EXHIBIT A

RTD-142

List of Commenting Parties
Comments on Draft Bay Delta Conservation Plan, EIR/EIS, and Implementing Agreement
July 29, 2014

Anderson-Cottonwood Irrigation District
Biggs-West Gridley Water District
Browns Valley Irrigation District
Butte Water District
Calaveras County Water District
El Dorado County Water Agency
El Dorado Water & Power Authority
City of Folsom
Glenn-Colusa Irrigation District
Meridian Farms Water Company
Natomas Central Mutual Water Company
Northern California Water Association
Paradise Irrigation District
Pelger Mutual Water Company
Placer County Water Agency
Princeton Codora Glenn Irrigation District
Provident Irrigation District
Reclamation District 108
Reclamation District 1004
Richvale Irrigation District
River Garden Farms
City of Roseville
City of Sacramento
Sacramento County Water Agency
Sacramento Municipal Utility District
Sacramento Suburban Water District
San Juan Water District
South Feather Water and Power
South Sutter Water District
Sutter Extension Water District
Sutter Mutual Water Company
Western Canal Water District
Yolo County Flood Control & Water Conservation District
Yuba County Water Agency

EXHIBIT

Technical review of the Bay-Delta Conservation Plan (BDCP) and related Environmental Impact Review (EIR)

Prepared for:

The Sacramento Valley Water Users Group

By

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Consultant

9 July, 2014

Introduction

The Bay Delta Conservation Plan (BDCP) and associated Environmental Impact Report/Environmental Impact Statement (EIR/EIS[2]; referred to herein as the Plan) is intended to be a comprehensive conservation strategy to meet a series of broad biological goals and objectives for the Sacramento-San Joaquin Delta (Delta). Specific characteristics of the Plan were developed to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework. The core of the Plan is rooted in habitat conservation, and as result, it is intended to conserve the Delta ecosystem in a sustainable manner and contribute to the recovery of threatened and endangered fish species. The Plan is the result of a multiyear collaboration among public water agencies, state and federal fish and wildlife agencies, nongovernment organizations, agricultural interests, local governments, and the public. The conservation strategy inherent to the Plan was founded on an array of broad goals adopted and agreed to by stakeholders in 2006, and it is intended to be based on the best available science.

In December 2013, a draft of the Plan was released for public review/comment and I was asked to provide a technical review of several sections, most notably those relating to Delta fish species. The Plan is an extremely lengthy document that is structured as a series of chapters. The Executive Summary and beginning chapters provide overview information about the origin of the Plan, its geographic scope, and ecological conditions (past and present) of the Delta. Subsequent chapters contain specific details regarding the core conservation strategy, adaptive

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[2] The EIR/EIS states that it incorporates the BDCP by reference (EIR/EIS, p. 1-2 fn. 3).

management program, effects analyses, implementation strategy, and costs. In many respects, the Plan can be viewed as layers of technical material, where the initial chapters are layers devoted to discussing the Plan's conceptual approach, and later chapters are layers focused on specific details about how the Plan may or may not benefit the Delta ecosystem. Given this layered structure, I elected to break my review into two phases: (1) high level evaluation focused on the overarching conceptual approach used to assess impacts, and (2) more detailed evaluation of specific methods and conclusions about perceived benefits or negative effects on Delta ecosystem structure, functioning, and constituent biota. The leading theme of the entire review was whether or not the Plan is based on the best available scientific information and practices.

Following phase 1 of the review, it became clear that the Plan's overarching conceptual approach used to assess impacts, both positive and negative, lacks a number of requisite analytical elements. The Plan calls for a series of large-scale physical manipulations to the Delta, and several fundamental areas of consideration for assessing the impacts of those manipulations are either missing or insufficiently developed. Below I highlight five broad areas of consideration and provide supporting explanations as to why they are vital for either inclusion or further development within the Plan. Given the presence of significant weaknesses in the Plan's conceptual approach, phase 2 of the review was not exhaustively conducted. Evaluation of specific details and conclusions was limited to selected instances that provided supporting rationale for the five broad areas of consideration. Comments focused on the plausibility of specific ecosystem and fish species-specific benefits at this stage would, in effect, implicitly and incongruously provide support for the Plan's conceptual approach. Should the conceptual approach evolve over time to become more refined and based more directly on supporting quantitative analyses, then a full evaluation of the analytical details underpinning statements/conclusions pertaining to Delta ecosystem attributes and resident fish species would be appropriate. I welcome the opportunity to provide such an evaluation at a later date.

Areas for Consideration

1) Lessons Learned from Elsewhere: The Plan articulates lofty restoration goals and the plausibility of achieving those goals should naturally elicit some degree of skepticism. The scale of physical manipulations and restoration objectives appear to be nearly unprecedented (certainly for the Delta), and key unknowns about ecosystem processes and functioning are always present, even for the most studied aquatic ecosystems. Although I have not reviewed an exhaustive list of previous aquatic ecosystem restoration efforts across U.S., it suffices to say that many have been initiated over the past several decades. A few recent examples include: (i) the numerous dam removals along the east coast (e.g., Penobscot River , Mill River, Patapsco

River, Little River, Uwharrie River) and west coast (e.g., Columbia River, Carmel River) to provide native and anadromous fishes access to historically utilized habitats (see Stanley and Doyle 2003 for a review on tradeoffs of dam removal); (ii) tidal wetland restoration in Delaware Bay (i.e., the Estuary Enhancement Program, see Weinstein et al. 2001 for review), and (iii) the Everglades Restoration Plan (NRC 2012), which is a multifaceted effort to improve overall ecosystem health. Several of these restoration efforts are in various stages of completion, which presents what would seem like an ideal opportunity to conduct a meta-analysis of many restoration programs to understand the intended and unintended consequences. Have the desired positive benefits been realized in other places, and how/why? Were those benefits not realized, and how/why? What were (if any) the unintended positive or negative impacts resulting from restoration activities, and how/why were those realized?

The Plan, however, contains no review of previous restoration efforts nor does it reference past efforts elsewhere in its determinations about potential benefits or negative consequences of the proposed restoration activities to the Delta ecosystem and associated fish species. The Plan acknowledges that not everything is known about the Delta ecosystem, which implies there is uncertainty (perhaps notable in some instances) regarding its likelihood for successfully achieving stated goals and objectives. Therefore, from the perspective of maximizing the foundational information from which inferences about success/failure can be drawn, it would seem important and necessary to formulate the Plan within the context of ‘lessons learned from elsewhere.’ The Plan's failure to include a formal evaluation of the experiences of other major restoration efforts represents a glaring omission, which in turn, supports the conclusion that the Plan is not based on a complete analysis of available science.

2) Build it and They Will Come: The current Delta is a highly altered ecosystem. Most naturally occurring wetlands in the estuary have been lost due to morphological changes for agriculture, flood control, navigation, and water reclamation activities (Atwater et al. 1979). Other notable changes include modifications to the volume of freshwater entering the Delta and thus the natural delivery of land based sediment (Arthur et al. 1996), massive sediment loading resulting from large-scale hydraulic mining activities (Schoellhamer 2011), introduction and invasion of non-indigenous species (Cohen and Carlton 1998), input of contaminants (Connor et al. 2007), and reported decreases in chlorophyll-*a* (Alpine and Cloern 1992), zooplankton (Orsi and Mecum 1996), and fish abundance (Sommer et al. 2007). Monitoring data have indicated that relative abundances of several pelagic species declined dramatically in the early 2000s, giving rise to the phenomenon deemed the Pelagic Organism Decline (POD; Sommer et al. 2007). The best available science collectively indicates that various physical, biological, and chemical attributes of the Delta ecosystem are in need of restoration, which is consistent with the Plan's most basic and core objective.

The Plan outlines numerous conservation measures to restore a variety of habitat types, including tidal marshes, floodplains, channel margins, and riparian areas. The scale of habitat restoration in terms of proposed new acreage is ambitious and recognition that the quality, quantity, and availability of food in the Delta are limiting factors for fish species is generally consistent with prevailing scientific literature. Therefore, the focus to recreate and enhance the once abundant Delta habitat types that possess environmental (e.g., temperature, salinity, turbidity) and physical (e.g., depth, topography, vegetation, tidal influence) attributes for stimulating primary production and increasing fish growth and survival is conceptually appropriate. A key conclusion of the Plan, however, is that implementation of the proposed habitat restoration conservation measures will result in greater fish population abundances – 'the build it and they will come' phenomenon. The Plan's conclusion that more habitat will lead to more fish is largely based on a habitat suitability analysis, which takes into account habitat preferences by different life stages of fishes and the total number of habitat units (HUs) in the system (Section 5.E.4.4.1.1, Appendix 5E, Habitat Restoration). The Habitat Suitability Index (HSI) for life stage i of species j is given by:

$$\mathrm{HSI}_{ij} = \sqrt[n]{F_1 \cdot F_2 \cdots F_n} \tag{1}$$

where F_i is the suitability factor for a life stage i that reflects conditions for an environmental attribute (e.g., temperature, salinity, turbidity) ranging from 0 (unsuitable) to 1 (ideal). Equation (1) is the geometric mean of the life-stage HSIs. Habitat units, which are indices of habitat potential, are then calculated for species' life stages:

$$\mathrm{HU}_{ijk} = \sum_{h=1}^{n} \mathrm{HSI}_{ij} \cdot P_{ijh} \cdot A_h \tag{2}$$

where for life stage i of species j, HSI_{ij} is the Habitat Suitability Index, P_{ijh} is the life stage preference for habitat type h, and A_h is the area of habitat type h.

Successfully increasing the number of viable HUs for fishes requires a detailed understanding of species-specific habitat suitability factors (F_i's in equation 1) and habitat preferences (P_{ijh}'s in equation 2). Specifying values for those parameters, which are the building blocks of equations (1) and (2), amounts to defining Essential Fish Habitat (EFH) for Delta fish species. Additionally, conditioned on there being more habitat area that is EFH, it would seem vital to conduct analyses that quantify potential gains in fish production in relation to the amount of newly proposed habitat area. These latter two points are now discussed in more detail.

Essential Fish Habitat[3] As defined by NOAA, EFH includes all types of aquatic habitat – wetlands, coral reefs, seagrasses, rivers – where fish spawn, breed, feed, and grow to maturity (http://www.habitat.noaa.gov/protection/efh/index.html). While there is published literature on aspects of habitat utilization of fishes in the Delta (e.g., Bennett 2005, Feyrer et al. 2007), the results do not appear to be unequivocal. For example, Kimmerer 2011 stated 'the distribution of delta smelt seems to have shifted northward in the last few years.' Fishes typically distribute in accordance to their own resource needs (e.g., requirements for food, habitat characteristics, etc.), and the notion that delta smelt may be recently more abundant in the northern Delta suggests one of two possibilities, (i) previously documented patterns in habitat use were incorrectly or incompletely described, or (ii) habitat preferences have shifted over time. Either case implies that the contemporary understanding of EFH for delta smelt (and other fishes in all likelihood) is not comprehensively documented. In light of this uncertainty, the question in relation to the Plan becomes, what will the exact characteristics of the newly proposed HUs be, and what level of assurance is there that those characteristics will match the needs of fishes in the Delta (i.e., qualify as EFH) and generate the Plan's projected benefits for those species? Limitations and uncertainties associated with the Habitat Suitability Analysis are listed in bullet form within the Plan (section 5.E.4.4.1.1, Appendix 5.E), and while these may represent important acknowledged issues, they are not directly incorporated into the Plan's analysis. The Plan does not include any analyses of the potential resulting effects (perhaps in the form of risk analyses) on the likelihood that it will succeed in producing the projected benefits for the relevant Delta fish species. Therefore, since the components of equations (1) and (2) are not formulated to include uncertainty in defining EFH, it is unlikely that the Plan's conclusions about beneficial effects of habitat restoration for fishes are known with acceptable levels of precision (more on the general topic of uncertainty below).

Food Web Modeling A primary purpose of the proposed restoration of the various tidal natural communities is to increase the food supply for fish species. The Plan's supporting rationale for this objective is because the POD is perceived to be related to an ecological regime shift in the Delta (Sommer et al. 2007, Baxter et al. 2010). Causes of the regime shift include introduced species (plants, invertebrates, and fishes) and a shift in nutrient dynamics supporting phytoplankton resulting in part from pollutant discharge (Sommer et al. 2007). The Plan describes how habitat restoration activities will quantitatively increase primary production (Section 5.E.4.4.2.5, Appendix 5E, Habitat Restoration). However, projected benefits of increased primary production realized by fish populations are based on a qualitative analysis of published literature rather than quantitative analyses such as food web modeling. The Plan cites the lack of a Delta food web model as the reason for its reliance on qualitative methods,

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[3] Appendix 5.I. *Critical Habitat and Essential Fish Habitat Analysis* was not part of the public review draft and thus not reviewed.

yet an ecosystem food web model based on the Ecopath software (Christensen and Walters 2004) was recently developed for the Delta (Bauer 2010). Ecopath is a flexible and well-accepted ecosystem modeling tool designed to characterize the trophic linkages and community food web structure within aquatic ecosystems. Generally, the model requires inputs such as biomass, production, mortality, and diet composition for trophic groups ranging from detritus to plankton to fishes to marine mammals and birds. Although the model developed by Bauer (2010) is a mass balanced static snapshot of the Delta food web (Ecopath), with a modest amount of additional work, the time dynamic module (Ecosim) could be invoked to simulate food web interactions and to quantify potential gains in ecosystem production through increased HUs. Although hundreds of Ecopath with Ecosim (EwE) models have been developed for various ecosystems globally, two particularly relevant examples are highlighted here.

First, current approaches to restore Louisiana's estuaries include the reintroduction of Mississippi River water through freshwater diversions to wetlands that are hydrologically isolated from the main channel. To address questions surrounding how reduced salinities associated with freshwater input might impact estuarine organisms, de Mutsert et al. (2012) developed an EwE model to simulate the effects of diversion-induced salinity changes on species biomass distributions, food web dynamics, and community composition within the Breton Sound estuary. A key and unexpected conclusion of the de Mutsert et al. (2012) study was that the model demonstrated that the reintroduction of water diversion would not significantly change species distributions. In this instance, time dynamic food web modeling analysis provided evidence for an outcome that appeared to be unlikely when restoration activities were viewed within a strictly qualitative framework. The Plan contains no similar quantitative refinement of its qualitative analysis of projected food web benefits.

Second, the Delaware Bay ecosystem has been the focus of extensive habitat restoration efforts to offset finfish losses due to mortality associated with impingement. During the mid-1990s, the Public Service Enterprise Group increased the total marsh area of the bay by 3% (45 km^2), and while there was general consensus among experts that this restoration effort positively impacted the bay, exactly how and by what amount were unknown. To address these questions, Frisk et al. (2010) developed an EwE model of Delaware Bay to quantify effects of increased habitat on system productivity, and estimated that ecosystem biomass increased by approximately 47.7 t km^{-2} $year^{-1}$. The value of this study is that it provided a quantitative estimate of realized ecosystem benefits resulting from newly created habitat.

These highlighted studies are simply two of many published analyses that provided quantitative insights into restoration activities, and by analogy, the absence of similar analyses in the Plan lends support to the conclusion that the Plan has fallen short of utilizing the best available science.

3) Reliance on Qualitative Methods: The Plan's approach for determining net effects on covered fish species involves predicting expected benefits and/or adverse impacts by drawing on a general conceptual model (flow diagram) for each fish species and synthesizing available literature and analyses. The intent of the approach is to distinguish among four possible conclusions for the effects of the conservation measures:

- The Plan has a substantial impact on environmental attributes that have little importance to the covered fish species.
- The Plan has a small impact on attributes of major importance to the species.
- The Plan has a substantial impact on attributes of major importance to the species.
- The Plan has no effect on an attribute.

The first step of the effects analysis approach involves qualitatively ranking the relative importance of different attributes (stressors) to different life stages of covered fish populations. The next step involves formulating a qualitative conclusion regarding the magnitude of change to an attribute resulting from the Plan. The last step in the process involves considering the magnitude of change predicted to occur to an attribute because of the Plan in light of the importance of that attribute. Following these three steps, the Plan makes a judgment as to which of the four potential outcomes is likely for each life stage of each species. Scientific uncertainty of the underlying assumptions and conclusions regarding the effects analysis is also qualitatively scored from low to very high.

A benefit of the approach taken to determine net effects on fish species is its transparency and general ease of understanding, as noted in the Plan. In many respects, the qualitative ranking approach taken represents a fruitful first step to assessing impacts. It is, however, only a first step and the absence of subsequent quantitative analyses based on that first step is a significant omission. Expert judgment is important but its value does not compare to, and cannot replace information obtained environmental or ecosystem process-oriented analyses. As briefly noted above, absent from the Plan are mechanistic, quantitative, dynamic simulation analyses designed to evaluate and potentially validate the Plan's projected restoration outcomes. Conceptual, 'flow-chart' models of fish populations and associated exogenous stressors provide visualizations of linkages that (at most) support the formation of hypotheses regarding restoration impacts. They do not simulate ecosystem or individual fish population dynamics and thus cannot provide insight into how species abundances change over time. More quantitative-oriented methods exist, but the Plan fails to make use of them.

For example, Maunder and Deriso (2011) developed a multistage, state space population dynamics model for delta smelt, and although the results of this study are cited in the Plan, it does not utilize the model explicitly. The Maunder and Deriso (2011) model is an ideal tool for quantitatively projecting the population level effects of potential changes to vital rates (e.g., stage-specific survival terms) suggested to occur as a result of the Plan. The model assumes a one year life cycle for delta smelt, and it relates abundances of larval, juvenile, and adult stages through density dependent relationships. Stage-specific abundance projections are accomplished using the following general equations:

$$N_{t,s} = f(N_{t,s-1}) e^{\sigma_{s-1} \cdot \varepsilon_{t,s-1} - 0.5\sigma_{s-1}^2} \tag{3a}$$

$$N_{t,1} = f(N_{t-1,A}) e^{\sigma_{A} \cdot \varepsilon_{t-1,A} - 0.5\sigma_{A}^2} \tag{3b}$$

where $N_{t,s}$ is the abundance of stage s at time t, A denotes adults stage, σ_s is the standard deviation of the process variability for stage s, and $f()$ denotes the functional form of the transition among stages.

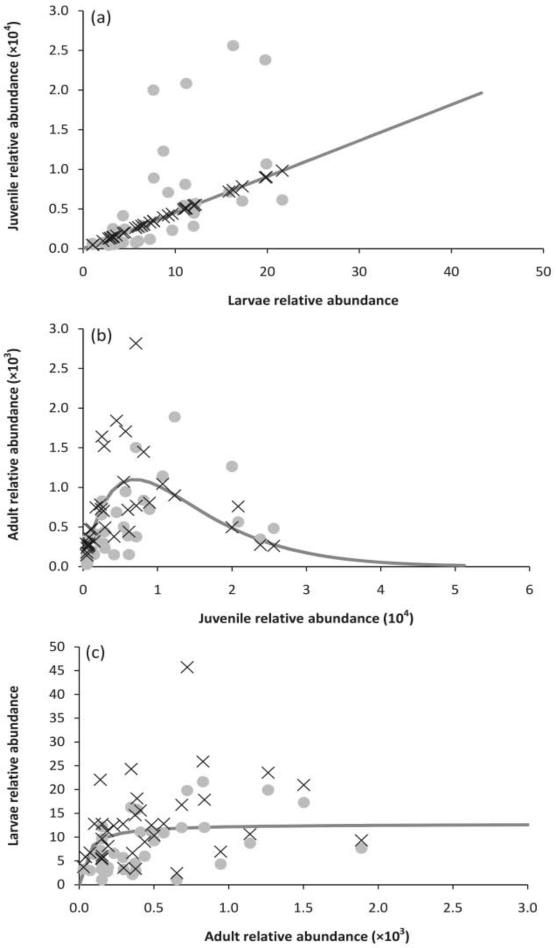


Fig. 1. Relationships among delta smelt stages: linear for larvae to juveniles, Ricker for juveniles to adults, and Beverton-Holt for adults to next year's larvae (Fig. 2 in Maunder and Deriso 2011).

Maunder and Deriso (2011) fitted the above model to various indices of delta smelt relative abundance and found that (i) larval (stage 1) abundance related to future juvenile (stage 2) abundance linearly, (ii) juvenile abundance related to future adult (stage 3) abundance nonlinearly through a traditional Ricker function, and (iii) adult abundance related to next year's larval abundance nonlinearly through a traditional Beverton-Holt function (Fig. 1). The nonlinearity of the transitions from stage 1 to 2 and stage 2 to 3 are the result of density-dependent effects on survival. For many fish species, density-dependent effects are quite common and there has been scientific support for this phenomenon for delta smelt (Bennett 2005). Important to note is the difference in the density-dependence among stages; the Ricker function (Fig. 1b) indicates there is a peak juvenile-adult relationship and that too many juveniles can negatively affect adult abundance (declining portion of the curve), and the Beverton-Holt function (Fig. 1c) indicates a plateau such that maximal future larval abundance can be achieved across a wide domain of adult abundances.

To illustrate how a quantitative model – even if not perfectly predictive – can expose possible uncertainties and variability in results projected by qualitative analyses, I applied the model from Maunder and Deriso (2011) in a hypothetical manner to generally evaluate possible benefits for delta smelt that the Plan projects. I used equations (3a, 3b) along with the estimated parameters provided by Maunder and Deriso (2011) to project delta smelt annual abundance forward in time (25 years) under base conditions (scenario 1) and where the slope of the line depicting the larval to juvenile transition (Fig. 1a) was increased by 20% (scenario 2). In other words, I assumed that environmental conditions improved so that the relative abundance of delta smelt larvae that successfully transition to juveniles increased 20%. The increased slope value was chosen arbitrarily, but is intended to loosely represent higher juvenile production, perhaps through increased food availability resulting from the Plan's habitat restoration efforts.

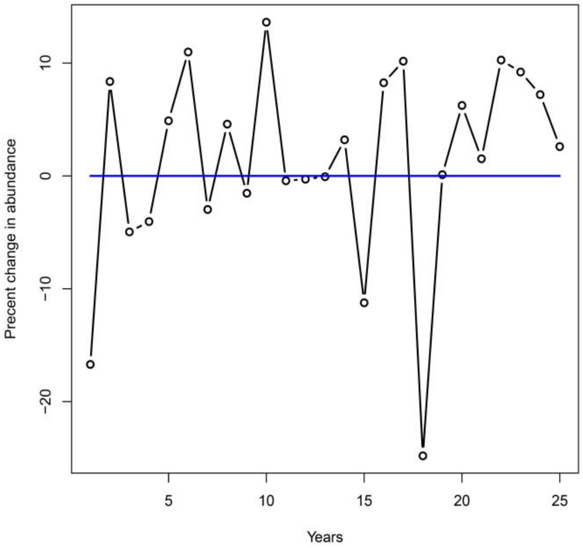


Fig. 2. Percent change in annual delta smelt abundance over a 25 year simulation when the slope of the line relating larval abundance to juvenile abundance was increased by 20%. Horizontal blue line represents no change in abundance between the two scenarios. Underlying population dynamics model and parameter estimates taken from Maunder and Deriso (2011).

The results of these projections were summarized as percent change in annual adult relative abundance for scenario 2 relative to scenario 1. Model output showed that scenario 2 yielded positive percent changes in annual adult delta smelt relative abundance for 15 out of 25 years, and the minimum, mean, and maximum percent changes were -24.8%, 1.4%, and 13.6%, respectively (Fig. 2). The lack of more frequent positive percent changes in annual delta smelt abundance is largely due to the nonlinear density-dependent effects governing the post-larval stage transitions. Sometimes there are negative feedbacks.

Caution should be exercised to not over interpret the results since the simulation was a bit simplistic and primarily designed to demonstrate the importance of mechanistic, dynamic fish population modeling activities when trying to infer the effects (both positive and negative) of habitat alterations such as those outlined in the Plan. Nonetheless, this exercise demonstrates the importance of using quantitative models to test hypotheses generated by qualitative models. This exercise shows that quantitative models identify possible uncertainty and variability in ecosystem results that may appear as smooth progress in qualitative analyses. The Plan's lack of quantitative modeling of its qualitative hypotheses concerning Delta fish species demonstrates that the Plan does not adequately account for factors that may affect the Plan's ability to generate the projected benefits for Delta fish species. Again, the Plan falls short of utilizing the best available scientific practices.

4) Absence of Uncertainty Analyses: The Plan does not explicitly build uncertainty into its effects analyses, which is inconsistent with state-of-the-art quantitative fisheries science methods. The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (Act) of 2006 set forth very significant changes to how fisheries operating in federal U.S. waters are managed. Although there are many facets to the Act, core provisions relate to setting Annual Catch Limits (ACLs) that avoid overfishing while simultaneously accounting for scientific and management uncertainty. Even for the most heavily studies fish stocks, significant uncertainties exist in our understanding of life history, migration patterns, and fundamental population dynamics. Compliance with the Act requires the development of ACL buffers designed to minimize the risk of overfishing, and the risk is assessed via a formal treatment of uncertainty.

For many Delta fish species, the Act does not apply directly because home ranges are restricted to state waters and also because of no harvest. However, the spirit of the Act is important to note, particularly the formal acceptance that uncertainty is present even for the most extensively studied fish stocks. So, by analogy, if the fisheries management standard within the U.S. is to actively characterize and account for uncertainty, then it seems reasonable that the Plan should follow suit, at least to the extent possible.

Throughout the Plan, there is a lack of systematic, explicit quantitative analyses of uncertainty, particularly with respect to how scientific uncertainty may or may not affect the stated anticipated effects derived from restoration activities. Uncertainties are listed in numerous places within the Plan, which is an important first step, but identification of them does not facilitate understanding how they impact the likelihood of achieving desired restoration goals and objectives. Failure to include explicit analyses of error promulgation indicates that the Plan does not meet the standard used to federally manage fisheries (the Act) which further suggests that the Plan does not meet the best available science criterion.

<u>Example</u> Here I focus on a series of specific details regarding the Plan's approach to assessing potential increases in food supply to the Delta resulting from restoration activities. A primary objective of the Plan is to increase the quantity of habitat for fishes, which is thought to enhance the supply of food within the Delta ecosystem. Here the term food refers to phytoplankton, which are photosynthesizing microscopic organisms that create organic compounds from inorganic compounds such as carbon dioxide in water. Phytoplankton are agents for primary production, which is a process that supports aquatic food webs. The Plan's projected increases in food supply in the Delta resulting from newly created habitat are based on estimates of phytoplankton growth rate per day (G), as a function of depth (d):

$$G = -0.27\ln(d) + 0.86. \tag{4}$$

Equation (4) was originally published by Lopez et al. (2006) but differs from the equation on Fig. 3 taken from the Plan because the Plan converted the measurement of depth from meters to feet. Although the phytoplankton growth equation published by Lopez et al. (2006) was based on sound, peer-reviewed scientific practices, the Plan's use of it in the context of projecting food availability for fishes and other higher trophic level organisms is questionable for several reasons.

First, the Plan's projected increases in food supply to the Delta are based on the following equation:

$$\text{Prod-acres} = (\text{phytoplankton growth rate/day})_{\text{avg depth of stratum}} \times (\text{area of stratum}), \tag{5}$$

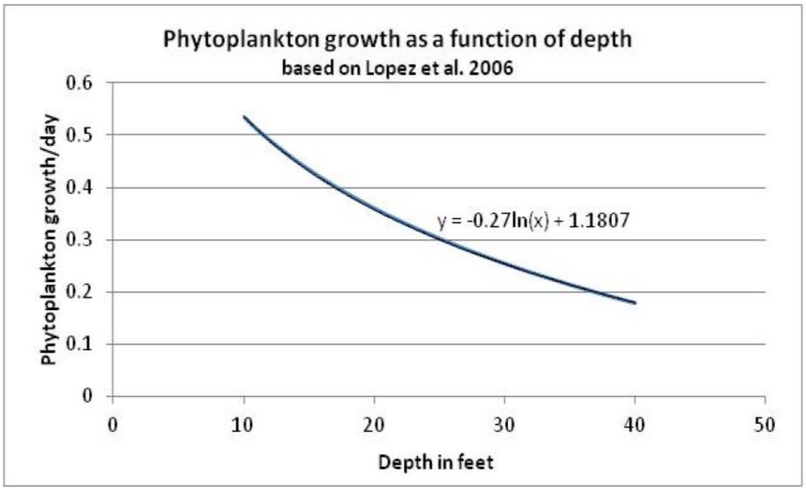


Fig. 3. Relationship between phytoplankton daily growth rate and depth published in the Plan.

where Prod-acres is an index of food production and calculated as the product of the area of a newly proposed habitat stratum and the phytoplankton daily growth rate from equation (4) defined at the average depth of that habitat stratum. Thus, the Plan is assuming that more habitat acreage will produce more phytoplankton. However, strictly basing Prod-acres on phytoplankton growth rate does not necessarily provide information about the biomass of phytoplankton available to fishes and other higher trophic level organisms (more on this below). Since most contemporary ecosystem food web models (e.g., EwE, Christensen and Walters 2004) require inputs of both biomass and production (the product of growth rate and biomass) of modeled groups, the Plan's reliance on phytoplankton growth rate is highly questionable.

An additional weakness of the Prod-acres metric is that it implicitly assumes that all phytoplankton growth is available as food for the zooplankton consumed by Delta fish species. However, large portions of the phytoplankton community in the Delta and elsewhere are consumed by benthic organisms (e.g., clams) and microzooplankton (American Rivers review of the BDCP, Lopez et al. 2006). Thus, the projected increases in food availability and associated benefits for Delta fish species are very likely overly optimistic.

Not evident in Fig. 3 is the quality of the fit of the statistical model to the observed data, though review of Lopez et al. (2006) showed a reasonably good statistical fit of the original model (equation (3), $r^2 = 0.72$). The parameter r^2 is the coefficient of variation, which ranges between 0 and 1 and is a measure of the amount of variation in the raw data explained by a linear regression model. Therefore, a value of 0.72 indicates that 72% of the variation was explained, which is good. However, and following from above, further review of Lopez et al. (2006) revealed additional uncertainties in the phytoplankton/depth relationship not accounted for by the Plan. If phytoplankton biomass (PB) is regulated primarily by growth rate, then PB should vary with depth in a manner similar to that in Fig. 3. However, Lopez et al. (2006) indicated that discrete field sampling of PB throughout the Delta over several years showed that the variability of PB was irregular along the habitat depth gradient and uncorrelated to phytoplankton growth rate. Moreover, net phytoplankton production (gross primary production less losses due to respiration by phytoplankton) also weakly related to depth of the water column ($r^2 = 0.12$), and this result led Lopez et al. (2006) to reject the hypothesis 'that phytoplankton biomass varies systematically across gradients of habitat depth.' In other words, the biomass component of phytoplankton production does not vary with depth in a highly predictable manner. The Plan ignores these very important considerations, which further calls into serious question the accuracy of the Plan's projected increases in food supply available to Delta fish species.

Second, and building on the above comments about the inclusion of uncertainty, the Plan's evaluation of restoration benefits with respect to food production involves a combination of quantitative and qualitative analyses. By definition, qualitative metrics do not have associated estimates of precision, so error promulgation analyses cannot be conducted. Where qualitative metrics represent the only analytical option, uncertainty should be characterized as a range of plausible hypothesized outcomes, or by summarizing output resulting from a range of configurations of the qualitative metrics (e.g., low, medium, high).

However, in instances where the Plan makes use of quantitative metrics that have associated measures of precision, it does not carry those listed uncertainties into secondary analyses of the ecological mechanisms it relies on to support the projected benefits for Delta fish species. This omission implies that there are no error promulgation analyses within the Plan, and as a result, there is no way to assess the likelihood of realizing the Plan's projected outcomes. Formal uncertainty and error promulgation analyses can be conducted when quantitative methods are used, particularly statistical methods. Since equation (4) is based on regression techniques applied by Lopez et al. (2006), there is some uncertainty in the estimated slope, y-intercept values (standard errors), and the collective predictive relationship (prediction confidence intervals). Such standard error or confidence bounds, however, are not provided or incorporated into analyses of uncertainty regarding Prod-acres calculations within the Plan.

A hypothetical example demonstrates the importance of this omission. As means of illustrating the effects of modest uncertainty in the slope and y-intercept estimates of the phytoplankton growth rate function, 1000 simulated equations were generated by randomly selecting unique pairs of slope and y-intercept values each from separate normal distributions with means equal to the estimated values (-0.27 and 1.1807, respectively) and standard deviations equal to 10% of those means (0.027 and 0.11807, respectively). The results show that the daily phytoplankton growth rate as a function of depth can be quite variable when a small amount of uncertainty in the model parameters is simulated. That is, at a depth of 10 feet, daily phytoplankton growth ranges from 0.15 to 0.95 per day (Fig. 4). This raises the natural question, how does uncertainty in the phytoplankton growth function across depths affect estimated Prod-acres values and subsequent projected benefits of the proposed habitat restoration subregions?

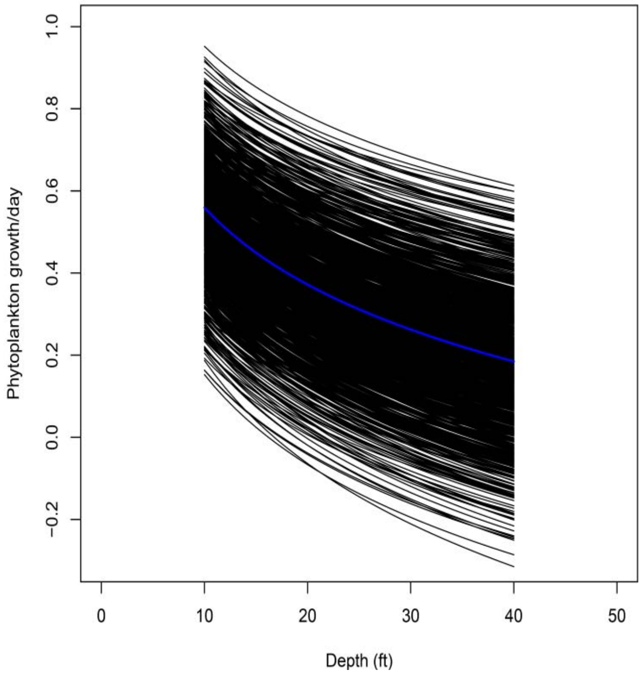


Fig. 4. Daily phytoplankton growth rates as a function of depth based on 1000 simulations of the equation on Fig. 3. The blue line is the base curve, and for each simulated curve, the slope and y-intercept values were chosen randomly assuming a modest amount of uncertainty (black lines).

Although this error simulation is simplistic, it serves to illustrate the importance of carrying forward uncertainty in predictive-type analyses. The absence of uncertainty analyses in the spirit of the hypothetical one here further supports the conclusion that the Plan does not make use of best available scientific practices.

5) Overly Conceptual Management and Monitoring Program: For any restoration effort, it is vital to enact a comprehensive management and monitoring program than will provide robust information in support of policies designed to achieve stated goals and objectives. To the degree possible, the management and monitoring program should specify a wide range of design elements, including but not limited to, the oversight manager or team, field approaches, sampling design characteristics, measured quantities and associated methods, approaches for data analysis and characterizing uncertainty, strategies for integration with existing monitoring programs, selection criteria for reference targets and thresholds, approaches for evaluating restoration progress, database management, tactics for disseminating results, and costs. In the case of the Plan, the global conservation strategy consists of 22 conservation measures and an adaptive management and monitoring approach is described for evaluating progress toward achieving those conservation measures (section 3.6, Chapter 3, Conservation Strategy). The adaptive management and monitoring program was designed in consultation with expert independent science advisors and several thoughtful principles are described. The essence of the program involves the following nine-step process:

1) Characterize the problem
2) Identify biological goals and objectives
3) Model linkages between objectives and proposed implementation actions
4) Plan and design implementation actions
5) Perform implementation actions
6) Design and implement performance
7) Analyze, synthesize, and evaluate
8) Communicate current understanding
9) Adapt.

Each of these steps is described in moderate detail within the Plan along with other process oriented attributes. Although having a well-defined administrative process is important to any management and monitoring program, the likelihood for successful implementation depends on having data collection and analysis protocols that will yield the types of information needed to measure performance. Unfortunately for the Plan, these elements have not been sufficiently developed. There is very little description of the science and monitoring program. The Plan only broadly discusses sampling strategies and it does not describe the measured quantities, methods for data analysis, specifics as to how the monitoring program will be integrated with the numerous existing data collection programs in the Delta, or reference points used to gauge restoration progress or the status of various biological components within the Delta ecosystem.

At most, the Plan provides a conceptual description of the characteristics of its monitoring program to be considered but it fails to define any of them in a tangible manner. Maintaining flexibility in a management and monitoring program is important so that necessary modifications can be made as the program matures; however, given the scale and specificity of many of the proposed restoration objectives and physical modifications to the Delta, it would seem necessary to articulate a far more developed and detailed approach. Simply delineating a plan to have a management and monitoring program is inadequate at this juncture especially since such a loosely defined approach provides no insight into whether or not the management and monitoring program will allow performance of the conservation measures to be successfully evaluated.

Literature Cited

Arthur, J.F., M.D. Ball, and S.Y. Baughman. 1996. Summary of federal and state water project environmental impacts in the San Francisco Bay-Delta Estuary, California. In San Francisco Bay: The Ecosystem, ed. J.T. Hollibaugh, 445-495. San Francisco: Pacific Division American Association for the Advancement of Science.

Atwater, B.F., S.G. Conrad, J.N. Dowden, C.W. Hedel, R.L. MacDonald, and W. Savage. 1979. History, landforms and vegetation of the estuary’s tidal marshes. In San Francisco Bay: The Urbanized Estuary, ed. T.J. Conomos, 347-385. San Francisco: Pacific Division American Association for the Advancement of Science.

Bauer, M. 2010. An ecosystem model of the Sacramento-San Joaquin Delta and Suisun Bay, California, USA. Master of Science Project, California State University, Chico, CA.

Baxter, R. D., R. Breuer, L. R. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Müeller-Solger, T. Sommer, and K. Souza. 2010. Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results: Interagency Ecological Program for the San Francisco Estuary. Sacramento, CA.

Bennett, W.A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science 3(2).

Christensen, V. and C.J. Walters. 2004. Ecopath with Ecosim: methods, capabilities and limitations. Ecological Modelling 172:109-139.

Cohen, A.N., and J.T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary. Science 279:555-558.

Connor, M.S., J.A. Davis, J. Leatherbarrow, B.K. Greenfield, A. Gunther, D. Hardin, T. Mumley, J.J. Oram, and C. Werme. 2007. The slow recovery of San Francisco Bay from the legacy of organochlorine pesticides. Environmental Research 105:87-100.

de Mutsert, K., J.H. Cowan Jr., and C.J. Walters. 2012. Using Ecopath with Ecosim to explore nekton community response to freshwater diversion into a Louisiana estuary. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 4:104-116.

Feyrer, F., M.L. Nobriga, and T. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734.

Frisk, M.G., T.J. Miller, R.J. Latour, and S.J.D. Martell. 2011. Assessing biomass gains from marsh restoration in Delaware Bay using Ecopath with Ecosim. Ecological Modeling 222:190-200.

Kimmerer, W.J. 2011. Modeling delta smelt losses at the south export facilities. San Francisco Estuary and Watershed Science 9(1).

Lopez, C.B., J.E. Cloern, T.S. Schraga, A.J. Little, L.V. Lucas, J.K. Thompson, and J.R. Burau. 2006. Ecological values of shallow-water habitats: implications for the restoration of disturbed ecosystems. Ecosystems 9:422-440.

Maunder, M.N. and R.B. Deriso. 2011. A state-space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrate with application to delta smelt (*Hyposmesus transpacificus*). Canadian Journal of Fisheries and Aquatic Sciences 68:1285-1306.

National Research Council. Progress Toward Restoring the Everglades: The Fourth Biennial Review, 2012. Washington, DC: The National Academies Press, 2012.

Orsi, J.J., and W.L. Mecum. 1996. Food limitation as the probable cause of a long-term decline in the abundance of *Neomysis mercedis* the opossum shrimp in the Sacramento-San Joaquin Estuary. In San Francisco Bay: The Ecosystem, ed. J.T. Hollibaugh, 375-401. San Francisco: Pacific Division American Association for the Advancement of Science.

