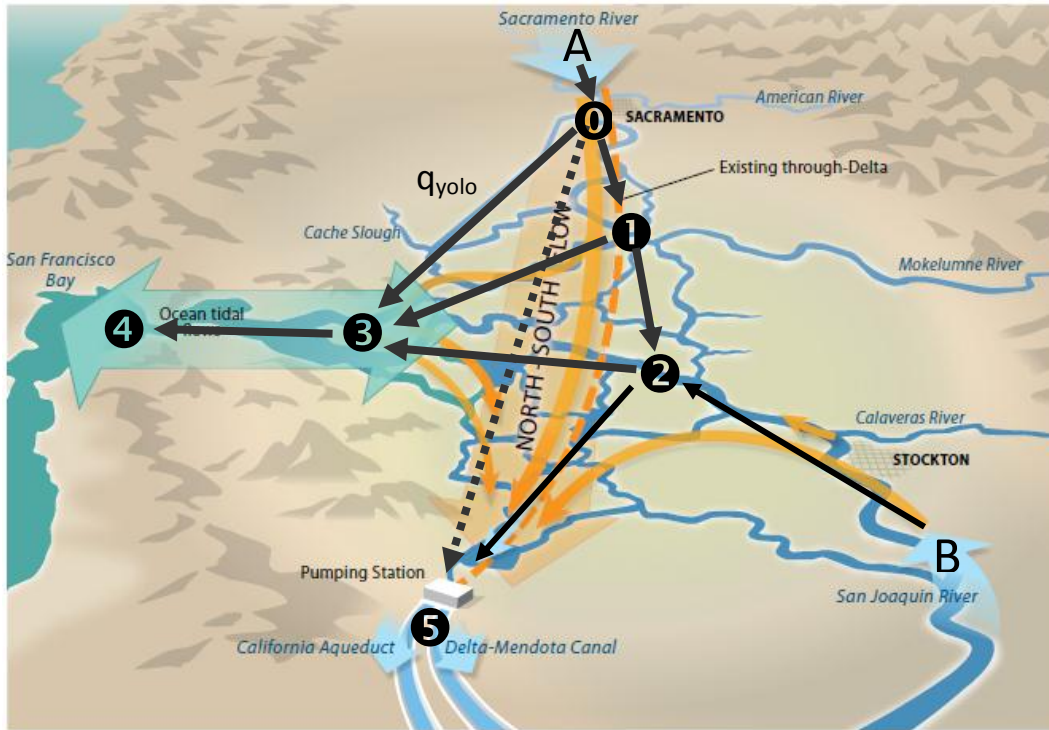


Figure 3. Schematic for modeling routing of fish and water through the Delta.

The model assumes fish are screened from entering the North Diversion and no fish survive when entering the South Diversion. Each route i,j is characterized by a survival $S_{i,j}$ and the fraction of fish that take the route is $f_{i,j}$. Similarly i,j,k is a route that goes from location j to k via node j . No survival for fish diverted towards the pumps is expressed $S_{25} = 0$ and no fish diversion into the North Diversion is expressed $f_{05} = 0$, i.e. fish are screened at the diversion intake. The survival of fish migrating downstream through the Sacramento to San Francisco Bay is expressed:

$$S_{04} = S_{34} \left(S_{03} f_{03} + (1 - f_{03}) \left(S_{013} (1 - f_{12}) + S_{012} f_{12} \left(S_{23} (1 - f_{25}) \right) \right) \right) \quad (2)$$

Where the fraction of fish partitioned to route f_{ij} can be defined in terms of the fraction of flow to the route or if a behavioral guidance system is employed the fish partition fraction is independent of flow. For the case of fish following flow the partition fractions can be defined:

$$f_{03} = \frac{F_{03}}{F_A - F_{05}} = \frac{q_{03}}{1 - q_{05}}$$

$$f_{12} = 1 - \frac{F_{13}}{(F_A - F_{05})(1 - f_{03})} = 1 - \frac{q_{13}}{(1 - q_{05})(1 - f_{03})}$$

$$f_{25} = \frac{F_{25}}{(F_A - F_{05})(1 - f_{03})f_{12} + F_B} = \frac{q_{25}}{(1 - q_{05})(1 - f_{03})f_{12} + q_B}$$

Where F_{ij} are flows and q_{ij} flows normalized to the Sacramento flow.

For reach survivals we use Perry et al. (2010) to set $S_{013} = 0.5$ and $S_{012} * S_{23} = 0.3$. Using the study of Sommer et al. (2001a) we set the relationship between survivals through Yolo Bypass and the Sacramento River as $S_{03} = 1.5 * S_{013}$.

Using eq (2) we consider the relative effects of three routing alternatives: 1) Yolo Bypass vs. Delta Cross Channel Diversion 2) Yolo Bypass vs. South Delta Diversion, 3) Delta Cross Channel vs. South Delta Diversion. In modeling these scenarios, the base survival through the reaches for each scenario are $S_{012} = 0.6$, $S_{013} = 0.5$, $S_{03} = 0.7$, $S_{23} = 0.3$ and the base fish partitions are $f_{03} = 0.5$, $f_{12} = 0.5$, $f_{25} = 0.6$. These actions are taken together to meet the objective of doubling the current level of survival. There is no fixed set of actions. In effect to achieve the objective the diversion at Delta Cross Channel and Southern diversions depend on the diversion achieved at Yolo Bypass.

Routing Action 1: Yolo Bypass vs. Delta Cross Channel Diversion (Figure 4). Survival from the Sacramento to the Bay increases with increased fraction of fish diverted into Yolo Bypass. Correspondingly, the negative effect of diversion to the Delta Cross Channel decreases with increased Yolo Bypass. The greatest survival improvement is obtained through Yolo Bypass diversions.

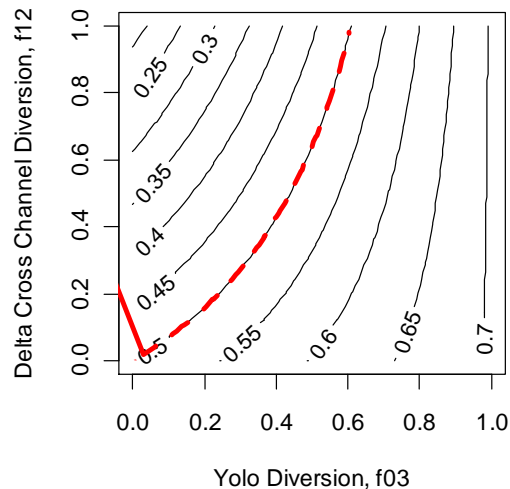


Figure 4. Survival Sacramento to Bay with fractions of Yolo and Delta Cross Channel diversions. Dashed line is survival objective.

Routing Action 2: Yolo Bypass vs. South Delta Diversion (Figure 5). Survival from the Sacramento to the Bay increases with increased fraction of fish diverted into Yolo Bypass. The negative effect of diversion to the South Delta decreases with increased Yolo Bypass. Note South Delta diversions have little effect on total survival, so actions related to entrainment at the pumps are largely ineffective in increasing Sacramento fish survival.

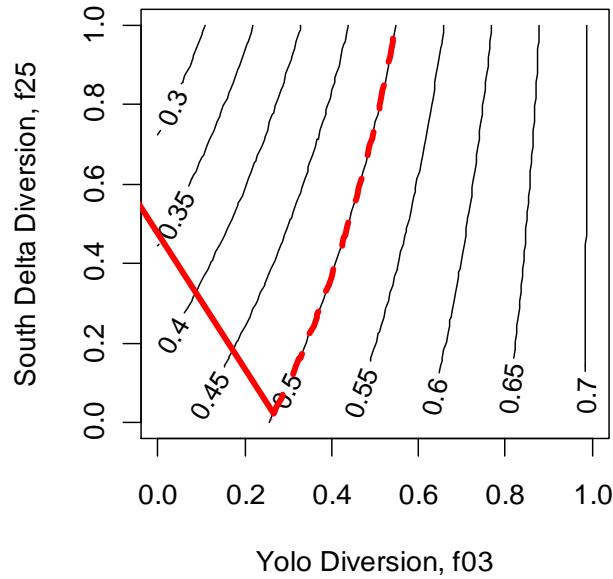


Figure 5. Survival Sacramento to Bay with fractions of Yolo and South Delta diversions. Dashed line is survival objective.