Parker, A. E., R. C. Dugdale, and F. P. Wilkerson. 2012. Elevated ammonium concentrations from wastewater discharge depress primary productivity in the Sacramento River and the Northern San Francisco Estuary. Marine Pollution Bulletin 64:574–586.

Schoellhamer, D.H. 2011. Sudden clearing of estuarine waters upon crossing the threshold fromtransport to supply regulation of sediment transport as an erodible sediment pool is depleted: San Francisco Bay, 1999. Estuaries and Coasts 34:885-899.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270-277.

Stanley, E.H. and M.W. Doyle. 2003. Trading off: the ecological effects of dam removal. Frontiers in Ecology and the Environment 1:15-22.

Weinstein, M.P., J.M. Teal, J.H. Balletto, and K.A. Strait. 2001. Restoration principles emerging from one of the world’s largest tidal marsh restoration projects. Wetlands Ecology and Management 9: 387-407.

Appendix

Sections of the Plan reviewed.

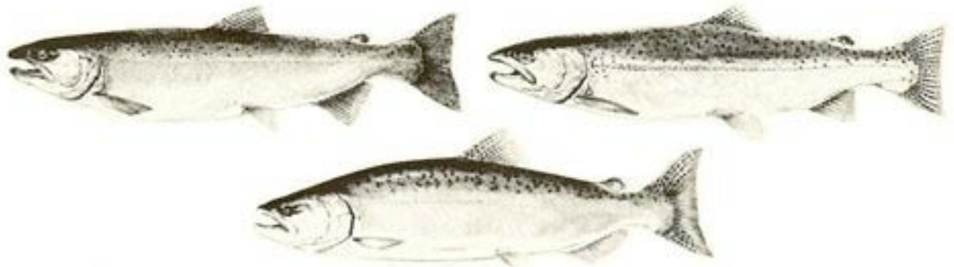
BDCP

- Executive Summary
- Chapter 2.3 – Existing Biological Conditions
- Chapter 3.2 – Methods and Approaches Used to Develop the Conservation Strategy
- Chapter 3.3 – Biological Goals and Objectives
- Chapter 5 - Effects Analysis: Effects on Covered Fish (sections 5.5.1 delta smelt, 5.5.2 longfin smelt)
- Appendix 2.A – Covered Species Accounts
- Appendix 3.G – Proposed Interim Delta Salmonid Survival Objectives
- Appendix 5.A.2 – Climate Change Approach and Implications for Aquatic Species
- Appendix 5.C - Flow, Passage, Salinity, and Turbidity
- Appendix 5.E - Habitat Restoration (section 5.E)
- Appendix 5.F – Biological Stressors on Covered Fish
- Appendix 5.G - Fish Life Cycle Models (delta smelt models only)
- Appendix 5.I Critical Habitat and Essential Fish Habitat Analysis

EIR

- Chapter 11 – Fish and Aquatic Resources: Reader's Guide (section 11.0)
- Chapter 11 – Fish and Aquatic Resources: Summary of Effects – Alternative 4 (section 11.0.2.8)
- Chapter 11 – Fish and Aquatic Resources: Stressors (section 11.1.5)
- Chapter 11 – Fish and Aquatic Resources: Methods for Analysis (section 11.3.2)
- Chapter 11 – Fish and Aquatic Resources: Determination of Effects (section 11.3.3)
- Chapter 11 – Fish and Aquatic Resources: No Action Alternative (section 11.3.4.1)
- Chapter 11 – Fish and Aquatic Resources: Alternative 1A (section 11.3.4.2)
- Chapter 11 – Fish and Aquatic Resources: Alternative 4 (section 11.3.4.9)
- Chapter 11 – Fish and Aquatic Resources: Cumulative Effects (sections 11.3.5, 11.3.5.1, 11.3.5.2)
- Chapter 11A – Covered Fish Species Descriptions (sections 11A.1, 11A.2 for delta smelt and longfin smelt)
- Chapter 11B - Non-Covered Fish and Aquatic Species Descriptions (sections 11.B.8, 11.B.9 for threadfin shad and bay shrimp)

EXHIBIT C



California Advisory Committee On Salmon and Steelhead Trout

February 26, 2014

Charlton H. Bonham, Director
California Department of Fish and Wildlife
1416 Ninth St., 12th Floor
Sacramento, CA 95814

Subject: Recommendation to deny incidental take permit and Natural Communities Conservation Plan for Bay Delta Conservation Plan

Dear Director Bonham;

The California Advisory Committee on Salmon and Steelhead in our capacity to advise you, the director of the California Department of Fish and Wildlife, in preparing and maintaining "a comprehensive program for the protection and increase of salmon, steelhead trout, and anadromous fisheries" in California,[1] recommends that the you deny issuance of an incidental take permit for the Bay Delta Conservation Plan's Alternative 4 (BDCP) as a Natural Communities Conservation Plan (NCCP). The BDCP does not meet the requirements of Fish and Game Code 2820 for an NCCP and cannot legally be approved because it will contribute to the further decline of Sacramento River Winter Run and Spring Run Chinook salmon.

All races and runs of Central Valley salmon and steelhead populations have experienced over 90% declines since the State Water Project came on line in the 1960's. In particular, naturally produced Chinook populations have experienced severe declines resulting in the listing of Sacramento Winter Run as endangered and the Spring Run as threatened under the federal and state Endangered Species Acts. Adult returns of these two species are far below the fish doubling goals of the Anadromous Fish Restoration Program. Attachments 1 and 2 are figures from the Anadromous Fish Restoration Program showing the severe declines these two runs of Chinook salmon have experienced in the Sacramento River basin.[2]

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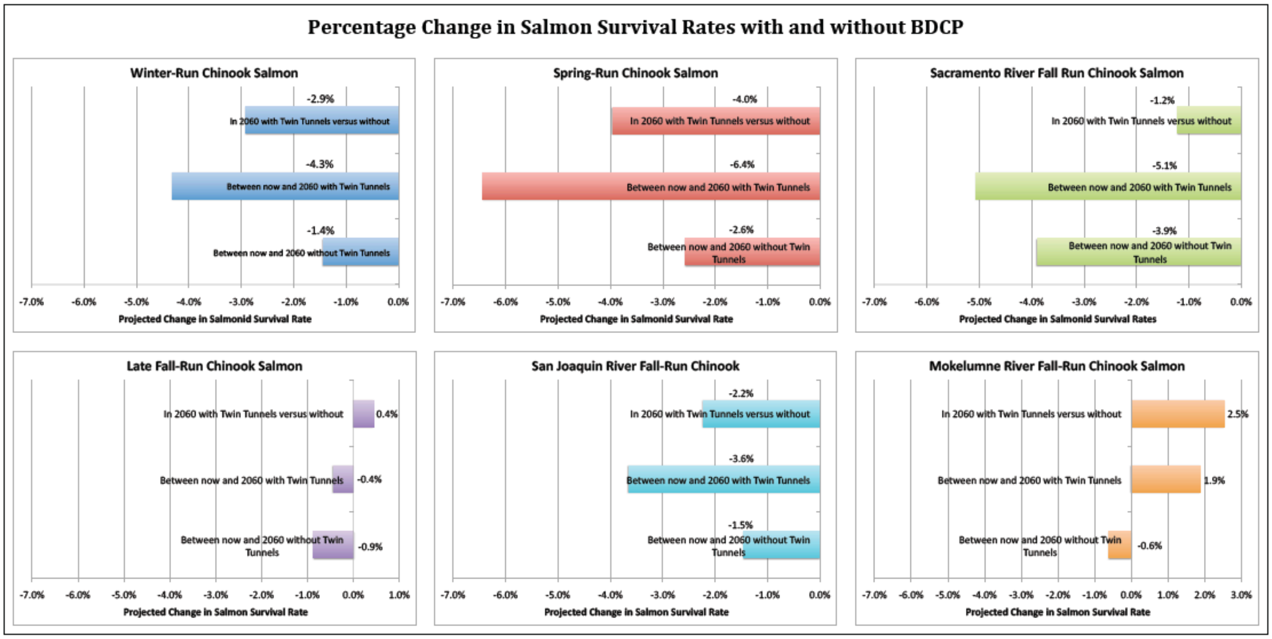
[1] California Fish and Game Code § 6920 (2008)
§ 6920. Preparation and maintenance of program; Consultation with public agencies
(a) The department shall, with the advice of the Advisory Committee on Salmon and Steelhead Trout and the Commercial Salmon Trollers Advisory Committee, prepare and maintain a detailed and comprehensive program for the protection and increase of salmon, steelhead trout, and anadromous fisheries.

[2] http://www.fws.gov/stockton/afrp/Documents/Doubling_goal_graphs_020113.pdf

Furthermore, according to data from Chapter 5, Effects Analysis of the November 2013 Draft BDCP, operation of the Twin Tunnels project will reduce winter run and spring Chinook salmon smolt survival by 2.9% and 4%, respectively. See Salmon Survival Rates Figure below taken from BDCP Chapter 5. Supporting data and source tables are shown in Attachment 3.[3]


Percentage Change in Salmon Survival Rates with and without BDCP

BDCP promotes the unproven scientific hypothesis that habitat restoration can substitute for flow. However, the State Water Resources Control Board has already indicated that Delta inflows and outflows are presently insufficient to help listed species recover their former abundance.[4] BDCP would reduce Delta outflow, which contributes to the decreases to salmon smolt survival rates modeled by BDCP.

The concept of improving riparian and subtidal habitat to create an aquatic food supply for the Delta to make up for too much water diverted is an unproven theory that has been criticized extensively by federal agencies in their "red flag" comments on the BDCP.[5] Climate change will

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[3] Figure A taken from Draft Bay-Delta Conservation Plan, Chapter 5, Effects Analysis, Sections 5.5.3 through 5.5.6, Tables 5.5.3-10, 5.5.4-5, 5.5.5-8, 5.5.5-10, 5.5.5-18 and 5.5.5-20 See http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Public_Draft_BDCP_Chapter_5_-_Effects_Analysis.sflb.ashx

[4] "Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem
Prepared Pursuant to the Sacramento-San Joaquin Delta Reform Act of 2009." SWRCB, August 3, 2010. Page 4, second bullet. See http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/final_rpt080310.pdf

[5] See http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Federal_Agency_Comments_on_Consultant_Administrative_Draft_EIR-EIS_7-18-13.sflb.ashx and http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library_-_Archived/Effects_Analysis_-_Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx and http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/NMFS_Progress_Assessment_Regarding_the_BDCP_Administrative_Draft_4-11-13.sflb.ashx and http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/NMFS_Evaluation_of_Flow_Effects_on_Survival_-_BDCP_Admin_Draft_-_4-11-13.sflb.ashx and

contribute to sea level rise directly in the Delta; this will help push X2 eastward into the Delta. BDCP analysis also shows that Sacramento River inflow will decrease directly from operation of the Twin Tunnels, and to some degree from lower upstream runoff (controlled by climate change and reservoir operation). The combined effect of continued high diversions from the Delta through BDCP (for the sake of "increased reliability") and the effects of climate change and X2 movement eastward will have a deleterious effect on Sacramento Winter Run and Spring Run Chinook salmon.

All of the conservation measures in BDCP with the exception of CM1 (Twin Tunnels) are programmatic in nature. Funding is far from assured, as identified in a recent Legislative Analyst's report. The LAO report identified that ecosystem restoration funding has not been secured and cost overruns are likely for land acquisition for habitat restoration. According to the report, [6]

"*If bond funds are not available in the near future and no additional funding sources are identified, some ecosystem restoration may not be funded, including the restoration actions needed before the tunnels begin operation. The BDCP states that the SWP and CVP will not pay additional costs or forgo water in the event of a funding shortfall*."

The funding plan at Table 8-37 of Chapter 8 in BDCP confirms the LAO's conclusion. The state and federal water contractors propose that they will only pay for 68.4 percent of BDCP's costs. Nearly 95 percent of their financing commitment is solely to the Twin Tunnels project in Conservation Measure 1, and the rest of BDCP's costs would be borne by taxpayers at large.

Because Sacramento River Winter Run and Spring Run Chinook salmon are already significantly depleted and BDCP will further reduce smolt survival, the Department of Fish and Wildlife cannot make a finding that the BDCP NCCP will lead to recovery of the species.

None of the alternatives considered in the BDCP Draft Environmental Impact Statement and Report would lead to the recovery of Sacramento River Winter Run and Spring Run Chinook salmon. None of the alternatives analyzed reduces the amount of water diverted upstream of or within the Delta. None of the alternatives analyzed considers meeting or moving toward meeting the State Water Resources' Control Board's Delta Outflow Criteria of 2010 that was specifically required by the legislature in 2009 "to inform planning decisions for the Delta Plan and the BDCP."[7]

Therefore, findings approving a NCCP for the Bay-Delta Conservation Plan cannot be made pursuant to Section 2820 of the Fish and Game Code for the following reasons:

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http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/U_S_Fish_and_Wildlife_Service_Staff_BDCP_Progress_Assessment_4-11-13.sflb.ashx

[6] "Financing the Bay-Delta Conservation Plan", Legislative Analyst's Office, 2/12/14. p 8. See http://www.lao.ca.gov/handouts/resources/2014/Financing-the-BDCP-02-12-14.pdf

[7] Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem by the State Water Resources Control Board, August 3, 2010. See http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/final_rpt080310.pdf

1. BDCP does not contribute to recovery and would jeopardize the continued existence of Sacramento River winter-run and spring-run Chinook salmon because smolt survival through the Delta is reduced by the project. (Fish & Game Code Section 2081(c))
2. The concept of habitat restoration measures to offset impacts from increased water withdrawals from the Delta (increased "reliability") is not supported by science, including but not limited to the 2010 SWRCB Delta Outflow Criteria. (Fish & Game Code Section 2081(b)(2))
3. The applicants do not assure funding and water supplies for habitat restoration measures. Habitat restoration measures will not be "shovel-ready" when the Twin Tunnels begin construction. (Fish & Game Code Section 2081(b)(4) and 2820(a)(10))
4. BDCP does not include analysis of an alternative or alternatives that would meet the recovery goals for Sacramento River Winter Run and Spring Run Chinook salmon. Such an analysis should at least take into consideration the State Water Resources Control Board's 2010 Delta Outflow decision. (Fish & Game Code Section and 2820(e))

In summary, the Bay-Delta Conservation Plan does not meet the requirements of the California Endangered Species Act or the Natural Communities Conservation Plan Act to recover Sacramento River winter-run and spring-run Chinook salmon. The BDCP NCCP is to be submitted to support issuance of an incidental take permit by the Department of Fish and Wildlife. For all of the above reasons, we urge you to reject approval of the BDCP as an NCCP.

We thank you for your consideration of these points and look forward to hearing back from you on this important matter.

Sincerely,

Vivian Helliwell

Vivian Helliwell, Chairman
P.O. Box 307
Eureka, CA 95502
vhelliwell@mcn.org

cc: Honorable Wesley Chesbro, Chairman Joint Committee on Fisheries and Aquaculture
Kevin Shaffer, CDFW Program Manager, Anadromous Fisheries Branch

Attachments:

1- Anadromous Fish Restoration Program Figure 4: Estimated yearly adult natural production, and in river adult escapements of Winter Run Chinook salmon
2- Anadromous Fish Restoration Program Figure 5: Estimated yearly adult natural production, and in river adult escapements of Spring Run Chinook salmon in the Central Valley rivers and streams.
3- Central Valley Salmon Smolt Survival With and Without BDCP

2-1-13

ATTACHMENT 1

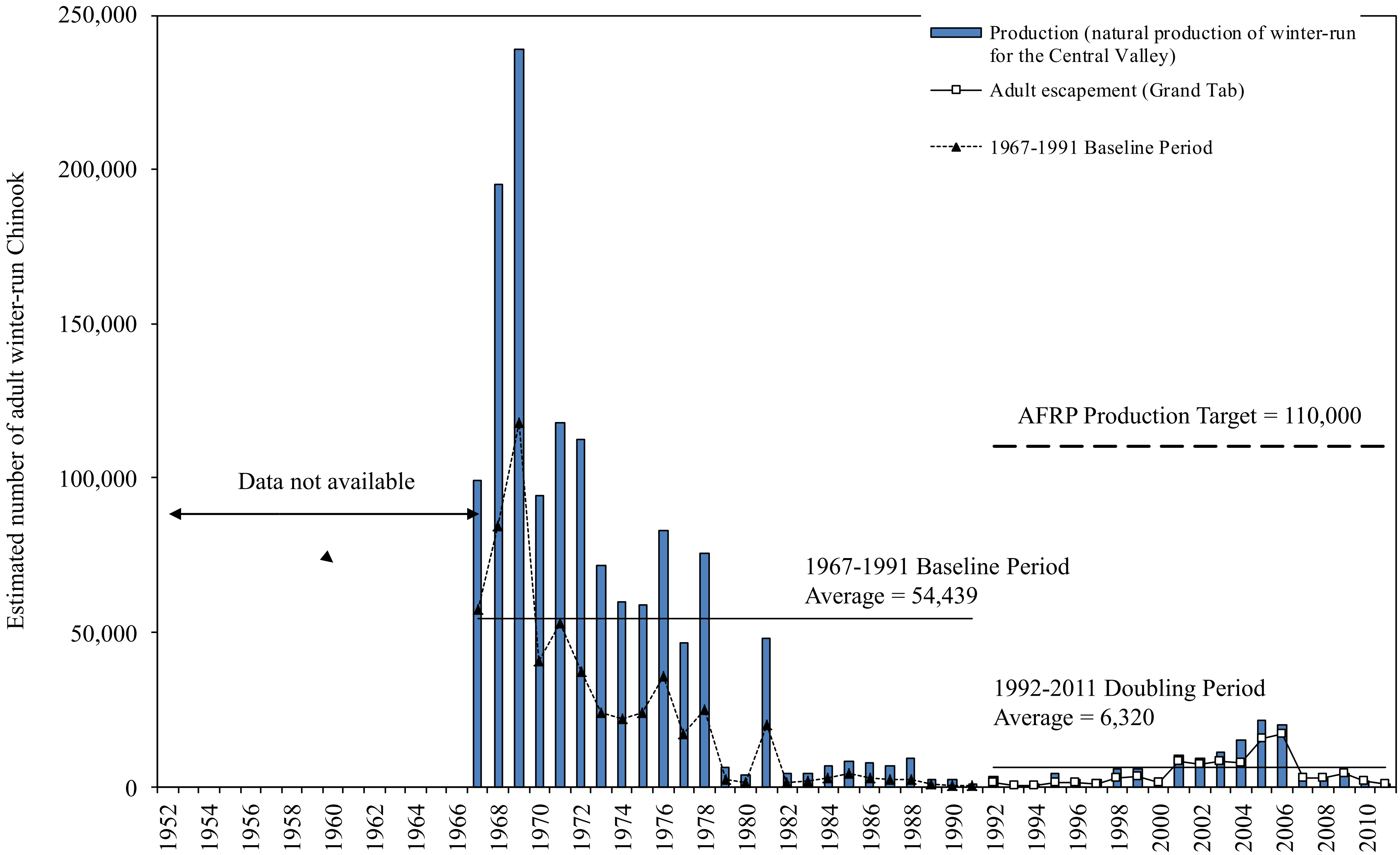

Figure 4. Estimated yearly adult natural production, and in river adult escapements of winter-run Chinook salmon in the Central Valley rivers and streams. 1992 - 2011 numbers are from CDFG Grand Tab (Apr 24, 2012). 1967-1991 Baseline Period numbers are from Mills and Fisher (CDFG, 1994).

2-1-13

ATTACHMENT 2

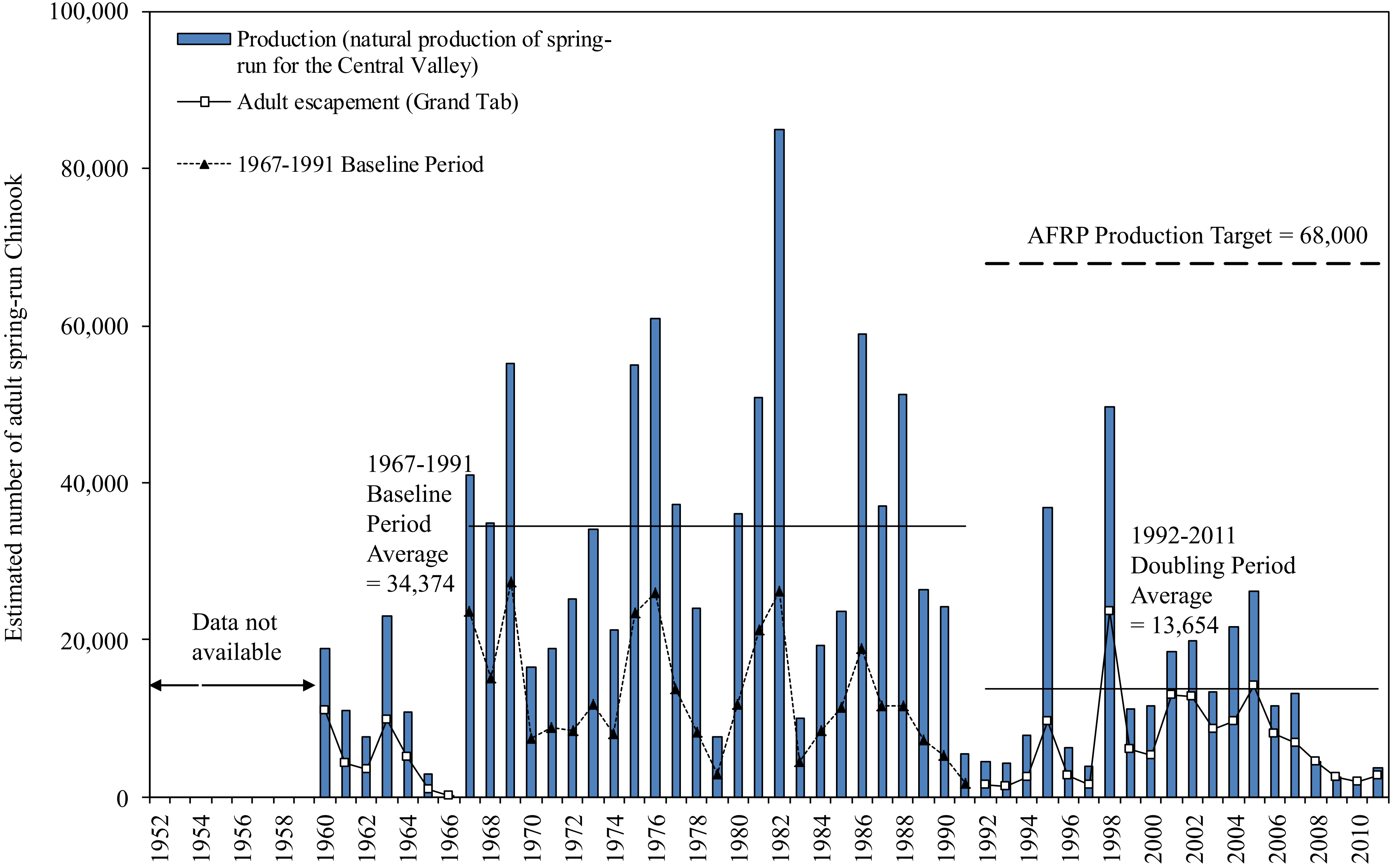

Figure 5. Estimated yearly adult natural production, and in-river adult escapements of spring-run Chinook salmon in the Central Valley rivers and streams. 1960 - 1966 and 1992 - 2011 numbers are from CDFG Grand Tab (Apr 24, 2012). 1967-1991 Baseline Period number are from Mills and Fisher (CDFG, 1994).

ATTACHMENT 3

Percentage Change in Salmon Survival Rates with and without BDCP

Salmon Run/Statistic	BDCP Chapter 5 Source Table	Baseline Conditions Now (EBC1)	Baseline Conditions in 2060 Without BDCP (EBC2-LLT)	Twin Tunnels Operation in 2060 (ESO-LLT)	Between Now and Without Twin Tunnels by 2060	Between Now and With Twin Tunnels by 2060	In 2060 With Twin Tunnels versus Without
Winter-Run	5.5.3-10						
Average		34.7%	34.2%	33.2%	-1.4%	-4.3%	-2.9%
Median		32.4%	31.8%	28.7%	-1.9%	-11.4%	-9.7%
Spring-Run	5.5.4-5						
Average		31.1%	30.3%	29.1%	-2.6%	-6.4%	-4.0%
Median		27.0%	26.4%	25.1%	-2.2%	-7.0%	-4.9%
Sac River Fall Run	5.5.5-8						
Average		25.7%	24.7%	24.4%	-3.9%	-5.1%	-1.2%
Median		22.8%	21.6%	22.4%	-5.3%	-1.8%	3.7%
Late Fall-Run	5.5.5-10						
Average		23.1%	22.9%	23.0%	-0.9%	-0.4%	0.4%
Median		20.1%	20.6%	21.3%	2.5%	6.0%	3.4%
San Joaquin River Fall-Run	5.5.5-18						
Average		13.7%	13.5%	13.2%	-1.5%	-3.6%	-2.2%
Median		10.7%	10.3%	12.1%	-3.7%	13.1%	17.5%
Mokelumne River Fall-Run	5.5.5-20						
Average		16.0%	15.9%	16.3%	-0.6%	1.9%	2.5%
Median		15.2%	14.0%	14.1%	-7.9%	-7.2%	0.7%

Source: Chapter 5, Effects Analysis, Sections 5.5.3 through 5.5.6, Bay Delta Conservation Plan, 2013.

June 6, 2014

Comments on the Public Draft Bay-Delta Conservation Plan (BDCP) and Draft BDCP Environmental Impact Report/Environmental Impact Statement

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GENERAL OVERVIEW

On an overall basis, the Public Draft Bay-Delta Conservation Plan (BDCP) and the Draft BDCP Environmental Impact Report/Environmental Impact Statement (EIR/EIS) (collectively, BDCP documents) are unreasonably voluminous, poorly structured, highly fragmented, extremely repetitive, nearly incomprehensible, and replete with contradictory statements and logic.

The BDCP is based on a premise that purports to provide an alternative or supplemental means to export northern California water past the Delta[2] to supposedly reduce impacts on fishery resources as compared to sole use of the existing federal and state south Delta water export facilities. The linchpin of this concept is to build three large water diversions on the lower Sacramento River. Many major design features and critical operational criteria have not been determined. As such, the proposed north Delta water diversions are an unprecedented, extremely high-risk experiment with a very high probability of failure for fish protection and an irreversible commitment of resources. Adverse impacts to anadromous fish could potentially be catastrophic.

These comments primarily focus on the potential effects of the BDCP on Sacramento River basin anadromous salmonids and the following key issues:

1) Oversimplification of salmonid behavior and BDCP impacts on salmonids. Salmonid fry, parr, and smolt behaviors are highly complex and variable but are not adequately incorporated into the BDCP analyses. For example, the BDCP used simplified, composite estimates in its analyses of juvenile salmon emigration into the Delta that does not account for very important inter-annual variability in outmigration timing caused by upstream precipitation events and hydrologic conditions. Due to the nature of how the north Delta intakes would operate, there is an unaccounted for variability in salmon exposure to the intakes, Fremont Weir, and downstream flow splits (e.g., Georgiana

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[1] A copy of my current resume is attached hereto as Exhibit 1.

[2] Conflicting statements on the topic of water supply are in the BDCP documents: "It is not intended to imply that increased quantities of water will be delivered under the BDCP." (EIR/EIS Page 2-5) "The BDCP is intended to minimize entrainment levels, while also *increasing water supply* and water supply reliability (emphasis added)." (BDCP Page 5.B-2)

Slough) that significantly compromises the ability to compare BDCP alternatives and assess potential effectiveness of its conservation measures.

2) Extensive unresolved uncertainties concerning impacts on salmonids associated with the BDCP and its various elements. The effects of every BDCP conservation measure associated with salmon are characterized as "uncertain" or "highly uncertain". In turn, the BDCP sequentially builds upon each uncertainty with the end product revealing the project's purported benefits for salmon to be untenable.
3) Conclusive statements strongly suggesting positive effects for salmonids that have no legitimate foundation. For example, the BDCP's proposed use of non-physical barriers throughout the Delta to guide fish, predator control at the north Delta intakes, and fish screen refugia lack reliable supporting basis and justification but are promoted as beneficial actions. Worse, some actions may actually cause more harm than good.
4) Consistent pattern of overstatement of potential benefits and understatement of potential adverse impacts to salmonids. Despite caveats primarily dispersed in BDCP appendices, the BDCP analyses and conclusions in the main body of the BDCP display a trend where favorable fish model outputs are overstated and unfavorable outputs are downplayed. For reasons described in these comments, the BDCP models, in reality, have a very low sensitivity for adequately providing the necessary comparative analyses to estimate benefits.
5) Frequent erroneous or invalid assumptions in the analyses of effects on salmonids. For example, the BDCP fish models' estimates of salmon survival and fish route selection used to evaluate various BDCP alternatives are unreliable for making management decisions among BDCP scenarios and conservation measures. Some of the salmon survival estimates used for BDCP models were undoubtedly inflated, but also possessed highly questionable and unknown variance in estimated salmon route selection at critical Delta flow splits, reach-specific survival, and overall survival through the Delta.
6) Propagation of errors in BDCP fish models resulting from faulty BDCP CalSim II water supply and water operations modeling (BDCP Model). Much of the BDCP fish modeling efforts relied on CalSim II model outputs but a recent independent review of the BDCP Model revealed numerous significant flaws (MBK 2014) that were, unfortunately, carried through to the BDCP fish models. The BDCP's inaccurate depiction of changes in water storage in upstream reservoirs, reservoir releases, and water exports in the north and south Delta would undoubtedly significantly alter analyses of the BDCP effects on salmonids and other fish species. The BDCP Model errors result in an adverse cascading affect on the reliability of the BDCP fish models and, therefore, the BDCP effects on salmonids were obviously mischaracterized by an unknown, but probably very severe, degree. Given the limitations and errors of the BDCP fish models described in these comments, the fish models' reliance on faulty BDCP Model outputs at the outset further adds to the undependably modeled and unknown BDCP effects.
7) Lack of essential details on key BDCP elements. For example, numerous critical design features and fish protective criteria of the north Delta intakes are not described or have not yet been developed, Fremont Weir fish passage options are unclear or undeveloped, and many conservation measures (e.g. in-Delta habitat alterations) lack any relevant supportive details as to their efficacy.
8) Improper complete reliance on ill-defined passive adaptive management without explicitly describing how future problems may be resolved. Recent, prominent examples

are provided in these comments to clearly demonstrate that there has been a strong, consistent legacy in the Central Valley and Delta of *not* implementing adaptive management for the protection of fishery resources, even for relatively simple actions. The BDCP is entirely dependent on so-called adaptive management to attempt correction of deficiencies in the plan after it is implemented. Recent experience indicates otherwise and statements in the BDCP documents lack reliability and do not inspire confidence that anticipated future problems for salmon caused by the BDCP would be resolved.

9) <u>Misuse or lack of use of the best available science.</u>[3] Among other examples, the BDCP failed to utilize the basic tenets of protective criteria for effective fish screen design (e.g., sweeping velocities and fish exposure time), misapplied data from juvenile salmon studies in the Delta, displayed a faulty understanding of juvenile salmon and predatory fish behavior and habitat preferences, misinterpreted past fish screen research projects, and omitted substantial relevant data for evaluative fish models.

The BDCP documents are severely biased in the ultimate conclusions because they are predicated on information that is highly tenuous, speculative, and substantially misleading. The documents frequently overlooked highly relevant scientific facts and instead chose to rely upon sparse information that was outdated or incorrect. The BDCP documents appear to selectively “pick and choose” reports and opinions that support its rationale while ignoring science that points to the opposite. The BDCP derived numerous conclusions from limited or erroneous information. For example, when modeling results suggested positive effects for fish, they were embellished and overemphasized, and when results indicated negative impacts on fish, they were downplayed and deemed insignificant. To summarize, the BDCP’s effects analyses lack scientific objectivity.

As described in detail later in these comments, the BDCP has questionable benefits and feasibility, and is built upon invalid or extremely dubious assumptions. Major uncertainties are sequentially built upon major uncertainties throughout the BDCP documents, but the many caveats sprinkled throughout the EIR/EIS and BDCP do not carry through to the conclusions. A main concern is that the BDCP documents have relied extensively on assumptions about juvenile salmonids that are either incorrect or unfounded, and are full of highly speculative assertions and oversimplification regarding how BDCP actions may or may not affect these fish. Those assumptions are then used as a foundation for conclusions that are unsupported.

BDCP’s So-Called “Best Available Science”

The BDCP claims to be based on the “best available science”, directly implying to an uninformed reader that the document is “correct” in its analyses and interpretation. The BDCP provides the following statements in this regard:

> “The effects analysis is built on and reflects an extensive body of monitoring data, scientific investigation, and analysis of the Delta compiled over several decades, including the results and findings of numerous studies initiated under the California Bay-Delta Authority Bay-Delta Science Program, the long-term

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[3] Due to the enormity and poor readability of the documents, comments not provided here on any particular statement or element in the BDCP do not imply agreement.

> monitoring programs conducted by the Interagency Ecological Program, research and monitoring conducted by state and federal resource agencies, and research contributions of academic investigators. It provides the fish and wildlife agencies with the information that they will need to make their regulatory findings and issue incidental take permits and authorizations for the BDCP." (BDCP Executive Summary Page 19)
>
> "The conservation strategy was informed by the collective experiences of professionals working in the Delta over the course of several decades, monitoring results and conceptual models developed over time through prior scientific efforts (e.g., those conducted by the California Bay-Delta Authority [CALFED] Science Program), and supplemented by data and analysis developed through the BDCP process. The conservation strategy is based on the best available science …" (BDCP Page 1-2)
>
> "The Bay Delta Conservation Plan (BDCP or the Plan) is built upon and reflects the extensive body of scientific investigation, study, and analysis of the Delta compiled over several decades, …" (BDCP Page 10-1)
>
> "Those conclusions are reached through a systematic, scientific evaluation of the Plan's potential adverse, beneficial, and net effects." (BDCP Page 5.1-1)

Such assertions (and a voluminous number of others throughout the BDCP documents containing similar wording), imply that the BDCP's foundation, models, findings, and conclusions are indisputable and beyond reproach. On the contrary, however, my review indicates that, in the BDCP much of the available scientific information was misused and/or misinterpreted and substantial quantities of some critically important scientific information were incorrect, outdated, overlooked, or perhaps purposefully not included. Many of the assumptions concerning anadromous salmonids are in error.

Overstatement of Potential Benefits

The BDCP has clearly overstated potential benefits to salmonids. For example:

> "Increasing the through-Delta survival of juvenile salmonids will be accomplished by maximizing survival rates at the new north Delta intakes, increasing survival rates at the south Delta export facilities, reducing mortality at predation hotspots, increasing habitat complexity through restoration actions along key migration corridors, guiding fish originating in the Sacramento River away from entry into the interior Delta, and ensuring pumping operations do not increase the occurrence of reverse flows in the Sacramento River at the Georgiana Slough junction." (BDCP Page 3.3-140)
>
> "Operation of the north and south Delta intakes provides the operational flexibility to achieve the following improvements." (BDCP Page 3.2-7)

> - "Improve passage of fish within and through the Delta by improving hydrodynamic and water quality conditions that can create barriers to movement and high susceptibility to predators." (BDCP Page 3.2-7)
>
> - "Reduce the risk of entrainment of covered fishes by conveying water from either the north or south Delta, depending on the seasonal distribution of their sensitive life stages." (BDCP Page 3.2-7)
>
> "The combination of moving water through a new isolated tunnel/pipeline facility in conjunction with the existing south Delta facilities—referred to as dual conveyance—is expected to provide flexibility sufficient to substantially reduce the entrainment of covered fish species while providing the desired average water supply." (BDCP Page 3.2-8)
>
> "DWR will construct new diversion and conveyance facilities that will be designed and operated to improve conditions for fish by conveying water from the Sacramento River in the north Delta to the existing water export pumping plants in the south Delta. This new tunnel/pipeline conveyance facility will allow for reductions in diversions at the existing SWP and CVP south Delta facilities, thereby minimizing reverse flows and reducing entrainment of covered fish species by the SWP and CVP in the south Delta." (BDCP Page 4-7)

Notably lacking in the BDCP documents are clearly articulated objective and impartial analyses and balanced statements concerning the project's potentially serious impacts (both positive and negative) to fish. This is discussed further below.

SPECIFIC COMMENTS

BDCP Conservation Measures

The BDCP proposes a suite of largely general, non-specific actions (conservation measures) to meet regulatory requirements for implementation of the plan.

> "The conservation strategy has been developed to meet the regulatory standards of Sections 7 and 10 of the federal Endangered Species Act (ESA), the Natural Community 7 Conservation Planning Act (NCCPA), and the California Endangered Species Act (CESA)." (BDCP Page 3.1-1)

Generalized statements are provided to suggest that the proposed conservation measures in the plan will result in a net improvement for conditions for fish and other species:

> "Landscape-scale conservation measures are designed to improve the overall condition of hydrological, physical, chemical, and biological processes in the Plan Area. These measures include improving the method, timing, and amount of flow and quality of water into and through the Delta for the benefit of covered species and natural communities." (BDCP Page 3.1-3)

However, as described below, some of the prominent proposed conservation measures and interrelated elements are non-specific, based on limited or no supporting data, have highly questionable benefits, and may actually create worse conditions for salmonids than the existing environmental baseline.

Conservation Measure 1 (CM1): Water Facilities and Operation

Fundamentally, it is not at all clear why CM1 is deemed a "conservation measure". The primary purpose of conservation measures is to offset adverse impacts *caused by* the water facilities and operations. There is no question that the proposed three massive north Delta water diversions, fish screens, and indirect effects of operations will have some degree of negative consequences to salmonids, possibly very severe. It is important to remember that the majority of Chinook salmon in the Sacramento Valley—the most important spawning and rearing habitat for salmon in California—would need to migrate past the proposed north Delta diversions. Indeed, some of the most prominent other conservation measures are specifically proposed to counterbalance the anticipated adverse impact of the north Delta diversions on salmon (e.g., CM2, CM6, CM15, and CM16).

The BDCP proposes to construct new fish screen facilities in front of each of three new, large (3,000 cfs) intake facilities with a 9,000-cfs-capacity pumping facility[4] on the Sacramento River upstream of Sutter Slough. The size of the proposed fish screen structures will be massive, greatly exceeding the size of existing fish protective facilities currently in use on the Sacramento River: "A number of potential intakes were investigated and those selected were numbers 2, 3, and 5, with screen lengths of 1,800 feet, 1,900 feet, and 1,950 feet, respectively."(BDCP Page 5.B-7) One of the most perplexing aspects of the BDCP is the proposal to add three or more extremely large diversions in the north Delta without any factual understanding of how those diversions and the corresponding structures would impact juvenile salmon. For example, the BDCP goes to considerable effort to downplay associated risks of predation associated with the intakes and promotes the ability to "control" predation in the future (e.g., BDCP Executive Summary, Page 60, BDCP Page 3.4-39, BDCP Page 4-75). With lack of that empirical knowledge, the BDCP relies on highly speculative opinions on the topic to derive definitive (but unsupported) conclusions. Worse, many of those convictions are one-sided and fail to adequately recognize alternative scientific views indicating that the water diversions and associated structures may have major adverse impacts to young salmon.

In terms of hydraulic and physical conditions for fish protection, the proposed north Delta intakes are sited in some of the worst locations. As stated by Fish Facilities Technical Team (FFTT) (2011), "There is *a high level of uncertainty as to the type and magnitude of impacts* that these diversions will have on covered fish species that occur within the proposed diversion reach

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[4] On BDCP Page 5.B-7, the BDCP states "The 15,000 cfs-capacity tunnels would allow gravity-driven transport of water from the three new 3,000 cfs intakes on the left bank of the Sacramento River …". Presumably, this is an incorrect statement and was not altered since the BDCP was changed from a 15,000-cfs facility to a 9,000 cfs facility; this should be corrected.

(emphasis added).[5]" Based on decades of experience in the design and evaluation of fish screens and water diversions, I partially agree with this statement but would characterize the effects differently and as follows: There is *a high level of certainty the diversions will adversely impact salmonids, but the type and magnitude of those impacts are uncertain*. The following describes some of the primary limitations and problems associated with the proposed three north Delta diversions.

Fish Screen Sweeping Velocities

For fish screens of the nature described in the BDCP documents, high sweeping flows and velocities are critically necessary to protect juvenile salmon because it reduces exposure time to not only the screen face [lessening the likelihood of impingement against the screens (BDCP Page 5.B-5)] but to predatory fish that will certainly harbor around the facilities. Based on my prior work, the BDCP itself states that the new diversions "would be likely predator hotspots." (BDCP Page 3.4-300.) However, the BDCP provides numerous conflicting and confusing statements concerning how the three new fish screen intakes would be operated to meet the fishery resource agencies' [National Marine Fisheries Service (NMFS), California Department of Fish and Wildlife (CDFW), and the U.S. Fish and Wildlife Service (USFWS)] criteria for fish protection. For example:

> "The positive-barrier fish screens will be designed and operated in accordance with design criteria (e.g., screen mesh size, approach velocity) *currently used* by the fish and wildlife agencies (emphasis added)." (BDCP Page 3.2-8)
>
> "CM1 calls for the North Delta intake structure to be constructed *to meet and exceed current NMFS criteria for approach and sweep velocities*, as discussed in more detail for winter-run Chinook salmon (emphasis added)." (BDCP Page 5.5.4-16)
>
> "The sweeping velocity of water passing the intakes should be greater than the approach velocity under the NMFS (1997) criteria, and *at least double the approach velocity* per the CDFW (2000) criteria (emphasis added)." (BDCP Page 5.B-7)
>
> "These self-cleaning, positive- barrier fish screens will be designed to the established protection standards for salmonids and delta smelt, and *will comply with CDFW, NMFS, and USFWS fish screening criteria* as discussed in Appendix 5.B, *Entrainment* (emphasis added)." (BDCP Page 4-9)
>
> "The intakes would be sized to provide screen area, in accordance with federal and state standards, sufficient to prevent entrainment and impingement of salmonids and delta smelt." (EIR/EIS Page 3-87)

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[5] The FFTT (2011) report was written at the time when five diversion intakes were proposed for the BDCP; at the present time, three intakes are proposed.

It is important to note that the criteria currently used by NMFS and CDFW requires that the sweeping velocities be two times or greater than the approach velocities into the screens. With the mandated maximum through-screen approach velocities of 0.33 ft/s for juvenile salmon, the sweeping velocity criteria must be 0.67 ft/s or greater.

However, elsewhere in the BDCP, the documents perplexingly state that *fish screen criteria have not been finalized*. In the BDCP Appendix 5B, Entrainment, it reads: "… actual criteria for the fish screens have not been finalized" and that the BDCP analysis of the fish screens is simply "a general discussion because specific operational criteria and fish screen lengths have not been finalized". (BDCP Page 5.B-58) Other conflicting examples in the BDCP include:

> "Approach and sweeping velocity criteria for the north Delta intake screens have not been finalized, but approach velocity will be 0.33 foot per second (fps) (the criterion for salmonid fry) or less, …" (BDCP Page 5.5.1-31)
>
> "As noted for other species, approach and sweeping velocity criteria for the north Delta intake screens have not been finalized, but approach velocity will be less than or equal to 0.33 fps (the criterion for salmonid fry) and may at times be limited to 0.2 fps (the existing criterion for juvenile delta smelt)." (BDCP Page 5.5.3-23)

The BDCP acknowledges (in an appendix) that higher sweeping velocities are beneficial for young salmon but does not carry the critically important information forward in its analyses and conclusions:

> "Final specifications have not been established fully for the screens but laboratory studies show that salmonid screen passage time would be expected to be facilitated by greater sweeping velocity." (BDCP Page 5.B-387)

Adding more confusion to the topic, the BDCP indicates elsewhere that the sweeping velocities would be in the range of 0.4 ft/s, not 0.67 ft/s or greater (thereby violating existing criteria):

> "The detailed DSM2 tidal modeling of the intakes included a downstream sweeping velocity criteria of 0.4 foot per second; the intakes were not operated when the tidal velocity was less than 0.4 foot per second, as measured downstream of the intake." (BDCP Page 5.3-7)
>
> "DSM2 modeling of tidal velocities at the north Delta intakes indicated that these bypass rules would be compatible with a downstream sweeping velocity of 0.4 ft/sec that was assumed protective for reducing juvenile fish impingement on the screens." (BDCP Page 5C.A-114)
>
> "Compliance Monitoring Action: Confirm screen operation produces sweeping velocities greater than or equal to approach velocities." (BDCP Page 3.D-3)

The existing CDFW requirement[6] is that fish screen sweeping velocity should be at least two times the allowable approach velocity (or ≥ 0.67 ft/s) and that fish exposure time to the fish screen shall not exceed 15 minutes. The NMFS (1997) states that large stream-side installations may require intermediate bypasses along the screen face to prevent excessive exposure time to avoid fry impingement. A variance to that requirement was developed for the 1,000-ft long GCID screens, but only because of the very high sweeping flows at the facility. Some agencies outside California prefer that the sweeping velocities be at least 2 ft/s (USBR 2006). Emphasizing the importance and benefits of high sweeping velocities, Swanson et al. (2004b) state:

> "For young Chinook salmon subjected to prolonged exposure at a single large screened diversion or repeated exposures to multiple screens in their habitat or along their migratory route, the cumulative energetic costs could be substantial. … Collectively, the results indicate that, for juvenile Chinook salmon, optimal fish screen design should be guided by the objective of minimizing screen exposure duration, largely through balancing screen size (or length) with prevailing or engineered sweeping velocities."

The proposed BDCP intakes screens would possess insufficiently low sweeping velocities passing three extremely long screens positioned in close proximity causing very high, and therefore harmful, fish exposure time to the screens (discussed in more detail later in these comments).

The BDCP frequently cites a July 2011 Technical Memorandum by the FFTT to justify various components of the proposed new large fish screens. An examination of that document provides some revealing information relevant to the facilities' unsuitable locations. In reality, the FFTT was provided with poor options for fish protection due to the unique, unfavorable sites for water withdrawal from the north Delta. It is evident that the team had no choice but to recommend only general criteria that were severely constrained by the site-specific conditions of the various intakes, and not criteria necessary to protect fish. The FFTT (2011) stated that the proposed north Delta intake fish screens "… make it challenging to literally apply sweeping velocity criteria …". It is evident from the EIR/EIS that all of the numerous sites put forth for the intakes are poor for fish protection. The sites selected to carry forth from the EIR/EIS to the BDCP (Intakes 2, 3, and 5) were not chosen because those locations would provide good protection for fish but, instead, viewed as more favorable (but still bad) among the worst sites.

The BDCP modeling exercise for evaluating sweeping velocities at the proposed north Delta intakes utilized results of DSM2 modeling.

> "DSM2 modeling of tidal velocities at the north Delta intakes indicated that these bypass rules would be compatible with a downstream sweeping velocity of 0.4 ft/sec that was assumed protective for reducing juvenile fish impingement on the screens." (BDCP Page 5C.A-114)

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[6] http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp

> "The salient point from these detailed modeling assumptions is that the north Delta intake operations largely were governed by cross-section-averaged sweeping velocity (unadjusted for the velocity at the screen face) downstream of each intake, as opposed to further downstream. There was no explicit consideration of tidal state (e.g., "do not pump during flood tides"), although tidal state would influence the criteria expressed in the modeling assumptions. Multi-dimensional modeling will be necessary to refine estimates of potential diversions." (BDCP Page 5C.4-92)

As an initial matter, an average channel velocity of 0.4 ft/s is not reflective of water velocities near the river banks where the fish screens would be located. The FFTT recognized this problem:

> "For an on-bank screen, there may be a significant difference between the average channel velocity and the sweeping velocity along the screen face due to the boundary effect of the river channel. This can be addressed to some degree by selecting screen sites on or just below the outside of river bends and modeling the flow past the screen to optimize the alignment of the screen." (FFTT 2011)

Additionally, in a BDCP appendix, the same problem is identified:

> "However, velocities in CALSIM/DSM2 are channel cross-section averages, and therefore would not represent the range of velocities that would occur across the channel, with lower velocities expected at the channel margins where the on-bank intakes would be (Pandey and Smith 2010)." (BDCP Page 5.B-88)

This issue is conceptually illustrated in cross-sectional profiles of a river (Figure 1). Scenario A depicts a relatively straight reach of river where the highest water velocities are near the center of the channel and the lowest near the channel margins thereby providing unfavorable locations to site long, flat-plate fish screens. However, in Scenario B, a bend in the river offers the highest water velocities on the outside of the river bend and, therefore, are preferred locations to position long, flat-plate fish screens and reduce fish exposure time.

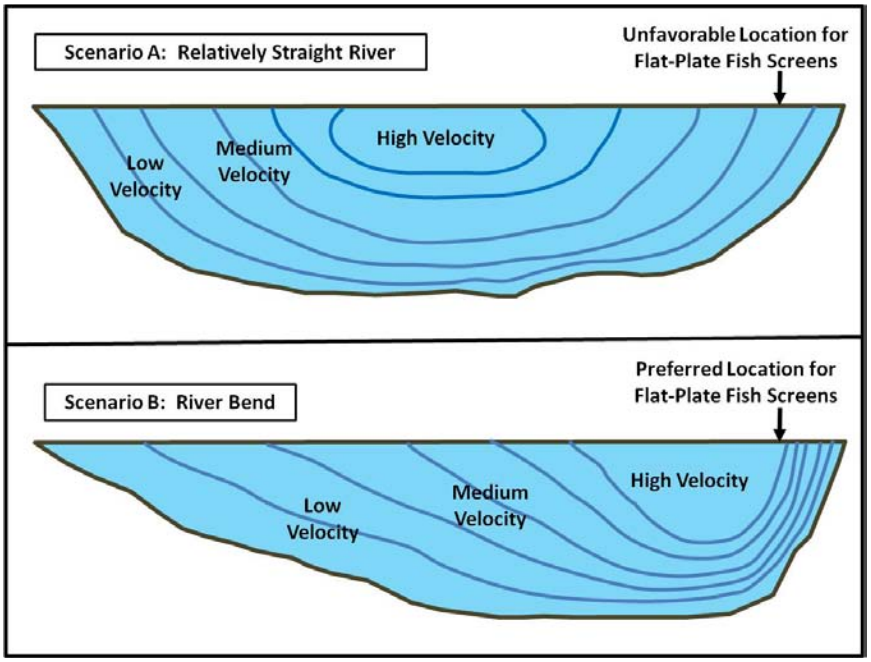

Figure 1. Conceptual diagrams of river cross sections showing locations of highest and lowest water velocities in a relatively straight river reach (Scenario A) and at a river bend (Scenario B).

These riverine hydraulic attributes are empirically demonstrated for cross-sectional profiles in Figures 2 and 3. Note that these examples are located in the Sacramento River upstream of the Delta where river gradient is much steeper, the channel is narrower, and overall water velocities are higher than the locations where the three north Delta intakes are proposed; however, the foregoing principles remain the same.

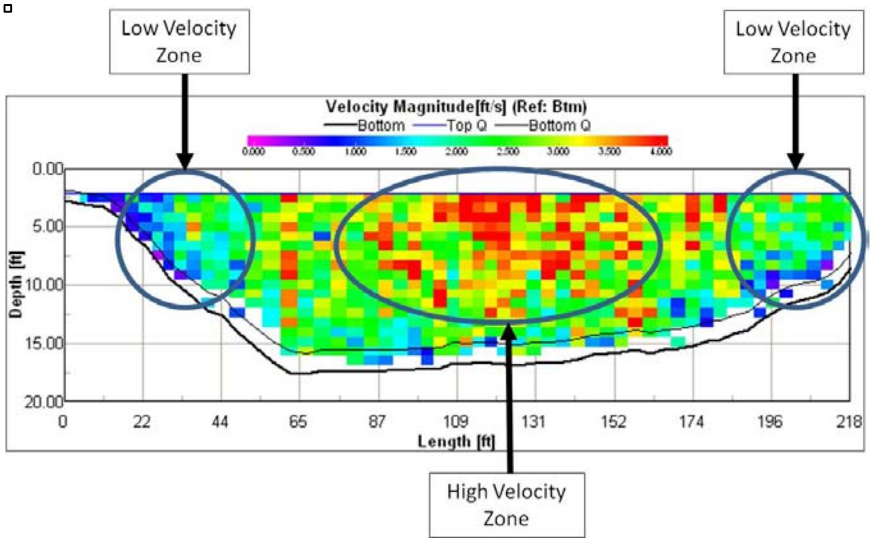

Figure 2. An Acoustic-Doppler Current Profiler (ADCP) cross-sectional transect of a relatively straight reach of the Sacramento River upstream of Knights Landing (from Vogel 2008a).

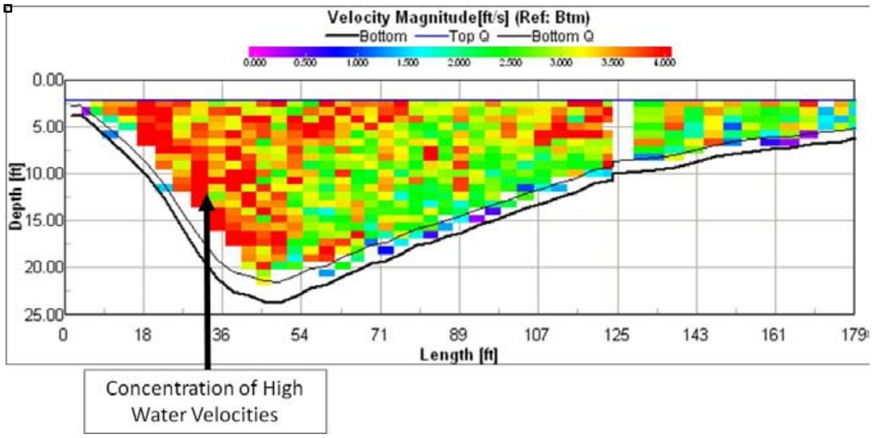

Figure 3. An Acoustic-Doppler Current Profiler (ADCP) cross-sectional transect of a river bend in the Sacramento River upstream of Knights Landing (from Vogel 2008a).

As pointed out by FFTT (2011), this problem for flat-plate fish screen siting to improve sweeping flows can be partially alleviated by locating the fish screens on the outside bends of the river channel. Existing examples of large Sacramento River flat-plate fish screens demonstrate how that measure has been successfully implemented (e.g., Figures 4 - 6).

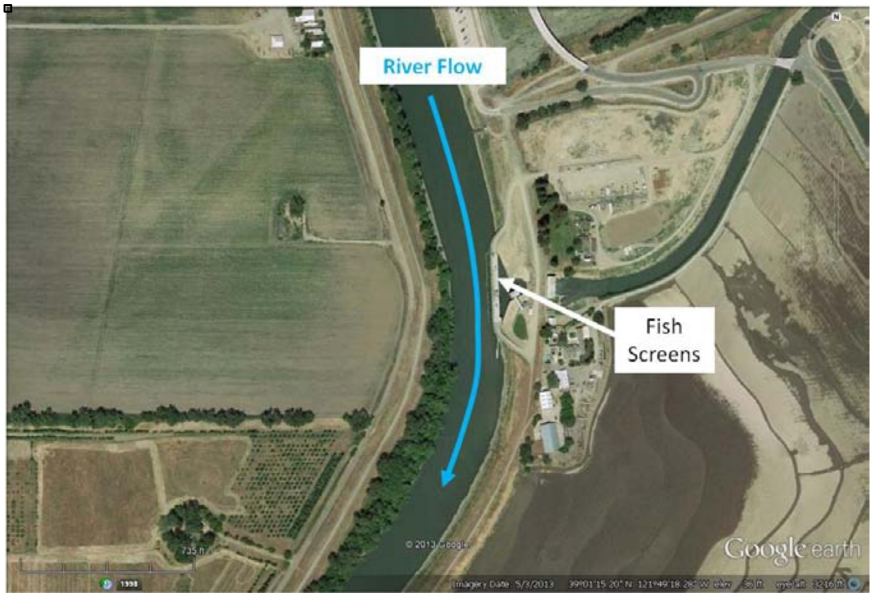

Figure 4. Aerial photograph of an example of an existing Sacramento River flat-plate fish screen located on an outside river bend to maintain high sweeping velocities.

Figure 5. Aerial photograph of an example of an existing Sacramento River flat-plate fish screen located on an outside river bend to maintain high sweeping velocities. Water velocities passing the screen typically range between 2 to 4 feet/second (USBR 2006).

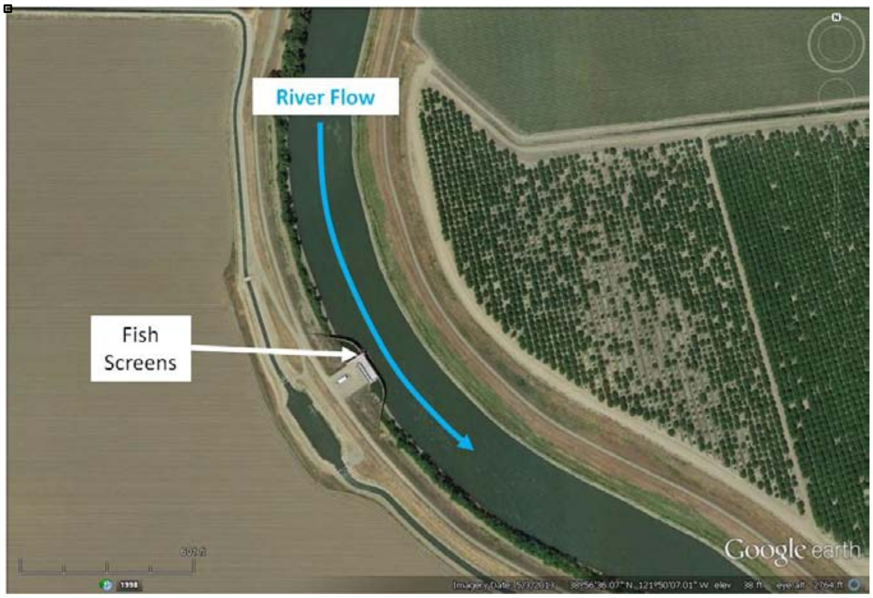

Figure 6. Aerial photograph of an example of an existing Sacramento River flat-plate fish screen located on an outside river bend to maintain high sweeping velocities.

In sharp contrast to these real-world examples, the three proposed north Delta intakes would be positioned in only *very slight* (or "gentle"[7]) river bends or relatively straight sections of the river channel (Figures 7 - 9) and lower gradient reaches of the river. (BDCP EIR/EIS, Page 3F-15, BDCP EIR/EIS Chapter 3, Appendix 3H)

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[7] Adjective used in the BDCP documents.

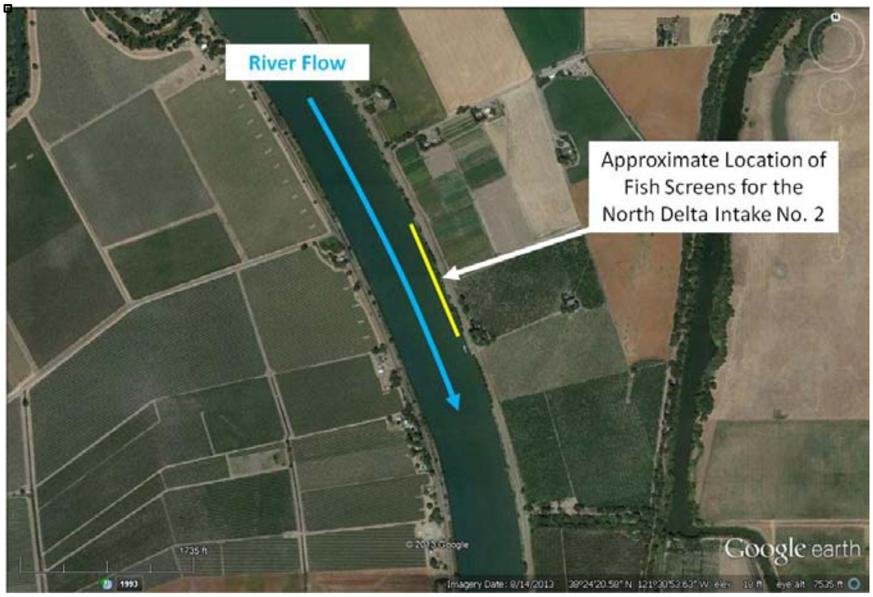

Figure 7. Aerial photograph of the approximate location of the proposed north Delta intake alternative no. 2.

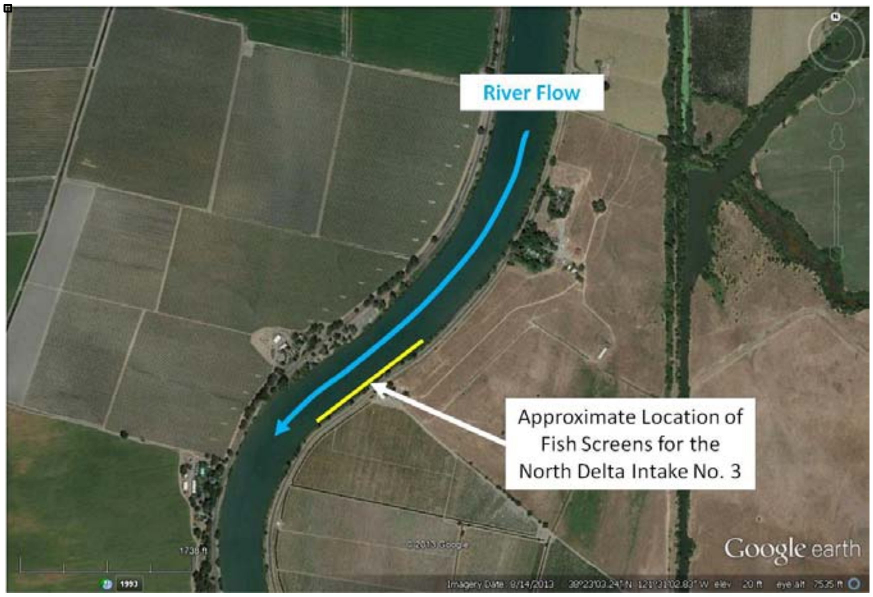

Figure 8. Aerial photograph of the approximate location of the proposed north Delta intake alternative no. 3.

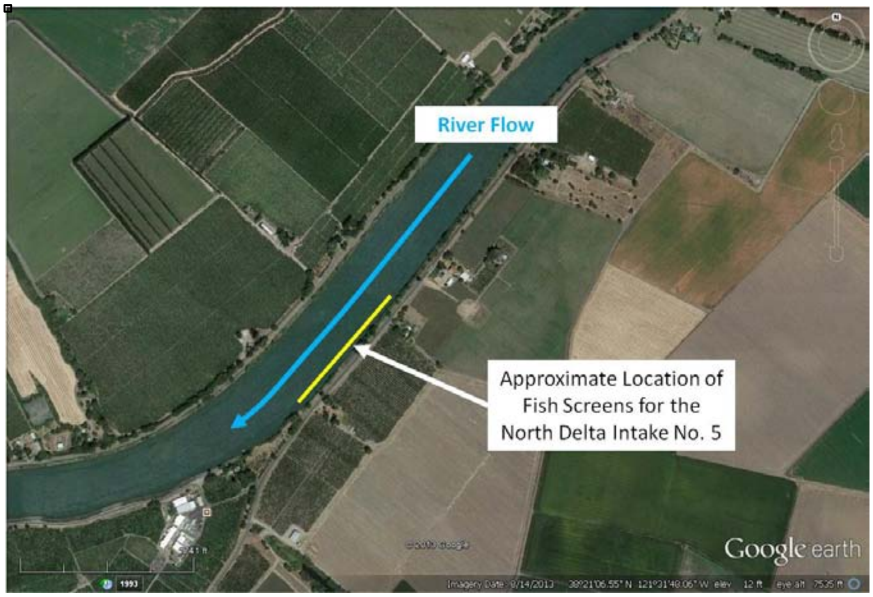

Figure 9. Aerial photograph of the approximate location of the proposed north Delta intake alternative no. 5.

These sites will not provide the near-screen sweeping velocities necessary to protect downstream-migrating salmon. The salient point is that past experience has clearly demonstrated that maintaining high sweeping velocities in front of large riverine flat-plate fish screens requires one of following to take place:

1) Alter river channel geometry and create channel constrictions to control the hydraulic conditions at the fish screens.
2) Position the fish screens on the outside sharp (not "gentle") bend of the river channel where high water velocities are naturally present (e.g., Figures 4 - 6).
3) Angle the fish screen out into the river channel in a downstream direction or jut the entire structure out into the channel in deeper, swifter water to maintain sweeping flows.

The locations of the north Delta intakes, as presently envisioned in the BDCP, do not possess any of those conditions. Of the options above, only number 3 could be implemented, in theory, to maintain high sweeping velocities on the face of the fish screens. However, doing so will create significant hydraulic controls in the river channel causing back-water effects and could produce unacceptable flood risks in the region. Additionally, this alternative would also create ideal predatory fish habitats. As shown in the schematic in Figure 10, ideal predator habitats are created by jutting the screen out into the river channel causing slack water and/or back eddies. Predatory areas are also generated adjacent to sheet pile walls upstream and downstream of the fish screens by eliminating laminar flow and causing hydraulic turbulence and eddies near the walls favoring predatory fish holding habitats and reducing predatory fish energy expenditure. As a result, juvenile salmon moving downstream past these locations are greatly subjected to predation. This problematic scenario is seen in Figure 10 at location "B" where fish become concentrated by reduced flow entrained through the fish screens. When migrating past the screens, the fish sequentially become more and more concentrated until reaching the lower-most portion of the structure where the small salmon can become easy prey for predators residing in the back eddies or slack water. Furthermore, even during periods when the north Delta intakes are not diverting water, young salmon would still be exposed to the predatory fish habitat in locations "A" and "B". Such problematic areas to avoid in fish screen designs have been described by others (e.g., Odenweller and Brown 1982, Vogel and Marine 1995, NMFS 1997, USBR 2006, CDFW 2010). These serious problems are not adequately described in the BDCP documents or are downplayed.

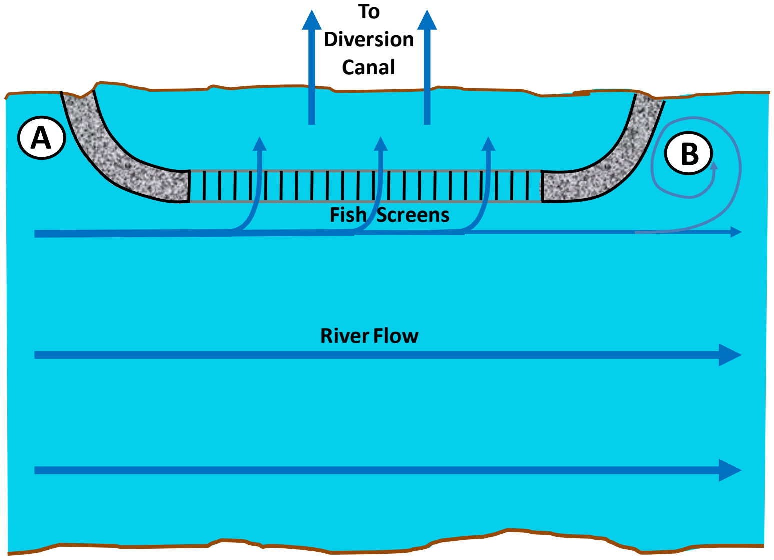

Figure 10. Top view schematic showing predatory fish habitats ("A" and "B") upstream and downstream of a hypothetical fish screen at a proposed north Delta water intake.

Notably, the BDCP portrays the positioning of the three large north Delta intakes as essentially flush with the riverbank (Figures 11 and 12). This is deceiving and makes the intake facilities look more benign than in reality. It would not be possible to construct and operate these types of facilities while subsequently providing protection for fish because of the previously- and later-described reasons. Among other problems, these configurations would not provide sufficient screen area and sweeping flows to protect salmon. The conceptual configurations displayed in Figures 11 and 12 would be unacceptable and not capable of meeting criteria for fish protection. It is not clear why the BDCP documents provide such misleading graphics when it is well known through technical details provided in NMFS (1997), USBR (2006), and CDFW (2010) such designs would fail to meet the fishery resource agencies' protection criteria for young salmonids. This is particularly disturbing because so much depends on the specific, yet undisclosed, design details of the intake facilities. The BDCP is extremely murky in regard to the critically important features of the facilities, and implies that many additional BDCP elements also lack transparency and have not used the best available scientific information. Additional fallacies in the facilities' basic designs are described elsewhere in these comments.

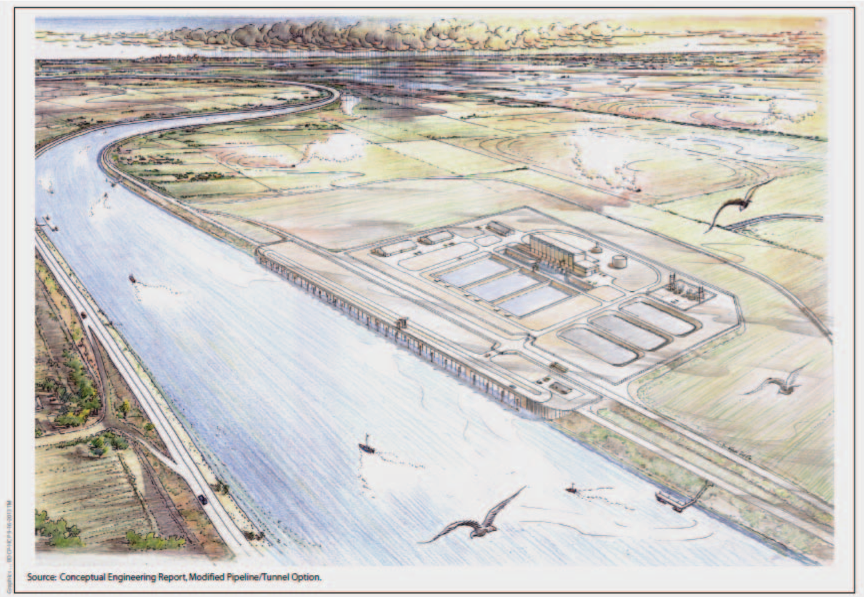
Source: Conceptual Engineering Report, Modified Pipeline/Tunnel Option.

Figure 11. Conceptual rendering of a north Delta intake structure (BDCP Figure 4-7).

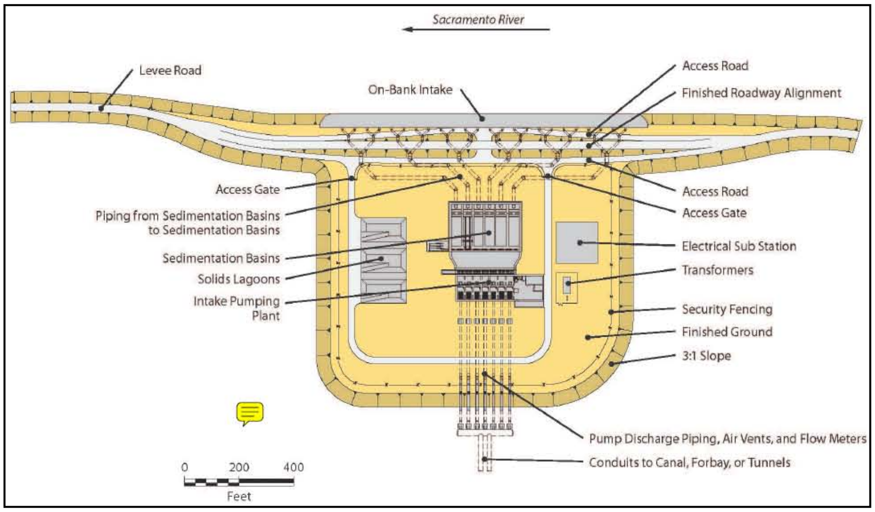

Figure 12. Conceptual intake structure for a 3,000 cfs proposed north Delta diversion (From BDCP figure 5.B.3-1 Source: Adapted from TM 20-2 Rev 0 Proposed North Intake Facilities for the Draft EIS, Figure O-5. Note that length differs from actual proposed intakes.)

The BDCP documents do not provide any information on how these serious limitations would be overcome and how negative results to fish can be avoided (other than “predator removal” and “adaptive management” discussed later in these comments). The puzzling part of the BDCP is that the river channel velocities near the proposed water intakes could have easily been empirically measured using an ADCP (e.g., Figures 2 - 3) during flow conditions when the diversions would operate in the future; theoretical modeling would not have been necessary. This deficiency is unexplained in the BDCP, and the information was not provided in the BDCP documents.

It must be emphasized that large, long fish screens of the type contemplated for the north Delta diversions using a criterion of such an exceptionally low sweeping velocity only equal to the approach velocities through the screens have never been constructed in the Central Valley. The proposed north Delta screen would be very long [up to 1,800 feet in length (BDCP Page 4-9)], greatly exceeding the length of existing screens. The estimated fish exposure times are extreme and vastly inferior to fish protection measures designed and implemented at other fish screens throughout the Central Valley (e.g., the 1,000-foot-long GCID facility described later in these comments), and would certainly result in adverse effects on salmon. No logical basis is provided in the BDCP to support viable protection resulting from such long fish exposure times and associated substandard conditions. To the contrary, the exposure times contemplated in the BDCP strongly suggest this will be a major problem for young salmon. Fish impingement and injury can result when exposure time to the screens is too long (USBR 2006). As cited by USBR (2006), a study by Smith and Carpenter (1987) evaluated duration of exposure for salmon fry and found that over 98 percent of the salmon fry tested were able to swim for at least 1 minute (and up to 3 minutes) before impinging on the screen with a screen operating at the NMFS approach velocity criterion of 0.33 ft/s. Those findings led to the NMFS criterion that salmon fry maximum exposure to fish screens should not exceed 60 seconds (USBR 2006). Because very large numbers of salmon fry will be exposed to the expansive north Delta intake screens and exposure times will be very long (discussed below), impingement will almost certainly occur and be high.

It is also important to note that fry impingement will likely be greater during periods of high water turbidity because of significantly reduced visual stimuli to avoid screen contact. For example, Swanson et al. (2004b) indicated that young salmon impingement rates on fish screens could increase with low water visibility, including high turbidity. Existing Sacramento River intakes utilizing long, flat-plate fish screens divert water during periods of relatively high water clarity in the spring, summer, and fall irrigation seasons. In sharp dissimilarity, the BDCP intakes will operate only when flows are very turbid following significant precipitation events in the upper watershed (generally during the winter months). To summarize, the expectation is that high rates of fry impingement will occur, not only because of low sweeping velocities (and associated very long transit times past the screens – discussed below), but also because of very low water clarity when the diversions would be in operation.

The BDCP discussion concerning the estimated enormous juvenile fish exposure times along the face of new fish screens positioned in front of the proposed large water diversion structures is particularly disturbing from a fish-protection standpoint. The BDCP provides extremely important, but very brief, illustrations of the severity of adverse conditions for young salmon at the proposed north Delta intakes. This information demonstrates the high degree of significance for adequate sweeping velocities past the extremely long proposed fish screens. Experimental trials at the University of California – Davis (UCD) Fish Treadmill facility suggest that juvenile salmon would experience very long passage times past the proposed north Delta intakes because of low sweeping velocities and long screen lengths (Figures 13 and 14). As described in the BDCP, the equations of Swanson et al. (2004a), upon which Figures 13 and 14 are based, estimate that with an approach velocity of 0.33 ft/sec and sweeping velocity of at least twice this[8], screen passage time would range from around 30 minutes (4.4-cm fish passing an 800-foot

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[8] The BDCP actually proposes a much-less protective criterion.

screen[9] during the night) to nearly 5 hours (7.9-cm fish passing a 2,000-foot screen during the day) (BDCP Page 5.B-304). Compare those estimates to the 1,000-foot-long GCID fish screens possessing higher than 2 ft/s sweeping velocities (CH2M HILL 2002) and salmon passage times of only about 10 minutes. The 225-foot-long RD 108 Wilkins Slough screen has sweeping velocities ranging from 2 to 4 ft/s (USBR 2006). The estimated fish passage times for the north Delta intakes are excessive, far exceeding values for existing Sacramento River fish screens, and will likely result in impingement and predation. Importantly, many of the salmonids encountering the north Delta fish screens will be even smaller (i.e., weaker swimmers) than the size of salmon used in the UCD tests, further exacerbating the problem. This obvious adverse impact to salmon is remarkably downplayed in the BDCP documents. As discussed below, the BDCP has suggested a major relaxation of that criterion to sweeping velocities being only equal to or greater than the approach velocities, making passage times far longer (i.e., more severe) for juvenile salmon than depicted in Figures 13 - 14. Although empirical evidence indicates adverse impacts to salmon are probable, the BDCP states that the effects are “uncertain” and would be addressed *after the screens are constructed* by “monitoring and targeted studies” and, yet again, “adaptive management” (BDCP Pages 3.4-31, BDCP Appendix 3D). This proposed BDCP approach and poor, unreasoned analyses clearly did not use the best available science.

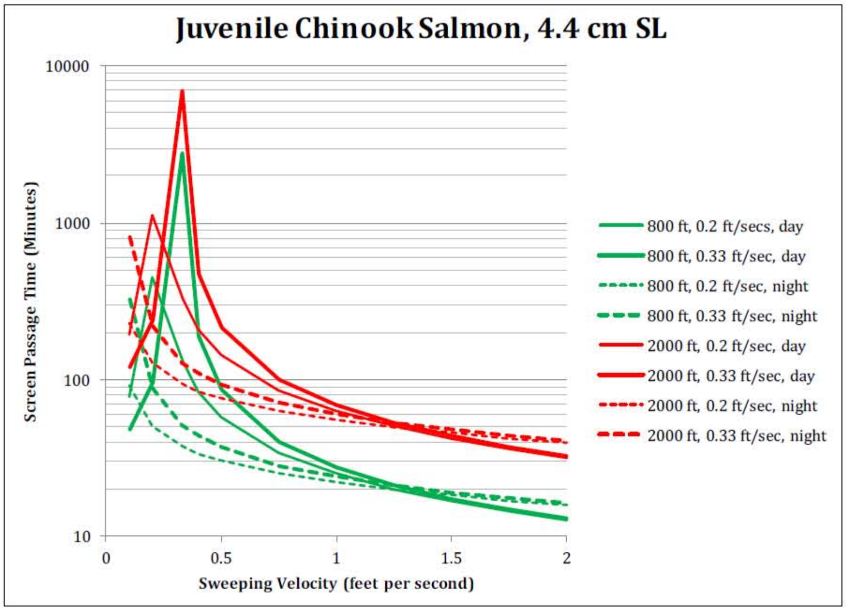

Figure 13. Estimate screen passage time for juvenile Chinook salmon (4.4 cm standard length) encountering an 800- or 2000-foot-long fish screen at approach velocities of 0.2 or 0.33 feet per second during the day and night. (from BDCP Figure 5.B.6-43)

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[9] Note that the shortest proposed north Delta intake screen is 1,800 feet.

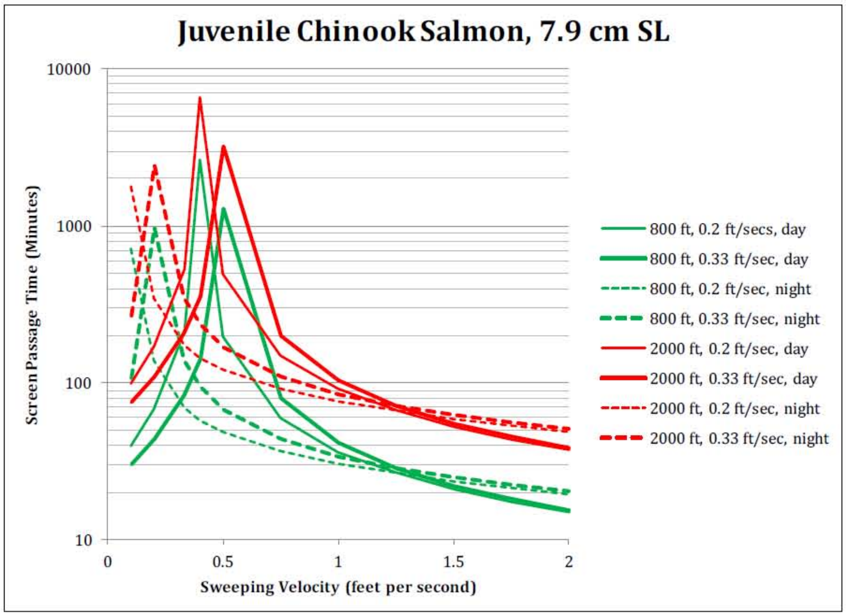

Figure 14. Estimate screen passage time for juvenile Chinook salmon (7.9 cm standard length) encountering an 800- or 2000-foot-long fish screen at approach velocities of 0.2 or 0.33 feet per second during the day and night. (from BDCP Figure 5.B.6-44)

The BDCP ignores these basic tenets of fish screen designs that have been formulated from years of extensive research and empirical studies and, instead, have used the following as a basis for the design of the fish screens:

> "North Delta intakes screening effectiveness analysis. Assessed potential for direct entrainment loss and impingement at screens for different sizes of fish based on literature and professional judgment." (BDCP Page 5.B-iii)

Although entrainment loss of salmon at the north Delta intakes would be expected to be very low, the literature and professional judgment should have indicated that impingement of salmon fry to likely be very high. The BDCP provides no scientific justification to support this serious discrepancy. It is not clear why the BDCP did not use the widely available best science concerning this critical element (e.g., Fisher 1981, NMFS 1997, Swanson et al. 2004a, Swanson et al. 2004b, USBR 2006, CDFW 2010).