Routing Action 3: Delta Cross Channel vs. South Delta Diversion (Figure 6). Survival from the Sacramento to the Bay is strongly dependent on Delta Cross Channel and South Delta diversions when no fish pass through Yolo Bypass ($f_{03} = 0$) (Figure 6 left panel). However, when greater than half of fish pass through Yolo Bypass ($f_{03} = 0.5$) (Figure 6 right panel) water diversion into the Cross Channel and the South Delta have only a small effect of Sacramento fish survival.

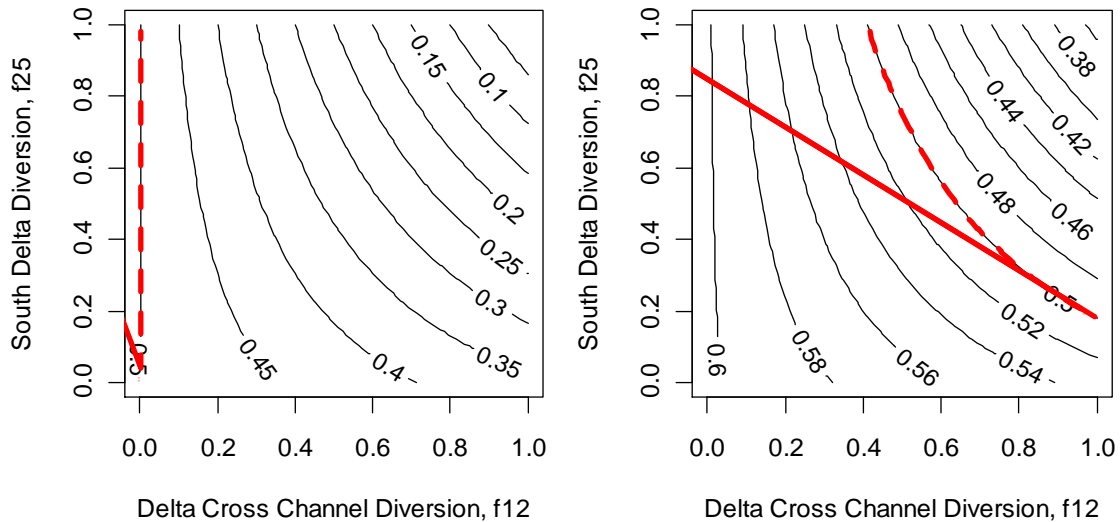


Figure 6. Survival Sacramento to Bay with fractions of Delta Cross Channel and South Delta diversions. Left Panel shows conditions without Yolo Bypass. Right Panel shows conditions with 50% diversion into Yolo Bypass. Dashed line is survival objective.

2.1.3 Winter-run Chinook Adult Passage Objective

<i>Species life stage and Process</i>	Adult and juvenile winter-run Chinook salmon Migration
<i>Relevant Global Goals (as provided)</i>	GG1. Attainment of the winter-run Chinook salmon global abundance goal will occur by 2060 with achievement of 6-year geometric mean escapement levels of: 20,000 in the mainstem Sacramento River with no year below 5,000; 3,000 in the Battle Creek watershed with no year below 500; and 500 in a third dependent population with no year below 200.
<i>Relevant Global Objectives (as provided)</i>	VSP1. Increase abundance. VSP4. Increase productivity (population growth rate = births-deaths)
<i>Stressors</i>	Passage delays at weirs
<i>Recommended BDCP Objective</i>	<i>Maintain median passage delays at weirs less than 1.5 days</i>

Rationale

While generally the adult winter-run Chinook upstream passage is unobstructed (NMFS 2009), modifications of the migratory corridor are warranted in particular within the Yolo Bypass-Freemont Weir and Sutter Bypass-Tisdale Weir to insure that fish delays in passing weirs are minimal.

To assess the delay we suggest applying time to event analysis, which characterizes the effects of passage conditions on delay (Castro-Santos and Haro 2003). For setting objectives, the time to events are, the time to pass a weir. To quantify the objective assume passage occurs as random events following a Poisson distribution. Then, for a cohort of fish arriving at a weir at time $t = 0$ the fraction that have not passed $P(t)$ is defined:

$$P(t) = \exp(-at) \quad (3)$$

Where the passage rate is $a = 0.69/T$ and T is the median delay time. Timely passage for Pacific Northwest salmon has been defined as a 1 day median passage time with no more than 5% of active migrants taking longer than a week to pass (Nordlund 2010). The first criteria gives $a = 0.68$ while the second criteria gives $a = 0.42$. Taking the average of these gives $a = 0.56$, which equates to 43% of the fish being delayed less than 1 day.

2.2 Sacramento Splittail

As a resident species of the Delta, Sacramento splittail can complete their life cycle wholly within the BDCP area, even though they show some characteristics of migratory species (i.e., migrate upstream toward vegetated floodplain spawning/rearing areas in winter/early spring (Nov-Mar) and downstream in late spring/summer (May-July) throughout the Delta, but with concentrations in and around brackish sloughs, especially Suisun Marsh. Of all 11 taxa of concern, splittail are likely the most adaptable and tolerant of variable environmental conditions in all life stages. Embryo development is rapid, with hatching occurring in as little as 4 days post-spawning. Splittail are benthic foragers, except in the early life stages when, like most other species, they tend to feed on zooplankton (rotifers, cladocerans), and chironomid larvae, amphipods, mysids, bivalves and detritus as they grow larger. Adults may feed on earthworms and other terrestrial organism when they migrate into inundated floodplains to spawn (Moyle et al. 2004).

We recommend two objectives for Sacramento splittail as follows:

1. Dry-year Floodplain Inundation – The amount of inundated floodplain (acre-days) in the Delta during dry years should be no less than 10% of that in wet years during January-May.
2. Growth - Mean growth rates of larval/early juvenile splittail should be 0.3 to 0.5 mm/d so that they can begin emigrating from inundated floodplain and commence a downriver migration to shallow brackish tidal sloughs marshes around Suisun and San Pablo Bays within 60-80 days post-hatch.

**Note that these objectives are based on a set of assumptions and an approach which are outlined below. Different assumptions or approaches would yield different values for the objectives. We did not attempt to be comprehensive in our approach and have not considered every possible stressor affecting splittail. Additional objectives will likely be needed for this species. In addition, the development of objectives for splittail was limited by the lack of global goals and objectives for the species.*

2.2.1 Sacramento Splittail Floodplain Habitat Objective

<i>Species life stage and focal rate</i>	Splittail eggs, embryos and early juveniles Survival
<i>Relevant Global Goals</i>	Not provided
<i>Relevant Global Objectives</i>	Not provided
<i>Stressors</i>	Reduced spawning and early juvenile rearing habitat
<i>Recommended</i>	<i>The amount of inundated floodplain (acre-days) in the Delta during dry</i>

BDCP Objective	years should be no less than 10% of that in wet years during January-May.
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Rationale

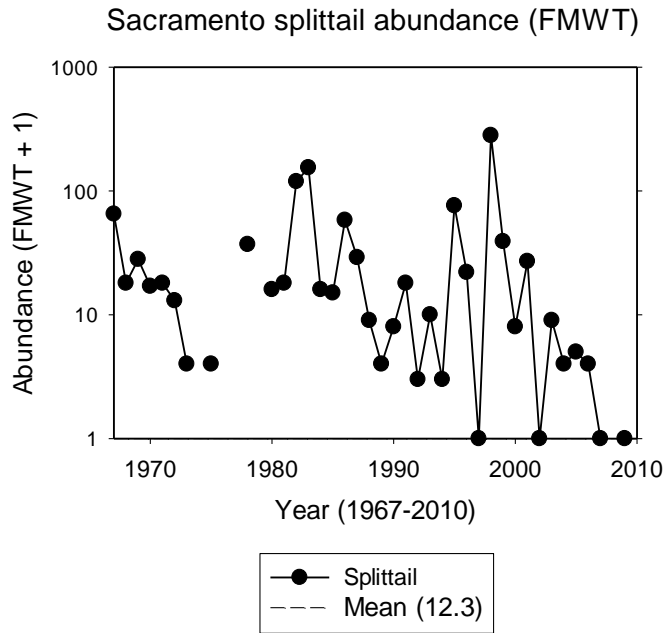


Figure 7. Temporal variation in abundance index for Sacramento splittail from the Fall Mid-Water Trawl (FMWT), 1967-2010

Splittail are relatively long-lived (5-9 years) and reach maturity in 2 years, so have multiple opportunities for successful spawning. Females are capable of spawning 23,000 to 266,000 eggs (Feyrer & Baxter 1998), and under the proper conditions the population has demonstrated rapid increases associated with wet years in the past. The large natural inter-annual variability in population size and the potential to produce strong year classes was a large factor in the removal of this species from threatened status (Sommer et al. 2007).