It must be emphasized that all large fish screens constructed on the Sacramento River over the past 17 years were designed to meet the existing fishery resource agencies' criteria for high sweeping flows past the screens (NMFS 1997, CDFW 2010[10]). This measure was specifically implemented to protect juvenile anadromous salmonids, particularly fry (the weakest swimming life stage). Although the BDCP provides conflicting statements concerning exactly what the criteria would be for the proposed north Delta intakes, it appears that a major relaxation in that standard may be contemplated, primarily prompted by the serious physical constraints of the north Delta intake sites and ignoring protection for salmon. Based on questionable logic, the BDCP documents suggest that such a relaxation (if it does occur) is to protect small numbers of

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[10] Note that CDFW updated the agency's criteria in 1997 (Petrovich 1997) to the present-day standards.

Delta smelt, not salmon (e.g., EIR/EIS Pages 3F-2, -3, -5, -7, -8, -13, -15 and BDCP Pages 5.B-311-313, 5-B-387). If the criteria are relaxed, it will likely have major adverse impacts on salmon fry originating *throughout* the Sacramento River basin. Except when the Yolo Bypass is flooding, the entire production of all runs and species of anadromous salmonids (unlike Delta smelt) must pass in front of each of the three proposed north Delta intakes (all positioned in close proximity). Impacts on salmonids could be disastrous.

Predation

The FFTT (2011) recommended that the new fish screens be designed to avoid creation of predatory fish habitat or increased vulnerability of prey. The BDCP claims that the three new fish screens at intakes on the Sacramento River will "minimize hydrodynamic conditions suitable for predatory fish". (BDCP Page 5.B-7) However, nowhere in the BDCP or EIR/EIS is it described how that near certainty will be avoided. The BDCP admittedly states:

> "… there is potential for an increase in predation risks at the north Delta intakes if they create holding habitat for piscivorous fish." (BDCP Page 5.B-303)
>
> "The north Delta export facilities on the banks of the Sacramento River likely will attract piscivorous fish around the intake structures." (BDCP Page 5.F-iii)
>
> … the proposed BDCP is expected to create new [predation] hotspots: North Delta water diversion facilities – Large intake structures have been associated with increased predation by creating predator ambush opportunities and flow fields that disorient juvenile fish." (EIR/EIS Page 3-157)

Unfortunately, the fish screen structures contemplated in the BDCP will create ideal conditions for predation on juvenile salmon and the documents provide no details on how that major problem can be avoided.

Furthermore, in the worst possible scenario for salmon, all three north Delta water intakes are to be located on the same side of the Sacramento River and in close proximity; water (and therefore fish) will be drawn toward the east riverbank. Apparently, this choice was not based on fish protection but, instead, for advantageous tunneling considerations (EIR/EIS Page 3F-15). Up to 3,000 cfs will be removed from the river at each of the three intakes but the fish will remain in the river channel. Downstream-migrating juvenile salmon will become more and more concentrated along the east bank of the river as the fish traverse the long length of each individual screen structure and arrive (if the fish do not perish from impingement or predation in transit) at the downstream end (Figure 15). This sequence of events will create a compounding concentration of fish. Predatory fish will undoubtedly become very accustomed to these ideal "feeding stations" at the lower end of each fish screen and the resultant impacts on juvenile salmon could be catastrophic. The BDCP does not describe how this serious dilemma can be avoided other than some undefined form of "predator removal" and "adaptive management" that are likely to fail (discussed later in these comments).

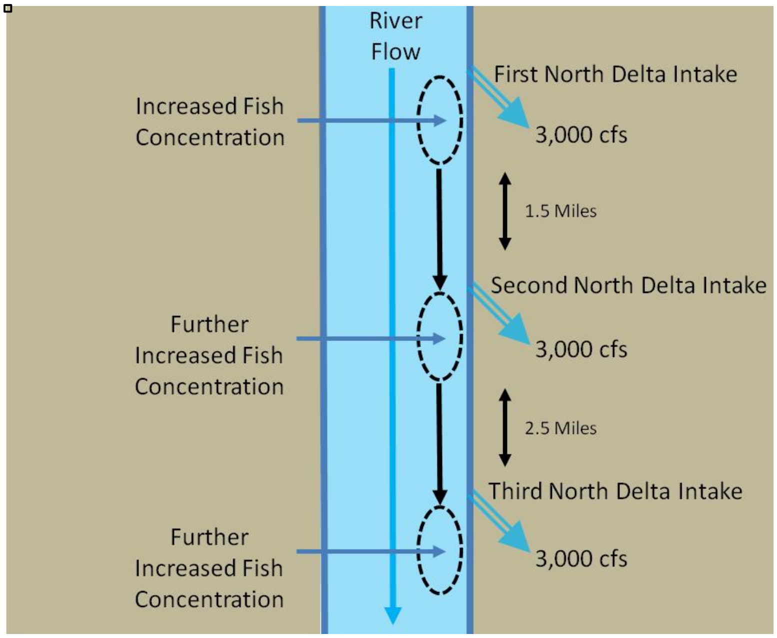

Figure 15. Conceptual plan-view schematic (not-to-scale) of the three proposed north Delta intakes on the Sacramento River and the concentrating effect on downstream migrating salmon toward the east or left bank (facing downstream).

Again, although the BDCP acknowledges this issue, no proven remedial measures are proposed to prevent it.

> "The vulnerability of covered fish to predation at the new north Delta intake structures is, to a large extent, dependent on the physical characteristic of each structure, whether fish would be concentrated or disoriented, and areas of turbulence and lower velocity refuge habitat that attract predatory fish." (BDCP Page 5.F-5)

It is important to note that the predation problem for salmon will not just exist at the lower end of the screens, but also across the entire length of the structures where salmon will experience an unquestionably long transit time and high exposure to predation. Predatory fish swimming in front of existing Sacramento River screens is already known to occur, even when sweeping velocities past the screens are very high (e.g., Figure 16). Predatory fish (e.g., striped bass) can easily swim in high velocity zones when prey (e.g., salmon) are abundant and vulnerable. This problem will be intensified with the very low sweeping velocities at the proposed north Delta fish screens where predatory fish can easily swim back and forth in front of the screens with minimal expenditure of energy. Indeed, the screen design, as presently contemplated, will provide additional "feeding grounds" for predatory fish such as striped bass and Sacramento pikeminnow that will "patrol" back and forth along the screen face. In that environment, salmonids have no protection from predation. In a very real sense, the three north Delta intakes will constitute three major gauntlets for salmon. In addition, the cumulative length of screens salmon may traverse will be nearly 1.1 miles of high vulnerability. The BDCP suggests that such structures should first be constructed, then monitored to determine if there are problems for fish. The BDCP appears to advocate the approach: "Build it and hope the fish survive."

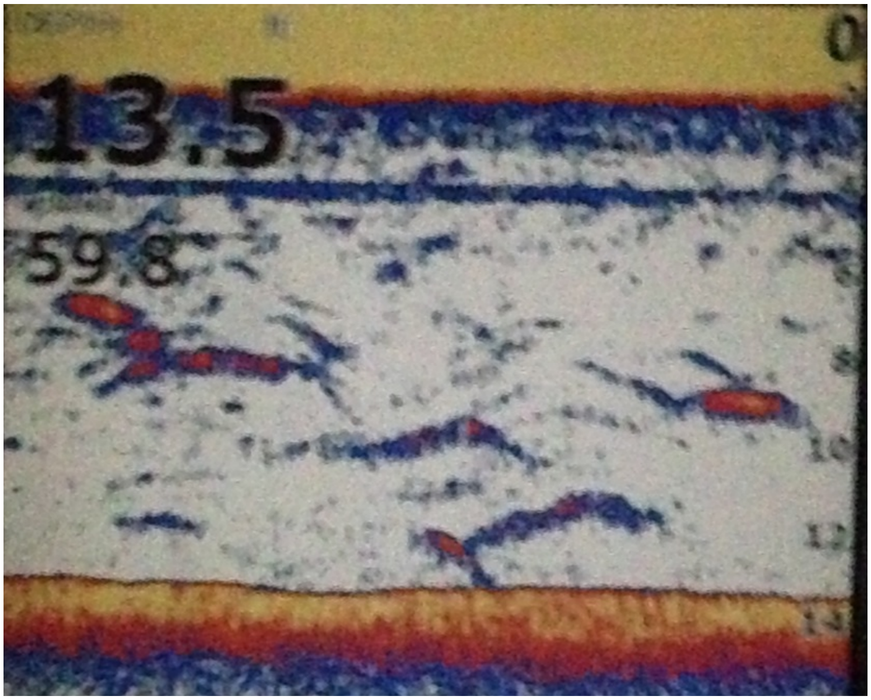

Figure 16. Depth sounder ("fish finder") image of numerous large striped bass swimming in front of a large Sacramento River fish screen. Species determined by hook and line angling. Photo by Dave Jacobs.

The BDCP states:

> "After intake structure construction is complete, the cofferdam will be flooded and the sheet pile walls in front of the intake structure removed. Sheet pile wall removal will be performed by underwater divers using torches or plasma cutters to trim the sheet piles at the finished intake structure slab grade. After removing the cofferdams, the riverbed in front of the intakes will be dredged to provide smooth hydrologic conditions along the face of the intake screens." (BDCP Page 4-10)

The last sentence of the preceding statement is very misleading and inaccurate. Dredging the riverbed in front of the cut off cofferdams will have minimal effect on hydraulic conditions along the face of the fish screens. Furthermore, the sheet pile areas described (upstream of the fish screens, along the cut off cofferdam near the base of the length of the screens, and downstream of the screens) are known areas where predatory fish may accumulate (e.g., Vogel and Marine 1995, USBR 2006). The BDCP does not explain remedial actions to avoid these problem areas for young salmon.

In addition to the convoluted sheet piles upstream, downstream, and along the base of the screens, each structure will possess additional complexities that create predatory fish holding habitat hazards for juvenile salmon. These include piles and floating booms in front of the screens and numerous large vertical wiper blades along the face of the screens. Based on an extensive literature review by Odenweller and Brown (1982), those hazards are described as follows:

> "The literature offers some assistance for minimizing and discouraging predation at the intakes and fish facilities. Piers, pilings, other supportive structures, and corners or other irregularities in a channel are referred to as structural complexities. Such structures may cause uneven flows and can create shadows and turbulent conditions. A structurally complex environment should be avoided. Corners, interstices, or other structural components that create boundary edges contribute to maximum foraging efficiency of large predatory fishes and the highest populations of predators will occur where structural boundary edges are present. Structural complexity can increase predation by providing locations for waiting predators (shadows, interstices, corners, etc.). The risk of prey to predation is a function of exposure, often directly related to the structural complexity of the system." (Odenweller and Brown 1982, at p. 48.)

Again, the BDCP does not address those known problems for salmon and, furthermore, why the readily available science on the topic was not utilized (e.g., NMFS 1997, USBR 2006, CDFW 2010).

Most importantly, the BDCP documents do not describe valid or proven remedial actions that would be undertaken to rectify predation problems when they would likely surface after the facilities are constructed. Instead, the BDCP states that it will use "adaptive management" to "inform" this predation uncertainty:

> "The uncertainty associated with predation at the north Delta intakes will be addressed with targeted research and adaptive management during implementation of the BDCP, and will also be informed by early implementation studies currently in the planning stage." (BDCP Pages 5.5.3-28 and -29)

Such ambiguous statements are inappropriate for such a potentially serious problem. The BDCP must provide descriptions of much more definitive measures for remedial actions.

Refugia Areas

In recognition of the probable adverse impacts to young salmon at the north Delta intakes from impingement and predation along the long face of the flat-plate fish screens, the BDCP recommends that fish "refugia" be incorporated into the design of the new screens (e.g., BDCP Pages 3.4-31-33, 3D-3, -10, - 28 and -29). The refugia are intended to be small resting areas along the fish screens behind racks that juvenile salmon could enter, yet would exclude predatory fish. This hypothetical concept evolved years ago from my personal underwater observations at a Sacramento River fish screen intake structure where large numbers of juvenile salmon were seen between the trash racks and fish screens: http://www.youtube.com/watch?v=kxzDCtTRiVo The FFTT (2011) report recommended that the refugia "panels" be the same length and height of a typical screen panel (15-ft wide) and be positioned approximately 100 feet apart along the entire length of each of the three new fish screens. If incorporated into the screen design, each screen would be considerably longer than without refugia. This concept is in its very early stages of experimental application and has been integrated into only one fish screen to date; it has yet to be field tested and it is entirely unknown if it will work. However, based on the one

Tehama-Colusa Canal (TCC) screen installation, the configuration (in this author's opinion) is unlikely to be favorable for salmon because of the sizing, spacing, and orientation of the racks in front of the refugia and shallow impression into the fish screen structure. The FFTT (2011) report recommended that the refugia concept be thoroughly evaluated prior to incorporation into the proposed north Delta fish screens. With such an untested theory that has enormous bearing and ramifications for fish protection, the BDCP should not be so reliant on this potential measure for salmon survival.

Because the designs of such refugia are unknown and untested, the BDCP proposes to:

> "Develop a physical hydraulic model to measure hydraulics and observe fish behavior in a controlled environment. Size/shape of refugia areas can be modified to optimize fish usage. Predators can be added to examine predation behavior near refugia (same as preconstruction study 3, *Refugia Lab Study* [Fish Facilities Technical Team 2013])." (BDCP Page 3.4-32)

and,

> "Perform field evaluation of one or more existing (or soon-to-be-completed) fish screening facilities using fish refugia. Use these data to develop understanding of expected effectiveness of fish refugia and to identify areas for improvement (same as preconstruction study 4, *Refugia Field Study* [Fish Facilities Technical Team 2013])." (BDCP Page 3.4-33)

Scale models are highly unlikely to provide useful information and data. It is this author's understanding that the one scale model of a refugia device used for the design of the new, untested TCC intake screens was conducted in clear water and artificially lighted conditions. Even when the TCC refugia are eventually evaluated, those screens are generally operated during clear-water conditions; applicability of those study results to the proposed BCDP intakes will be highly questionable. How salmon will respond to real-world conditions at the proposed BDCP north Delta intakes, with turbid water, poor (low) sweeping velocities, at night, and very long transit times along the screens are all unknown. For example, given that the BDCP intakes would be primarily operated during high Sacramento River flows when water clarity is very low, how would salmon have any visual stimuli to find and enter the so-called refugia?

Also, as mentioned previously, the BDCP failed to recognize that the north Delta intake screens will primarily operate during far different seasonal periods than when other large Sacramento River agricultural diversion flat-plate screens operate. Agricultural diversions operate in the spring, summer, and fall when water clarity is often high and the presence of anadromous fish is generally low. In contrast, the north Delta intakes would mainly be operated during the winter when water clarity is low and the presence of anadromous fish is very high. Debris loading on the fish screens and on the louvered fish refugia will be massive and unprecedented. My personal research and experience has demonstrated that Sacramento River flows during the winter possess enormous quantities of fine particulate material that could easily clog the screens and refugia. During such high river flow and debris-loading conditions, existing flat-plate screens either do not divert water or operate at only very low diversion rates. The north Delta intakes' operations will be just the opposite, and the maintenance problems could be insurmountable. The BDCP documents provide no specific insights, guidance, and analyses on this important issue.

With so much ambivalence in the BDCP documents due to a lack of empirical data to back up these decisions, how can one determine effects on fish? Because of all the unresolved uncertainties associated with the BDCP intakes, the FFTT (2011) report recommended that the effects of phasing construction of the north Delta intakes be analyzed in the EIR/EIS. The EIR/EIS subsequently did so (EIR/EIS Appendix 3F) and found that it would not be feasible to phase the construction as advocated in FFTT (2011). The inability to phase the construction greatly increases the risk to fishery resources because if the entire three-diversion facilities are completed and post-project evaluations determine critical design features have failed, impacts on salmonids could be ruinous. Building the massive facilities is an irretrievable commitment of physical and financial resources and, by their nature, significant structural modifications are implausible. It is improbable that the multi-billion dollar facilities would be removed if harmful effects on fish were discovered at a later date.

Sedimentation

The BDCP's description of the effects of the intake structures due to suspended sediment in the river and sedimentation within the facilities lacks supporting detail that will be integral to the efficacy of the project. The brief description of the facilities downplays the likely major problem that will be experienced with heavy sediment loading behind the screens. As mentioned previously, unlike most existing Sacramento River water diversions, the BDCP's three intakes will only be operated during high-flow conditions when suspended sediment in the water column will be very elevated. As a result, the three north Delta intakes will entrain enormous quantities of sediment. However, the description of the intake facilities provides an over-optimistic portrayal of how heavy sediment loads will be accommodated:

> "Water will travel in pipelines from each intake bay to a sedimentation basin and thence to intake pumping plants." (BDCP Page 4-8)
>
> "The planned operation of proposed intakes will help mitigate sediment deposition within the intake bays and conveyance conduits." (BDCP Page 4-19)

In this regard, based on my long experience and familiarity with evaluations of the 2,700 cfs Tehama-Colusa Canal (TCC) and 3,000 cfs GCID intakes, BDCP Figure 5.B.3-1 (Figure 17 below) is misleading and the portrayed design's feasibility is questionable. I participated in evaluations of sediment depositions at the TCC and GCID intakes and water velocity distributions at the GCID intake. Based on that experience, I believe that the "footprint" of the north Delta intake facilities would probably need to be much larger than illustrated in the BDCP documents. It is debatable that the extremely small sedimentation basins shown in the conceptual diagram and very briefly described in the EIR/EIS[11] could efficiently accommodate the large quantities of entrained sediment. With up to 3,000 cfs passing through the intakes, the

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[11] "The sedimentation basin would be approximately 120 feet long by 40 feet wide by 55 feet deep, and would have interior concrete walls to create separate sedimentation channels." (EIR/EIS Page 3-87)

distribution of flow into the small basins would cause high water velocities that would not allow much of the sediments to settle out of the water column; the basins appear to be too short and narrow. Likewise, the spacing between the screens and the pump intakes is extremely short and may not provide sediment-settling effects. To achieve the salmon protection criteria of approach- or through-screen velocities of $\leq$ 0.33 ft/s, the piped intakes' design, as presented, could create numerous irregularities causing "hot spots" of high approach velocities and prevent uniformity regardless of use of flow-control baffling behind the screens. Additionally, I have conducted many dozens of underwater inspections of fish screens and have observed large sediment accumulations immediately behind the screens (upstream of forebays and sediment basins) that have proven to be problematic. To summarize, the actual footprint of the each of the three intake facilities would appear to require a larger area than implied by the BDCP.

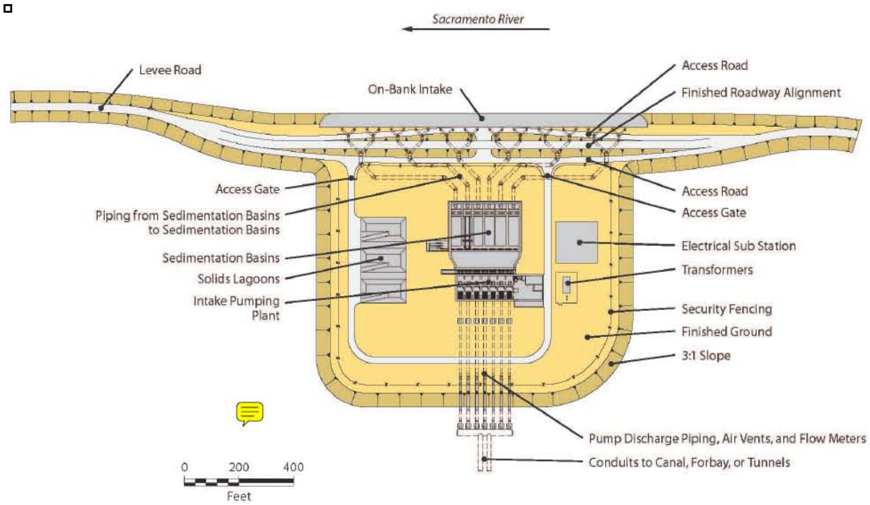

Figure 17. Conceptual intake structure for a 3,000 cfs proposed north Delta diversion (BDCP figure 5.B.3-1 Source: Adapted from TM 20-2 Rev 0 Proposed North Intake Facilities for the Draft EIS, Figure O-5. Note that length differs from actual proposed intakes.)

The following provides two empirical examples to demonstrate the foregoing concern. First, the design for the original TCC, a 2,700 cfs diversion on the Sacramento River located at the Red Bluff Diversion Dam, included a very large desilting basin at the headworks to prevent sediments from being deposited in the spawning channels of the Tehama-Colusa Fish Facilities located in the initial segments of the TCC downstream of the headworks (Figure 18). The upper portion of the TCC was designed to allow the conveyance of irrigation water and provide spawning habitats in a dual-purpose canal (which has since been abandoned) (Vogel 1983). This desilting basin was designed to settle out particles 50 microns and larger and is 0.45 miles long. Periodically, the TCC basin was dredged and the sediment was deposited into adjacent basins (Figure 18). Even with this enormous settling basin, large quantities of silt were nevertheless passed though the basin and deposited in the dual-purpose canal. The second example is a large forebay behind the GCID fish screens on the Sacramento River near Hamilton City. This design feature functions both as a settling basin to reduce silt entering the GCID main canal and provides sufficient area to accommodate uniform approach velocities through the 1,000-foot-long fish screens that include flow-control baffles (Figure 19). In both cases, the forebays are very large to accommodate less sediment loading than the north Delta intakes would experience. In sharp contrast, the design of the proposed three 3,000 cfs north Delta intakes does not accommodate any large forebays behind the fish screens to 1) contain the certain heavy silt loads or 2) have the ability to provide uniformity in screen approach velocities (Figure 17). These anticipated major problems with the north Delta intake facilities are not described in the BDCP documents nor do the documents describe how the problems would be rectified after the facilities are built. The design deficiencies and misleading information must be reconciled and corrected in the BDCP.

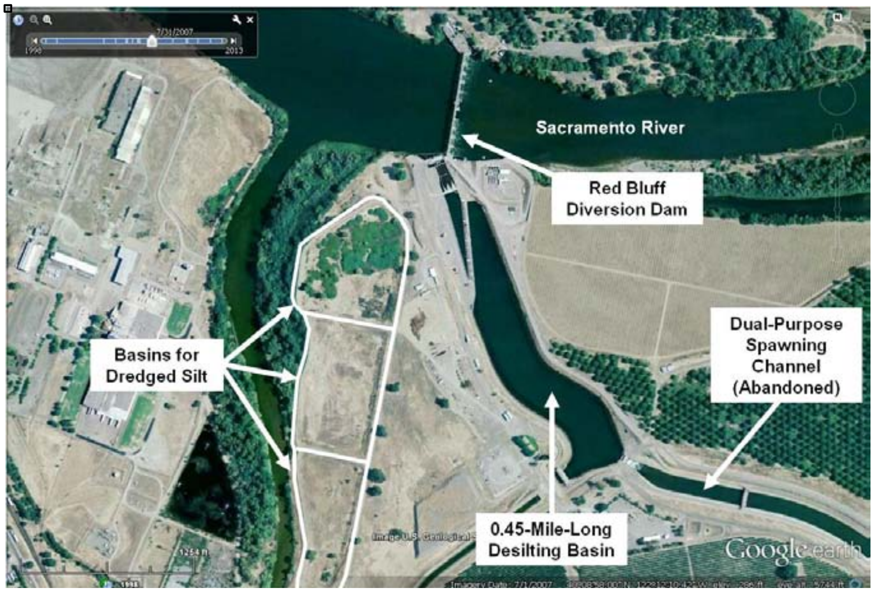

Figure 18. Aerial photograph of the Tehama-Colusa Canal headworks showing the 0.45-mile long desilting basin.

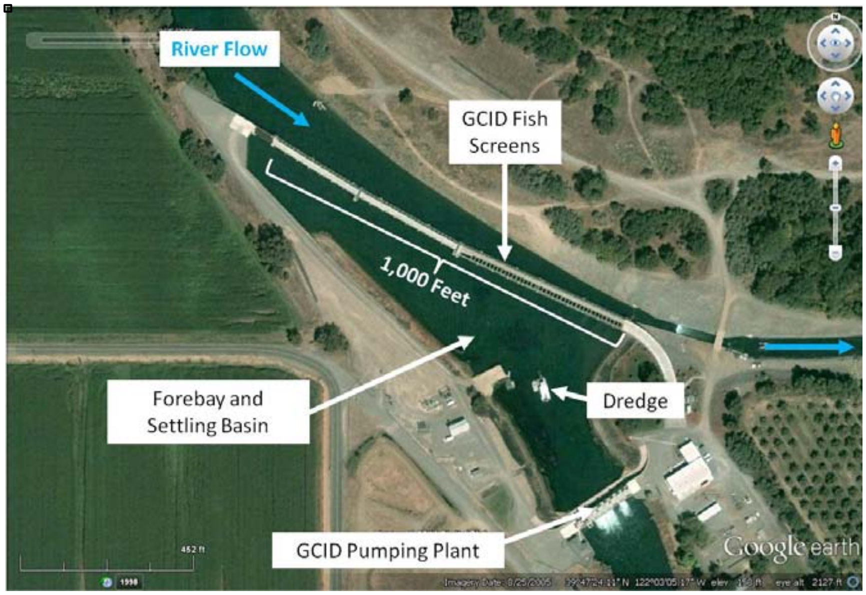

Figure 19. Aerial photograph of the GCID fish screens showing the large forebay behind the fish screens and upstream of the GCID pumping plant.

Also, there is insufficient spatial orientation for flow baffles behind the screens to perform the intended function of providing uniformity of flow distribution through the screens. This circumstance will undoubtedly produce hot spots of unacceptably high through-screen water velocities thereby creating additional hazards for young salmon by impingement. Clearly, if there is any promise of designing the north Delta intake facilities with some semblance of feasible operational capabilities, a much greater footprint for each intake may be required.

Furthermore, although the BDCP documents admit the north Delta intakes will remove large quantities of suspended sediment from the river, the documents do not adequately analyze and describe the resulting adverse impact on native fish in the Delta. Over the past three decades, there has been a reduction of turbidity (a surrogate of suspended sediment concentration) in the Delta (Hestir et al. 2010). A recent Delta Science Program workshop indicated that suspended sediment in the Delta provides significant benefits to fish. There appears to be consensus that even further reduction in turbidity and sediment in the Delta would have deleterious effects on native fish. Additionally, reduced sediment input to the Delta would also adversely impact planned fish habitat restoration projects (e.g., restoration of shallow-water habitats, wetlands restoration, etc.).

Bypass Flows

The BDCP has not adequately addressed the reduced flow in the Sacramento River downstream from the proposed multiple, large-scale water diversions positioned a short distance upstream of Sutter and Steamboat Sloughs, the Delta Cross Channel, and Georgiana Slough. When the diversions are in operation, flows in downstream areas will unquestionably be affected. And yet the BDCP provides the following incongruous statements:

> "Migration flows. Ensure that north Delta intake operations do not increase the incidence of reverse flows in the Sacramento River at the Georgiana Slough junction." (BDCP Page 3.3-139)
>
> "Operations will be managed at all times to avoid increasing the magnitude or frequency of flow reversals in Georgiana Slough." (BDCP Page 4-18)
>
> "At this point, implement Level III post-pulse bypass rule (BDCP Table 3.4.1-2) so that bypass flows are sufficient to prevent any increase in duration, magnitude, or frequency of reverse flows at two points of control: Sacramento River upstream of Sutter Slough and Sacramento River downstream of Georgiana Slough. These points of control are used to prevent upstream transport toward the proposed intakes and to prevent any more upstream transport into Georgiana Slough than under existing conditions." (BDCP Page 3.4-17)

These BDCP assertions are counter-intuitive and it is not at all clear how these measures will be accomplished.

Elsewhere in the BDCP, the documents acknowledge the physical reality of reduced flows:

> "Operation of the proposed north Delta diversions under the BDCP has the potential to adversely affect juvenile winter-run Chinook salmon through near-field (physical contact with the screens and aggregation of predators) and far-field

> (reduced downstream flows leading to greater probability of predation) effects." (BDCP Executive Summary Page 48)
>
> "Salmonids migrating down the Sacramento River generally will experience lower migration flows because of the north Delta diversions compared to existing conditions, which is a far-field effect of the north Delta diversions." (BDCP Page 5.5.3-24)
>
> "The principal BDCP effects on the mainstem Sacramento River in the Plan Area will be associated with the reductions of flow caused by operation of the new north Delta diversions. The adverse effect of this flow reduction on covered species will be minimized by maintaining minimum instream flows past the intakes, called bypass flows."
>
> "These results indicate that residence time will increase by 3 to 4 days (9 to 19%) as a result of the lower Sacramento River flow downstream of the north Delta intakes and the lower south Delta pumping under ESO for the hydrologic modeling scenarios used in the DSM2 analyses (WY 1976 through 1991)." (BDCP Page 5.3-36)

In more conflicting rationale, the BDCP suggests that reduced flow in reaches downstream of the north Delta intakes would supposedly result in more salmon entering Sutter and Steamboat Sloughs as favorable migration routes:

> "Providing an alternative migration route for salmonids (Perry and Skalski 2008) and possibly splittail, sturgeon, and lamprey that circumvents the Delta Cross Channel and Georgiana Slough, thereby reducing the likelihood of covered fish species moving into the interior Delta where they may be exposed to higher predation pressure and entrainment into the south Delta pumps.
>
> Providing high-value juvenile rearing habitat. Both slough channels support substantially more woody riparian vegetation and greater habitat diversity (e.g., water depths, velocities, in-channel habitat) than is present along the mainstem Sacramento River between Courtland and Rio Vista." … (BDCP Page 3.4-9)

Despite these purported benefits, the BDCP goes on elsewhere to provide even more conflicting statements:

> "Despite these anticipated benefits, Perry and Skalski (2009) and Perry et al. (2010) indicate that survival rates of juvenile Chinook salmon in Sutter and Steamboat Sloughs are highly variable relative to the mainstem Sacramento River. They have found that survival has been higher than, lower than, and similar to survival rates in the mainstem Sacramento River rates." (BDCP Page 3.4-9)

Therefore, how can one conclude there are benefits to salmon resulting from increased entrainment into Sutter and Steamboat Sloughs?

Adding more confusion to the topic, the BDCP states that the timing and magnitude of bypass flows for the north Delta intakes are still under consideration:

> "The magnitude of bypass flows that may be required to limit adverse effects on juvenile salmonids remains under examination by the BDCP proponents and fish and wildlife agencies." (BDCP Page 5.5.3-25 and similar statement on BDCP Page 5.5.3-20)
>
> "The exact triggers and responses for [Real-Time Operations] RTO at the north Delta diversions are still under development." (BDCP Page 3.4-28)

Additional confusion is added by the following statement:

> "The CALSIM model assumed that there would be some south Delta exports in all months and the monthly pattern of north Delta diversions is not fully explained by the bypass rules; there were many months when the north Delta diversion could have been higher than CALSIM estimated." (BDCP Page 5C.A-114)

It is unclear what this statement means. It suggests that impacts are likely greater than that modeled by the CALSIM model.

Given the foregoing circumstances, the BDCP documents fail to provide for meaningful review a comment on impacts to fish. In this case and many others, it appears that release of the BDCP documents was premature.

BDCP Effects on Tidal Prisms in the Delta

On an overall basis, it appears that the BDCP documents acknowledge that the three north Delta intakes will adversely impact flows and salmon distributions in areas downstream from the intakes. However, the discussion of DSM2-HYDRO model analyses provides confusing information that appears to suggest that the north Delta diversions would not adversely affect flows, in relation to salmon migration, in the Sacramento River at Georgiana Slough (BDCP Appendix 5.C, Part 3). It is unclear how detrimental flow conditions for salmon would not occur with reduced flows resulting from the upstream north Delta intakes. Elsewhere in the documents, it appears that the BDCP is reliant on future habitat restoration in the Delta to offset potential flow distribution perturbations (including reverse flows) by altering tidal prisms which would subsequently result in no significant net change in flow characteristics at areas such as the Sacramento River/Georgiana Slough flow split[12] but would alter flows into Sutter and Steamboat Sloughs (e.g., BDCP Page 3.2-3). The underlying assumptions appear to be on shaky grounds. The entire discussion on this topic in Appendix 5.C, Part 3 is ambiguous, confusing, and full of uncertainties. Furthermore, the BDCP states that this topic is the subject of "ongoing research"

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[12] E.g., "However, it is concluded, based on the currently available information presented above, that changes that may occur under the BDCP because of the North Delta Diversion and tidal restoration would result in neither a greater frequency of reverse flows nor a greater percentage of flow (and fish) entering the Interior Delta at this location, compared to EBC2_ELT and EBC2_LLT conditions." (BDCP Page 5C.5.3-331)

and stresses the need for improved model calibrations. Much of the existing discussion appears to be based on speculative information, considerable modeling uncertainties[13], and, perhaps, flawed model inputs and outputs. Much more specificity is necessary to adequately describe exactly where habitats would be changed, how much impact those habitat alterations would have on tidal prisms, and exactly how flow characteristics would change at Georgiana, Sutter, and Steamboat Sloughs.

The Proposed Three New North Delta Intake Fish Screens Compared to the GCID Fish Screens

The proposed north Delta intakes would have large, flat-plate screens (not facilities) similar to those used at GCID's intake farther north on the Sacramento River near Hamilton City. Notably, the physical nature of the actual screens would be similar, but the overall facilities' designs and operations would be radically different. Much of the justification for the design of the BDCP screens was ostensibly based on knowledge acquired from experience and research at the GCID screens. However, the BDCP erroneously applied and misrepresented the findings at GCID causing serious errors in the BDCP's analyses. Those fallacies were propagated throughout the BDCP resulting in fatal flaws in the BDCP's conclusions concerning effects on juvenile salmon. The following are examples.

First, the BDCP suggests that the proposed BDCP screens and the existing GCID screens would be similar:

> "The GCID fish screens are large, on-bank diversions comparable to the diversions proposed as part of the conservation strategy." (BDCP Page 5.F-20)

However, elsewhere, the BDCP states the structures are dissimilar:

> "…the north Delta diversion design and siting are considerably different [than the GCID screens]." (BDCP Page 5.F-iii)

Nevertheless, the BDCP frequently refers to the GCID screens for comparisons of features and salmon survival estimates as a basis for the north Delta intake facilities. For example:

> "The GCID screen is the closest correlate in size to the proposed north Delta intakes, and the Vogel (2008) study represents the only known observational study of Chinook salmon predation loss associated with large water diversion structures in a lotic system." (BDCP Page 5.F-22)

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[13] E.g., "There are a number of uncertainties related to large-scale restoration of tidal natural communities and transitional uplands within the Plan Area. For example, it is unknown whether the presently limiting conveyance capacity of a number of Delta channels for tidal flows may become enlarged by scouring in response to Plan Area changes in geometry resulting from habitat restoration. These factors may have consequences for the hydrodynamics at the Sacramento River-Georgiana Slough divergence and other locations." (BDCP Page 5C.5.3-331)

> "Estimates of predator abundance and predation rates [at the three proposed BDCP intakes] were developed from fish screen studies conducted at GCID (Vogel 2008)." (BDCP Page 5.F-86)

Therefore, it is highly instructive and necessary to more-accurately describe the GCID fish protective facility in comparison to the proposed BDCP intakes to clarify serious misunderstandings and misconceptions within the BDCP documents. The following provides pertinent, clarifying information.

The GCID Sacramento River pumping station is located approximately 100 miles north of the city of Sacramento on the west side of the main stem Sacramento River and 206 river miles upstream from San Francisco Bay. It is located on a side channel off the main river channel with fish screens positioned upstream of the pumping plant (Figures 20 and 21). A Fish Screen Improvement Project (Project) was constructed at the site which included (among other features):

1) an extension of the existing flat-plate screens;
2) an upgrade to the existing facility;
3) an internal fish bypass system (which was closed in 2007) to route fish through pipes and back to an oxbow outlet channel a short distance downstream of the new screens;
4) a rock training wall on the river bank opposite the screens to enhance sweeping velocities past the screens,
5) a flow-control weir in the oxbow channel (which was removed in 2007); and
6) configuration of the oxbow outlet channel to route fish back to the Sacramento River.

Additionally, a large-scale, river gradient-control structure was constructed on the main stem Sacramento River near the diversion site to ensure long-term reliability of the fish protective facilities (Figure 20) (Vogel 2008b).

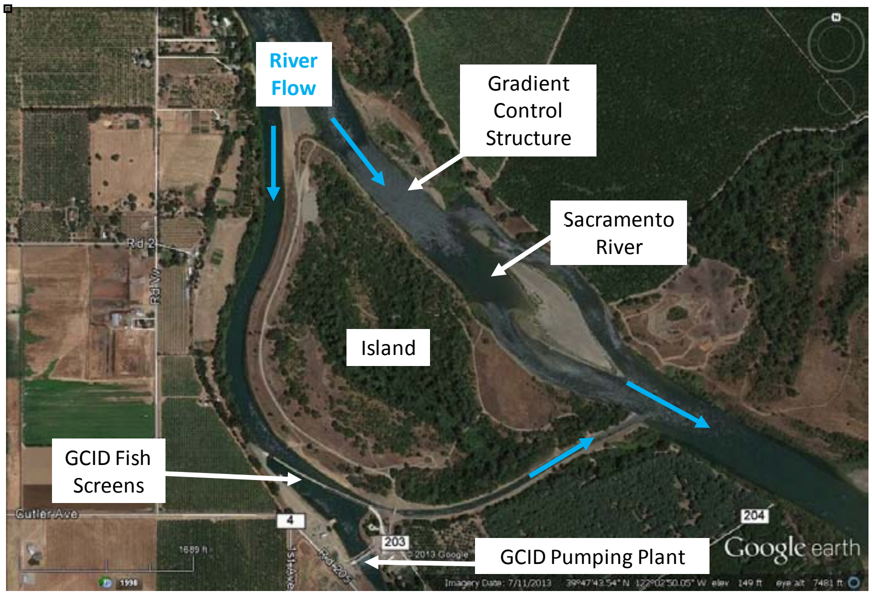

Figure 20. The GCID Hamilton City Pumping Plant and associated features of the Fish Screen Improvement Project.

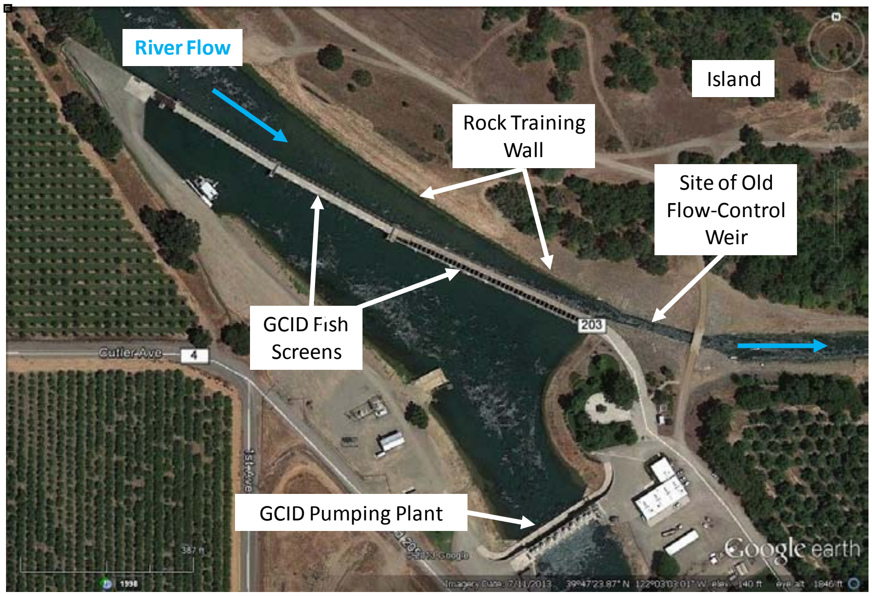

Figure 21. A close-up view of the GCID Hamilton City Pumping Plant and associated features of the Fish Screen Improvement Project.

A Fish Protection Evaluation and Monitoring Program (FPEMP) was established prior to completion of the GCID Project. A Guidance Manual was developed for the FPEMP to identify the experimental design, field methods, and equipment necessary to evaluate the biological performance of the new fish screen structure and gradient facility. The FPEMP was overseen and peer reviewed by a Technical Oversight Committee, including the California Department of Fish and Wildlife, National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, GCID and other cooperating agencies. The Guidance Manual outlined extensive studies to evaluate overall fish survival at the screens, assess fish passage at the gradient facility, and determine relative abundance and distribution of predatory fish at the gradient site and nearby areas. Specifically, field tests were structured to provide empirical data in determining the effectiveness of the fish screen improvements. Biological field testing at the site (using live juvenile salmonids) was performed under a range of riverine and pumping conditions to ensure the Project provides sufficient protection for fish under future, naturally occurring conditions.

The BDCP provides misleading and inaccurate statements concerning the GCID studies:

> "The assumed 5% loss term is based on observations of acoustically tagged hatchery-raised juvenile salmon released at the GCID screens (Vogel 2008). Approximately 5% of acoustically tagged juvenile salmon migrating past the GCID fish screen were not detected downstream of the screen, presumably because they were consumed by predators. There is uncertainty in this estimate of predation loss because the lack of detections can also be due to malfunctioning of the acoustic tags or receivers, or by juvenile salmon swimming upstream out of detection of the acoustic-tag receiver." (BDCP Page 5.F-22)
>
> "In addition, a fixed estimate of 5% predation loss at each screened intakes was used, based on predation assumptions from the Glenn Colusa Irrigation District

> (GCID) facility on the upper Sacramento River (Vogel 2008).” (BDCP Page 5.F-14)

The origin of these statements is unknown but the assertions are incorrect. Vogel (2008b) used numerous salmonid mark/recapture studies as the primary method to estimate fish survival at the GCID screens, not acoustic-tagged salmon. Although acoustic telemetry was one of the many analytical methods to evaluate the fish screens, 237 fish mark/recapture experiments using several hundred thousand juvenile salmonids were conducted over a six-year period (2002 – 2007) by releasing experimental and control groups of marked salmonids; those tests were the principal basis for developing salmonid survival estimates at the GCID screen facility in Vogel (2008b). Additionally, the BDCP and its analyses failed to report the fact that the principal source of fish mortality at GCID discussed in Vogel (2008) was attributable to a flow-control weir that had been used to provide hydraulic head differential to operate the internal fish screen bypasses. In 2007, using true adaptive management resulting from the studies, the weir was removed, the bypasses were closed, and that source of fish mortality was eliminated (Vogel 2008b).

The BDCP provides additional misleading, inaccurate, and distorted statements concerning the GCID studies:

> “Uncertainties exist for striped bass densities associated with structures. Estimates of predator abundances are based on a few underwater pictures of predators observed holding around the GCID fish screens (Vogel 2008) and extrapolated to estimate predator abundances at north Delta intakes. These predators may be Sacramento pikeminnow, not striped bass, based on Vogel’s (1995) review of GCID studies.” (BDCP Pages 5.F-15 and -16)

The statement referencing a few underwater pictures by Vogel (2008b) is inaccurate and a mischaracterization. Additionally, the suggestion that striped bass observed at GCID were actually Sacramento pikeminnow is also erroneous and misleading. Unfortunately, the BDCP analyses used incorrect information in its attempts to model potential striped bass predation on salmon at the proposed new north Delta intakes (discussed later in these comments). To be clear, the extensive research at GCID was conducted over many years and high numbers of both striped bass and Sacramento pikeminnow were observed countless times by numerous individuals using multiple field methods including electrofishing, angling, fish traps, direct underwater SCUBA observations and underwater hand-held videography, surface-deployed underwater videography, surface observations, and extensive use of a dual-frequency identification sonar camera (DIDSON^{TM}).

The concentration of striped bass in the vicinity of the north Delta screens will undoubtedly be far greater and over longer seasonal durations than observed at GCID, the latter of which is much farther upstream of the Delta. Although striped bass seasonally migrate upstream of GCID, the vast majority of the population is in the Delta, the fish’s principal freshwater habitat. High concentrations of striped bass are known to accumulate in the lower Sacramento River near structures such as a pipeline on the riverbed at Freeport just upstream of the proposed north Delta intakes (e.g., sonar camera footage showing striped bass at the pipeline:

http://www.youtube.com/watch?v=jOvjjx_10KM). Therefore, the BDCP assumptions and corresponding model results are invalid.

Although the BDCP gives confusing and conflicting information concerning how salmon survival/mortality were estimated for the proposed three north Delta intakes, those estimates were, nevertheless, based on the GCID studies (albeit, incorrectly):

> "The fixed 5% per intake loss assumption provides an upper bound of estimated losses at the north Delta diversion. Of the Sacramento Basin population of Chinook salmon smolts that reach the Delta, an estimated 3 to 10% (depending on the run) would migrate via the Yolo Bypass and would thus avoid exposure to the north Delta intakes. An estimated 12.0 to 12.8% of the migrating smolt population is assumed lost to predation, impingement, or injury as smolts emigrate past the three north Delta diversion intakes. This loss assumption, based on the Glenn Colusa Irrigation District (GCID) diversion, likely overestimates the mortality rates because the north Delta diversion design and siting are considerably different." (BDCP Page 5.F-iii)

Actually, mortality estimates at the north Delta intakes would be expected to be much higher than that observed at GCID, or just opposite of the BDCP's assumption. Because the GCID screens are located in a side channel of the Sacramento River, only a portion of the downstream migrating fish pass the screens. For example, if the side channel flow constitutes one third of the Sacramento River flow and fish are uniformly distributed with flow, only one third of the downstream migrating fish would pass the GCID fish screens. Also, downstream migrating fish originating from tributaries such as Butte Creek, Feather River, and American River are located downstream of GCID and those fish never encounter the GCID screens. Furthermore, for those salmonids passing GCID, most fish pass the site when pumping plant is not in operation or pumping is very low. Most naturally-produced salmon pass GCID's intake during the winter whereas GCID's primary diversion season is in the spring, summer, and fall.

Conversely, for the north Delta intakes, *all* of the downstream migrating fish in the entire Sacramento River basin would pass the north Delta intake screens, except during periods when the Yolo Bypass floods. Unlike GCID, most of the salmonids passing the north Delta intakes will likely do so when the diversions are in operation. Most importantly, in sharp disparity to the GCID fish screens, the north Delta intake fish screens do not possess the critically important features to control hydraulic conditions and many other features for safe salmon passage.

Because the BDCP analyses relied so heavily on the GCID studies and inaccurately portrayed that research, the entire discussion relative to the GCID screens must be rewritten to accurately represent the research findings. Furthermore, the BDCP analyses would be informed and benefit from much of the additional relevant research at GCID that was not used by the BDCP in analyzing potential effects of the north Delta intakes on salmon. Again, the BDCP has not used the readily available best available science on a topic critically essential for the BDCP analyses; this serious deficiency is not disclosed in the documents. Although the sites are significantly different, the research at GCID, spanning 14 years, provides valuable information on the topic of fish protection at large fish screens. The following technical reports, most of which have been peer reviewed, are examples:

- Vogel, D.A. and K.R. Marine. 1995. 1994 biological evaluation of the new fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Natural Resource Scientists, Inc. February 1995. 77 p. plus appendices.

- Vogel, D.A. and K.R. Marine. 1995. 1995 evaluation of juvenile Chinook salmon transport timing in the vicinity of the new fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Natural Resource Scientists, Inc. Prepared for Glenn-Colusa Irrigation District, Willows, California. November 1995. 34 p.

- Vogel, D.A. and K.R. Marine. 1995. A technical memorandum on 1995 predation evaluations near the GCID Sacramento River pump station. Natural Resource Scientists, Inc. Prepared for Glenn-Colusa Irrigation District, Willows, California. December 1995. 17 p.

- Vogel, D.A. and K.R. Marine. 1997. Fish passage and stress effects on juvenile Chinook salmon physiology and predator avoidance abilities. Technical report prepared as supporting research for the proposed Glenn-Colusa Irrigation District fish screens. Natural Resource Scientists, Inc. February 1997. 32 p. plus appendices.

- Vogel, D.A. 1998. Riverine habitat monitoring data in the Glenn-Colusa Irrigation District's oxbow bypass channel on the Sacramento River. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. 55 p.

- Vogel, D.A. 2000. Fish monitoring in the vicinity of the future Glenn-Colusa Irrigation District gradient facility on the Sacramento River, 1998 - 1999. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. September 2000. 29 p. plus appendices.

- Montgomery Watson, Natural Resource Scientists, Inc., and Jones and Stokes Associates. 2000. Guidance Manual for the Glenn-Colusa Irrigation District Fish Protection Evaluation and Monitoring Program. Prepared for the multi-agency Technical Oversight Committee. October 2000.

- Vogel, D.A. 2003. Fish monitoring in the vicinity of the Glenn-Colusa Irrigation District Sacramento River gradient facility, 1998 – 2001 (pre- and post-construction). Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. February 2003. 45 p. plus appendices.

- Vogel, D.A. 2003. 2002 biological evaluation of the fish screens and gradient facility at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. October 2003. 27 p.

- Vogel, D.A. 2005. 2003 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. January 2005. Natural Resource Scientists, Inc. 37 p.

- Vogel, D.A. 2005. 2004 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. May 2005. Natural Resource Scientists, Inc. 24 p.

- Vogel, D.A. 2006. 2005 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. May 2006. 40 p.

- Vogel, D.A. 2007. 2006 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. June 2007. 24 p.

- Vogel, D.A. 2008. Biological evaluations of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station, 2002 – 2007. Final Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. April 2008. 48 p.

- Vogel, D.A. 2008. Technical memorandum prepared for the multi-agency Technical Oversight Committee for the GCID Fish Protection Evaluation and Monitoring Plan Biological Evaluations. Natural Resource Scientists, Inc. December 8, 2008. 5 p.

Additionally, the following peer-reviewed technical reports provide informative material for the BDCP concerning fish protection at Sacramento River diversions.

- Vogel, D.A. 1995. Losses of young anadromous salmonids at water diversions on the Sacramento and Mokelumne rivers. Report prepared for the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. January 1995. 34 p.

- Vogel, D.A. 2013. Evaluation of fish entrainment in 12 unscreened Sacramento River diversions, Final Report. Report prepared for the CVPIA Anadromous Fish Screen Program (U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation) and Ecosystem Restoration Program (California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, NOAA Fisheries). Natural Resource Scientists, Inc. July 2013. 153 p.

Fish Survival Rates at the North Delta Intakes

The estimates of juvenile salmon mortality at the three north Delta intakes have errors that likely underestimate impacts on salmon. The principal adverse effects to young salmon at the intake screens are described in the BDCP as likely attributable to predation:

> "The north Delta export facilities on the banks of the Sacramento River likely will attract piscivorous fish around the intake structures. Predation losses at the intakes were estimated using striped bass bioenergetics modeling of salmon and splittail predation, and a fixed 5% per intake assumed loss of Chinook salmon smolts migrating past the facilities. While bioenergetics modeling predicted high numbers of juvenile Chinook consumed (tens of thousands), the population level effect is minimal (less than 1% of the annual Sacramento Valley production). The bioenergetics model likely overestimates predation of juvenile salmon and splittail because of simplified model assumptions, further indicating potential predation losses at the north Delta would be low." (BDCP Page 5.F-iii)
>
> "Potential predation losses are estimated using two methods: bioenergetics modeling and estimates based on a presumed 5% loss per intake." (BDCP Page 5.F-75)

As an initial matter, the discussion of the percentage of juvenile salmon mortality at the north Delta intakes is very confusing and conflicting. On one hand, the predation mortality is assumed to be 5% for each intake based on assumptions buried in the appendices (e.g., BDCP Pages

5.5.3-28 and -29). This would be equal to an overall salmon mortality of 14.3% past all three intakes.[14] On the other hand, in the main body of the BDCP, overall salmon mortality in the river reach past all three intakes is assumed to be only 5% (or only 1.7% per intake) and is used as the final estimate in the modeling effort (e.g., BDCP Page 3.3-139, BDCP Page 3.3-151, BDCP Page 4-18). For reasons described in comments on CM1, such a low, optimistic mortality estimate is unlikely.

It appears that the BDCP chose the lowest estimate of salmon mortality because assumptions of higher salmon mortality would not allow BDCP fish benefits to "pencil out". This very large discrepancy is not explained or justified in the BDCP. In order to provide a more-balanced portrayal of estimated salmon mortality, it is recommended that the calculations be bracketed from a low to high[15] estimate per intake. For example, the BDCP could model the mortalities with estimates of 1%, 5%, and 10% per intake or overall mortality through river reach of intakes of 3%, 14.3%, and 27.1%, respectively.[16] Also, there is reason to believe that there may be considerable variability in salmon mortality among the three intakes. For example, the highest mortality would likely occur at the downstream-most screen because the fish would be more concentrated with river flow due to the upstream water withdrawals from the other two intakes (discussed previously).

Also, the BDCP must assume that predation mortality at the north Delta intakes would occur even when the diversions are not in operation. It does not appear that impact on salmon was taken into account. Although impingement and entrainment would not occur during non-diversion periods, predation mortality on salmon would still be evident for the previously-described reasons.

Unequal Transfer of Adverse Impacts to Sacramento River Basin salmonids from the south Delta to the North Delta

It seems that the premise of the purported BDCP benefits for Sacramento River salmonids resulting from the three north Delta diversions is to alleviate present-day adverse impacts caused by the south Delta diversions (e.g., EIR/EIS Page 31-5). The BDCP concept is to reduce south Delta diversions in wet years by diverting more water in the north Delta and then in dry years, rely on the south Delta diversions instead of the north Delta diversions (e.g., BDCP Page 5.B-11). Unfortunately, this is just opposite of favorable conditions for Sacramento River basin salmonids. In wet years, Sacramento River salmonids have a higher survival rate than in dry years. Reducing Delta inflow during wet years as a result of the north Delta diversions would be expected to reduce survival rates for Sacramento River basin salmonids, not increase them. Furthermore, under existing conditions, only a portion of the Sacramento River basin salmonids are adversely impacted by south Delta exports whereas the north Delta diversions will influence a far greater portion of the salmonids resulting in disproportionate impacts. Misleading statements in the BDCP suggest overall benefits to salmon resulting from reduced entrainment as

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[14] The BDCP apparently mistakenly assumed the cumulative survival as 12% (BDCP Pages 5.5.3-28 and -29).

[15] "High" is used only as a relative comparison among three scenarios postulated here. For example, actual mortality could be higher than 10%.

[16] **Scenario 1:** $.99^3$ x 100% = 99% survival or 1% mortality. **Scenario 2:** $.95^3$ x 100% = 85.7% survival or 14.3% mortality. **Scenario 3:** $.90^3$ x 100% = 72.9% survival or 27.1% mortality.

a result of the BDCP. Entrainment reduction, as portrayed in the BDCP, is linked to the south Delta export facilities, not north Delta intakes. Entrainment reduction at the south Delta facilities does not offset the higher adverse impacts caused by impingement and predation anticipated at the north Delta intakes.

These problems are alluded to in the BDCP documents but they are not expanded upon at appropriate, more-prominent places. For example:

> "Improved flow management will be achieved primarily through relocation and operation of the primary point of diversion to the north Delta. This change in water operations is expected to reduce entrainment in the south Delta but may increase impingement and predation-related losses in the north Delta depending upon water- year type and model used to evaluate these elements (Appendix 5.B, *Entrainment*)." (BDCP Page 3.3-148)

New North Bay Aqueduct Diversion Impacts

The BDCP also proposes to provide a new, alternative intake for the North Bay Aqueduct:

> "Combined operations of a new intake on the Sacramento River and the existing intake at Barker Slough will be included under covered activities for future peak demand of up to 240 cfs." (BDCP Page 4-29)
>
> "Changes to the North Bay Aqueduct's Barker Slough Pumping Plant and its proposed alternative intake on the Sacramento River will represent no change to this attribute for salmonids because the intake is currently screened and will remain so in the future, at both locations." (BDCP Page 5.5.3-18)

It is not clear if the effects of this new intake on Sacramento River salmonids were evaluated. If not, there should be analyses of the effects of that intake resulting from potential impingement, predation, and reduced bypass flows downstream of the new diversion.

Conservation Measure 2 (CM2): Yolo Bypass Fisheries Enhancement

Conservation Measure 2 is described in the BDCP as a key element of the strategy to improve survival of covered fish species. However, as described in Appendix 3D, Monitoring and Research Actions, a primary incertitude with this measure is, "Do the modifications at Yolo Bypass function as expected, and if so, how effective are they?" (BDCP Page 3.D-30). To address this, the BDCP identifies 10 main "Potential Research Actions". Despite having no idea of the level of success, the BDCP advances this measure under the strong assumption it will bring about major benefits to fishery resources. Although inundation of the Yolo Bypass under certain conditions may generate favorable conditions for salmon, it is important for the BDCP to not overstate the currently unknown benefits and portray the potentially positive effects on salmon with a high degree of confidence.[17] For example, the BDCP states:

> "Growth and survival of larval and juvenile fish can be higher within the inundated floodplain compared to those rearing in the mainstem Sacramento River (Sommer et al. 2001b)." (BDCP Page 3.4-41, BDCP Page 3.4-42, EIR/EIS Page 3-122
>
> "However, an increase in the frequency, duration, and extent of inundation of the Yolo Bypass will be achieved and will contribute to an increase in the extent of suitable rearing habitat and the abundance of food available to juvenile salmonids, which is expected to contribute to an increase in survival." (BDCP Page 3.3-143)
>
> "Shallow-water habitat of floodplains provides for higher abundances of food and warmer temperatures which promote rapid growth. This results in larger out-migrants (Sommer et al. 2001a, 2001b), which presumably have higher survival rates in the ocean compared to mainstem Sacramento River out-migrants." (BDCP Page 5.5.3-1)
>
> "The Yolo Bypass provides a relatively high survival migration route through the lower Sacramento River." (BDCP Pages 5.5.4-3 and -4)
>
> "Sommer and coauthors (2001) examined the survival issue during 1998 and 1999 studies by conducting paired releases of tagged juvenile salmon into the Yolo Bypass and the Sacramento River. They found that the Yolo Bypass release groups had somewhat higher survival indices than the Sacramento River." (BDCP Page 5.F-80)
>
> "Other studies indicate that the relative survival of Chinook fall-run fry migrating through Yolo Bypass to Chipps Island was on average 50% higher than fish passing over the comparable section of the Sacramento River (Sommer, Harrell, et al. 2001)." (BDCP Page 3.3-143)

An examination of the original source document reveals the prior statements are incorrect in the level of conviction:

> "Sommer et al. (2001) examined the survival issue by doing paired releases of juvenile coded-wire-tagged salmon in Yolo Bypass and Sacramento River to obtain comparative data. They found that the Yolo Bypass release groups had somewhat higher survival indices than Sacramento River fish in both 1998 and 1999, but the sample size (n=2 paired releases) was too low to demonstrate statistical significance." (Sommer et al. 2001)

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[17] This discussion is not intended to refute the assumption of potential importance of salmon rearing in the Yolo Bypass, but rather point out that the BDCP should be more cautious and scientifically objective in its discussion and analyses of the topic.

Also, the BDCP did not report the differing salmon survival information available in a more-recent report by Sommer et al. (2005). In a comparison of the survival of groups of coded-wire tagged salmon released into the Yolo Bypass with salmon released into the Sacramento River downstream of the Bypass, Sommer et al. (2005) found that estimated survival of fish released in the Yolo Bypass was higher in 1998, similar in 1999, and lower in 2000 (Table 1). This pattern of overstating positive results and downplaying negative results is prevalent in the BDCP documents and analyses.

Table 1. Number of coded-wire tags recovered in the ocean sport and commercial fisheries for Chinook salmon released in the Yolo Bypass and Sacramento River. The total number of tagged fish released in each location for each year is shown in parentheses. The survival ratio is calculated as the number of Yolo Bypass recoveries divided by the number of Sacramento River recoveries. (Table from Sommer et al. (2005)

Release Group	1998 (53,000)	1999 (105,000)	2000 (55,000)
Yolo Bypass	75	136	27
Sacramento River	35	138	47
Survival Ratio	2.14	0.99	0.57

In yet another example of the BDCP overemphasizing or mischaracterizing potential benefits of the BDCP, it states:

> "In the Yolo Bypass, Sommer et al. (2005) found the potential stranding losses are offset for juvenile Chinook salmon by the improvement in rearing conditions." (BDCP Page 5C.5.4-7)

In fact, the authors of that source document did not make that conclusive statement:

> "In the case of highly variable seasonal environments such as floodplains, stranding losses might cause excessive mortality in some years, but the risks ***may be*** offset by increased rearing habitat and food resources in other years (Sommer et al. 2001b, Brown 2002) (emphasis added)."

This is another example of the BDCP overstating potential fish benefits and understating possible detriments.

Although the BDCP CM2 is portrayed as one of the largest benefits to juvenile salmon that may result from the BDCP, obscure, contrary information buried throughout the BDCP documents indicates the benefits may be unsubstantial or could be offset by negative impacts at the north Delta intakes. For example, BDCP Table 5.F.6-5 (below) suggests overall negative outcomes for salmon, but downplays those impacts elsewhere in the BDCP.

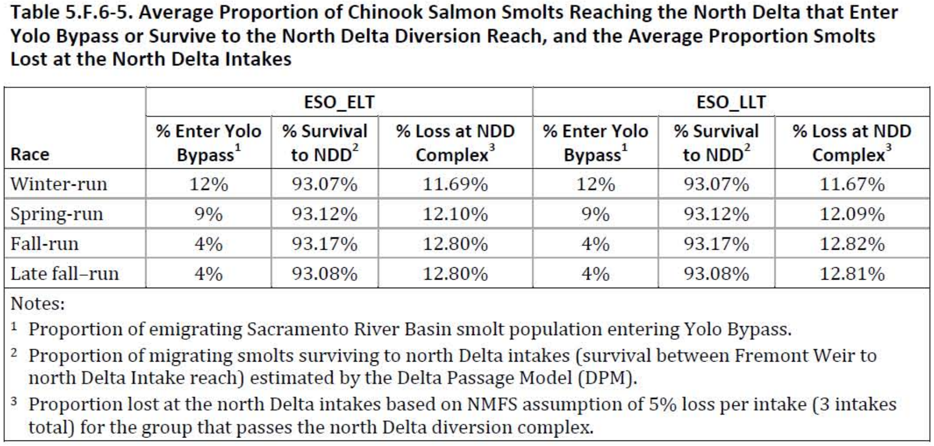

Table 5.F.6-5. Average Proportion of Chinook Salmon Smolts Reaching the North Delta that Enter Yolo Bypass or Survive to the North Delta Diversion Reach, and the Average Proportion Smolts Lost at the North Delta Intakes

Race	ESO_ELT % Enter Yolo Bypass[1]	 % Survival to NDD[2]	 % Loss at NDD Complex[3]	ESO_LLT % Enter Yolo Bypass[1]	 % Survival to NDD[2]	 % Loss at NDD Complex[3]
Winter-run	12%	93.07%	11.69%	12%	93.07%	11.67%
Spring-run	9%	93.12%	12.10%	9%	93.12%	12.09%
Fall-run	4%	93.17%	12.80%	4%	93.17%	12.82%
Late fall–run	4%	93.08%	12.80%	4%	93.08%	12.81%

Notes:

[1] Proportion of emigrating Sacramento River Basin smolt population entering Yolo Bypass.

[2] Proportion of migrating smolts surviving to north Delta intakes (survival between Fremont Weir to north Delta Intake reach) estimated by the Delta Passage Model (DPM).

[3] Proportion lost at the north Delta intakes based on NMFS assumption of 5% loss per intake (3 intakes total) for the group that passes the north Delta diversion complex.

> "In summary, the DPM results for winter-run Chinook salmon demonstrate that survival under the ESO scenarios generally was similar to, or slightly lower than, that of the EBC scenarios because there was a balance between elements contributing to higher survival (greater use of the Yolo Bypass and lower south Delta exports under ESO scenarios) and elements contributing to lower survival (lower survival in the Sacramento River mainstem and Sutter-Steamboat Sloughs because of the north Delta diversions under ESO scenarios)." (BDCP Page 5C.5.3-66)

The BDCP documents suggest that a primary benefit of CM2 is to "route" more salmon through the Yolo Bypass to avoid potentially negative effects resulting from exposure to the three north Delta intakes. For example:

> "The proportion of the population that may use the Yolo Bypass as an alternate migration corridor, as opposed to the mainstem Sacramento River, may be relatively small, but those fish that do migrate through the Yolo Bypass will not be exposed to the north Delta intakes." (BDCP Page 3.3-141)
>
> *"CM2 Yolo Bypass Fisheries Enhancement* intends to improve passage at the Fremont Weir and increase Yolo Bypass inundation, which may reduce predation risk on migrating covered fish by providing a migration route with potentially lower predation and entrainment risk (i.e., avoiding the north and south Delta diversions)." (BDCP Page 5.F-6)

These assumptions may ultimately be true if the Fremont Weir facilities are built. However, it is not clear if the BDCP analyses and modeling efforts accounted for the fact that, because of reduced flows in the Sacramento River downstream of Fremont Weir, the salmon remaining in the river will be more concentrated and may suffer higher mortality rates compared to the existing environmental baseline. If this circumstance was not analyzed, it should be addressed. If the scenario was addressed, the description of the analyses should be made clearer.

The BDCP documents should re-examine the specific spatial-temporal distribution of fry and juvenile salmon (all runs) and steelhead that may enter the Yolo Bypass under different water-year types. There appear to be discrepancies at different locations in the documents. This is important because those errors would carry through to subsequent analyses of potential benefits or detriments to the different runs and species. In this regard, an excellent database on the emigration of juvenile salmon has been developed by CDFW in the lower Sacramento River. CDFW operates two eight-foot-diameter rotary screw traps a half mile downstream of Knights Landing at Sacramento River mile 89.5. Among other purposes, the CDFW fish monitoring program is conducted to determine the timing and relative abundance of juvenile anadromous salmonids emigrating from the upper Sacramento River system (Vincik and Bajjaliya 2008). While the BDCP documents mention this sampling program and used some of the data in part, it is not clear if the BDCP fully utilized the appropriate data for the CM2 analyses and fish models (discussed later in comments on the BDCP fish models).

Juvenile salmon downstream migrations tend to occur in groups and pulses; these pulses may correspond to increased flow events and turbidity (Vogel 2011a, 2012b). For example, USFWS salmon research by Kjelson *et al.* (1982) and Vogel (1982, 1989) reported increased downstream movements of Chinook fry corresponding to increased river flows and turbidity, respectively. Young Chinook salmon may migrate downstream from the mainstem Sacramento River and its tributaries into the Sacramento-San Joaquin Delta as pre-smolts (fry and parr) or as smolts. The majority of the salmon emigration during wet winter conditions occurs during January through March (Vogel and Marine 1991). Storm events increase river flow and turbidity which causes many salmon to either volitionally or non-volitionally move from the upper river to the Delta. A later emigration of juvenile salmon occurs during spring as smolts, if the fish have not already left the primary rearing grounds in the upper river (Vogel 2013). Those characteristics are clearly demonstrated in detail by the CDFW fish sampling program. It appears that the BDCP documents used a more-generalized, composite type of analysis (including the sections on fish modeling) instead of a more-detailed scrutiny of salmon run emigration variability (using the CDFW database) in relation to specific hydrologic and riverine conditions (e.g., BDCP Pages 5C.4-46-47). Again, this should be clarified in the BDCP documents and checked for consistency.

Fremont Weir Fish Passage

CM2 is not possible without remedial fish passage measures at Fremont Weir in the northern Yolo Bypass. There are two primary issues with Fremont Weir fish passage:

1) The blockage of upstream migrating adult anadromous fish (salmon and sturgeon) at the weir when flows over the weir cease.
2) The passage of juvenile salmon over the weir into the Yolo Bypass.

The BDCP has largely tied these two issues together, making it difficult to evaluate the topics independently. For example, it is unclear what specific measure or suite of measures would be implemented at Fremont Weir to improve fish passage. At different locations in the BDCP documents, there are discussions of “notching” the weir, lowering a portion of the weir, modifying the weir, installing an operable gate facility, installing new weir gates, installation of a gated seasonal floodplain inundation channel, adding new adult salmon ladders, adding new adult sturgeon ladders, evaluating experimental sturgeon ramps, adding “auxiliary” fish ladders, etc. The BDCP appears to throw a hodgepodge of fish passage concepts at this issue, confusingly juxtaposing different jargon, with little regard as to the feasibility or practicality of the potential measures and how the different concepts would be integrated or used independently. Making the topic even more difficult to assess is that the BDCP provides no details on the designs, operations, or effectiveness of the various measures:

> "The efficacy of the passage improvements at the Fremont Weir and other locations in the Yolo Bypass (e.g., Lisbon Weir) cannot be estimated but will be monitored, and adjustments will be made through adaptive management." (BDCP Page 3.3-145)
>
> . .. should improve [sturgeon] passage over Fremont Weir, although there is low certainty that this will occur because those attributes have not yet been identified." (BDCP Page 5C.5.3-343)
>
> "Evaluations of the impacts of improvements to the Fremont Weir to increase inundation of the Yolo Bypass and reduce passage delays at the Fremont Weir have shown positive and negative effects." (BDCP Page 3.3-153)

The entire discussion of Fremont Weir fish passage should be reorganized to clarify (in a logical, sequential format), exactly what is being proposed with details on each separate proposal, including the pros and cons, and how the different measures would work independently or in concert.

Importantly, rectifying the problem of adult salmon blockage at Fremont Weir should (and likely will) occur independent of the BDCP. There is no reason why this dilemma for fish cannot be pursued absent the BDCP. This predominant problem for salmon has been known for many decades. The existing so-called Fremont Weir fish ladder is really nothing more than a solitary, very small, rectangular notch in the weir (Figure 22). A variety of non-controversial measures could be implemented to significantly reduce this problem, but no progress has been made. The 2009 NMFS Biological Opinion requires DWR and USBR to improve salmon passage at the site[18]. Progress has languished and ongoing destructive impacts to salmon continue. Other fish restoration programs (e.g., CVPIA) could employ actions to improve fish passage at the weir separate from the BDCP implementation.

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[18] Reasonable and Prudent Alternative Action I.7 (Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass).

Figure 22. The Fremont Weir “fish ladder”. Photo by Dave Vogel.

Additionally, adult fish stranding has been known to occur in a deep pool just downstream of the weir for many years (Figures 23 and 24). This site is on California State land and could easily be filled in to eliminate stranding, but no progress has been made.

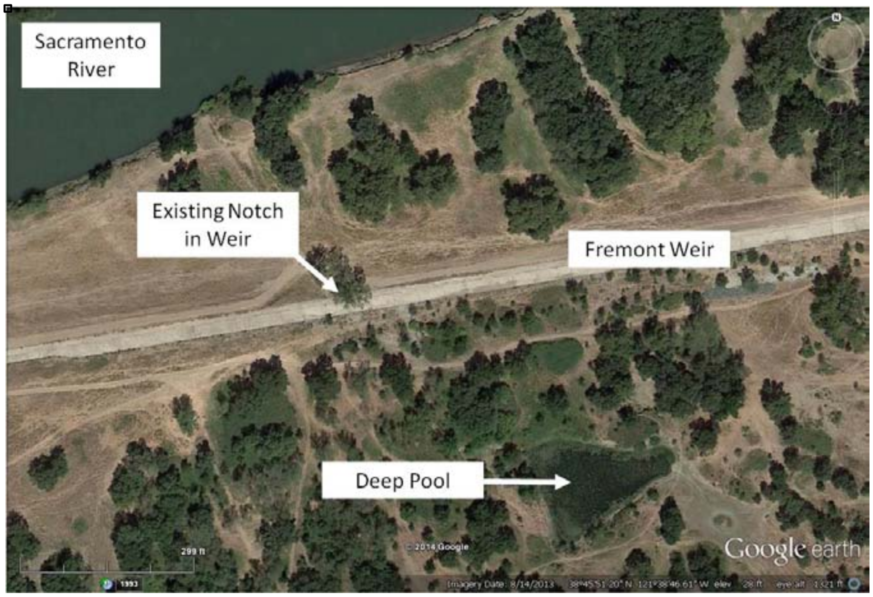

Figure 23. Aerial photograph of the deep pool just downstream of Fremont Weir where adult fish have been stranded.

Figure 24. Deep pool just downstream of Fremont Weir where adult fish have been stranded (see Figure 23). Photo by Dave Vogel.

Furthermore, there are culverts or unimproved road crossings on the northeast side of the Yolo Bypass in the Tule Canal that can trap juvenile salmon when flood flows recede in the Bypass (Figure 25 and 26). When entrapped upstream of these culverts or crossings, salmon perish from eventual warm water temperatures or predation, unless subsequent flooding of the Bypass occurs the same season. Timing of the flooding events cannot be controlled but physical features in the Tule Canal can be altered. These areas can be easily fixed at relatively low cost and are non-controversial. For example, operable gates combined with new road crossings would allow salmon to emigrate and still maintain the integrity of the crossings.

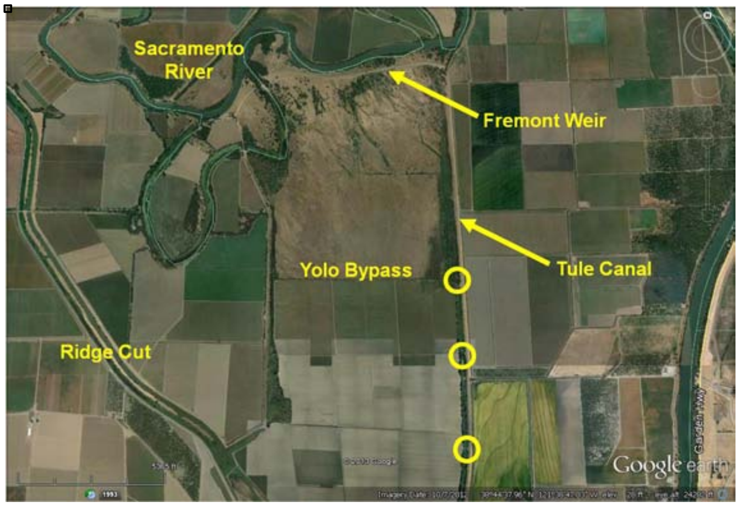

Figure 25. The northern portion of the Yolo Bypass showing the locations (circles) where new structures would be installed in the Tule Canal to improve juvenile salmon survival.

Figure 26. A culvert and unimproved road crossing in the Tule Canal. Photo by Dave Vogel.

Despite the 2009 NMFS Biological Opinion, there does not appear to be sufficient incentive by appropriate agencies to rectify these significant problems at this time. Remedial actions do not have to wait for the BDCP and could begin now in an incremental fashion. This false dichotomy presents CM2 as an all-or-none package which delays significant fishery restoration actions. If these problems, and others discussed in these comments, are fixed in advance of the BDCP, the potential fish benefits of the BDCP become less positive.

Adult Salmon Straying into the Colusa Basin Drain (CBD)

An important issue that continues to be unresolved in the BDCP is the serious problem with straying of adult salmon into the CBD. For those salmon that are attracted to flows exiting the southern portion of the Yolo Bypass in northern Cache Slough, some apparently enter the Ridge Cut and end up stranded in the CBD and perish. With increased flows into the Yolo Bypass resulting from the "notch" in Fremont Weir, more adult salmon may end up straying into the CBD without corrective measures. First, with increased flow entering Cache Slough, more adult fish would be expected to be attracted into the Bypass and if those fish are attracted to flows exiting the Ridge Cut and not the Fremont notch, those fish cannot re-enter the Sacramento River. Second, even with a notch in the weir, when flows subsequently recede to elevations lower than the notch, there still will be a threshold when fish passage has to be accommodated to prevent fish stranding. The BDCP does not provide any specific recommended solution for this problem even though increased frequency of Yolo Bypass inundation may exacerbate the problem. Instead, the documents recommend constructing and testing un-described, flood-neutral fish barriers "to prevent fish from straying into Knights Landing Ridge Cut and the Colusa Basin Drain." (EIR/EIS Page 3-127). Here again, much like the remedial actions described above, this action could be undertaken currently, and need not be delayed for the BDCP.

Relationship to the NMFS (2009) Biological Opinion (BiOp)

It is unclear why the BDCP apparently believes that DWR and USBR need not pursue the reasonable and prudent alternatives (RPAs) in the 2009 NMFS Biological Opinion related to upstream and downstream fish passage in the Yolo Bypass separately from the BDCP. The BDCP in fact argues that the Yolo Bypass RPAs will only be done through the BDCP and not taken up independently as indicated by the actuality that those RPAs were not included in the BDCP environmental baseline and other statements in the BDCP documents (e.g., EIR/EIS Pages 3-44 and 3-45). The BDCP largely claims the CM2 measures will provide bigger and better benefits for fish and, therefore, it makes more sense to only follow those measures collectively through the BDCP and not the 2009 NMFS RPAs. Additionally, with the advent of an EIR/EIS specific to Yolo Bypass fisheries enhancements, the BDCP suggests that process will take many years and cannot be accommodated through the 2009 NMFS RPAs. A progress report on the Yolo Bypass Salmonid Habitat and Fish Passage EIR/EIS at a March 20, 2014 meeting of the Yolo Bypass Fishery Enhancement Planning Team indicated that process is still in its infancy and substantial delays are expected even beyond that indicated in the BDCP. The BDCP also asserts that regulatory permits for the Yolo Bypass RPAs and the BDCP will take many years, and therefore, the agencies may as well pursue those permits under just one time frame: the BDCP's.

The BDCP evidently has inextricably linked BDCP CM2 to the 2009 NMFS BiOp Yolo Bypass RPAs such that DWR and USBR have no intention of pursuing those actions independently of the BDCP. It begs the question: What if the BDCP is not implemented? Many years will (and already) have passed without pursuit of beneficial actions for anadromous fish (particularly threatened and endangered fish) (e.g., reduced blockage of salmon at Fremont Weir and fish stranding discussed previously). There is nothing to prevent DWR and USBR from pursuing incremental beneficial actions on the NMFS RPAs such as those described above. The prominent step of "notching" the Fremont Weir to provide up to 6,000 cfs into the Yolo Bypass is the one measure that appears to be holding up progress toward implementation of all the other beneficial actions that are lower in cost, could be implemented in a more-rapid time frame, are much less controversial, and have unquestionable, immediate benefits to salmon. There is no need to link all of the associated actions within CM2 into a single package. The BDCP appears to be claiming credit for many Fremont Weir/Yolo Bypass improvements that are supposed to occur under the NMFS BiOp.