There is no sampling program specifically intended to assess the population size of splittail, but the abundance index for splittail collected in

the Fall Mid-Water Trawl (Figure 7) is positively correlated with high Delta outflows (Kimmerer 2002), and outflows are related to the amount of inundated floodplain within the Delta (Sommer et al. 2004).

The objective is expected to be achieved primarily through the protection, restoration and expansion of floodplain habitat within the Delta. Yolo Bypass is the largest remaining floodplain (24,000 ha) within the Delta and Age-0 splittail produced in this area are thought to contribute a substantial proportion of the year-class strength expressed for the entire Delta population (Sommer et al. 2001, Feyrer et al. 2006). Although the Yolo Bypass floods in nearly 60% of all years, the acreage flooded and the length of time the floodplain is inundated are also critical for the survival of splittail early life stages.

The acres of floodplain expected to be inundated in Yolo Bypass with proposed adjustments to the Fremont Weir at different levels of Sacramento River flow can be estimated using the equation and the relationships in Figures 9 and 15, respectively of the Draft (12.05.08) North Delta Migration Corridors document. At Sacramento flows under 57,513 cfs, less than 10% of the Yolo Bypass area is flooded. In order to flood a third of the Yolo Bypass flood plain (20,000 acres) requires ca. 60,810 cfs in the Sac (i.e., a wet year). This would insure that about 3300 cfs

was flowing over the weir. The inundation of 10% of the Yolo floodplain requires ca. 500 cfs of Yolo flow during the winter-spring spawning and rearing season.

In wet years, there should always be sufficient floodplain habitat within the Delta to support spawning and rearing of splittail and as long as wet years occur at no less than 5-yr intervals, the splittail population will likely continue to survive. In dry years, when inundated floodplain habitat in the Yolo Bypass and elsewhere is scarce, shallow, vegetated channel margins that are not armored by rip-rap may serve to provide some spawning and nursery habitat for splittail (Moyle et al. 2004, Feyrer et al. 2005).

There are also a number of smaller riverine floodplains within the Delta watershed that are also known to serve as nursery and rearing habitats for larval and juvenile splittail. These include the Cosumnes River (Ribeiro et al. 2004) as well as the Petaluma and Napa Rivers. There has been recent evidence that splittail populations using the Petaluma and Napa Rivers as natal floodplains are genetically distinct from the Central Valley populations (Baerwald et al. 2008) as well as exhibiting different migration patterns (Feyrer et al. 2010). While these populations may be insulated to some degree from effects of major water diversions and could provide sufficient spawning and rearing habitat to maintain a small splittail population, fish from these may not range far from their natal river systems and so should not be relied upon to restock a generally depleted population of splittail within the Delta ecosystem. Maintaining multiple areas of inundated floodplain throughout the Delta seems the most reliable means of insuring the continued survival of this species.

Figure 7 shows the splittail abundance index from 1967 to 2010

(<http://www.dfg.ca.gov/delta/data/fmwt/charts.asp>). This index could be used as one possible indicator of the population response to interannual changes in floodplain availability as spawning and rearing habitat. If sufficient spawning and early juvenile habitat has been provided to allow for at least one ‘good’ year during the spawning lifetime of most individuals, one would not expect to see annual index values remain below the average value (12.3) for more than 4 consecutive years.

2.2.2 Sacramento Splittail Growth Objective

<i>Species life stage and focal rate</i>	Splittail larvae and juveniles Growth
<i>Global Goals</i>	Not provided
<i>Global Objectives</i>	Not provided
<i>Stressors</i>	Food limitation
<i>Recommended BDCP Objective</i>	<p><i>Mean growth rates of larval (ca. 6 mm at hatching)/early juvenile splittail should be 0.3 to 0.5 mm/d so that they can begin emigrating from inundated floodplain and commence a downriver migration to shallow brackish tidal sloughs of marshes around Suisun and San Pablo Bays within 60-80 days post-hatch.</i></p> <p><i>Once within the downriver brackish marsh slough and channel habitat, juveniles should grow 110-115 within their first year and Age-1 individuals should add an additional mean increment of 30-50 mm (total length of 145-170 mm) to insure that fish attain the minimum size (180 mm SL) to spawn for the first time at Age 2+.</i></p>

Rationale

Duration of floodplain inundation within the Delta during March to May when most splittail are spawning and early juveniles are rearing may vary considerably among years. Even in wet years when extensive areas are inundated (Sommer et al. 2004). The growth objective aims to minimize dependence on extended periods of floodplain inundation, which in dry years may not be sufficiently long to develop the benthic prey assemblage required to attain the size (30-40 mm) at which emigration from floodplain habitats normally occurs (Feyrer et al. 2006).

Mean growth rates expected for Age-0 and Age-1 juveniles should be no slower than to allow spawning at Age 2+ (minimum mature size of 180 mm SL). Higher rates of growth could be expected in tidal sloughs and marsh channels where larger crustacean prey (e.g., *Neomysis*) are available. Invasion of overbite clam is suspected to be involved in the decline of *Neomysis* populations (Moyle et al. 2004), so the promotion of conditions that are unfavorable to the expansion and growth of bivalve invaders into existing or restored brackish water rearing areas would contribute to meeting the growth objective for late-stage juveniles.

Sacramento Splittail Entrainment: No recommendation for an entrainment objective is provided at this time. Entrainment is being addressed for other taxa, and the impact on population size is not well known for splittail; developing objectives related to entrainment may be unnecessary for this species. Given the widespread distribution of splittail in the Delta, and particularly on the western side, it is unclear how important entrainment really is for this species. Large numbers sometimes have been reported in the salvage from pumping operations but this has been in high flow wet years when the population has done well. For this species, it is very difficult to determine whether entrainment is an index of impact or an index of abundance.

Quantifying maximum levels of entrainment mortality for splittail is complicated by the lack of a reliable and consistent measure of splittail population size in the Delta. Also, the habit of splittail to remain in relatively shallow, slow-moving water close to shorelines makes them less susceptible to pumping operations. However, a portion of the population may be impacted by entrainment associated with the North Delta Diversion project because water will be drawn from the side of the channel. This may only be an issue in drier years when the major floodplain habitats are not inundated and splittail migrate farther upriver in search of suitable spawning habitat (inundated terrestrial vegetation).

Sacramento Splittail Predation: An objective addressing this stressor may be unnecessary. Predation is considered a low impact stressor on the splittail population and measures to control predation may be unrealistic. Splittail are consumed by a number of piscivorous predators in the Delta, including birds as well as fishes. As splittail abundance increases – presumably in response to the conservation actions – there may be a positive effect on the survival and growth of both native and non-native piscivores that may, at times, ultimately result in an indirect negative effect on other fish species/life stages of concern that may also be subjected to mortality from the more robust predator field that is augmented by the trophic support derived from abundant splittail. The idea of negative unintended effects developing as a consequence of enhancing the populations of some species of concern such that the populations of other species are disproportionately and negatively impacted has not been incorporated here.

2.3 Delta smelt

The life history strategy of delta smelt is generally considered opportunistic (Winemiller and Rose, 1992), in that individuals mature at a relatively young age and have relatively low fecundity (Bennett, 2005). Delta smelt have a small geographic range, and are endemic to the San Francisco Estuary. They are primarily an annual species with some unknown (likely small) fraction of the population surviving a second year to spawn. Spawning takes place in freshwater from February through May at temperatures between 12 and 20°C, and appears to be clustered in two-week intervals presumably related to the tidal cycle. Eggs are demersal; larval stages rear in freshwater before moving to brackish waters generally found between the confluence of the San Joaquin and Sacramento Rivers and Suisun Bay. Adults migrating to spawn and resulting larvae and juveniles migrating back to the low salinity zone are vulnerable to entrainment at the project facilities. Juvenile and adult life stages remain at a salinity of about 0.5 to 6 (the low salinity zone) until the end of the year when migration to freshwater begins. Delta smelt are generally found in turbid waters, either to avoid suffering high mortality in clear water or for foraging; in the laboratory, larval smelt will not feed in clear water. Delta smelt eat zooplankton throughout their lives and as typical of many small-bodied forage species, are consumed by a variety of fish, principally visual predators.

We developed three objectives for Delta smelt as follows:

1. Growth - Increase fall mean body length of juvenile delta smelt by 10% (to about 65 mm in December rather than 60 mm) by increasing summer growth rates.
2. Adult Entrainment - Maintain the proportion of the adult delta smelt population that are entrained in the CVP and SWP facilities during December to March below a level that is consistent with values estimated for years with historically low entrainment and relatively high delta smelt population growth⁵.
3. Juvenile Entrainment - Maintain the proportion of delta smelt juveniles lost to entrainment at the project diversions (during the spring and early summer) below a value based on historical entrainment relative to the FMWT or Kodiak population indices.