Conservation Measure 6 (CM6): Channel Margin Enhancement

BDCP CM6, channel margin habitat improvements, show promise for juvenile salmon rearing in the Delta, but it is not presently known exactly how to accomplish that objective. The BDCP touts admirable advocacy for providing benefits for salmon, but also acknowledges the lack of confidence on exactly how to do so:

> "There is uncertainty, however, about the effectiveness of channel margin restoration to increase the survival of juvenile salmonids passing through the Delta. Enhancement of 20 linear miles of channel margin was deemed to be

> sufficient to determine the effectiveness of enhancing channel margin habitats to increase survival." (BDCP Page 3.A-37)

The BDCP suggests adding woody debris at channel margins in the Delta as a means to increase rearing habitat quantity and quality for salmonids:

> "Install large woody debris (e.g., tree trunks, logs, and stumps) into constructed benches to provide physical complexity. Use finely branched material to minimize refuge for aquatic predators. Large woody debris will be installed to replace debris lost during enhancement; woody debris also is expected to increase or be replaced over time through recruitment from adjacent riparian vegetation." (BDCP Page 4-40)

Although such measures have demonstrated to work well for juvenile salmon in upstream riverine habitats, those practices have yet to prove success in the Delta. Such measures may actually create ideal conditions for predatory fish and worsen conditions for salmon in the Delta. The BDCP acknowledges this concern:

> "Because actions under CM6 have the potential to provide habitat for nonnative predatory fish, monitoring will evaluate the use of enhanced channel margin sites and associated woody debris by predators." (BDCP Page 4-40)

It is recommended that pilot projects on this measure be implemented and evaluated soon in the Delta; it should not wait for the BDCP.

Alternatively, the BDCP ought to provide more emphasis on the measure to increase the quantity and quality of salmon rearing habitats in the Delta channel margins through set-back levees and shallow-water habitats that are presently severely lacking in the region. As mentioned by Lindley et al. (2009): "One of the most obvious alterations to fall Chinook habitat has been the loss of shallow-water rearing habitat in the Delta." In Delta studies where fish sampling to compare shallow beaches with rip-rapped zones was achieved, salmon fry densities were higher in shallow beach areas (McLain and Castillo 2009). An obvious restoration measure which should be pursued to a larger degree because of its high probability of success is the re-creation of shallow, near-shore water habitats that juvenile salmon favor in the Delta (as contrasted to flooded islands). Importantly, these sites must be designed to avoid creation of predatory fish habitats and established in locations likely to be utilized within the principal fish migration corridors (Vogel 2011a, 2012a).

Creation of new shallow-water rearing habitats would likely have considerable merit toward salmon restoration. The Golden State Salmon Association has proposed such projects that could be incorporated into the BDCP process or other fishery restoration programs (Figure 27).

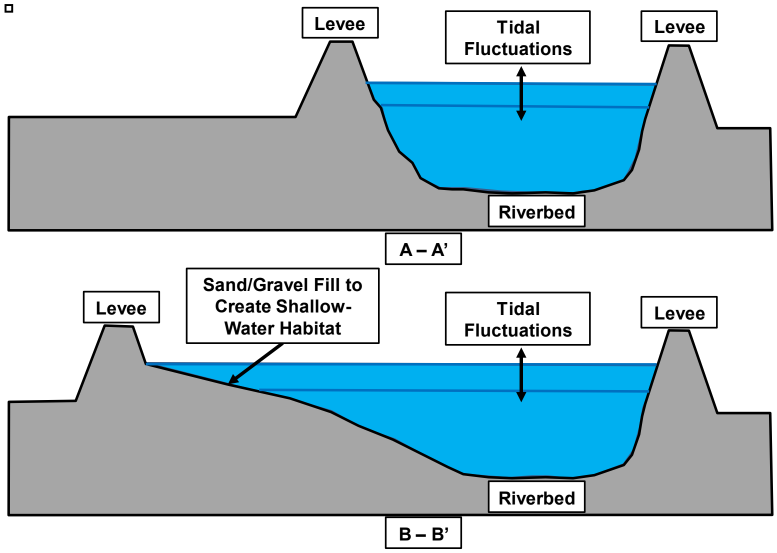

Figure 27. Conceptual before and after cross-sectional channel profiles of a shallow-water habitat restoration site with a set-back levee. Figure from Golden State Salmon Association Project Proposal D.15: Re-create shallow-water rearing habitats for salmon in the primary Delta migration routes while minimizing predatory fish habitat.

By its own admission, the BDCP states that salmon fry and smolts need safe habitats on the edge of the river channel to reduce exposure to predators.

> "However, enhanced channel margins are expected to facilitate safe downstream migration by increasing the habitat complexity that is needed for both smolts and fry to escape predators." (BDCP Page 3.3-45)

That admission in the BDCP is a counter-argument against the supposed benefit of the three new, large fish screen facilities (CM1). The above BDCP statement could be re-worded for CM1 to state: "However, worse channel margins caused by CM1 are expected to impede safe downstream migration by decreasing the habitat complexity that is needed for both smolts and fry to escape predators". CM1 will eliminate long reaches of upstream edge habitats important for salmon but CM6 is promoted to create edge habitats in downstream areas. Again, this points to the question why CM1 is proposed as a conservation measure because it appears that CM6 is proposed, in part, to offset the adverse impacts caused by CM1.

Conservation Measure 15 (CM15): Localized Reduction of Predatory Fishes

The BDCP CM15 is an unorthodox approach to a so-called conservation measure. By first implementing the plan, then exploring ways to control predator problems afterwards is highly unusual and not credible. The fact remains that there are numerous areas in the Delta where localized predation "hot spots" have long been known to occur, yet no actions have been taken to fix those problem areas. From a practical, logical standpoint, CM15's proposed effectiveness must first be demonstrated by: 1) initially working on alleviating predation problems at existing areas and 2) learning from those actions prior to building massive new structures. For example, the severe predation problem areas in front of the Tracy Fish Facilities and immediately behind the Clifton Court Forebay gates have been known for decades. It should be proven that those areas can be fixed prior to building the north Delta intakes. The lack of progress in addressing known predation problems at existing export facilities does not inspire confidence that predation problems at the proposed north Delta diversions would be handled effectively. The credibility of the BDCP could only be enhanced by showing in-place success of such actions instead of simply proposing untested, unspecified actions that would be attempted at some future date after the north Delta intakes become operational.

In the consistent pattern presented throughout the BDCP documents of overstating fish benefits, CM15 is also postulated as an action that will provide positive results. For example:

> "CM15 Localized Suppression of Predatory Fishes *will reduce* the local effects of predators on covered fish species by removing structures that host predatory nonnative fishes, conducting predator control at hotspot locations, conducting an extensive research program to evaluate alternative predatory fish control strategies, and implementing those strategies in an adaptive management context (emphasis added)." (BDCP Executive Summary, page 12)
>
> "In particular, CM15 Localized Reduction of Predatory Fishes *will reduce* local abundance of predatory fish and eliminate or modify holding habitat for predators at selected locations of high predation risk ("predation hotspots") (emphasis added)." (BDCP Page 5.F-3)
>
> "*It is concluded* that lowered predation under the BDCP through CM15 Localized Reduction of Predatory Fishes, in addition to other factors discussed above, has the potential to increase productivity and offset the potential for greater predation at some locations such as the north Delta intakes (emphasis added)." (BDCP Page 5.5.3-37)
>
> "Localized Reduction of Predatory Fishes (Predator Control) (CM15) – Actions implemented under this conservation measure *would reduce populations* of predatory fishes at specific locations and eliminate or modify holding habitat for predators at selected locations of high predation risk (emphasis added)." (EIR/EIS Pages 3-68 and 3-157

Also, in the recurring pattern of providing inconsistent and contradictory logic of the BDCP effects on fish, the documents elsewhere state:

> "The BDCP *could reduce* losses of juvenile winter-run Chinook salmon at existing localized areas where predation is intense (emphasis added)." (BDCP Executive Summary Page 48)
>
> "The primary purpose of CM15 is to contribute to biological goals and objectives related to abundance and passage of covered salmonids by locally reducing nonnative predatory fishes, which *it is hoped* will increase the survival of migrating salmonids (emphasis added)." (BDCP Page 4-74)

> "At the local scale, the benefits of targeted predator removal are likely to be localized spatially and of short duration unless efforts are maintained over a long period of time. *These benefits are highly uncertain, as the long-term feasibility and effectiveness of localized predator reduction measures are not known* (emphasis added)." (BDCP Page 5.F-iv)
>
> "*Because of the high degree of uncertainty* regarding predation/competition dynamics for covered fish species and the feasibility and effectiveness of safely removing large fractions of existing predator populations, the proposed predator reduction program is envisioned as an experimental pilot program within an adaptive management framework (emphasis added)." (BDCP Page 4-75)
>
> "Additionally, these restored areas may be targeted for predator removal during key occurrence of covered species in these areas, which may also reduce this effect, although *outcomes of localized predator removal are uncertain* (emphasis added)." (BDCP Page 5.F-iv)
>
> "*These benefits are highly uncertain, as the long-term feasibility and effectiveness of localized predator reduction measures are not known* (emphasis added)." (BDCP Page 5.F-iv)
>
> "*Predator removal treatments would likely have only have a short-term effect*, as the Delta is an open aquatic system and recolonization of treated areas by new fish predators may be rapid (emphasis added)." (BDCP Page 5.F-83)
>
> "*The effectiveness of a predator removal program is uncertain, as illustrated by the mixed results achieved by other programs* (emphasis added)." (BDCP Page 5.F-84)
>
> "*Actions to remove predators have a high degree of uncertainty* (emphasis added)." (BDCP Page 5.F-101)

CM15 is described in the BDCP as having major ambiguities as to its effectiveness and recommends an enormous amount of potential future unspecified research in an attempt to address that deficiency (BDCP Pages 3.D-33 and 3.D-34). However, most of the identified research in the BDCP should be more narrowly defined and conducted prior to embarking on a highly tenuous plan. Even simple actions such as performing literature reviews and interviews on the topic of predator control are identified as future activities (e.g., BDCP Pages 3.4-311, 3.D-34), but could have been performed and details included prior to the release of the BDCP. Indeed, many decades have passed since predator problems in the Delta were known, but no effective actions to address the topic have been implemented in those decades. After 50+ years of no progress, all of a sudden the BDCP now states that it will greatly reduce the predation problems at areas such as Clifton Court Forebay and other known, suspected, or future areas (i.e., north Delta intakes) in the Delta. It is incongruous to believe that suddenly the BDCP would now effectively address and resolve this complex issue.

The Delta Science Program sponsored a "State of the Science Workshop on Fish Predation on Central Valley Salmonids in the Bay-Delta Watershed" which convened a panel of six experts in July 2013 to examine the problem with predation on juvenile salmon in the Delta. Notably, the panel's final report lacked pragmatic advice on how to address the predation issue and provided no new or useful ideas for executable actions to alleviate predation. To a large degree, the panel simply threw up their hands and concluded that the predation dilemma in the Delta is an extremely complex problem and that much more research on the topic is needed. In fact, the primary emphasis of the panel's report focused on recommendations to conduct much more extensive standardized research and monitoring throughout the Delta. Based on my experience as a Principal Scientific Investigator for more than 100 fishery resource field research studies, most of the suggested studies would be extremely difficult to implement, exorbitantly expensive, highly questionable to achieve significant or valid results, logistically impractical, and very unlikely to lead to meaningful management actions. While the panel did not estimate the cost of implementing such studies, it would likely be in the neighborhood of several hundred million dollars. Given these conclusions, how and why would predator control and removal aspects of CM15 be deemed an effective conservation measure? Without known benefits for salmon, a highly debatable feasibility, past record of ineffective and non-actions, and the need to conduct many years of research, the predator control component of CM15 should be removed from the BDCP. Instead, the measure should focus on altering Delta habitats to favor juvenile salmon and reduce those areas where salmon are highly vulnerable to non-native predatory fish.

Conservation Measure 16 (CM16): Nonphysical Fish Barriers (NPB)

A key conservation measure proposed for the BDCP is the installation of NPBs (CM16) under the highly questionable ability to divert juvenile salmon from selecting unfavorable outmigration routes through the Delta. This conservation measure is confounding because of the BDCP's apparent faith in the success of future, yet-to-be-designed NPBs as a proposed measure to benefit salmonids. The specific type of NPBs proposed is the combination of a bubble curtain, sound, and lights in an attempt to deter juvenile salmon away from poor-survival migration pathways and toward higher-survival migration pathways. The most-prominent location proposed by the BDCP for NPBs is in the north Delta at Georgiana Slough in Walnut Grove, California, although numerous other sites are recommended (i.e., the Sacramento River at Fremont Weir, the Delta Cross Channel, the San Joaquin River at the head of Old River, Turner Cut, Columbia Cut, channels leading to Clifton Court Forebay and the Tracy Fish Facilities). The basic concept portrayed in the BDCP is as follows: If one assumes that juvenile salmon die at the three proposed intakes in the north Delta, installation of NPBs at fish migration route flow splits farther downstream and in the Delta will potentially help offset those fish losses. This conclusion, however, is at best speculative because of:

1) the highly experimental nature of NPBs,
2) the mixed results from studies of the NPBs (including failures),
3) the exorbitant costs for the type and locations of NPBs in the BDCP,
4) the very questionable practicality and feasibility of such a massive, infrastructure program throughout the Delta,
5) the potentially detrimental impacts on salmon and other native fish, and
6) NPBs have recently been abandoned in the Delta.

The BDCP nevertheless (and astonishingly) concludes:

> "Nonphysical Fish Barriers *will improve* the survival of outmigrating juvenile salmon and steelhead by using nonphysical barriers (underwater lights, sound, and bubbles) to encourage juvenile fish to avoid channels and river reaches in which survival is lower than in alternate routes (emphasis added)." (BDCP Executive Summary Page 12)
>
> "CM16 Nonphysical Fish Barriers *will be employed* to discourage juvenile salmonids from entering channels/migration routes that are known to have high predator abundance and/or predation rates, *further reducing predation rates within the Plan Area and contributing to an increase in survival* (emphasis added)." (BDCP Page 3.3-142)
>
> "Salmon, steelhead, and splittail *are expected to be effectively deterred* (emphasis added)." (BDCP Page 5.F-v)

Such barriers remain unproven for overall fish protection and should not be proposed as a positive remedial action for salmon to offset deleterious BDCP effects on salmon.[19] If and when testing of such behavioral barriers are shown to be effective at the sites proposed, then the BDCP could recommend those measures, but not before.

Because the BDCP relied so heavily on the potential benefits of NPBs and the BDCP fish models utilized some aspects of preliminary results of NPBs, the topic warrants closer scrutiny. Recently, a concept for a NPB in the lower San Joaquin River was introduced by Vogel (2009). The concept was to install a bubble curtain at the head of Old River in the San Joaquin River to determine if outmigrating juvenile salmon would behaviorally avoid entry into Old River. The goal was to increase the proportion of salmon migrating down the lower San Joaquin River where fish survival was assumed to be higher than the Old River migration route through the Delta. The California Department of Water Resources (DWR) decided to test the concept at the head of Old River in the spring of 2009, but with the use of not only bubbles, but sound and strobe lights. The BDCP cites the following results of those experiments:

> "Preliminary evidence suggests that a three-component barrier was effective in deterring, or discouraging acoustically tagged Chinook salmon juveniles from entering the head of Old River during a 2009 pilot study (Bowen et al. 2009)." (BDCP Page 3.4-314)
>
> "The three-component Nonphysical Barrier Test Project at the divergence of Old River from the San Joaquin River (head of Old River) in the Delta successfully deterred 81% of acoustically tagged Chinook salmon smolts from entering Old River (Bowen et al. 2009)." (BDCP Page 3.4-314)

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[19] "The effectiveness of nonphysical barriers and their interaction with predators is based on limited testing; thus, outcomes for salmonids remain uncertain." (BDCP Page 5.F-102)

Notably, the BDCP mentions (but does not adequately discuss) the significant fact that the head of Old River NPB was evaluated again in 2010 with mixed results and poor deterrence efficiency (SJRGA 2011). More importantly, on an overall basis, the predation impacts on juvenile salmon presumably caused by the physical presence of the NPB were believed to be so severe that the barrier is no longer considered a viable deterrent device at that location. For example:

> "A 2009 study found the deterrence rate to be as high as 81% (Bowen et al. 2009) while a follow-up study in 2010 found the deterrence rate to be 23%. … In fact, while the nonphysical barrier deterrence rate was 81% in 2009, the predation rate was so high that the juvenile salmon survival rate was not statistically different whether the barrier was on or off (Bowen et al. 2009)." (BDCP Page 5.F-85)

Yet the BDCP promotes installation of the same type of NPB at the head of Old River despite the fact that the best available scientific information indicates harmful effects on salmon; the illogical rationale is not disclosed in the BDCP. Confusingly, the BDCP also states that an operable gate (physical barrier) would be installed at the head of Old River to protect migrating fish (BDCP Page 5.3-11 and EIR/EIS Page 3-101). Then elsewhere, it is suggested that a traditional rock barrier may be installed at the site (EIR/EIS Page 3-119). What is the prevailing BDCP recommendation: a NPB, operable gates, or a rock barrier?

By far, the BDCP's greatest reliance on data used to support the concept of installation of NPBs, not only at Georgiana Slough, but throughout the Delta, is based on the results of a DWR pilot study at Georgiana Slough in 2011. However, the BDCP did not adequately describe the limitations and caveats of the study and, furthermore, did not disclose the fact that the use of a NPB at the site has since been abandoned. This is extremely important because the BDCP analyses, fish models, and resultant conclusions relied so heavily on that single study. The extrapolation of results from that study into BDCP fish models highly skewed model outputs and resultant conclusions of the BDCP effects on salmon.

DWR installed and evaluated a Bio-Acoustic Fish Fence (BAFF) (a form of a NPB advocated for use in the BDCP) at the entrance to Georgiana Slough in the winter and spring of 2011 and reported those results in 2012. A study was repeated in 2012 but those results are not yet available. Given the strong emphasis in the BDCP, closer examination of DWR's pilot study report (DWR 2012) is warranted to determine how accurately the BDCP portrays those results and how applicable they are to the BDCP's promotion for installation of NPBs throughout the Delta. The fish sizes used for the NPB experiment at Georgiana Slough ranged from 110 to 140 mm fork lengths (DWR 2012) which are larger than fall-, winter- and spring-run Chinook typically migrating past Georgiana Slough. The first fish releases occurred on March 16 and the last on May 15, 2011 (DWR 2012). Unfortunately, the 2011 experiments were conducted during abnormally high flow conditions (Figure 28) that complicated execution of the study.

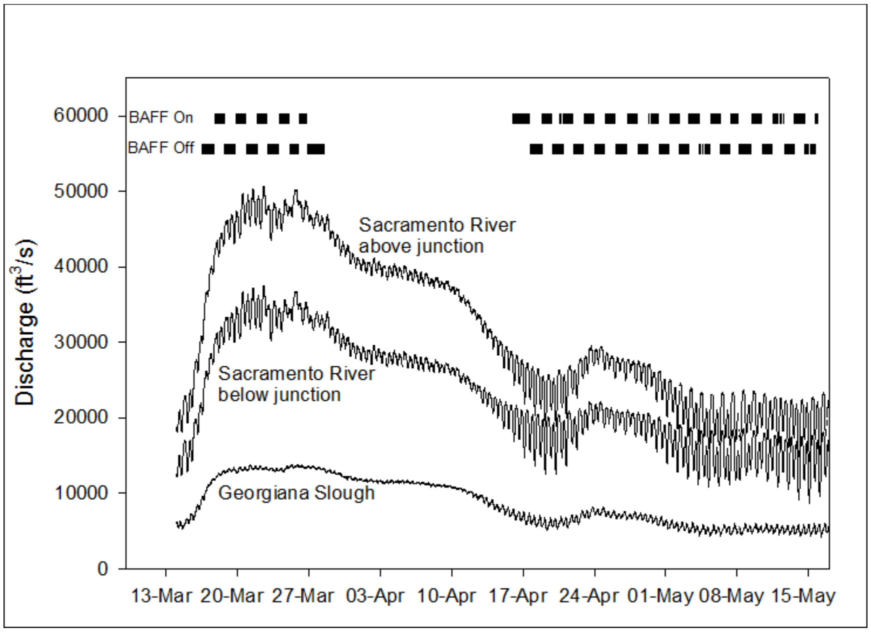

Figure 28. “River discharge and BAFF treatment at time of detection within the array” (from DWR 2012).

The BDCP failed to disclose that the 2011 Georgiana Slough experiment results varied depending on flow conditions at the time of the study. During higher flows, the NPB was not as effective in deterring salmon away from the entrance into Georgiana Slough compared to lower flows during the study. Importantly, the 2011 experiments were all conducted during abnormally high and strong unidirectional flows in the region and no experiments could be conducted during flood tides when Sacramento River flows are reversed and water can enter Georgiana Slough from both upstream and downstream of the Slough. Radio-telemetry studies at Georgiana Slough have demonstrated that juvenile salmon can initially safely pass the Slough and remain in the Sacramento River only to be subsequently advected back upstream during flood tide conditions and into Georgiana Slough (Vogel 2001a, 2002a, 2003a, 2011b). A NPB is unlikely to provide any significant protection for salmon under those conditions. This suggests that diversions through the upstream north Delta intakes would make salmon survival even worse by reducing Sacramento River outflows in this region of the Delta. The BDCP failed to adequately disclose or account for those foregoing circumstances.

Although the 2011 DWR study appeared to be well done, there nevertheless remains significant ambiguity in interpretation of study results. Some of the conclusions as to the effectiveness of the NPB in deterring salmon away from Georgiana Slough appeared subjective, allowing different interpretations. An example is shown in the following Figure 29 from the DWR (2012) report.

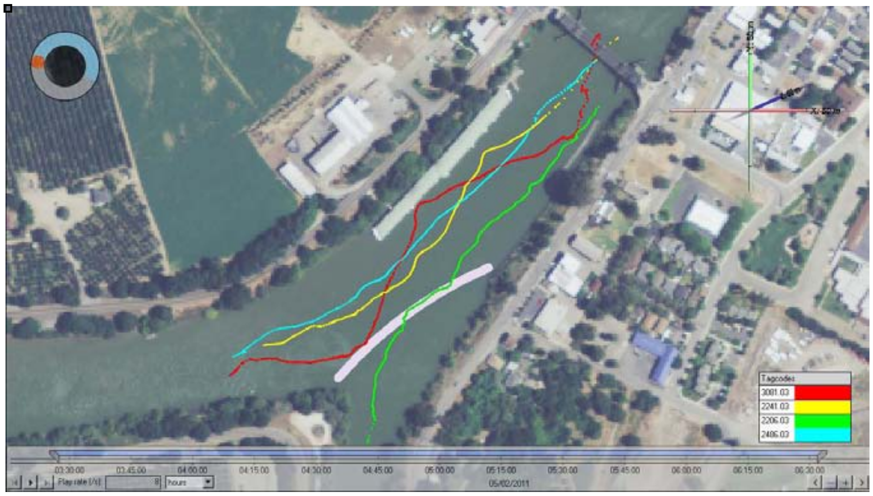

Figure 29. “Two-dimensional tracks of Chinook salmon smolts in the Sacramento River. Notes: All four smolts were released May 2, 2011 at 00:00 hours. All four tracks passed by the divergence of the Sacramento River and Georgiana Slough on May 2, 2011 between 03:17 and 03:44 hours. 2206.03 was undeterred and entered Georgiana Slough. 3081.03 and 2241.03 were deterred into the Sacramento River. 2486.03 was determined to be undeterred because it made no movement away from the BAFF.” (from DWR 2012) Note that the curved white line is the location of the BAFF (NPB) and the entrance to Georgiana Slough is at the bottom of the figure.” (from DWR 2012)

In this example, DWR (2012) assumed that fish no. 2241.03 (yellow line) was deterred from entry into Georgiana Slough. However, an alternative interpretation is that the fish was simply following the main flow of the Sacramento River and the NPB had no meaningful effect. In fact, this salmon behaved similarly to radio-tagged salmon observed during prior research at Georgiana Slough when no NPB was in place (Vogel 2002a, 2011b). Fish 3081.03 (red line) was also assumed by DWR (2012) to have been deterred from entry into Georgiana Slough; it may have been. However, the migration pattern for this fish was very unusual and uncharacteristic of smolt behavior seen in other telemetry studies. Note that this fish traversed diagonally (zigzagged) across the Sacramento River several times in a very short linear distance under exceedingly high flow conditions (>20,000 cfs). There are two alternative scenarios for this fish which are different than that postulated in DWR (2012). First, with the very high flows present at the time, when originally reaching the BAFF, the fish may have been simply following the main flow of the Sacramento River past Georgiana Slough. Second, based on prior research I conducted on the behavior and movements of radio-tagged salmon past Georgiana Slough, the behavior was not reflective of normal smolt migration. This unusual migration pattern may have actually been a result of the acoustic-tagged salmon being inside a predatory fish, not a live salmon (discussed later in these comments). In fact, the study could not determine if any of the fish approaching the barrier were live acoustic-tagged salmon or dead acoustic tagged salmon inside predatory fish. If these data interpretations are indicative of the study, significant differences of opinion on the study results are probable. The BDCP’s discussion on NPBs did not disclose this considerable uncertainty.

Notably, the BDCP downplayed or largely dismissed the potential for the Georgiana Slough NPB to attract predatory fish over time even though it admits there is “considerable uncertainty” about potential predation (BDCP Page 5.B-57). As mentioned previously, the predator “magnet” problem caused by the NPB at the head of Old River was deemed to be too severe and risky for salmon so the barrier has not been pursed at that location. For Georgiana Slough, DWR (2012) states:

> "It is important to note that if the BAFF is used as a long-term management tool, predators could become conditioned to the BAFF On mode and may prey on salmon to a greater extent than under experimental operational conditions (BAFF On/BAFF Off). In addition, the habitat selected by and movement patterns of predators in the Sacramento River adjacent to the BAFF may vary within and among years in response to factors such as river flow and velocities, water temperatures, and recreational harvest. These factors, in combination with possible conditioning to BAFF operations, could result in different predation rates than those observed during the 2011 study." (DWR 2012)

Importantly (as it relates to the BDCP), since the 2011 and 2012 experiments at Georgiana Slough, DWR has abandoned plans to continue experimentation of the NPB at that location. That decision was made, in part, because of local landowners' complaints concerning the noise created by the generators used at the site to operate the NPB (notes from a March 4, 2014 meeting concerning USBR experiments on an electrical barrier in Deadhorse Cut). Instead, DWR has installed and is evaluating a floating shallow-draft metal-plate boom in front of Georgiana Slough to determine its efficacy in diverting juvenile salmon away from the Slough (Figures 30 and 31). This surface deflector wall currently under evaluation at Georgiana Slough may pose significant predation hazards for juvenile salmon. It could actually increase overall salmon mortality by providing ideal predator holding habitats and prey ambush sites. Although this predation topic was discussed previously in comments on CM2, it warrants repeating here:

> "The literature offers some assistance for minimizing and discouraging predation at the intakes and fish facilities. Piers, pilings, other supportive structures, and corners or other irregularities in a channel are referred to as structural complexities. Such structures may cause uneven flows and can create shadows and turbulent conditions. A structurally complex environment should be avoided. Corners, interstices, or other structural components that create boundary edges contribute to maximum foraging efficiency of large predatory fishes and the highest populations of predators will occur where structural boundary edges are present. Structural complexity can increase predation by providing locations for waiting predators (shadows, interstices, corners, etc.). The risk of prey to predation is a function of exposure, often directly related to the structural complexity of the system." (Odenweller and Brown 1982)

Again, the BDCP does not address those known problems for salmon and, again, overlooked the readily available science on the topic.

Additionally, the BDCP has not integrated the fact that salmon will be more concentrated in a lesser volume of water at the Sacramento River – Georgiana Slough flow split when the north Delta diversions are in operation (up to 9,000 cfs diverted from the river) and if the Fremont Weir "notch" is being utilized (up to 6,000 cfs diverted from the river). The result will be a higher proportion of salmon (and therefore numbers of fish) entering Georgiana Slough. Those adverse impacts do not appear to be described in the BDCP documents. If the detrimental effects were addressed, the accompanying description should be prominent and explicit. If those impacts were not accounted for in the analyses, this is an enormous shortcoming.

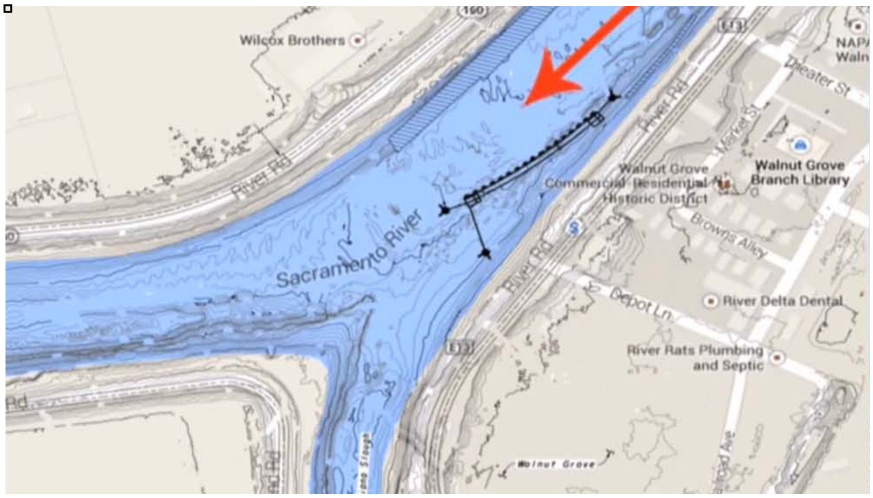

Figure 30. Plan-view diagram of the location of a floating defector wall installed near the entrance to Georgiana Slough on the Sacramento River. Georgiana Slough is at the bottom of the figure. Screen capture from: http://www.youtube.com/watch?v=937bXx9QMn8&feature=youtu.be

Figure 31. Floating wall being installed near the entrance to Georgiana Slough in 2014 (screen capture from: http://www.youtube.com/watch?v=937bXx9QMn8&feature=youtu.be

Despite the fact that the effectiveness of NPBs remains unproven for fish protection, and that experimentation of the device has been abandoned at Georgiana Slough and failed at the head of Old River, the BDCP nevertheless has proposed installing these devices at a total of seven sites in the Delta[20]: Delta Cross Channel, the Sacramento River at Fremont Weir, Turner Cut, Columbia Cut, head of Old River, Georgiana Slough, and the entrances to the south Delta export facilities (Clifton Court Forebay and the Delta-Mendota Canal intake). It is noteworthy that the BDCP provides no information on the efficacy of installing NPBs at these additional sites. Information is readily available to clearly demonstrate that some of those areas are not feasible

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[20] BDCP Page 4-80.

and would provide no protection for salmon. In yet another example of promoting benefits to salmon without supporting information and not using the best available science, the BDCP states: "Barriers at these locations have a high potential to deter juvenile salmonids from using specific channels/migration routes that may contribute to decreased survival …" (BDCP Page 4-80). Some of the proposed sites are absurd. For example, the BDCP suggests installation of bubble curtains or log booms in the Sacramento River to shunt downstream migrating salmon into the Yolo Bypass at Fremont Weir:

> "If deemed necessary to enhance the attraction of juveniles into Yolo Bypass through the gated seasonal floodplain inundation channel (described above), construct and operate nonphysical or physical barriers in the Sacramento River. Examples of such barriers include bubble curtains or log booms (Phase 2 or 3, Category 3 Action)." (BDCP Page 3.4-53, BDCP Page 4-32, and EIR/EIS Page 3-127)

Figure 32 shows a hypothetical location for such a barrier north of Fremont Weir. Although the BDCP provides no details on this concept, it does not require an engineering analysis to determine it is infeasible and has no merit. During the period when salmon are emigrating past the weir and Sutter and Yolo Bypasses are flooding, the Sacramento River is a hostile environment for static in-river structures. Large trees and debris would destroy a structure positioned in this location. Furthermore, with extremely high channel velocities and low water clarity, there is no reason to believe that young salmon would behaviorally respond to such a barrier. The best available science indicates the fish would not respond favorably.

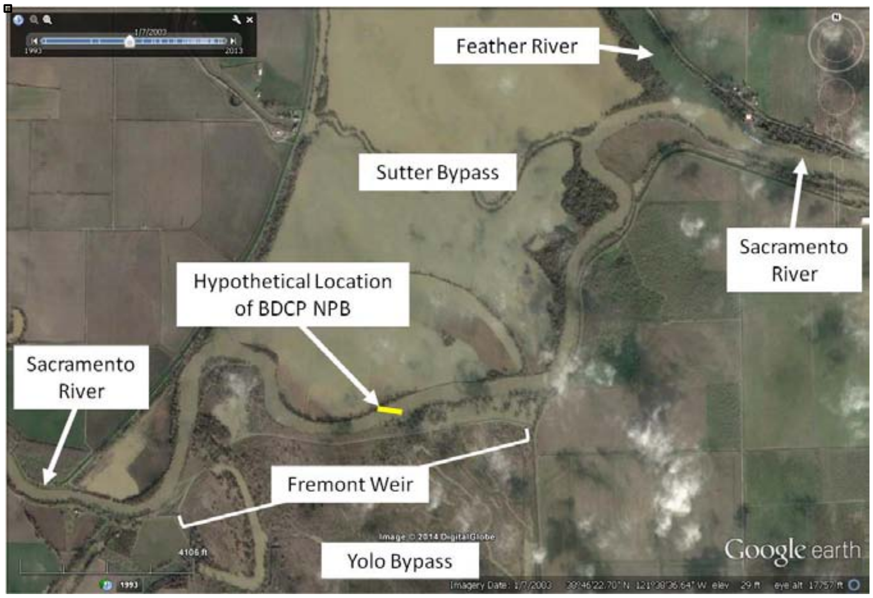

Figure 32. Aerial photo of the northern Yolo Bypass, Fremont Weir, and southern Sutter Bypass showing a hypothetical location of a bubble curtain or log boom suggested in the BDCP.

If the NPB at Georgiana Slough is deemed unacceptable (which apparently it already has), the BDCP, astoundingly, proposes construction of a flat-plate fish screen in front of the Slough:

> “Because about 25% of the Sacramento River water is diverted into the central Delta, additional consideration for screening Georgiana Slough may be warranted. If the non-physical barrier (bubble, light and sound) being investigated by DWR and Reclamation for the 2009 NMFS BiOp does not prove effective, <u>a flat wedge-wire fish screen, similar to what is proposed for the north Delta intakes could be designed and constructed</u>. The likely fish benefits and possible fish impacts could be investigated under the BDCP adaptive management process. (emphasis added)” (BDCP Pages 5C.A-121 and -122

This measure is also illogical and doesn’t require an engineering analysis to know it is not feasible and would violate existing fishery resource agencies’ criteria for fish protection. Clearly, the BDCP has not used the best available science that demonstrates negative impacts on fish would certainly occur. A positive barrier at that location would be disastrous for salmon. The sheer magnitude of flow entering the Slough would create extremely high through-screen velocities that would certainly impinge and kill young salmon and other species such as Delta smelt. Also, flow reversals under certain conditions occur in that vicinity (as described previously) and there is no bypass flow to route fish past the screens; enormous numbers of fish would be impinged. Furthermore, it is readily apparent from discussions in the EIR/EIS that some of the primary reasons for selecting the north Delta intake locations farther upstream was to avoid adverse impacts on Delta smelt and the lower sweeping flows present at locations farther downstream. The unreasoned and inconsistent logic is not described in the BDCP documents.

Other locations where the BDCP recommends installing NPBs are in the channels leading to Clifton Court Forebay (CCF) and the Delta-Mendota Canal:

> “Nonphysical barriers would be installed at the south Delta entrance canals leading to CCF and the Delta-Mendota Canal.” (BDCP Page 5.B-57)
>
> “Nonphysical barriers at the entrances to Clifton Court Forebay (CCF) and the Delta-Mendota Canal (DMC) have the best potential to reduce entrainment of juvenile Chinook salmon and steelhead … The effectiveness of nonphysical barriers will depend on the water velocity characteristics in the vicinity of the barrier and on the extent to which predatory fish occur along the barrier. There is also uncertainty as to whether preventing entrainment into CCF and the DMC will enhance survival given the prevailing hydrodynamics in the area, i.e., if net reverse flows are present that may not allow fish to move away from the area and make them more susceptible to entrainment. Such uncertainties necessitate study to assess the effectiveness of nonphysical barriers at these locations.” (BDCP Page 5.B-387)

As with the previously described sites, NPBs in the south Delta recommended in the BDCP are already known to be infeasible. The BDCP states that there is “considerable uncertainty” about velocities in the vicinity of proposed NPB locations (BDCP Page 5.B-57). Large amounts of existing data are readily available to demonstrate this is not true. Flow and channel velocities leading to the south Delta water export facilities are commonly high and there is no biological reason to expect juvenile salmon to behaviorally respond in the manner suggested in the BDCP. All the best available data and science demonstrates otherwise. For example, extensive historical ADCP channel velocity data available through the California Data Exchange Center for Old River leading to the export facilities clearly demonstrate that southerly water velocities can commonly be as high as 3 to 5 ft/s. Young salmon cannot swim against such high velocities for extended periods (Fisher 1981, Swanson et al. (2004a, 2004b). During an evaluation of radio-tagged Chinook salmon movements in the south Delta during December 2000 (Vogel 2002b), it was determined that salmon moved rapidly with direction of flow toward the export facilities, not against it (Figure 33). With south Delta exports, flow in northern Old River is often negative, very high, and salmon are forced to move southerly with the flow (Vogel 2005, telemetry data from Vogel 2010). Under those conditions, there is no bypass flow and salmon would move rapidly and unidirectionally into and through the NPBs. Note that even with high bypass flows during experiments with a NPB at the head of Old River, high flow through the NPB reduced its effectiveness.[21] With no bypass flow, why would NPBs be expected to work at the canals leading to CCF and the Delta-Mendota Canal? Again, the BDCP assumptions are not well reasoned and the documents do not explain such illogical conclusions.

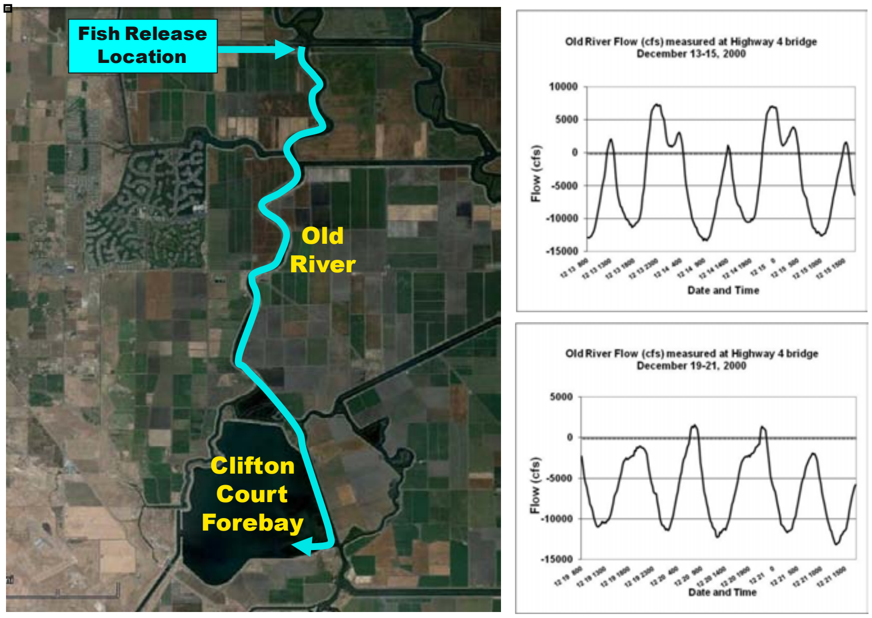

Figure 33. Migration route for some radio-tagged juvenile Chinook salmon released in northern Old River and flow measured at the Highway 4 bridge in northern Old River in December 2000 (adapted from Vogel 2002b, 2011b).

Recommendations for the installation of NPBs at sites already known to be infeasible should be removed from the BDCP. As pointed out later in the comments on the use of the BDCP fish models, the speculative assumptions on very high benefits for salmon resulting from NPBs should be changed to reflect more-realistic assumptions and balanced analyses.

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[21] "Higher flows in 2010 resulted in reduced effectiveness [of the nonphysical barrier] in deterring juvenile salmonids, as juveniles may have lacked the swimming ability to avoid the barrier and be effectively deterred from entering the Old River (Bowen et al. 2009; Bowen and Bark 2010)." (BDCP Page 5.B-83)

The BDCP also provides no evidence that the installation of NPBs would not adversely impact the upstream migration of anadromous fish (not only adult salmon, but adult sturgeon). The BDCP gives short shrift to this important topic by indicating it was only qualitatively evaluated:

> "In addition, a qualitative analysis of the potential impeding effects of such barriers [on upstream migrating anadromous fish] was conducted that evaluated the relative position of the barriers in relation to species' position in the water column and the hearing and escape abilities of the species in relation to the acoustic deterrent provided by the barriers." (BDCP Page 5C.4-36)

This potentially serious problem must be investigated prior to reliance on NPBs. Even if NPBs are eventually found to provide benefits for salmon, those measures could be pursued independently of the BDCP. Here again, it appears that the BDCP is attempting to demonstrate fish benefits for actions that could be implemented separately from construction and operation of the north Delta water diversions.