⁵ In our demonstration analysis for setting numerical objectives, we used modeling to determine that the level was 5% (and no higher than 10%). These percentages are based on a preliminary analysis using an unpublished individual-based life cycle model. They are presented to illustrate how models can be used to generate such numbers. Additional analyses will be needed to refine these numbers and develop final BDCP objectives.

**Note that these objectives are based on a set of assumptions and an approach which are outlined below. Different assumptions or approaches would yield different values for the objectives. We did not attempt to be comprehensive in our approach and have not considered every possible stressor affecting delta smelt. Additional objectives will likely be needed for this species. In addition, the development of objectives for delta smelt was limited by the lack of global goals and objectives for the species.*

Additional BDCP objectives are likely needed for Delta smelt. For example, an objective to address the stressor of limited fall habitat could be developed. The linkage between the provision of fall habitat and key population dynamic processes of delta smelt is currently the subject of several investigations initiated by the Habitat Study Group. As the findings of those studies and of additional monitoring efforts become available it should be possible to develop quantitative objectives for delta smelt associated with changes in fall habitat. There may be utility in incorporating turbidity into the above objectives or defining additional objectives based on turbidity (e.g., trigger for spawning migration).

2.3.1 Delta Smelt Growth Objectives

<i>Species life stage and Process</i>	Delta smelt juveniles and adults Growth
<i>Relevant Global Goals</i>	Not provided
<i>Relevant Global Objectives</i>	Not provided
<i>Stressor(s)</i>	Growth is affected by several stressors including limited food availability.
<i>Recommended BDCP Objective(s)</i>	<i>Increase fall mean body length of juvenile delta smelt by 10% (to about 65 mm in December rather than 60 mm) by increasing summer growth rates.</i> <i>Increase summer-time growth rates by increasing the density of zooplankton in the lower Sacramento, lower San Joaquin, and confluence areas in low outflow years, and confluence and below in high flow years. The average daily summer zooplankton production should increase in quantities and quality such that Delta smelt growth rates become similar to their growth rates in 1970's and 1980's.</i>

Rationale

This objective focuses on increasing growth of juvenile Delta smelt as a critical fitness measure influencing egg production (i.e., fecundity) of adults. Food availability is a limiting factor for delta smelt and changes in food have been identified as an important contributor to their decline (Baxter, et. al. 2010). Kimmerer (2008) noted a statistically significant relationship between juvenile smelt survival and zooplankton biomass. There has also been a decline in the mean size of young-of-the-year delta smelt in December following the introduction of the clam *C. amurensis* (Sweetnam 1999, Bennett 2005). Small size at the end of the growing season is thought to lead to possible delayed maturation and lower fecundity (Bennett et al. 2008). Delta smelt growth rates are potentially limited during summer by a combination of high water temperature, and low food quality and low food quantity (Baxter, et. al. 2010).

Water temperature influences the growth rates of delta smelt as well as its prey. Temperature will also modulate the effects of increased food. In the bioenergetics equation presented below, temperature affects both maximum consumption and respiration. Basically, temperature controls scope for growth. Water temperatures in the Delta in the summer are controlled by climate conditions. This is not a stressor that can be controlled by BDCP, but it may be possible to create habitat for delta smelt in areas that are less susceptible to temperatures that would restrict juvenile smelt growth.

There are known optimal temperatures for egg survival (10-18° C) and juvenile growth (18-22° C). Ideally temperatures would be in the ranges for egg survival and juvenile growth for as long as possible to allow a bet hedging strategy to spread out cohorts over longer period of time or for adults to spawn twice within a spawning season. The temperature range for spawning is 14-18° C. For larvae, it is important to have conducive temperatures during April and May in the upper and lower Sacramento River, Delta, and lower San Joaquin River.

2.3.2 Delta Smelt Adult Entrainment Objective

<i>Species life stage and Process</i>	Delta smelt adults Mortality and reproduction
<i>Relevant Global Goals</i>	Not provided
<i>Relevant Global Objectives</i>	Not provided
<i>Stressor(s)</i>	Entrainment due to pumping has been identified as an important stressor on delta smelt, especially spawning adults, in certain years.
<i>Recommended BDCP Objective</i>	<i>Maintain the proportion of the adult delta smelt population that are entrained in the CVP and SWP facilities during December to March below a level that is consistent with values estimated for years with historically low entrainment and relatively high delta smelt population growth. In our demonstration analysis for setting numerical objectives, we used modeling to determine that the level was 5% (and no higher than 10%).</i>

Rationale

Entrainment of adult Delta smelt has been the focus of many studies (e.g., Kimmerer 2008; Grimaldo et al. 2009) and the role of entrainment on the long-term and recent declines continues to be discussed (Baxter et al. 2010). Kimmerer (2008) concluded that losses of adults due to entrainment were important in certain years, while in other years, the population-level effects were small. The most recent POD synthesis continued in this logic of entrainment likely being important under certain conditions but not universally important in all years.

Sufficient information is available to set a numerical objective for entrainment of adult Delta smelt. Entrainment can be estimated from the salvage data, and the FMWT index provides a basis for expressing the entrainment losses relative to the population.

2.3.3 Delta Smelt Juvenile Entrainment Objective

<i>Species life stage and Process</i>	Delta smelt juveniles Mortality
<i>Relevant Global Goals</i>	Not provided
<i>Relevant Global Objectives</i>	Not provided
<i>Stressor(s)</i>	Entrainment of juveniles has been identified as an important stressor on the Delta smelt population in certain years.
<i>Recommended BDCP Objective</i>	<i>Maintain the proportion of delta smelt juveniles lost to entrainment at the project diversions during the spring and early summer below a value based on historical entrainment relative to the FMWT or Kodiak population indices. (Can be estimated with further analysis)</i>

Rationale

As with adult entrainment, the thinking about entrainment of juvenile Delta smelt is that it varies greatly from year to year. Kimmerer (2008) estimated that larval and juvenile population losses ranged from 0 to about 25% from 1995 to 2006.

The Kodiak trawl provides data regarding the number of spawning fish located on or near the spawning grounds. This data can be related to the number of young juveniles that appear during the spring. The Kodiak index would be better to use than the FMWT because it benchmarks abundance in a point in the life cycle closer to entrainment, and thus should be more sensitive to changes in entrainment and less influenced by other factors. For example, in other analyses, relationships between subsequent indices (e.g., summer tow net to FMWT) show variability (i.e., are not perfectly correlated). This suggests that the factors operate to affect survival between the two sampling points. The same argument can be applied to using the FMWT versus the Kodiak to benchmark population losses of juveniles to entrainment. The disadvantage to using the Kodiak index is that far fewer years of data are available compared to the FMWT.

A similar analysis as we demonstrated for setting the numerical objective for adult Delta smelt entrainment can be applied to setting a numerical objective for juvenile entrainment.

2.3.4 Approach to Quantifying Growth Objectives for Delta Smelt

The following describes the steps in an analysis that have been used to quantify the delta smelt growth objective recommended above. Changes in the food web have been identified as a stressor on delta smelt contributing to their decline. Zooplankton showed a dramatic shift in 1987 (Figure 8). We will use 1987 as distinguishing early and present years. How much food would have to increase to sufficiently increase growth is a difficult question. We have a series of models and data that enable, with many assumptions, an analysis strategy for providing a semi-quantitative objective.

Several cautions and caveats are needed. First, the results presented are for illustrative purposes; to actually define the quantitative objectives, a more careful analysis needs to be done. Second, the analysis relies on unpublished models. One of the advisors (Dr. Kenneth Rose) has developed an individual-based population model for delta smelt (with Dr. Wim Kimmerer and Dr. Bill Bennett). The model has as one of its components a bioenergetics sub-model. We use the bioenergetics sub-model in our setting of the quantitative target. We also use data from a variety of sources that were synthesized for use in the model. None of this has yet been published. Third, this was prepared in a short time frame and should be re-evaluated to ensure defensibility. The main purpose of this section is to show that, in a few cases, quantitative objectives can be set. If agreeable, then a small group of experts should do a more rigorous and systematic analysis.

Our focus is on juvenile growth during the summer months (May through August). The idea is to determine how much zooplankton needs to be increased in order for delta smelt to grow as they did prior to the food web change in 1987.

The proposed approach is as follows:

Step 1: Determine the spatial boxes that juveniles use for summer growth. This can be determined by examination of the summer tow net survey (TNS) and FMWT data. The TNS includes late larvae and juveniles; FMWT includes later juveniles and adults. For example, in 1995 (a high flow year), TNS data showed young delta smelt in confluence box and downstream into the Suisun boxes. In 2001 (a low flow year), young smelt in the summer were in the confluence box and above the confluence in the lower Sacramento River box. Young smelt are generally found in 0.5 to 6 salinity waters.

Step 2: Prepare the zooplankton density data available from the IEP database. The modeling team has done this for years 1973 to 2005 for the spatial boxes shown in Figure 9. The modeling team defined 6 groups of zooplankton based on what delta smelt eat and to include shifts in zooplankton that have occurred historically. These groups are: Adult Limnoithona (Limno), all calanoid juveniles (Allcaljuv), calanoid adults other than Eurytempora and Pseudodiaptomus (Ocaladults), adults of *Acanthocyclops vernalis* (Avernal), adults of Eurytempora (Eury), and

adults of *Pseudodiaptomus forbesi* (Pdiat). This gets complicated because the zooplankton sampling stations must be mapped to the spatial boxes, and the modeling team used a complicated windowing approach to interpolate to obtain daily values of each group for each spatial box. Thus, we have daily zooplankton densities for each of the six groups for each spatial box for 1973 to 2005, and daily temperature and salinity for each box from 1994 to 2005. We used this in the individual-based population model.

Step 3: Develop a bioenergetics growth model. The modeling team developed a Wisconsin-style bioenergetics model that simulates the growth of an individual delta smelt from first feeding through age-2. The model is:

$$W_t = W_{t-1} + (C - R - F - U - D) \bullet W_{t-1} \bullet \frac{e_s}{e_p} - E \quad (1)$$

Where W is the weight of each individual (grams wet weight), C is the realized consumption rate, R is the total metabolic rate, F is egestion, U is excretion, D is the proportion of assimilated energy lost to specific dynamic action, and E is loss due to spawning. All rates, except E , are $(\text{g prey}) \cdot (\text{g smelt}^{-1}) \cdot \text{d}^{-1}$ in wet weight; E is in $\text{g smelt} \cdot \text{individual}^{-1} \cdot \text{d}^{-1}$ and only occurs on the day of spawning (E is zero for juveniles). The e_s and e_p (J/g) are used to convert the $(\text{g prey}) \cdot (\text{g smelt}^{-1})$ to $(\text{g smelt}) \cdot (\text{g smelt}^{-1})$, which when multiplied by weight (W), gives $\text{g smelt} \cdot \text{individual}^{-1} \cdot \text{d}^{-1}$. Respiration is a function of body weight and temperature, and egestion, excretion, and SDA (D) are fractions of consumption. The parameter values for the bioenergetics model are shown in Table 2.

Maximum consumption is a function of body weight and temperature.

$$C_{\max} = a_c W^{b_c} f(T) \quad (2)$$

The temperature adjustment to maximum consumption [$f(T)$] increases from a value of CK1 at temperature CQ to 0.98 at T_0 , and then stays at 0.98 until T_M after which it declines to CK4 by T_L .

Step 4: Use a functional response algorithm to predict the p-value. Typically, one uses daily temperatures, and the unknown that is calibrated is how much of maximum consumption is realized each day (called the p-value). The modeling team has modified the usual bioenergetics approach and added a multi-species functional response calculation that uses zooplankton densities in each day to determine the p-value each day. The functional response is:

$$C_{ij} = \frac{C_{\max} W_i \left(\frac{PD_{ij} \bullet V_{ij}}{K_{ij}} \right)}{1 + \sum_{k=1}^{11} \left(\frac{PD_{ik} \bullet V_k}{K_{ik}} \right)} \quad (3)$$

$$C_i = \sum_{j=1}^n C_{ij} \quad (4)$$

where C_{ij} is the daily consumption rate by fish i of the j^{th} prey type (6 zooplankton groups), V_{ij} is the vulnerability of prey type j to fish i , and K_{ij} is the half-saturation constant for fish i feeding on each prey type k . Calibrated parameter values are shown in Table 2.

Equations (3) and (4) allow an individual fish to consume multiple prey types without exceeding its maximum consumption. The functional response allows for a fish to focus on abundant prey types when they are available and to broaden its diet when preferred prey types are at relatively low densities. The C_i from equation (4) divided by C_{max} is the p -value. The results of an example calculation are shown in Figure 10.

Step 5: Simulate juvenile delta smelt growth for the early years and later years to establish, within the modeling world, the target for growth. Using equations (1)-(4), and temperature and densities of the zooplankton on each day, we can predict daily growth in weight of an individual fish. The fish's weight is then updated based on yesterday's weight and today's growth rate; then we use temperature and zooplankton densities for tomorrow to predict growth. Calculations are repeated day after day until a weight in December is obtained. Weight can be converted to length using a length-weight relationship.

Field data and analyses using the individual-based population model showed that old food conditions resulted in juvenile delta smelt in late fall that were about 5 mm longer than under present day food conditions (about 65 mm versus 60 mm in December).

Step 6: Determine how much the densities of the present-day zooplankton composition need to increase by, and in which spatial boxes, in order to achieve the growth predicted under old zooplankton conditions. This could be done for all boxes, and then expected spatial distributions of juvenile delta smelt in the summer (from Step 1) overlain on the boxes to define where in the system (which boxes) the zooplankton should be increased. A simple approach would be to increase all zooplankton groups by incremental percentages (i.e., multiply the values by 1.2, 1.4, 1.6, etc.). This assumes that the zooplankton community composition would remain the same ("rising tide floats all boats" scenario). A more complicated approach would be to assume that however productivity is increased in the boxes, the zooplankton species composition would also change. One could use the historical species compositions to do this (i.e., substitute zooplankton densities from the early years).

Step 7: Obtain a final plot for determining the quantitative objective for how much zooplankton densities need to increase in specific spatial regions. The result of the analyses would be a graph that shows how close to the growth predicted for early years (65 mm in December) is possible by increasing present-day zooplankton densities in the summer in specific spatial regions. By then assuming the spatial distribution of the juveniles (% by region), say in low and high flow years, one can compute the expected fall mean weight (and length). One can then envision a dose response type plot with percent increase in zooplankton on the x-axis and the fall juvenile length on the y-axis, with separate lines for low and high flow conditions. The quantitative target, expressed as the percent increase in summertime zooplankton densities (relative to present densities, e.g., 1995-2005 used here) by region, would then be determined from the graph.

The biological significance of achieving old growth is based on the 5 mm longer juveniles in the early years when the population was performing better, and the results of simulations of the individual-based population model. The modeling team used the individual-based model to estimate that historical food conditions (for larvae, juveniles, and adults) would increase the finite population growth rate of delta smelt (λ , per year) by about 20-40% over the rates predicted for 1995 to 2005 with recent food conditions.

Table 2. Values of the parameters for the delta smelt bioenergetics sub-model.

Parameter		Larvae	Post-larvae, Juveniles, and Adults
Maximum Consumption (C_{max})			
	a_c	0.18	0.18
	b_c	-0.275	-0.275
	CQ ($^{\circ}$ C)	10.0	10.0
	T_0 ($^{\circ}$ C)	17.0	20.0
	T_m ($^{\circ}$ C)	20.0	23.0
	T_L ($^{\circ}$ C)	24.0	27.0
	CK ₁	0.4	0.4
	CK ₄	0.01	0.01
Metabolism (R)			
	a_r	0.0027	0.0027
	b_r	-0.216	-0.216
	RQ	0.036	0.036
	SDA	0.175	0.175
Egestion (F), excretion (U)			
	F_a	0.16	0.16
	U_a	0.1	0.1
Energy density		4812	4812

Table 3. Vulnerability values and K-values for the six zooplankton groups and four feeding life stages of delta smelt. Energy density of all prey groups was 2590 joules/g wet weight, except for Limno which was assumed to be 70% of the other groups.