In summary, CM16, like CM15, is yet another proposed action within the BDCP with highly tenuous outcomes in which purported fish benefits are assumed, but the BDCP identifies numerous uncertainties as to the potential effectiveness of this measure. The BDCP also recommends installation of NPBs at locations where it is already known the barriers would not be feasible. Additionally, it is unknown why the BDCP did not disclose highly relevant information that was contrary to the documents' assumed benefits to fish. Clearly, the BDCP has not used the best available science. Here again, answers to the numerous key uncertainties, such as those identified in BDCP Appendix D, should be pursued prior to implementation of the BDCP, not after; the risk of failure and severe impacts to salmon are too great.

Use of Fish Models for the BDCP Analyses

The BDCP used a variety of models to evaluate potential effects on salmon resulting from measures proposed for the BDCP. Although models are never perfect in predicting effects on salmon, those used for the BDCP were particularly constrained because of a lack of empirical data, incorrect data, and very low reliability and confidence in the models' outputs. Unfortunately, some of the fish models related to salmon survival and behavior are based on faulty data rendering model run outputs invalid and incapable of comparing BDCP alternatives. Some of the models' documentation aptly point out that the intent of the modeling exercises was not to estimate absolute fish survival, but instead to provide relative comparisons among BDCP scenarios (e.g., EIR/EIS Page 4-13). However, in many instances, inputs to the models were based on inflated and biased fish survival estimates (described below) that would not provide valid comparisons of the BDCP scenarios. Although the BDCP claims, "The methods used reflect the best available tools and data regarding fish abundance, movement, and behavior." (BDCP Page 5.B-i), that premise is simply not correct. It is also readily apparent that when the models suggested unfavorable results (i.e., adverse impacts on salmonids), they were downplayed or not used. Conversely, when the models suggested favorable results (i.e., beneficial impacts on salmonids), they were overplayed and used. Because there was so much reliance on models for the BDCP analyses, it is important to understand the limitations of those models. The documentation for various models describes some of the limitations, but those discussions are fragmented and buried in the voluminous appendices and commonly not carried forward into the main body of the BDCP document. In many instances, the models' documentation overlooked some serious limitations. The following discussion provides several example details on why many of the fish models are very limited or invalid for application to the BDCP.

Although large numbers of salmon fry enter the Delta each year, none of the fish models were capable of modeling the BDCP effects on this smaller-sized life stage salmon. This critical deficiency is an enormous shortcoming of the BDCP and leaves a tremendous amount of uncertainty in estimating the impacts of the BDCP on salmon. Some of the models attempted to evaluate BDCP effects only on the larger-sized, smolt life stage. For example, in use of the Delta Passage Model (DPM):

> "Many of the model assumptions are based on results from large, hatchery-reared fall-run Chinook salmon that may not be representative of smaller, wild-origin fish. Model is applicable only to migrating fish and not to those rearing in the Delta. Equations for estimating salvage have relatively low explanatory power for the data upon which they were derived." (BDCP Page 5.B-57)
>
> "Many of the model assumptions are based on results from large, hatchery-reared fall-run Chinook salmon that may not be representative of smaller, wild-origin fish. Model is applicable only to migrating fish and not to those rearing in the Delta. Model is mostly limited to operations-related effects on flow. Model only accounts for smolts and not other migrating juvenile life stages." (BDCP Page 5C.4-6)
>
> "Unfortunately, survival data are lacking for small (fry-sized) juvenile emigrants because of the difficulty of tagging such small individuals. Therefore, the DPM should be viewed as a smolt survival model only, with its survival relationships generally having been derived from larger smolts (>140 mm), with the fate of pre-smolt emigrants not incorporated into model results." (BDCP Page 5C.4-40)

Furthermore, the fish models were not capable of predicting BDCP effects on salmon because empirical data used for the input were based on existing (or more aptly, past) Delta conditions. Implementation of the BDCP would fundamentally change large-scale hydrodynamic, bathymetric, and fish habitat conditions in the Delta. These circumstances present an enormous dilemma for the BDCP analyses. Flow patterns (e.g., tidal and circulation) and physical habitats for salmonids would be substantially altered and the ultimate response of salmon to those conditions would change, probably significantly. The models used were based on data collected during conditions that would not be representative of future, altered conditions in the Delta. This major limitation is pointed out in BDCP Appendix 5.G:

> "The [life cycle] models are fundamentally constrained in that they are based on species–habitat relationships that have been established for the existing configuration of the San Francisco Bay/Sacramento–San Joaquin River Delta (Bay-Delta) and therefore do not incorporate the substantial changes in the

> landscape proposed to occur with proposed habitat restoration. This is a critical limitation because large-scale habitat restoration is a core component of the BDCP that is intended to produce significant ecological benefits." (BDCP Page 5.G-1)

This same limitation would also be applied to the DPM.

Additionally, it seems that some of the models are incomplete:

> "The DPM results presented here reflect the current version of the model, which continues to be reviewed and refined, and for which a sensitivity analysis is underway to examine various aspects of uncertainty related to the model's inputs and parameters." (BDCP Page 5C.4-40)

There also appears to be conflicting assumptions between some of the fish models. For example, the ISI growth model accounts for salmon emigration timing differences between years (which is accurate) whereas the DPM looks to assume a uniform distribution between years (which is not accurate).

Furthermore, some of the fish models are out of date and used incorrect information. For example, documentation on the Oncorhynchus Bayesian Analysis (OBAN) model states:

> "The current operation of RBDD makes counts of winter-run Chinook salmon after closing the gates on May 15. On average, 15% of the winter run passed RBDD by May 15, but the specific percentage in a given year was as low as 3% or as high as 48% (Snider et al. 2000). Egg abundance is calculated by assuming that each adult spawner produces 2,000 eggs (Williams 2006)." (BDCP Page G-22)

The fecundity of winter-run Chinook of 2,000 eggs per female is greatly underestimated. For instance, Hallock and Fisher (1985) reported an average of 3,353 eggs per female. More recently, Poytress and Carrillo (2012) reported an average of 5,277 eggs per female based on spawning records at the Livingston Stone National Fish Hatchery for the nine-year period from 2002 through 2010. The underestimate for the OBAN model would likely generate serious errors in the model outputs. Also, the information on winter run passage at RBDD is outdated. Since 2012, the RBDD gates have been removed year-round, resulting in unimpaired salmon passage (Vogel 2012a). The resultant change in passage timing (temporal shift to earlier passage) would affect OBAN model results, adding even more mistakes in the model outputs. Additionally, it is not clear if historical RBDD gate operations and effects on winter-run Chinook delay and blockage were included as a covariate in the OBAN model. If not, it would likely significantly change the integrity of the model. RBDD gate operations had a major adverse impact on annual runs of winter-run salmon and was a primary reason the dam gates were eventually raised (removed).

The OBAN model incorporated a covariate of the <u>number of days</u> during December through March with minimum flows of 100 cfs over the Fremont Weir (BDCP Page 5.G-23) and <u>not flow</u>

rates (e.g., 1,000 cfs, 5000 cfs, etc). The OBAN model assumes that *any increase* in Yolo Bypass inundation will increase through-Delta winter-run Chinook survival (BDCP Page 5.G-80), an assumption that is unlikely to be valid as indicated by statements elsewhere that flows of greater than 4,000 cfs would be necessary (BDCP Page 5.G-23). This limitation likely greatly overestimated beneficial effects on salmonids. Also, there did not appear to be any incorporation of the consecutive daily effects of Yolo Bypass inundation in the BDCP analyses. The BDCP model approach seems counter-intuitive. Higher flow rates over more consecutive days would presumably be more beneficial to salmon than sporadic, very low levels of flow over the Fremont Weir; furthermore, the flow/benefits relationships would likely be non-linear.
There is a very confusing discussion concerning the OBAN model results where it suggests that the BDCP would adversely impact winter-run Chinook because of higher water temperatures and lower flows in the upper Sacramento River (BDCP Page 5.G-54, BDCP Page 5.G-58, BDCP Page 5.G-60). For example:

> "In the Sacramento River spawning reaches, modeled water temperatures at Bend Bridge were higher (Figure 5.G-3) and minimum flow rate were lower (Figure 5.G-4) under the ESO compared to EBC2 scenarios, particularly during the ELT. These differences in Sacramento River conditions cause lower survival in ESO scenarios relative to EBC2 scenarios in the alevin and fry stages and are ultimately reflected in lower escapement under ESO." (BDCP Page 5.G-54)
>
> "Therefore, the OBAN model analysis suggests that the results are driven by modeled flow modifications in the upper Sacramento River and associated effects on water temperature conditions experienced by alevins on and near the spawning grounds. However, as noted above, the BDCP does not include Shasta Reservoir operational criteria changes, and therefore does not affect how cold water pool and flows in the upper Sacramento River are managed." (BDCP Page 5.G-60)

This discussion seems to conclude that model's results demonstrate that the BDCP scenarios will adversely impact winter-run Chinook due to deleterious effects on eggs caused by reduced reservoir releases and elevated water temperatures. But then the BDCP discussion suggests those impacts will not actually take place. In other words, it sounds like the conclusion is: "Modeling results predicted adverse impacts to winter run from the BDCP, but trust us, we won't allow that to occur." This begs the question as to whether there was any utility to the modeling exercise.

Additionally, water temperature modeling indicated that there would be a 5% increase in the number of years under ESO-ELT that would be classified as a "red" level of concern for winter-run Chinook egg incubation relative to EBC2_ELT. However, those impacts are deemed insignificant because it is considered within the range of "modeling error" (BDCP Page 5C.5.2-62). Water temperature modeling is far more sophisticated, accurate, and reliable than the fish models used for the BDCP. Notably, when the BDCP fish models suggest slightly positive or negative results for salmon, the caveat of "within the range of modeling error" is not discussed in context. For example, the statement is made: "Overall, the DPM results for late fall–run Chinook salmon demonstrated that survival under the ESO scenarios generally was similar to or slightly higher than that of the EBC scenarios." (BDCP Page 5C.5.3-96). However, as can be seen from examination of BDCP Table 5C.5.3-49 (below), the incremental differences in survival between scenarios are very small. The average difference in survival between EBC2_LLT versus ESO_LLT is only 0.2 or 1%. Given all the caveats on the model limitations described in the BDCP (and others described later in these comments), the relative differences (both positive and negative) in salmon survival among the BDCP scenarios are commonly very small and should have been characterized as within modeling error.

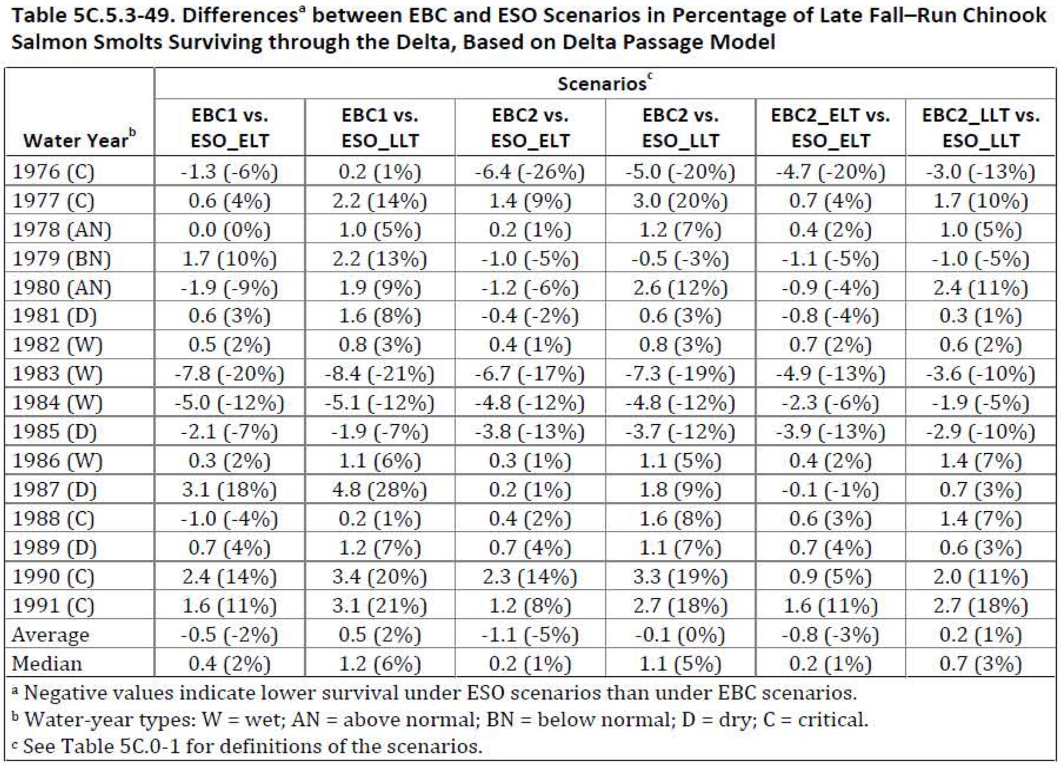

Table 5C.5.3-49. Differences[a] between EBC and ESO Scenarios in Percentage of Late Fall–Run Chinook Salmon Smolts Surviving through the Delta, Based on Delta Passage Model

	Scenarios[c]					
Water Year[b]	**EBC1 vs. ESO_ELT**	**EBC1 vs. ESO_LLT**	**EBC2 vs. ESO_ELT**	**EBC2 vs. ESO_LLT**	**EBC2_ELT vs. ESO_ELT**	**EBC2_LLT vs. ESO_LLT**
1976 (C)	-1.3 (-6%)	0.2 (1%)	-6.4 (-26%)	-5.0 (-20%)	-4.7 (-20%)	-3.0 (-13%)
1977 (C)	0.6 (4%)	2.2 (14%)	1.4 (9%)	3.0 (20%)	0.7 (4%)	1.7 (10%)
1978 (AN)	0.0 (0%)	1.0 (5%)	0.2 (1%)	1.2 (7%)	0.4 (2%)	1.0 (5%)
1979 (BN)	1.7 (10%)	2.2 (13%)	-1.0 (-5%)	-0.5 (-3%)	-1.1 (-5%)	-1.0 (-5%)
1980 (AN)	-1.9 (-9%)	1.9 (9%)	-1.2 (-6%)	2.6 (12%)	-0.9 (-4%)	2.4 (11%)
1981 (D)	0.6 (3%)	1.6 (8%)	-0.4 (-2%)	0.6 (3%)	-0.8 (-4%)	0.3 (1%)
1982 (W)	0.5 (2%)	0.8 (3%)	0.4 (1%)	0.8 (3%)	0.7 (2%)	0.6 (2%)
1983 (W)	-7.8 (-20%)	-8.4 (-21%)	-6.7 (-17%)	-7.3 (-19%)	-4.9 (-13%)	-3.6 (-10%)
1984 (W)	-5.0 (-12%)	-5.1 (-12%)	-4.8 (-12%)	-4.8 (-12%)	-2.3 (-6%)	-1.9 (-5%)
1985 (D)	-2.1 (-7%)	-1.9 (-7%)	-3.8 (-13%)	-3.7 (-12%)	-3.9 (-13%)	-2.9 (-10%)
1986 (W)	0.3 (2%)	1.1 (6%)	0.3 (1%)	1.1 (5%)	0.4 (2%)	1.4 (7%)
1987 (D)	3.1 (18%)	4.8 (28%)	0.2 (1%)	1.8 (9%)	-0.1 (-1%)	0.7 (3%)
1988 (C)	-1.0 (-4%)	0.2 (1%)	0.4 (2%)	1.6 (8%)	0.6 (3%)	1.4 (7%)
1989 (D)	0.7 (4%)	1.2 (7%)	0.7 (4%)	1.1 (7%)	0.7 (4%)	0.6 (3%)
1990 (C)	2.4 (14%)	3.4 (20%)	2.3 (14%)	3.3 (19%)	0.9 (5%)	2.0 (11%)
1991 (C)	1.6 (11%)	3.1 (21%)	1.2 (8%)	2.7 (18%)	1.6 (11%)	2.7 (18%)
Average	-0.5 (-2%)	0.5 (2%)	-1.1 (-5%)	-0.1 (0%)	-0.8 (-3%)	0.2 (1%)
Median	0.4 (2%)	1.2 (6%)	0.2 (1%)	1.1 (5%)	0.2 (1%)	0.7 (3%)

[a] Negative values indicate lower survival under ESO scenarios than under EBC scenarios.

[b] Water-year types: W = wet; AN = above normal; BN = below normal; D = dry; C = critical.

[c] See Table 5C.0-1 for definitions of the scenarios.

In this latter regard, the BDCP analyses display a disturbing trend where favorable fish model outputs are overstated and the unfavorable outputs are downplayed. For example, the Interactive Object-Oriented Simulation (IOS) Model results suggest that the BDCP would result in negative effects to winter-run Chinook salmon (Figures 34 and 35), but those results were downplayed:

> "In general, the BDCP scenarios resulted in slightly lower through-Delta survival rates overall, with the survival rates for each scenario varying over a similar range. … The lower BDCP scenario survival rates were the result of increased flow-related mortality in specific model reaches in the Delta." (BDCP Page 5.G-68)
>
> "IOS estimated lower escapement of winter-run Chinook under the ESO, HOS and LOS scenarios over the ELT, with the modeled decreased through-Delta survival being the primary driver of these effects, although only flow-related effects were included in the model." (BDCP Page 5.G-81)

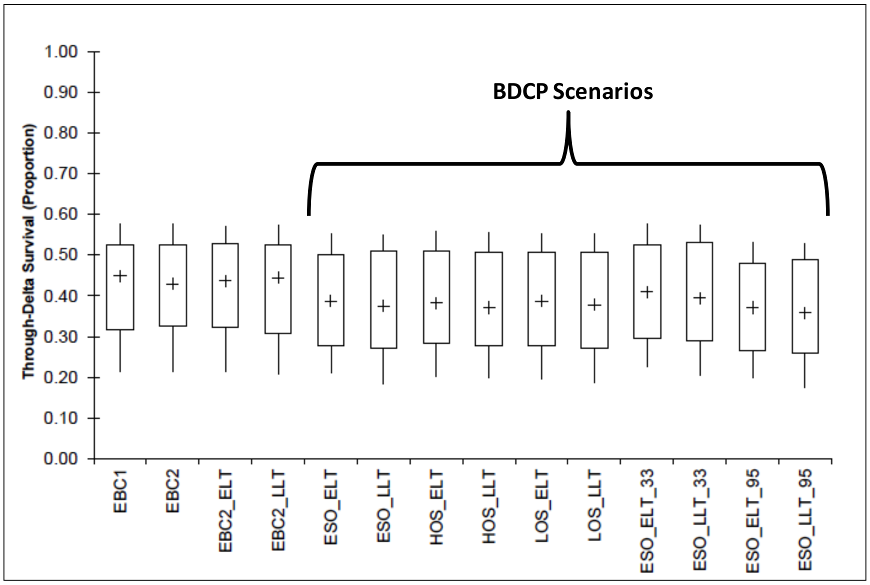

Figure 34. Box plots of Sacramento winter-run Chinook salmon smolt survival through the Delta for each model scenario (adapted from BDCP Page 5.G-69).

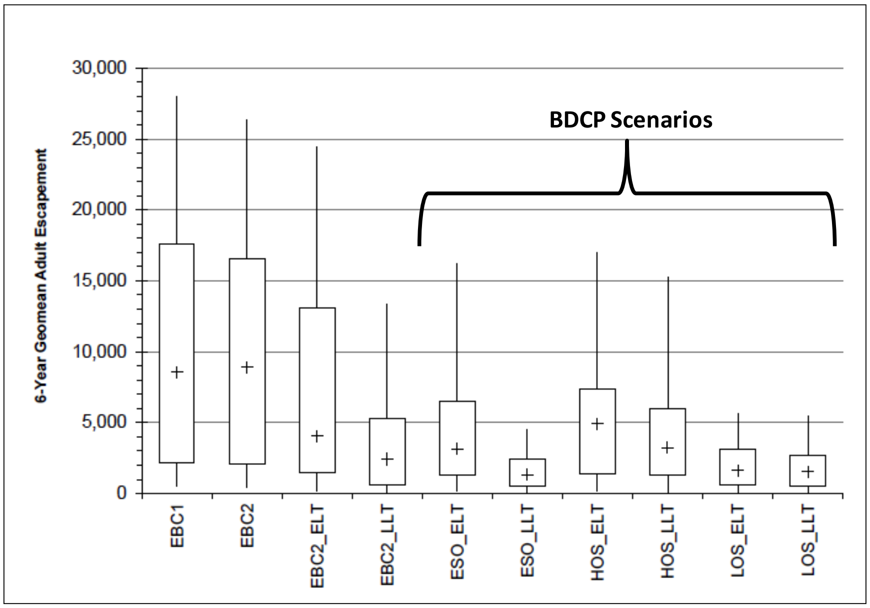

Figure 35. Box plots of 6-year geometric mean Sacramento winter-run Chinook salmon adult escapement for each model scenario (adapted from BDCP Page 5.G-74).

BDCP modeling also indicated that the BDCP would adversely impact winter-run Chinook redd dewatering:

> "The number of years with poor redd dewatering conditions would be 11% and 8% higher under ESO_ELT and ESO_LLT relative to EBC2_ELT and EBC2_LLT, respectively." (BDCP Page 5C.5.2-67)

But the BDCP concluded:

> "These results indicate that there would be a small adverse effect of the ESO on winter-run Chinook salmon". (BDCP Page 5C.5.2-67)

Normally, dewatering of winter-run Chinook redds has been considered a very serious concern by the fishery resource agencies. For example, in 2013, small numbers of winter-run redds began dewatering during the fall and USBR was required to maintain higher than normal Keswick Dam water releases until winter-run fry could emerge from the redds. As a consequence, large numbers of early-spawning fall-run Chinook laid eggs during relatively high-flow conditions on elevated benches of the riverbed. When flows subsequently and abruptly declined, it was estimated that millions of fall-run salmon eggs perished. At a May 3, 2014 Golden Gate Salmon Association Task Force meeting, a USFWS employee announced that if just five winter-run salmon redds were to begin to become dewatered during declining Sacramento River flows, it could "trigger" the need to maintain or increase reservoir releases. Apparently, the BDCP has a different opinion as to what constitutes a "small adverse effect".

However, although unfavorable consequences on winter-run Chinook are indicated on several fronts, the BDCP discounts the model outputs by providing numerous caveats suggesting the models do not reflect anything from which meaningful conclusions can be made. Furthermore, when negative impacts on fish are indicated, the BDCP adds speculative statements suggesting those impacts could be offset by unproven conservation measures such as the use of NPBs discussed previously. This points to fallacies in the BDCP analyses by assuming that proposed conservation measures with highly untenable and uncertain effects on salmon will be beneficial. The problem is then compounded when the BDCP extrapolates questionable presumed beneficial results from uncertain conservation measures to other, also uncertain, conservation measures concluding positive benefits for salmon, all the while lacking empirical foundation. In other words, the BDCP should not extrapolate the effects of one uncertain CM as an indicator for other uncertain CMs. For example:

> "These results indicate that IOS is sensitive to the beneficial effects of conservation measures like CM 16 [non-physical barriers] indicating that other conservation measures could have a similarly large effect on model outcomes if they could be incorporated into IOS or another similar life cycle model. Given this limitation, IOS results alone do not provide a sufficient basis for drawing conclusions about the overall effect of the BDCP on winter-run Chinook salmon." (BDCP Page 5.G-78)
>
> "Therefore IOS is likely underestimating the performance of the BDCP scenarios." (BDCP Page 5.G-80)
>
> "Therefore IOS results must be interpreted with caution when evaluating the potential effects of the BDCP because this analysis did not consider the beneficial effects of Delta habitat restoration or several other potentially beneficial conservation measures." (BDCP Page 5.G-81)

Overall, it seems that OBAN modeling suggests that higher mortality of winter-run Chinook occurs with the BDCP as compared to existing conditions due to egg mortality in the upper river whereas IOS modeling implies higher in-Delta mortality with the BDCP as compared to existing conditions. But then both are portrayed as not reasonable representations when it comes to negative impacts:

> "While both models predict lower overall performance for most BDCP scenarios relative to EBC2, these results must be viewed as incomplete. Neither model is fully representative of the conditions experienced by winter-run Chinook across their entire life history. Importantly, neither model considers the entire range of beneficial effects likely to occur under the BDCP." (BDCP Page 5.G-82)

None of the modeling adequately accounted for salmon fry mortality attributable to impingement on the north Delta intakes. As described previously, although it is reasonable to conclude that entrainment mortality will be zero or negligible, the opposite would be true for impingement mortality. The high certainty of adverse impacts should not be simply ignored. The BDCP provides conflicting assumptions of the sources of mortality; in some cases, the documents suggest the mortality would solely be attributable to predation and, in other cases, it is assumed to encompass predation, impingement, and entrainment. Here again, it would be useful for the BDCP to parse out and bracket potential impingement mortality with low, medium, and high estimates.

The bioenergetics modeling actually only accounted for striped bass predation which would greatly underestimate salmon losses. Salmon predation losses attributable to Sacramento pikeminnow and black bass would undoubtedly be expected. For example, Nobriga and Feyrer (2007) state: " Striped bass, largemouth bass, and Sacramento pikeminnow are three of the major predators of juvenile and small adult fishes in the Delta." Even though the BDCP mentions the fact that Sacramento pikeminnow are common in the Delta, the implication is put forth that the species is not a predator on salmon in the region[22]. However, Sacramento pikeminnow is considered a potential predator species on fish exiting the fish salvage release sites in the Delta (Odenweller and Brown 1982); DIDSON^{TM} sonar footage has documented that occurrence (Miranda et al. (2010). Notably, Odenweller and Brown (1982) concluded that Sacramento pikeminnow is one of the most important potential predatory fish species at future fish facilities on the lower Sacramento River. The BDCP also incorrectly states: "There is, however, a bounty fishery in the upper Sacramento River to reduce predation by these fish on emigrating salmonids (Nobriga and Feyrer 2007)." A factual check of the source document did not make that statement. Several decades ago, there was a targeted sport fishery for pikeminnow, mostly associated with the Red Bluff Diversion Dam (Moyle 2002), but that has long since ended. Pikeminnow are common and a well-known predator on salmon in the Sacramento River and Delta, especially in altered environments that would be created by the north Delta intakes. Here again, the BDCP has not used the best available science.

A considerable amount of error was likely introduced when the bioenergetics modeling evidently only accounted for small striped bass predation on larger-sized juvenile salmon and not small and large striped bass predation on smaller-sized salmon:

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[22] "Sacramento pikeminnow predation on salmonids has been documented upstream (Vogel et al. 1998) but not in the Delta (Nobriga et al. 2006) …" (BDCP Page 5.F-68)

> "Loboschefsky and Nobriga (2010) provide estimates of striped bass predation rates on "small prey" and "large prey." This bioenergetics analysis incorporates only the large prey equation, although smaller salmon fry would fall under the small prey category. The large prey predation regression was based on data for small striped bass (69 to 478 millimeters [mm]); thus they mainly reflect responses of juvenile striped bass. Therefore, they are not as applicable for larger striped bass and for larger sized prey fishes." (BDCP Page 5.F-16)

Therefore, that modeling effort undoubtedly and substantially underestimated striped bass predation on salmon because high numbers of small and large striped bass can consume very large numbers of salmon fry.

The BDCP analyses apparently greatly underestimated salmon losses attributable to the south Delta water export facilities by not accounting for high prescreen predation mortality:

> "However, expanded salvage loss estimates used for analysis here [Delta Passage Model salvage juvenile salmon estimates for the SWP/CVP south Delta export facilities] do not include prescreen predation mortality, for which a multiplier of several times may be necessary." (BDCP Page 5.B-81)

The actual multiplier would be much higher than "several times". The best available information has clearly demonstrated that the prescreen predation mortality can be up to an order of magnitude greater than the direct salvage loss estimates. With such an extremely wide range of unaccounted mortality, it is not clear how the BDCP analyses would allow a useful comparison among BDCP alternatives. Here again, it would be practical for the BDCP analyses to provide a range of total mortality estimates (salvage plus predation losses) (e.g., low, medium, high) to permit more-meaningful comparisons among BDCP scenarios.

A significant error in the assumption of the timing of salmon smolt entry into the Delta for the DPM model was introduced when the model did not account for the substantial inter-annual variability in emigration timing for each salmon run. The DPM assumed the timing would be the same regardless of water year type and upstream hydrologic conditions (Figure 36). Although the documentation acknowledges the model is used only for smolts, not fry, there nevertheless are substantial differences in emigration timing of smolts between years. It appears that the DPM used a summed composite of data across different years but did not account for the variability in inter-annual salmon emigration and interrelationships with naturally occurring hydrologic conditions. This limitation is important because of how CM1 and CM2 operations would vary substantially between different water types and hydrologic variability and the resultant timing and interaction of salmon smolts with those operations. For example, the emigration of winter-run and late-fall-run Chinook salmon smolts (both of which have a more-protracted smoltification period than fall-run salmon) from the upper river to the Delta is influenced to a large degree by timing and magnitude of precipitation and consequential accretions in the upper watershed. This variability in smolt emigration timing is not captured in DPM model outputs and makes it highly problematic to use those outputs to compare alternative BDCP scenarios.

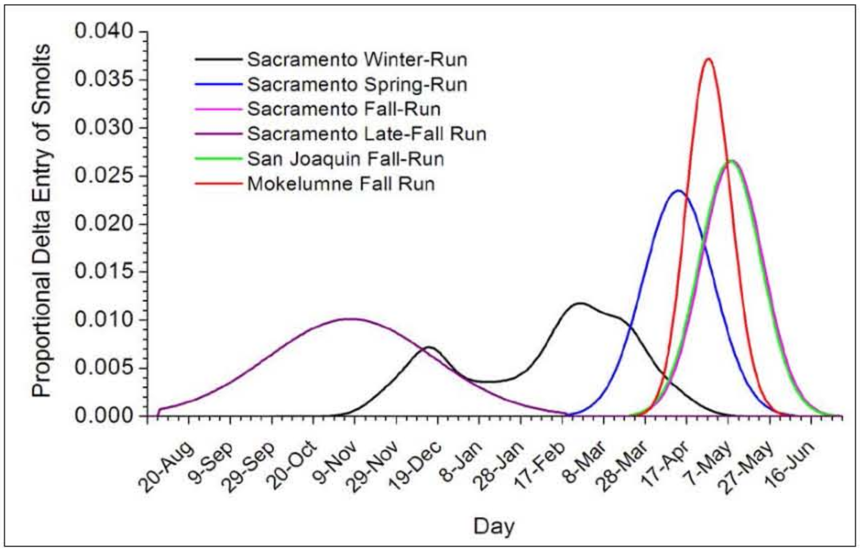

Figure 36. Delta entry distributions for Chinook salmon smolts applied in the Delta Passage Model for Sacramento River winter-run, Sacramento River spring-run, Sacramento River fall-run, Sacramento River late fall–run, San Joaquin River fall-run, and Mokelumne River fall-run Chinook salmon. (BDCP Figure 5.C.4-7)

The DPM has a significant erroneous assumption that installation of a NPB in front of the Delta Cross Channel would result in a large reduction of salmon entrainment:

> “As noted in the DPM methods, the assumption of a 67% proportional reduction in entry into the Interior Delta for late fall–run Chinook salmon actually involves assuming that there would be deterrence not only from entering Georgiana Slough but also the Delta Cross Channel, as the latter is largely open during the assumed late fall–run August-February migration period.” (BDCP Page 5C.5.3-102)

There is no scientific basis to assume deterrence would be the same for the DCC as Georgiana Slough and the best available science indicates otherwise. Past telemetry studies on salmon movements at the DCC and Georgiana Slough and the areas’ hydrodynamic conditions clearly demonstrate there are large differences in flow and fish entrainment at the two sites (Vogel 2002a, 2003a, 2008b, 2011a, 2011b). Discussion on the topic of non-physical barriers was previously provided within these comments (pages 53 – 63).

All of the fish models reliant on “through-Delta” salmon survival should be re-examined for consistency as to the specific salmon migration reach used for the survival estimates. Some modeling calculations used Chipps Island as the measurement end point whereas others used the Golden Gate Bridge as the end point. There are approximately 45 miles between those two end points and Michel (2010) found that there is a surprisingly high salmon mortality between Chipps Island and the Golden Gate Bridge.

Also, the BDCP fish models should be closely re-examined in an unbiased manner to assess if the models are actually rudimentary and incapable of predicting probable changes to salmon survival with the various BDCP scenarios and conservations measures. With so many questionable or erroneous assumptions built into the models based on incomplete, incorrect, or highly speculative information, one is led to believe the models, in reality, have a very low sensitivity for adequately providing the necessary comparative analyses.

Biased BDCP Analyses Based on Juvenile Salmonid Telemetry Studies in the Delta

The BDCP analyses relied heavily on outputs from a juvenile salmon "Delta Passage" computer model (DPM) to evaluate a variety of alternatives for water management in the Delta (BDCP Appendix 5C, Part 1). This dominant BDCP fish model relied on juvenile salmon acoustic-telemetry study results of Perry (2010) and a few other telemetry studies that provided estimates of acoustic-tagged juvenile salmon route selection and survival through the Delta. However, we now have a high degree of confidence that the accuracy and precision of the salmon survival estimates in those telemetry studies are not believable and, therefore, the DPM model and other models'[23] use of those study results for the BDCP analyses are unreliable.

To explain this assertion and demonstrate that the BDCP did not use the best available science, the following provides a background foundation and necessary amplification and clarification. This discussion is important to explain how the BDCP misused some past telemetry research on salmon, thereby resulting in misinterpretation of fish behavior and survival within the BDCP documents, and failed to build upon and use more-appropriate study findings. It is also essential because the BDCP indicates it will rely on future telemetry studies for its adaptive management program without disclosure of critical limitations discussed below.

Brief Background of the Use of Juvenile Salmon Telemetry in the Delta

Until the 1990s, detailed, empirical data on juvenile salmonid behavior and survival in the Delta's discrete reaches were largely unknown or severely lacking. There were widely-varying, speculative ideas on how juvenile salmonids behaved in the region's complex tidal environment. Opinions abounded, but all-important supportive data were unavailable until the mid-1990s when the first successful use of telemetry on juvenile salmonids in the Central Valley took place. Past efforts using traditional coded-wire tagging (CWT) did not, and could not, answer those critically important questions. Ultimately, from 1996 through 2010, I served as the principal scientific investigator for 22 separate research projects on juvenile salmon (including four studies of predatory fish) in the Delta using radio or acoustic telemetry as a means to acquire detailed data on fish behavior, fish movements with the tides, fish route selection at flow splits, migration through complex channels, migration rates, and estimates of fish survival (Vogel 2010a). As a result, comprehension of fish behavior has improved substantially in recent years due to breakthroughs in the creation, application and analysis of miniaturized telemetry technology for small fish. These readily-available tools have subsequently produced a proliferation of juvenile salmonid telemetry studies in the Delta.

Technological breakthroughs in miniaturization of radio transmitters allowed attachment or surgical implantation in juvenile salmonids (Figure 37). These transmitters could be

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[23] For example, these errors were even propagated to particle tracking model PTM results for BDCP analyses: "For all other reaches (Geo/DCC and Yolo), reach survival is assumed to be unaffected by Delta conditions and is informed by means and standard deviations of survival from acoustic-tagging studies." 5C.4-52

programmed for individually-identifiable frequencies to discriminate between tagged fish released and monitored throughout the Delta channels. Radio signals emitting underwater can break the water/air surface interface and be detected by land- or boat-based radio receivers. Triangulation of radio signals provided locations of the migrating salmon. These initial studies quickly determined that the fish did not move as a school, but instead, dispersed, exhibiting a wide range in migratory behaviors in the complex Delta environment. Numerous revealing findings were derived from these first telemetry investigations. Salmon moved many miles back and forth each day with the ebb and flood tides and the side channels (where flow was minimal) were largely unused. Site-specific hydrodynamic conditions present when telemetered fish arrived at channel flow splits had a major affect in initial route selection. Importantly, relevant to the BDCP models, some of the juvenile salmonids were believed to have been preyed upon based on aberrant telemetry patterns (Vogel 2003b, 2004, 2010a, 2011a, 2012b). An example was a sudden attenuation in the radio signal that was caused by a salmon being eaten by a predator. These observations lead to the first documentation of predation on telemetered salmon in the Delta.

Figure 37. A radio-tagged juvenile Chinook salmon one week after surgery.

Studies in the highly complex regions of the Delta Cross Channel and Georgiana Slough in 2000 and 2001 provided some of the most extensive, detailed fish behavior (in real-time and on a micro-scale). Results of this research established the first empirical evidence showing how juvenile salmon are entrained into the DCC and Georgiana Slough. It also demonstrated how juvenile salmon may migrate past those two flow splits during ebb tide conditions only to be subsequently advected back upstream during flood tide conditions and then entrained into the DCC and Georgiana Slough (Vogel 2001a, 2002a, 2003a, 2011a, 2012b). The research also provided evidence of high entrainment of smolts into Georgiana Slough when the DCC gates were closed which was attributed to a combination of physical and hydrodynamic conditions at that flow split in conjunction with fish positions within the water column and across the river channel (Vogel 2003a). Predation on telemetered salmon was also evident.

Concerns over water management effects on salmon smolt survival in the Delta lead to four separate research projects conducted during the winters of 2000 and 2002 (north Delta), winter of 2001 (south Delta), and the spring of 2002 (central Delta). Salmon were tracked via jet boats for hundreds of miles throughout nearly every conceivable route where salmon could migrate. Triangulating radio-tagged fish locations in real time clearly demonstrated how juvenile salmon moved long distances with the tides and were advected into regions with very large tidal prisms, such as upstream into Cache Slough and into the flooded Prospect and Liberty Islands. Importantly, these studies again found that some telemetered salmon were eaten by predatory fish based on unique characteristics of telemetry data (Vogel 2001b, 2003b, 2004, 2007a, 2010a, 2011a, 2011b). Results found that some radio-tagged salmon were eaten by predatory fish in northern Cache Slough, near the levee breaches into flooded islands and that higher predation occurred in Georgiana Slough as compared to the lower Sacramento River. While past studies utilizing coded-wire tags also found that salmon released into northern Georgiana Slough were found to have a higher mortality rate than fish released in the Sacramento River downstream of the flow split (Brandes and McLain 2001), the reasons for the mortality remained unknown until these telemetry studies were performed.

In 2005, a desire to develop more-quantitative as compared to qualitative data prompted a study using a relatively new miniaturized acoustic tag that could be surgically implanted in juvenile salmon (Figure 38). Unlike radio telemetry, acoustic technology requires underwater signal detection recorded by submerged hydrophones. Based on a series of experiments and field trials in the Sacramento River and Delta, it was determined that the technology had application for fish behavior and survival studies in the Delta (Vogel 2006a). In particular, it was discovered that a unique feature of the technology (through highly detailed and meticulous data processing techniques) allowed detection of predation on salmon smolts as well as accurate depiction of multiple predation events by individual predatory fish (Vogel 2006a, 2006b, 2007a, 2011a, 2011c). The first large-scale acoustic-telemetry study took place in the north Delta in 2006 - 2007 to further expand the understanding of how fish move, not only into the DCC and Georgiana Slough, but Sutter and Steamboat Sloughs as well (Vogel 2008b).