Parameter	Larvae	Post-larvae	Juvenile	Adult
Vulnerability (V_{ij} in equation 3)				
Limno	1	1	1	1
Allcaljuv	1	1	1	1
Ocaladults	0	1	1	1
Avernal	0	1	1	1
Eurytem	0	1	1	1
Pdiap	0	1	1	1
K-values (K_{ij} in equation 3)				
Limno	1.0	1.0	4.0	2.0
Allcaljuv	0.2	0.8	4.0	2.0
Ocaladults		1.5	6.0	0.07
Avernal		1.5	6.0	0.07
Eurytem		1.5	6.0	0.07
Pdiap		1.5	6.0	0.07

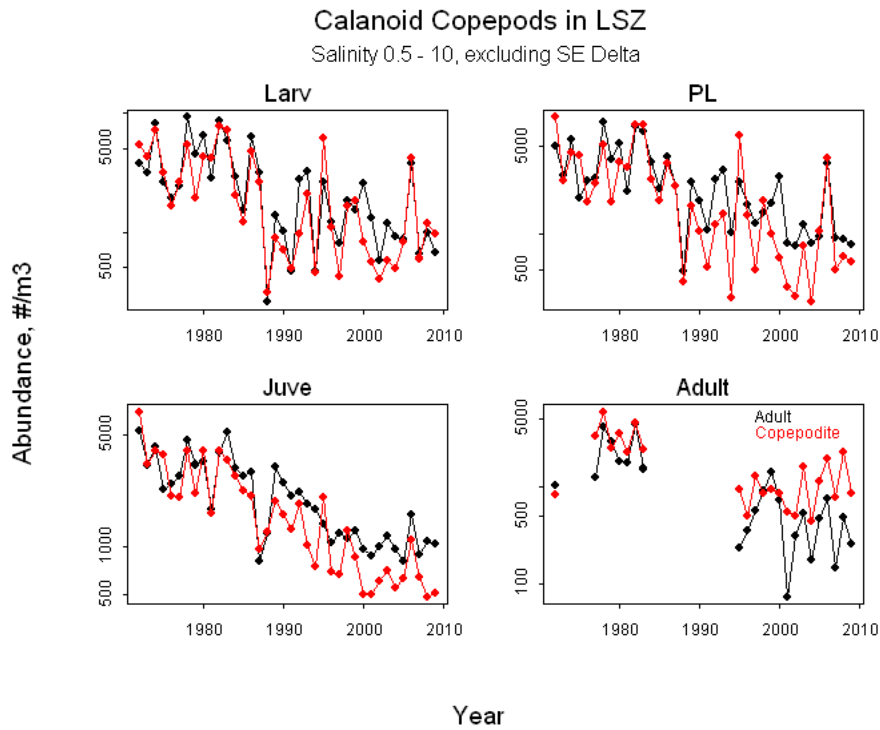


Figure 8. Copepod abundance for the low salinity zone averaged for time periods different life stages (larvae, post-larvae, juveniles, and adults) are typically present. Days 60-90 for larvae, 100-200 for post-larvae, and 150-365 for juveniles; ignore the adults because the time window used was tailored for specific use in the individual-based model. This is included to show: (1) caution is needed in using fixed geographic locations (spatial regions) to look at the food of juvenile delta smelt because juveniles follow the salinity, and (2) key zooplankton taxa have declined. [Figure provided by Wim Kimmerer as part of the individual-base modeling.]

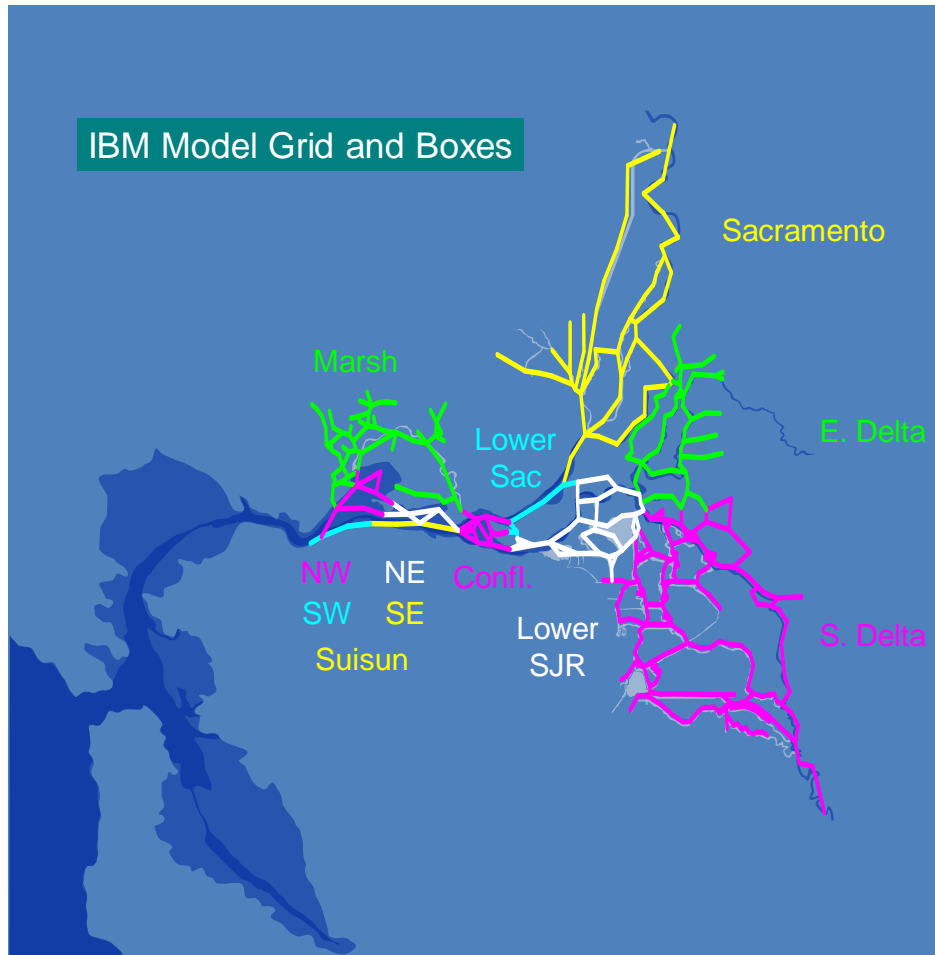


Figure 9. Spatial regions used in the individual-based population model.

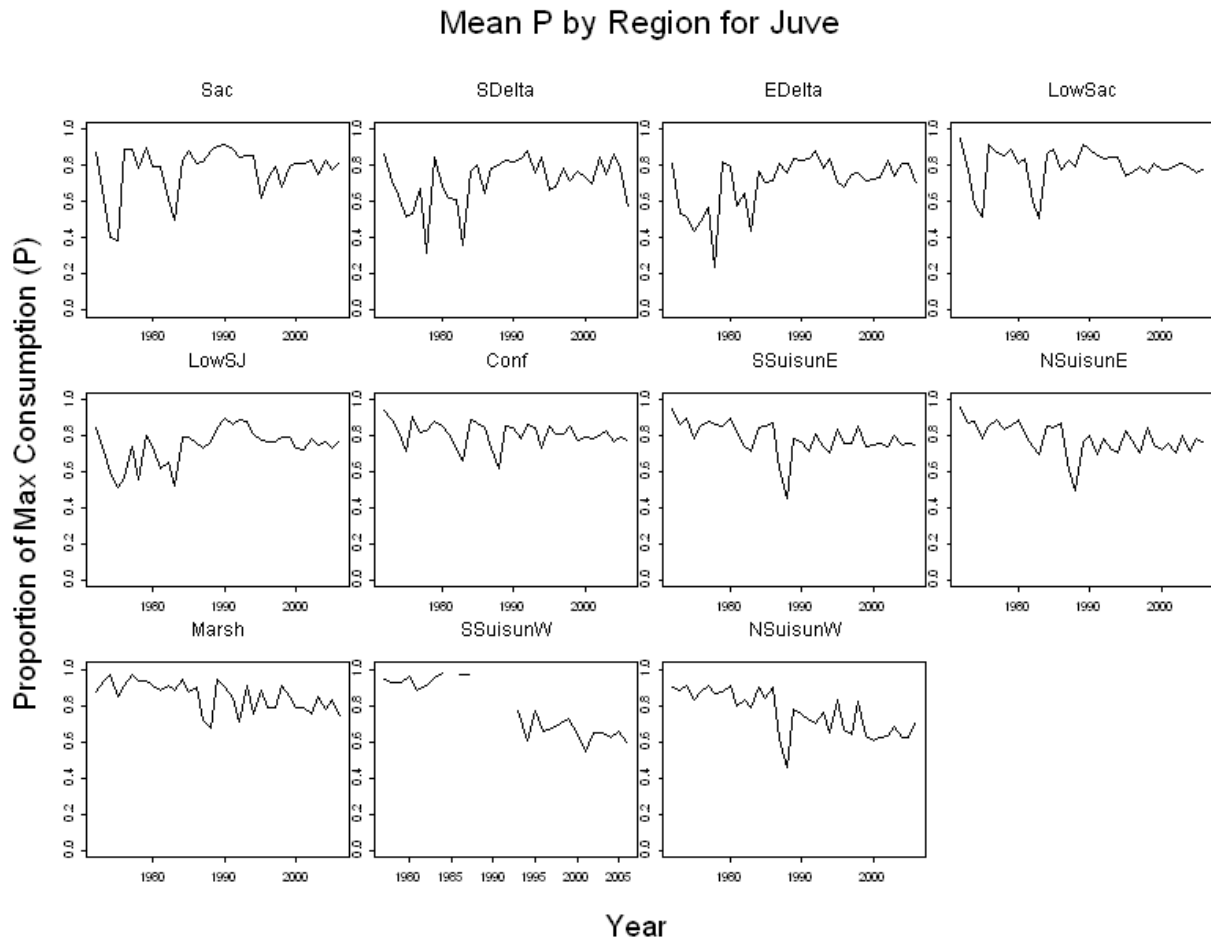


Figure 10. Averaged p-values for juveniles for each year for 1974 to 2006. Each day, the densities of the six zooplankton groups are used with equations (2) and (3) to compute consumption, which is then divided by the maximum consumption (equation 2) to obtain a p-value. The daily p-values were averaged over days 130 to 365 for each year to obtain a single average p-value per year. Note that p-values are reported so that temperatures are not needed for calculations. The p-values shown do not reflect where juveniles are actually found in the system. P-values were computed for each spatial region based on single fish staying in the region for the specific days each year. [Figure produced by Wim Kimmerer as part of the individual-based population modeling.]

2.3.5 Approach to Quantifying Entrainment Objective for Adult Delta Smelt

The following describes the steps in an analysis to support the development of quantitative objectives for the adult delta smelt entrainment. Entrainment due to pumping has been identified as an important stressor on delta smelt in certain years. How much entrainment is too much is a question best answered at the population level. We have a series of models and data that enable, with many assumptions, an analysis strategy for providing a semi-quantitative objective.

Several cautions and caveats are needed. First, the results presented are for illustrative purposes; to actually define the objective, a more careful analyses needs to be done. Second, the analysis relies on unpublished analyses. One of the advisors (KAR) has developed an individual-based population model for delta smelt (with Wim Kimmerer and Bill Bennett). The model has as one of its components a pumping mortality sub-model. We use some of the data analysis, with some modeling results, in our illustration below of how to set a quantitative target. We also use data from a variety of sources that were synthesized for use in the model. None of this has yet been published. Third, this was prepared in a short time frame and should be re-evaluated to ensure defensibility. The main purpose of this appendix is to show that, in a few cases, quantitative objectives can be set. If agreeable, then a small group of experts should do a more rigorous and systematic analysis.

Our focus is on adult entrainment during the winter months (December through March). The idea is to determine to what level entrainment should be maintained below in order for entrainment to be sufficiently reduced as a stressor on delta smelt.

The proposed approach is as follows:

Step 1: Estimate adult population abundance from the FMWT data for December. This involves many assumptions and calculations but is possible. The modeling team has made a first attempt at this for 1995 to 2006 for use in the individual-based population model.

Step 2: Use salvage data to estimate annual cumulative entrainment of adult delta smelt. Several groups have attempted to estimate entrainment on a monthly and annual basis. These calculations can be quite controversial because of the uncertainty about the expansion factors used to account for “unseen” losses (e.g., predation by fish). The modeling team has computed annual losses of adults for 1995-2006 for use in the individual-based population model.

Step 3: Compute fraction of December adult population lost each year due to entrainment. The modeling team computed fractions of the adult population lost for 1995-2006 (Table 4).

Step 4: Relate fraction lost to good and bad years for delta smelt to establish a quantitative target. Our initial analysis suggests that the fraction, computed with our methodology, should never exceed 10% and ideally should be below 5%.

Note: Steps 1-4 should be re-examined and the analyses expanded to earlier and later years than 1995-2006.

The biological significance of keeping entrainment losses below 5% is based on annual estimates during 1995-2006 being less than 5% for five years, and 5-6% for two more years. The modeling team used the individual-based model to estimate how population growth rate (λ , per year) would increase if there had been no pumping in each year for 1995-2005. In years when the data resulted in low pumping mortality (Table 4), there were relatively smaller effects on λ as predicted by the individual-based model (pumping resulted in an average of a 22% reduction in λ for losses <6%); larger effects on λ were predicted for 2003-2005 (average of a 37% reduction in λ) when estimated pumping losses based on the data were 16.6% or higher.

The percentages lost due to entrainment should be interpreted as an index of the population level losses. As long as the same calculation methods are used, estimates can be compared across years. Because of the uncertainties in the calculations, the percentages may not reflect the actual percent of the real population lost.

Table 4. Estimated percent of December adult delta smelt abundance lost to entrainment. These are estimates only to illustrate how such a metric could be calculated and should not be cited. [Numbers provided by Wim Kimmerer for calibration of the individual-based population model]

Year	Percent of December Adult abundance Lost Due to Entrainment
1995	17.8
1996	2.9
1997	2.8
1998	0.8
1999	2.8
2000	5.7
2001	5.8
2002	16.6
2003	22.7
2004	19.3
2005	8.9
2006	3.5

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3.0 Conclusions

1. ***The goals and objectives already articulated as part of the BDCP process for some species provide a good starting point for further refinement.***

However, the inability of agencies to provide global goals and objectives to the Advisors for their use in this effort limited the effectiveness of this advisory process. The advancement of effective conservation planning and use of the Logic Chain approach requires this information to be available.

2. ***Goals and objectives must use clearly defined, and agreed upon, terms (i.e., a glossary). To the extent possible they must be clear, concise, obtainable, and measurable.***

Lack of specificity hinders planning, implementation and the adaptive management process. A term such as “improving habitat” is too vague if there is no agreement on what constitutes the habitat and what is meant by “improving”. This report attempts to be as specific as possible in defining terminology.

3. ***Quantitative objectives may not be possible for many of the listed fish species.***

In most cases the difficulty is not how to determine quantitative objectives, but rather that the needed information, data, and modeling tools are not widely available at present. The Advisors have, to the extent possible, benchmarked objectives in quantitative terms and have demonstrated how analyses can be used to clarify expectations of the Plan.

4. ***There are presently a few situations where quantitative objectives can be determined. This will change in the future as improved understanding and predictive tools are available.***

Ongoing development of life-cycle models for salmonids by NOAA (e.g., presentation by Lindley to NRC 1 June 2011) illustrate the pace of development in this area. Quantitative objectives will become increasingly possible as more data related to the BDCP actions is collected and the development of quantitative tools (models) continues.

- 5. Quantitative objectives can be expressed in various ways including the reduction of stressors, responses of fish abundance, spatial distribution, or key population dynamic processes (growth, survival, reproduction, and migration).***

The objectives presented herein are based upon consideration of key species population dynamic processes. These processes include individual growth, reproduction, movement, survival, and individual growth (including bio-energetics, growth rates, and metabolism). These can often be measured.

- 6. Determining the objectives that address some of the stressors for a few of the listed species (e.g., delta smelt) will be controversial and refining objectives for these may be dependent on more focused discussion and/or the development of additional analyses.***

The risk is that a few very difficult issues can become the center of attention, which leads to focus on a few areas of disagreement, and overall progress toward improving Delta ecosystem conditions for fish species may get lost. One example of this is the provision of Fall habitat (as defined by specific turbidity and salinity conditions) for delta smelt.

- 7. The approaches to the development of quantitative objectives included here are for illustrative examples that require review and refinement before becoming the basis for a conservation plan.***

The approaches presented are for illustrative purposes; to actually define the quantitative objectives for use in the Plan, a more careful analyses needs to be done. The analysis also relies on unpublished data syntheses and models, some aspects of which may be altered during the peer review process. These examples were also developed in a short time frame and further consideration by the Advisors or other experts may result in changes.

- 8. Extending and applying the illustrative approaches to developing quantitative objectives is best achieved by BDCP experts working closely with a team of independent advisors; for the plan to be successful BDCP stakeholders must 'own' the objectives.***

Foundational elements as important as objectives should be understood and agreed on by all parties, rather than developed externally. Independent science advice can have a role in that process but should not be the ones to assess available information, mine data, apply relationships, and describe limitations. The example approaches to developing quantitative objectives included in this report could best be applied by a small group of highly qualified and experienced BDCP experts with a team of Advisors in an oversight and review role.

9. *Establishing baseline conditions that can be used as a foundation for the future refinement of objectives and the plan as a whole is essential.*

The lack of available information was one of the fundamental limitations on the ability of the Advisors to develop objectives that were all quantitative. Efforts such as this illustrate the areas where key information is missing and provide an opportunity to focus data collection and research.

10. *Development of conservation measures to achieve objectives developed for individual species must consider effects on other species, both positive and negative.*

While a focus on species objectives may be necessary for BDCP, the system context is essential for their application. Individual taxa within a biotic assemblage cannot be managed as independent and isolated elements of the ecosystem. Species interact with one another to varying degrees and all of the species within the Delta will likely respond in one way or another to any natural or anthropogenic alteration aimed at modifying conditions to benefit only one. Consequently, management of assemblages rather than species may be a useful direction to consider in the future.

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5.0 Appendices

A. Charge

BDCP Goals and Objectives Independent Science Advisors Process

Process Overview

- Establish a small group of independent science advisors to assist in finalizing biological goals and objectives for covered fish species.
- Establish a BDCP workgroup to interface with the advisors and address policy level issues.
- Engage a facilitator to manage the process.

Advisor's Charge

Produce a recommended set of BDCP biological goals and objectives for the 11 covered fish species that are measurable, and based on the best available science. Specific tasks summarized below and described in more detail in Attachment A.

1. Review existing background materials, including work to date on stressors, goals and objectives (including "global" goals), logic chain process, and proposed conservation measures.
2. Review other HCP/NCCPs and relevant regulatory guidance documents.
3. Engage with BDCP workgroup.
4. Solicit technical information as needed regarding covered fish species, including consulting with technical experts.
5. Prepare a draft set of BDCP goals and objectives for covered fish species, including information on spatial and temporal relevance and how they would be measured.
6. Present draft recommendations to BDCP workgroup.
7. Finalize recommendations and transmit to workgroup and Management Team.

Schedule

- | | |
|--|---|
| 1. <i>Develop draft approach and scope.</i> | <i>February 2011</i> |
| 2. <i>Review scope with stakeholders.</i> | <i>March 2011</i> |
| 3. <i>Finalize scope, list of science advisors, and G&O Workgroup.</i> | <i>March 30, 2011
Management Team Meeting</i> |
| 4. <i>Convene Science Advisors – interface with Workgroup</i> | <i>April 12, 2011</i> |
| 5. <i>Develop recommendations - Advisors</i> | <i>April 12 – May 30, 2011</i> |
| 6. <i>Workgroup meeting – midpoint check</i> | <i>April 26, 2011 (tentative)</i> |

- | | |
|---|----------------------------------|
| 7. <i>Circulate recommendations to Workgroup</i> | <i>May 30, 2011</i> |
| 8. <i>Present and discuss recommendations –
Advisor/Workgroup meeting</i> | <i>June 10, 2011 (tentative)</i> |
| 9. <i>Workgroup meeting (as needed)</i> | <i>June 11, 2011(tentative)</i> |
| 10. <i>Submit final recommendations to Workgroup and
Management Team</i> | <i>June 20, 2011</i> |

Science Advisors

1. Jim Anderson (Univ. of Washington)
2. Ron Kneib (Private Consultant)
3. Denise Reed (Univ. of New Orleans)
4. Kenny Rose (Louisiana State University)

G&O Workgroup Role and Charge

1. Serve as stakeholder interface for facilitator/advisors
2. Provide input to, and context for, science advisors
3. Receive recommendations from advisors
4. Provide forum for resolving policy issues related to G&Os
5. Transmit recommendations to Management Team

It is anticipated that the Workgroup members would participate in 2 meetings with the advisors; the kick-off meeting on April 12 (1-2 hours) and the presentation of recommendations on May 10 (2-4 hours). The Workgroup may schedule other meetings as needed to discuss policy issues as they arise and/or to discuss advisor recommendations and Management Team transmittal.

G&O Workgroup Members

1. John Cain
2. Carl Wilcox
3. Bill Harrell
4. Josh Israel
5. Cindy Kao
6. Jason Peltier
7. Jon Rosenfield
8. Maria Rae
9. Mike Hoover

ATTACHMENT A – Detailed Advisor’s Charge

Produce a recommended set of BDCP biological goals and objectives for the 11 covered fish species that are attainable, measurable, and based on the best available science. Rather than providing a “review” as has been done in previous independent panels, this group of advisors will roll up their sleeves and produce a set of recommended goals and objectives, including necessary background materials to support the recommendations. The advisors will focus specifically on technical issues. If policy issues arise during their work, they will document these issues and forward them to the G&O Workgroup. Specific tasks will include:

1. **Review existing background materials, including work to date on stressors, goals and objectives,** logic chain process, and proposed conservation measures. This background information will form the basis for the advisor’s work and deliberations.
2. **Review other HCP/NCCPs and relevant regulatory guidance documents.** The purpose of this review will be to provide adequate context to the effort and ensure that the product of the advisors is squarely focused on the needs of the Plan and it’s regulatory context.
3. **Engage with BDCP workgroup.** Engagement will include limited presentations to help ground the advisors coupled with interactive dialog regarding the G&O’s and their role in the overall planning process. Stakeholder engagement will occur at the beginning of the process and at the point that draft recommendations are available.
4. **Solicit technical information as needed regarding covered fish species, including consulting with technical experts.** All outreach to technical experts or stakeholder representatives will be coordinated by the facilitator and all conversations will be documented to ensure transparency and avoid bias.
5. **Prepare a draft set of BDCP goals and objectives for covered fish species, including information on spatial and temporal relevance and how they would be measured.** In those cases where there is sufficient scientific information, the advisors will identify and justify quantitative targets for specific objectives. In cases where this is limited data, and/or high degrees of uncertainty, the advisors will outline qualitative objectives and identify approaches for moving toward more quantitative targets over time. If the advisors identify clear policy issues, they will prepare a written description of the issue and forward those descriptions to the G&O Workgroup for their discussion.
6. **Present draft recommendations to BDCP workgroup.** Recommendations will be presented at a meeting with G&O workgroup members with an opportunity for open dialog and interaction to ensure the Workgroup members understand the draft G&Os and why the advisors have framed them the way they have. In addition to the G&O statements, the advisors will provide additional written materials that describe details regarding each objective including potential metrics, timeframes and spatial scale.
7. **Finalize recommendations and transmit to workgroup and Management Team.** Based on interactions with the Workgroup, the advisors will finalize their recommendations and transmit them to the Workgroup and Management Team.

B. Glossary of Terms

Definition of Key Terms

The BDCP Science Advisors are currently finalizing the glossary.

C. Global Goals and Objectives for Winter-run Chinook Salmon

The following describes global goals and objectives for winter run Chinook salmon as provided by NMFS on April 11, 2011. These reflect draft goals and objectives which have not been formally adopted.

Global Goals

GG1. Abundance - Attainment of the winter-run Chinook salmon global abundance goal will occur by 2060 with achievement of 6-year geometric mean escapement levels of: 20,000 in the mainstem Sacramento River with no year below 5,000; 3,000 in the Battle Creek watershed with no year below 500; and 500 in a third dependent population with no year below 200.

GG2. Spatial Distribution - Attainment of the winter-run Chinook salmon global spatial distribution goal will occur by 2060 with restoration of two self-sustaining, independent populations in two watersheds of the Sacramento River drainage, and a third dependent population in the Sacramento River drainage.

1. *GG3. History Diversity* - Attainment of the winter-run Chinook salmon global life history diversity goal will occur by 2060 with restoration of two self-sustaining, independent populations in two watersheds of the Sacramento River drainage, and a third dependent population in the Sacramento River drainage.

Global Objectives

A. *Global VSP Objectives:*

VSP1. Increase abundance;

VSP2. Increase spatial distribution;

- a. Secure all extant populations (all populations are important because there are so many “missing” populations in the Central Valley),
- b. Recover populations in each diversity group (only one diversity group for Winter-run)

VSP3. Protect and increase life history and genetic diversity.

VSP4. Increase productivity (population growth rate = births-deaths)

Viable populations should demonstrate a combination of population growth rate and abundance that produces an acceptable probability of population persistence (NMFS Draft Recovery Plan).

B. *Global Critical Habitat Objectives* (from primary constituent elements)

CH1. Provide access to spawning areas on the Upper Sacramento River, including upstream passage of adults to spawning grounds

CH2. Provide for adequate quality and quantity of spawning gravels

CH3. Provide for adequate river flows for successful spawning, incubations of eggs, fry development and emergence, and downstream transport of juveniles

CH4. Provide water temperatures for successful spawning, egg incubation, and Fry development

CH5. Provide habitat areas and prey that are not contaminated

CH6. Provide riparian (including floodplain) habitat for successful juvenile development and survival

CH7. Provide adequate downstream migration corridors for successful emigration of juveniles.