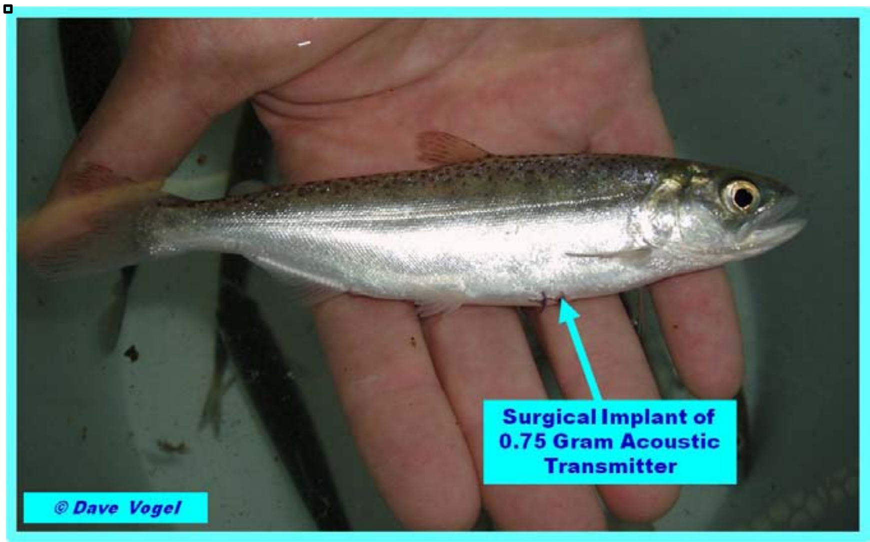

Figure 38. An acoustic-tagged juvenile Chinook salmon.

After it was demonstrated that miniaturized acoustic telemetry yielded valuable insights into juvenile salmon migratory behavior and survival/mortality, the San Joaquin River Group Authority (SJRGA) expressed interest in using the technology to supplement ongoing coded-wire tag studies that were being administered as part of the Vernalis Adaptive Management Program (VAMP). For many years, the VAMP studies were conducted by releasing groups of CWT salmon, but consistently ended in inconclusive results from poor (low) tag returns that could not inform meaningful management decisions. The SJRGA believed that the annually repeated CWT VAMP studies, by themselves, were not providing sufficient data to formulate actions to benefit salmon in the lower San Joaquin River and Delta. However, noting the success of telemetry technology, large-scale studies in the south and central Delta took place over several years (Vogel 2006b, 2007a, 2007b, 2010b, 2010c, 2011c). These latter, most-recent efforts led to a major breakthrough in the interpretation of juvenile acoustic telemetry studies in the Delta applicable to the BDCP flawed analyses and misinterpretation of research results (discussed below).

The Predation Problem and Salmon Survival Models

Limitations of the acoustic telemetry technology for salmon survival models were inadvertently discovered during experiments I conducted in 2005 by releasing acoustic-tagged juvenile salmon upstream of the Delta on the Sacramento River, then electronically recording passage of each fish at fixed-station electronic acoustic dataloggers positioned farther downstream (much like the strategy for later experiments in the Delta). Using simple presence/absence data recorded by the dataloggers (customarily and commonly applied by others in later Delta efforts), initial results indicated 100% survival. In this particular experiment, using the telemetry vendor's hardware and software, much more data than simple presence/absence of tagged fish detection was produced. It allowed close visual examination of the "echograms" or "acoustic signatures" of subtle movements of fish at a fine- or micro-scale within detection range of the dataloggers. Later, highly-detailed, manual post-processing of the study data found that three acoustic-tagged salmon released upstream at different times and locations reached the downstream dataloggers at the exact same second, a probability close to zero. Further, closer examination of the echograms showed that those three tags moved in perfect unison for extended periods (Figure 39). It was therefore confirmed that the three acoustic-tagged salmon had been eaten by a predator and the dataloggers had actually recorded the three dead fish inside the predator's stomach instead of as individual live salmon. Figure 40 depicts this problem. After manual re-examination of the echograms, the original salmon survival estimates using only presence/absence detection data changed from 100% survival to 100% mortality; all fish had been consumed by predatory fish. The findings clearly demonstrated the enormity of potential misinterpretation of telemetry results without thoughtful, careful application of the technology and understanding of fish behavior (which was not brought forth in the BDCP documents).

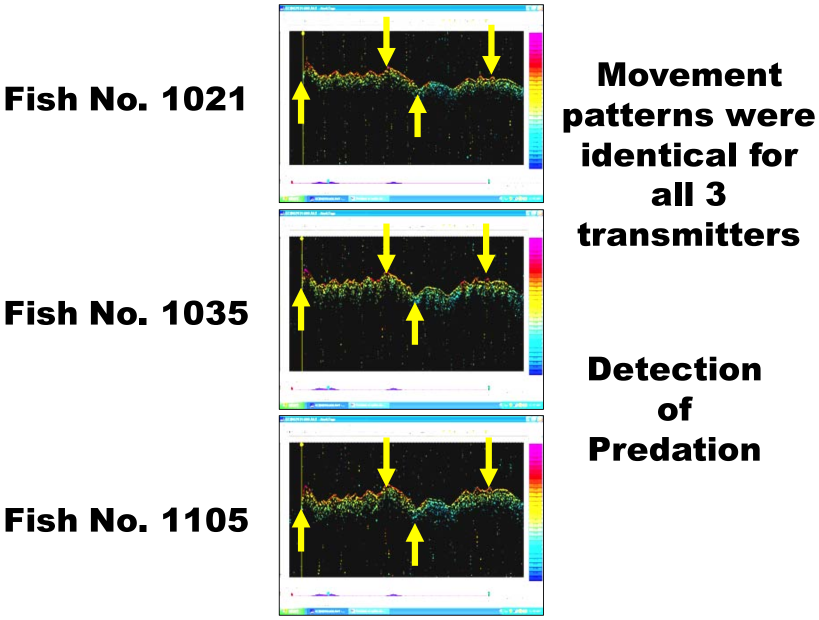

Figure 39. Three individual echograms of three different acoustic-tagged salmon (or the transmitters) during the identical time period showing changes in the amplitude and voltage of the signals (y-axis) over time (x-axis).

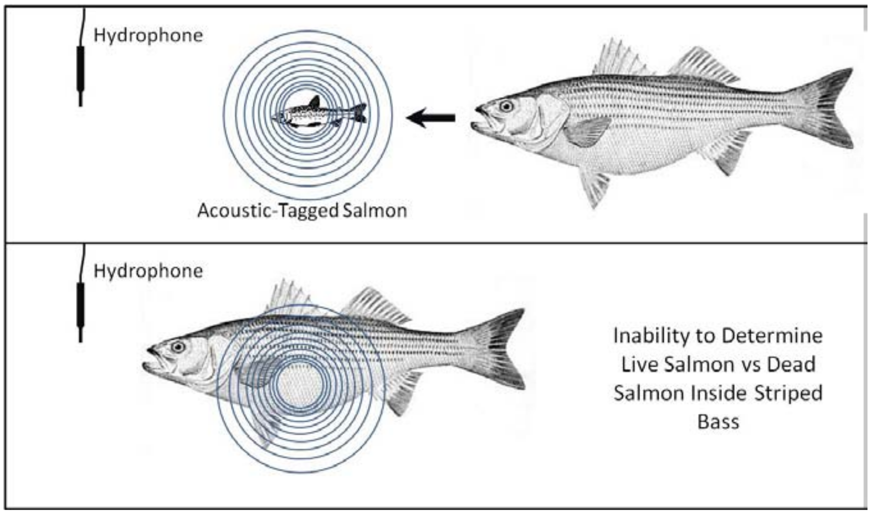

Figure 40. The problem with the inability to determine a live acoustic-tagged salmon versus a dead acoustic-tagged salmon inside a striped bass using only presence/absence tag detection data.

This major technological limitation for estimating juvenile salmon survival and fish route selection dramatically surfaced during the VAMP fish studies. Through detailed analyses of acoustic-tag echograms recorded by a large array of fixed-station dataloggers[24] distributed throughout the Delta, it was found that, in hundreds of instances, we were actually tracking the movements of dead salmon inside predatory fish, not live acoustic-tagged salmon (Vogel 2010c, 2011c). Importantly, a separate, concurrent study using different techniques for evaluating the behavior of migrating acoustic-tagged juvenile salmon during the VAMP study at the head of

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[24] We chose to manually examine each and every echogram instead of reliance of simple presence/absence data because of the previously discussed discovery.

Old River estimated that approximately 50% of the tagged salmon were actually dead salmon inside predatory fish. The magnitude of potential misinterpretation of study results would have been enormous if only the usual and customary tag presence/absence data were used. A peer-review workshop of the VAMP telemetry studies stated: "On the predator problem and acoustic tags – the problem should not be understated."[25]

In an attempt to overcome this predation issue with acoustic telemetry studies in the Delta, we developed procedures to estimate whether or not individual acoustic-tagged salmon detected by fixed-station acoustic receivers positioned throughout the Delta had been preyed upon. Highly detailed evaluations of telemetered fish movements were performed which included:

1) A near-field environment within the fish transmitter detection range of telemetry receivers;
2) Medium-field observations of movements in a fine time scale between receivers in close proximity; and
3) Far-field examinations of movements throughout Delta-wide telemetry arrays.

These data were integrated with flow measurements, site-specific characteristics in migration corridors, and, very importantly, knowledge of fish behavior acquired from prior radio- and acoustic-telemetry studies (Vogel 2010c, 2011c). In each year, the severity of the predation problem was demonstrated.

Subsequently, in a recent peer-reviewed journal publication, Buchanan et al. (2013) adopted this "predator filter" technique developed by Vogel (2010c, 2011c) to estimate salmon survival through the Delta (from the San Joaquin River upstream of Mossdale to Chipps Island). For the 2010 VAMP studies, the estimated survival through the Delta without application of the predator filter was 11%. However, with application of the predator filter, salmon survival was estimated at only 5% (Buchanan et al. 2013). These results indicate the magnitude of error that can occur (and unquestionably has occurred) in Delta telemetry studies without accounting for the predator problem. The BDCP did not account for these serious errors and bias in survival estimates used in the fish models. This best available science was completely ignored in the BDCP analyses. Therefore, the accuracy and precision of BDCP modeled estimates of relative salmon survival among the alternative BDCP scenarios are undoubtedly untenable and unusable and is another major shortcoming of the BDCP analyses.

The principal predator creating these primary telemetry study limitation problems in the Delta is non-native striped bass. Some acoustic telemetry study designs performed in the Delta (e.g., Perry 2010) expected that predatory fish would be relatively stationary[26] or not move in a downstream direction (like Columbia River dam studies), and the serious predicament described here would not surface. However, that critical assumption is now known to be invalid (as described previously). In fact, striped bass can exhibit a strong tendency to migrate from the northern, interior, and south Delta regions to the west Delta and showed a strong affinity to the area around Chipps and Mallard Islands (Vogel 2012). Unfortunately, this site is where the

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[25] Delta Science Program Workshop Summary, March 2 – 3, 2010.

[26] The studies also assumed that predators would only move in an upstream direction (uncharacteristic of a salmon smolt) and resultant telemetry data could be corrected for anomalous tag behavior.

western-most acoustic dataloggers were positioned as an "end point" in the hope of estimating overall salmon survival through the Delta (e.g., Perry et al. 2012). Some studies, including several in the peer-reviewed literature, have simply chosen to ignore the predation problem by assuming that no predated acoustic-tagged salmon would swim past the receivers in a downstream direction (e.g., Holbrook et al. 2009, Perry 2010, Perry et al. 2010, Perry et al. 2012). Fortunately, Buchanan et al. (2013) provided more-reliable and realistic estimates for San Joaquin River salmon survival through the Delta (accounting for the predation problem) but, to date, Sacramento River salmon studies have failed to do so. A recent study on juvenile steelhead in the Delta recognized the predation problem, but did not attempt to correct for false positive detections because of the uncertainty on how to do so (Delaney et al. 2014). These errors have subsequently been compounded and propagated sequentially through reports, science workshops, and even in peer-reviewed publications. The BDCP and its analyses fall into this category. Although this serious problem with telemetry studies has been ignored or slowly accepted, other researchers have finally acknowledged it (e.g., Michel 2010, Buchanan et al. 2013) and some have attempted to correct for the bias (e.g., Buchanan et al. 2013, Romine et al. 2014). In fact, NMFS now recognizes this major issue as well:

> "However, even acoustic telemetry estimates are not without limitations. For instance, survival measured using acoustic tags can be biased high if tagged fish are eaten by predators that subsequently move past receiver locations. Presently, there is no definitive way of determining if a tag detected at a receiver is in a live target species or in a predator." (BDCP Appendix 3.G, Proposed Interim Delta Salmonid Survival Objectives Page 6)

Unfortunately, the BDCP models and analyses did not use the best available science and ignored this dilemma. Instead, it relied on sparse, misleading information from isolated studies. As described in detail above, some telemetry studies failed to account for the severe technological limitation of the inability to differentiate between a live acoustic-tagged salmon and a dead tagged salmon inside a predator but were used for the BDCP analyses. For example, the Perry (2010) study (used for the DPM) only screened out acoustic tags found to have moved in an upstream direction and did not account for predated tags moving in a downstream direction:

> "The detection records of five tagged fish suggested they had been consumed by piscivorous predators as was evidenced by their directed upstream movement for long distance and against the flow. We truncated the detection record of these fish to the last known location of the live tagged fish. All other detections were considered to have been live juvenile salmon." (Perry 2010).

Additionally, it should be noted that the Perry (2010) study was also greatly hindered by releasing the experimental acoustic-tagged salmon during periods uncharacteristic of when salmon would normally migrate. For four of the five fish releases, river flows were unseasonably low, water turbidity was low, and the natural migration of salmon was essentially non-existent. The BDCP analyses have extrapolated results from a study not reflective of those environmental conditions when the north Delta diversions would operate (i.e., high-flow conditions). This demonstrates that caution must be used when using data that are not representative of real-world conditions and subsequently expanding those data to circumstances not applicable to how natural fish migration occurs under high riverine flows.

To further exacerbate this problem, the BDCP proposes to use acoustic telemetry in its "adaptive management" program without an understanding of the limitations.[27] Use of the technology to accurately quantify small fish survival and fish route selection in long reaches of the Delta and through the entire Delta is not viable at the present time until the major predation problem previously discussed is resolved. Therefore, the BDCP should not use any data and models derived from prior acoustic telemetry studies that have not been corrected for bias. This also illustrates the problem with a rush to publish research findings on very complex biological issues. Supposed "statistically robust" data are not useful when the underlying raw input data are simply wrong.

Because of the predation problem greatly compromising the integrity of estimates of salmon survival in the Delta (and fish survival models), I recommended that a miniaturized transmitter be developed to detect when an acoustic-tagged salmon has been eaten by a predator (Vogel 2010c). One telemetry vendor has now done so and the technology is currently being evaluated by USBR. The initial results show strong potential (Afentoulis and Schultz 2014). Also, now in recognition of the predation problem, some researchers are beginning to work on evaluative techniques to discriminate between acoustic detections of a live acoustic-tagged salmon versus a dead acoustic-tagged salmon inside a predator (Romine et al. 2014) using alternative techniques than used by Vogel (2010c, 2011c). Unfortunately, the promising methods for doing so described by Romine et al. (2014) require an extremely expensive and elaborate acoustic telemetry array with dozens of hydrophones positioned in close proximity to obtain highly detailed two- or three-dimensional movements of an acoustic transmitter. Even then, Romine (2014) could not determine if they were truly observing live acoustic-tagged salmon in their telemetry array or predators. More fundamentally and importantly, they did not address the much-larger problem with estimating Delta-wide salmon survival estimates which are reliant on single-hydrophone receivers.[28] Nevertheless, they provided further insight and corroboration into the serious nature of how this predation problem can adversely impact and bias salmon survival estimates in the Delta as described by Vogel (2010c, 2011c) that was not accounted for in the BDCP analyses.

In summary, the BDCP fish models' estimates of salmon survival and fish route selection used to evaluate various BDCP alternatives are unreliable for making management decisions among

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[27] For example: "Therefore, the level of uncertainty in using results of currently available acoustic-tag studies to establish both existing conditions and metrics within the objectives for wild-origin fall-run and late fall–run Chinook salmon is relatively high and will be the subject of additional experimental survival studies, monitoring, and analyses during the interim period." (BDCP Page 3.3-160)

[28] As an important note, Romine (2014) suggested that their techniques of using an elaborate acoustic-telemetry array could be used as an alternative approach of the "predator filter" developed by Vogel (2010). That comparison is not valid because it is an "apples and oranges" perspective between use of single hydrophones deployed independently over long distances versus dozens of integrated hydrophones deployed in close proximity. With present-day technology, installation and operation of the elaborate 2-D or 3-D telemetry arrays throughout the Delta would be expected to cost in excess of hundreds of millions of dollars and would not be feasible for the BDCP's proposed adaptive management program.

BDCP scenarios and conservation measures. Some of the salmon survival estimates used for BDCP models were undoubtedly inflated but also possessed highly questionable and unknown variance in estimated salmon route selection at critical Delta flow splits, reach-specific survival, and overall survival through the Delta. The negative ramifications of the BDCP assumptions cannot be overstated. The BDCP discussion on the topic and the associated analyses must be redone to appropriately build upon and accurately reflect the best available science.

Propagation of Errors in BDCP Fish Models Resulting from Faulty CalSim II Modeling

Much of the BDCP fish modeling efforts relied on CalSim II model outputs. An earlier version of the CalSim II model (herein after referred to as the "BDCP Model") was used as the primary analytical tool and foundation to model BDCP water project operations and water supply to compare the environmental baseline with various BDCP scenarios. In turn, comparisons of changes in water project operations and water supply were subsequently relied upon to estimate effects on fishery resources. However, a recent independent review of the BDCP Model revealed numerous significant flaws (MBK 2014) that were, unfortunately, carried through to the BDCP fish models. Some highlights of that independent modeling review, as it would undoubtedly affect BDCP fish modeling analyses[29], are summarized here.

- The CalSim II model has been substantially updated since the BDCP analyses were performed to correct technical errors and deficiencies in assumptions but the BDCP Model does not reflect the current CalSim II model.

- The BDCP Model results in impractical or unrealistic CVP and SWP operations.

- The BDCP Model High Outflow Scenario could result in releasing more stored water from upstream reservoirs.

- The BDCP Model significantly underestimates the amount of water diverted at the three north Delta intakes and overestimates the amount of water diverted at the south Delta water export facilities.

- Water diverted from the north Delta intakes could be approximately 680,000 acre-feet more than disclosed in the EIR/EIS.

- The amount of water exported from the Delta may be approximately 200,000 acre-feet/year higher than the amount disclosed in the EIR/EIS and Delta outflow would decrease by that amount.

- The BDCP Model assumed that USBR and DWR would not modify water project operations in response to adverse changes in climate and hydrology, which is an unrealistic assumption.

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[29] Analyses of the specific resulting effects on each BDCP fish model would require a substantial undertaking.

The BDCP's inaccurate depiction of changes in water storage in upstream reservoirs, reservoir releases, and water exports in the north and south Delta would undoubtedly significantly alter analyses of the BDCP effects on salmonids and other fish species. Changes in reservoir storage would affect water temperatures in downstream reaches with concomitant effects on salmonid spawning and rearing. Altered timing and magnitude of instream flows would alter salmonid rearing and outmigration, as well as passage through the Yolo Bypass. Variation in the amount and timing of water diverted through the three north Delta intakes would affect factors such as fish sweeping flows, exposure to the fish screens, predation, and impingement. Changes in the amount of flow bypassed at the north Delta intakes would change salmon survival in downstream reaches. Modifications to Delta exports and outflow would alter fish survival. All of these BDCP Model errors result in an adverse cascading affect on the reliability of the BDCP fish models. Therefore the BDCP effects on salmonids were obviously mischaracterized by an unknown, but probably very severe, degree. Given the limitations and errors of the BDCP fish models described in these comments, the fish models' reliance on faulty BDCP Model outputs at the outset further adds to the undependably modeled and unknown BDCP effects.

Old and Middle River Flows

The BDCP provides some misleading statements concerning BDCP effects on Old and Middle River (OMR) flows. For example:

> "Under the evaluated starting operations, average OMR flows generally are more positive in most months under all water-year conditions compared to existing biological conditions (Figure 5.B.4-3)." (BDCP Page 5.B-17)

Based on model results provided in BDCP Appendix 5B Entrainment, it appears that OMR flows will actually be "less negative" instead of "more positive". Most of the time, OMR will stay negative (southerly direction) instead of positive (northerly direction) (BDCP Figure 5.B.4-3 below). The significance of this fact is that juvenile salmon will still move southerly toward the export facilities even with less-negative flows. The zone of influence where juvenile salmonids may be entrained southerly toward the south Delta from export operations has not yet been specifically identified, but it may extend as far north as channels leading off the San Joaquin in the central Delta with stronger influence closer to the export facilities (Vogel 2005). A recent study of juvenile steelhead movements found that high mortality occurred even with less negative OMR compared to more negative OMR (Delany et al. 2014) demonstrating the adverse impact of the south Delta exports. This issue warrants much more description and analyses in the BDCP.

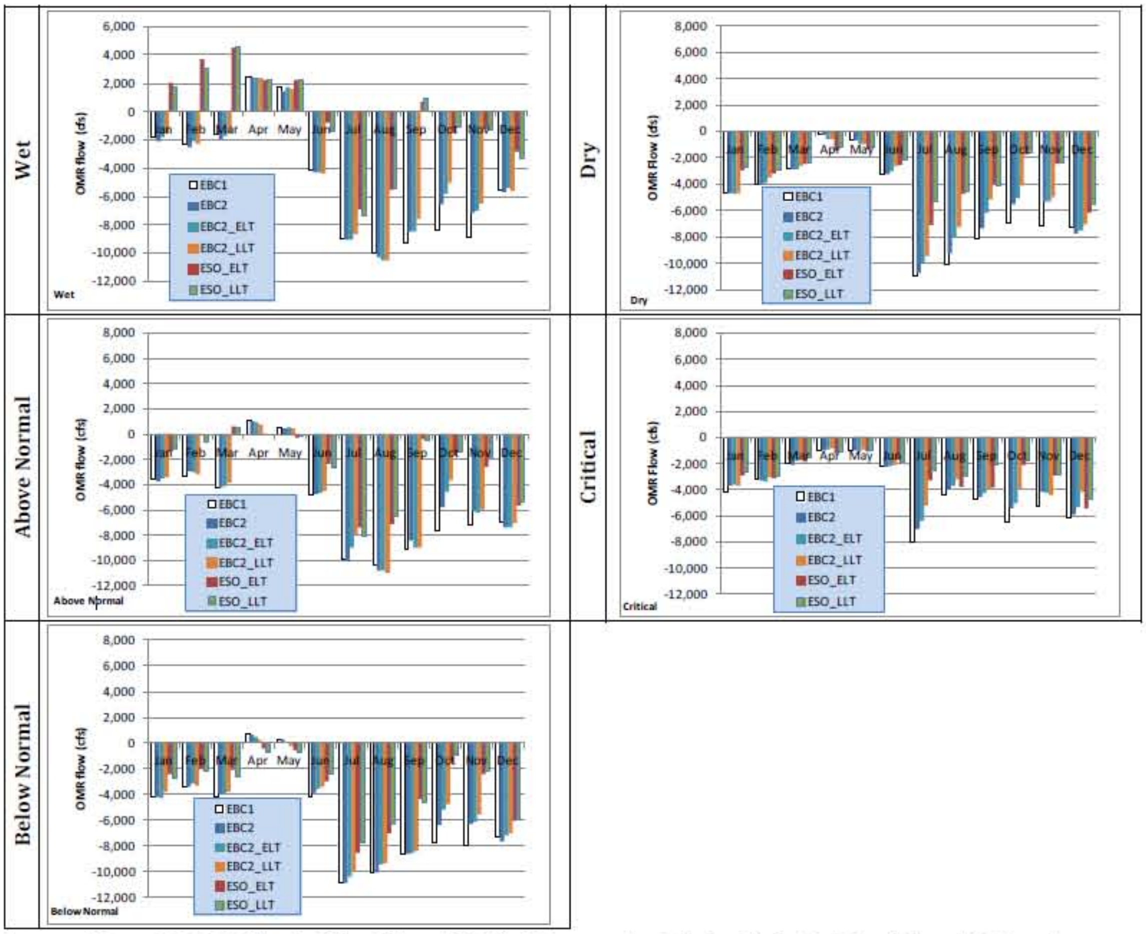

Figure 5.B.4-3. Flow (cfs) in Old and Middle Rivers under existing biological conditions (EBC) and Evaluated Starting Operations (ESO) in the Early Long-Term (ELT) and Late Long-Term (LLT) periods. (Figure from BDCP Appendix 5B, Entrainment.

Propagation of Misleading Information Concerning Salmon Behavior

Misleading information concerning juvenile salmon behavior, migration characteristics, and habitat preferences is permeated throughout the BDCP documents in the various assumptions, models, and conclusions. The popularized recent use of colorful and attractive PowerPoint graphics, computer animations, and other readily-available communication tools have often resulted in over-simplification of highly complex topics such as fish behavior. Those outside the fisheries science discipline have postulated ideas on salmon behavior and movements in the Delta and proposed remedial actions for fish that must be more-appropriately vetted through experts on Delta fishery resources. These forums have exacerbated the problem when only highly selective information is provided by individuals with inadequate training and expertise in the fishery science discipline. The problems and potential solutions "*du jour*" for fish posed by such individuals have become more frequent in recent years and runs the serious risk of erasing progress toward improved fish survival in the Delta. Once incorrect or misleading information is presented, it unfortunately propagates rapidly and widely, making it difficult to rectify; it can misdirect resources away from the most urgent problems. This issue is vital because it adds to scientific uncertainties and has negatively affected the credibility of the BDCP.

BDCP Uncertainties and Adaptive Management

It is readily apparent there is an enormous amount of ambiguity and uncertainty in the BDCP and its conservation measures. Every aspect of the potential impacts of the BDCP on salmonids is either "uncertain" or "highly uncertain". A simple search for the word or words containing "uncertain" found it mentioned *1,008 times* in the BDCP and appendices and *2,303 times* in the EIR/EIS and appendices.

As a result of all the uncertainties, the BDCP advocates the use of "adaptive management" in its implementation. In fact, the BDCP and associated EIR/EIS use the term with so much emphasis that it overwhelms the implementation strategy. Because of the enormous amount of uncertainty in impacts of the BDCP on salmon and the proposed conservation measures, the BDCP repeatedly states that if unanticipated adverse effects are found after plan implementation, adaptive management will be used to inform potential management actions in attempts to correct those defects. A simple phrase search for "adaptive management", "adaptively managed", and "adaptively mange" found it mentioned *1,314 times* in the BDCP and appendices and 2,008 times in the EIR/EIS and appendices. The following are just a few examples:

> "Adaptive management is intended to reduce uncertainty over time through a structured process that incorporates improved scientific understanding into Plan implementation. Information obtained from monitoring and research activities will be used to make recommendations regarding implementation of the conservation measures. This will continually improve the outcomes associated with water resource management and ecological restoration commitments." (BDCP Executive Summary Page 13)
>
> "The adaptive management and monitoring program has been designed to use new information and insight gained during the course of Plan implementation to assure that strategies employed by the BDCP can achieve the biological goals and objectives." (BDCP Page 3.1-4)
>
> "The adaptive management program provides a mechanism for making adjustments to avoid or minimize this effect." (BDCP Pages 5.F-iii and –iv)
>
> "Additionally, should a cause for not achieving a biological goal or objective be identified, adaptive management will be used to change conservation measures, if necessary, to address the cause." (BDCP Page 3.1-5)
>
> "Such adverse effects would be assessed through the adaptive management process, which could result in changes to the conservation measures to minimize these effects." (BDCP Page 3.2-8)
>
> "If results of monitoring identify adverse effects that will not support meeting the expected biological outcomes, the existing and future restoration actions will be modified and refined as part of adaptive management. In the event that a restored habitat is found to have substantial adverse effects on the reproductive success,

> growth, survival, or population dynamics of the covered fish, substantial modifications will be made to address and mitigate these adverse effects." (BDCP Page 5.3-32)

Unfortunately, the BDCP's approach to adaptive management lacks substance, credibility, and authenticity. Because the BDCP is so exceedingly reliant on adaptive management, it is highly instructive to examine recent uses of this concept in some relevant Central Valley and Delta salmon programs to determine how reliably adaptive management may actually be implemented for the BDCP. The trustworthiness of BDCP adaptive management is only as good or reliable as how the practice has recently been performed for other fishery resource projects in the Central Valley and Delta. A review of such projects is illustrative of the trustworthiness in statements in the BDCP to predict how well the BDCP will truly attain purported benefits to "achieve biological goals and objectives" and "avoid and minimize effects". The following are just some examples.

Central Valley Project Improvement Act, Anadromous Fish Restoration Program

In 1992, the Central Valley Project Improvement Act (CVPIA) was enacted by Congress and an Anadromous Fish Restoration Program (AFRP) to double the anadromous fish populations in the Central Valley by 2002 was developed. However, after twenty-two years and more than one billion dollars spent, extensive monitoring studies and the use of so-called "adaptive management", the salmon runs have not increased. Additionally, there is no measureable progress toward delisting any of the threatened or endangered anadromous fish, and the fall-run Chinook, the most abundant among the salmon runs, have now declined even further from historical levels. Some individuals have even recently suggested that the fall run may warrant listing as an endangered species (Williams 2012).

In 2008, a peer review of the CVPIA fisheries program was conducted and was highly critical of the government agencies' implementation of the anadromous fish restoration efforts. For example,

> "Yet it is also far from clear that the agencies have done what is possible and necessary to improve freshwater conditions to help these species weather environmental variability, halt their decline and begin rebuilding in a sustainable way. A number of the most serious impediments to survival and recovery are not being effectively addressed, especially in terms of the overall design and operation of the Central Valley Project system." (Cummins et al. 2008)

In particular, the review criticized the failures of implementing an effective, scientifically valid adaptive management program:

> "The absence of a unified program organized around a conceptual framework is one of the reasons the program appears to be a compartmentalized effort that lacks strategic planning and decision-making. As a result the program is unable to address the larger system issues, has a disjointed M&E [monitoring and evaluation] program, exhibits little of the traits expected from effective adaptive

> management, and is unable to effectively coordinate with related programs in the region. An uncoordinated approach also creates boundaries to the free flow of useful information and program-wide prioritization. We observed that most researchers and technicians seemed unclear how or even whether their local efforts related to or contributed to the overall program." (Cummins et al. 2008)
>
> "The CVPIA program does not use basic principles of adaptive management at a program level." (Cummins et al. 2008)

Cummins et al. (2008) provided numerous recommendations to improve implementation of the CVPIA anadromous fish restoration program. Included among those recommendations was development and utilization of an effective adaptive management program. However, it has now been six years since the review panel's report, yet the recommendations remain unimplemented by the involved agencies.

The BDCP provides no supporting rationale or guidance on how the BDCP would use adaptive management any differently than the CVPIA AFRP.

Vernalis Adaptive Management Program (VAMP)

Concluding in 2011, VAMP was a 12-year program implemented in the south Delta to evaluate and protect juvenile fall-run Chinook salmon emigrating from the San Joaquin River. The USFWS, the agency largely responsible for coordinating the salmon evaluations stated: "VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolts, while gathering information to allow more efficient protection in the future."[30]

However, after spending many millions of dollars in its 12-year run, the VAMP was largely a failure and the San Joaquin salmon runs are now in worse shape than before the program. The collection and quality of data necessary to formulate protective and restorative actions for fish were insufficient. Serious mistakes made in phases of the program (too lengthy to list and describe here) were repeated year after year; lessons were not learned. Despite annual data collection demonstrating very poor salmon survival, remedial actions were not implemented and the responsible agencies simply plowed forward without recognition of the problems and changing the program. Importantly, information that was developed from VAMP that could have been used to benefit fishery resources was not acted upon using adaptive management principles. A recent peer-review of the VAMP was highly critical of the program (Hankin et al., 2010). The failure of VAMP is summarized well by Lund et al. (2011):

> "The much-heralded Vernalis Adaptive Management Program (VAMP), conducted over the past decade, illustrates both[31] of these problems. VAMP paid

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[30] www.fws.gov/stockton/jfmp/vamp.asp

[31] "One challenge is that management experiments often involve large changes that affect real stakeholders. If financial compensation is required to individuals or groups who stand to lose land or water resources from the experiments, the costs can be substantial. Another challenge is mustering the resources and political will to conduct the necessary scientific analysis. Often, programs are labeled "adaptive management" if they try something

> farmers on San Joaquin tributaries to release pulses of water to speed young salmon on their way to sea. Because they profited from foregoing the use of this water, participating farmers developed an interest in having this become a long-lived experiment. Fish agencies collected data and avoided regulatory conflict. Water agencies benefitted by not having to make major changes in their own diversions. But in the end, the experiment appears to have been more successful for these various individuals and entities than for the salmon. Millions of dollars were spent, yet little synthetic modeling or experimental design was conducted to evaluate the effects on fish or to improve performance over time (Hankin et al., 2010)."

Interestingly, one aspect of the peer review of the VAMP program was the review panel's praise for trying the new telemetry techniques (previously discussed) to elucidate problems for salmon.

Despite the now-defunct VAMP and the lack of meaningful progress in restoring salmon and fixing known problems, the BDCP boldly states that it will use "adaptive management" to resolve problems for fish in the Delta. The track record from VAMP undermines any confidence in the BDCP utilizing effective adaptive management.

Fish Salvage at the South Delta Federal and State Water Export Facilities

Predation mortality at Tracy Fish Facilities (FF) for the south Delta federal water export facilities is an extremely serious problem for anadromous fish and is mentioned frequently in the BDCP documents. The high juvenile salmon mortality at the site has been known for a long time and is likely much higher than reported in the BDCP (Vogel 2011a). These issues are well-described in a recent peer review of CVPIA restoration program activities, which was highly critical of the lack of significant efforts to correct the problem:

> "… the operation of the Tracy Pumping Plant and Fish Collection Facility is a serious mortality source for salmon and steelhead (and for Delta smelt). All aspects of the pump operations have significant adverse impacts on salmon and steelhead, from the way juveniles are drawn to the pumps and away from the natural migration routes out through the Delta, to predation and other mortality factors in the channels leading to the pumps, to high mortalities at the out-dated louvers screening the pumps, to even higher mortalities likely during the archaic "salvage" collection and transport operation at the pumps, to predation mortality at the point of re-release, and finally to the overall adverse effects on salmon survival and productivity from regulating and diverting that much of the natural Delta outflow. Data on direct and indirect juvenile mortality is uncertain but likely to be high, and may run as high as 50% for spring-run Chinook and steelhead, and possibly 75% for winter-run Chinook." Cummins *et al.* 2008.

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different, even if they lack the significant follow-up analysis required to improve scientific understanding and policy response." Lund et al. (2011)

The serious salmon mortality problems associated with the Tracy FF have been known since the 1950s. USBR and other agency staff have studied and attempted minor, largely unbeneficial modifications to the Tracy FF for many decades. Despite purported adaptive management over many, many years at the Tracy FF, it appears little progress toward significant improvements in fish protection has been made. And yet the BDCP states that now, unlike all the prior decades of studies and activities at the Tracy FF and expenditures of many millions of dollars, the plan will now use adaptive management to fix the facilities' complex, intertwining problems but do not describe how.

The BDCP documents also frequently identify the extremely high salmon mortality associated with Clifton Court Forebay (CCF), part of the state water project south Delta water export facilities (e.g., BDCP Page 3.4-299, BDCP Page 5.B-6). Much like the Tracy FF, the problems for salmon at CCF have been known and studied for many decades. Since the late 1970s, CDFW has been studying this pre-screen loss and attributes the fish mortality to predation, primarily by striped bass (Coulston 1993), which are the primary predator in the Forebay (IEP 1993). Recent studies using acoustic-tagged juvenile salmon and acoustic-tagged striped bass also empirically demonstrated the severe predation problem in Clifton Court Forebay. Specifically, the small area immediately behind the CCF gates was shown to harbor striped bass for extended periods and mortality was severe when salmon passed under the gates and were eaten by predators (Vogel 2010b, 2010c, 2011c). This very small isolated area undoubtedly causes the highest mortality for anadromous fish reaching the south Delta. This predator haven has been, and will continue to be, severe without corrective measures (Vogel 2010c,Vogel 2011a)

Because of the concern about predation in CCF, a workshop was held in 1993 to discuss options to reduce predatory fish in the Forebay. The principal options examined included an increase in recreational fishing opportunities and an aggressive, non-lethal removal and relocation program. Interestingly, two of the primary reasons posed for not pursuing these actions were largely policy related. Water exporters were concerned that predator removal would result in increased numbers of salmon reaching the fish salvage facilities and would penalize exports due to a perceived increase in "take" of winter-run Chinook (unless a relaxation in the NMFS pre-screen loss estimates for winter-run Chinook was initiated) (Coulston 1993). Conversely, recreational fishing interests were opposed to predator removal because of their concern that increased water exports would take place, resulting in greater indirect losses of salmon (Coulston 1993). (from Vogel 2011a)

The BDCP provides statements that specific "stressor reduction targets" at the state and federal water export facilities will be achieved to improve conditions for salmon:

> "Reduce predation in Clifton Court Forebay and at the CVP trash-racks to achieve mortality rates across Clifton Court Forebay and past CVP trash-racks equivalent to no more than 40%, as reflected in the Reasonable and Prudent Alternative in the NMFS (2009) BiOp, by year 5. Reduction in predation mortality may be achieved through a variety of actions, including, but not limited to, modification to Clifton Court Forebay operations, modifications to physical habitat conditions within Clifton Court Forebay, as well as removal of predatory fish from Clifton

> Court Forebay and the CVP intake." (BDCP Page 3.3-139, BDCP Page 3.3-151, BDCP Page 3.3-169)

In summary, no significant progress toward alleviating these serious problems at Tracy FF has been accomplished since the 1950s and, similarly, no progress has been accomplished at Clifton Court Forebay since the 1960s. It has now been five years since the 2009 BiOp and no improvements (other than reduced water exports) have been made. Now, however, the BDCP proclaims that it will dramatically reduce these long-standing problems through adaptive management and unspecified or unproven measures. Such statements clearly lack credibility based on extensive past history. Additionally, this BiOp RPA is supposed to be fulfilled anyway, regardless if the BDCP is ultimately implemented.

Coleman National Fish Hatchery Fish Releases

Coleman National Fish Hatchery (CNFH) is a salmon production facility operated by the U.S. Fish and Wildlife Service (USFWS) on Battle Creek in the upper Sacramento River basin that serves as partial mitigation for lost natural salmon production resulting from the construction of USBR's Shasta Dam. It is the largest salmon hatchery in California. CNFH currently produces fall- and late-fall-run Chinook salmon and steelhead. A satellite hatchery facility just downstream of Shasta Dam also produces winter-run Chinook. The USFWS Office in Red Bluff is responsible for planning and scheduling the juvenile fish releases from both fish production facilities. In 2011, the USFWS completed a Biological Assessment (BA) for CNFH's operations to comply with the Endangered Species Act. In that BA, the USFWS states that the agency will use "adaptive management" for the hatchery's operations. As compared to the extremely complex and highly uncertain issues associated with the BDCP's effects on salmon, one would believe that adaptively managing hatchery fish releases would be far simpler. Fish hatcheries have a high degree of control on fish growth, release timing and locations, and good predictive capabilities for riverine conditions where and when salmon are released. These circumstances create fertile ground for the use of adaptive management to increase fish survival. For example, USFWS (2011) states:

> "All artificial propagation practices used at Coleman NFH, including incubation and rearing, are managed adaptively with the goal of producing high quality fish that maximize opportunity to accomplish program goals while reducing negative impacts to natural stocks."

The production of juvenile fall-run Chinook is usually released into Battle Creek during April. Presumably, using adaptive management, the USFWS would time those fish releases with precipitation and flow events when turbidity is high to maximize survival of outmigrating salmon and minimize adverse impacts on wild fish. However, Figure 41 shows a recent example of the release of fall-run salmon from the hatchery in 2013. The hatchery released 6,000,000 fall-run salmon (half of its entire production) shortly ***after*** precipitation events had occurred and the river flows were dramatically declining and water clarity increased. Prior to this fish release, short-term weather models and river forecasts through the California Data Exchange Center (CDEC) clearly predicted these environmental conditions. The resultant adverse impacts on those fish releases were likely severe with low, clear flows and slow downstream fish transport timing creating ideal conditions for predation. Reports by sports fishermen in areas downstream of the hatchery in the middle Sacramento River after the hatchery release described “feeding frenzies” by striped bass readily observable from the surface. Some striped bass caught by anglers were found to have stomachs full of juvenile salmon, probably from the hatchery fish release (Figure 42). If the fish release had been made the prior week, riverine conditions would have been ideal. The USFWS claimed the agency did not have any flexibility in the fish release timing, even by several days.[32] This action did not appear to be “adaptively managed” and the hatchery fish likely suffered very high in-river mortality that could have been avoided.

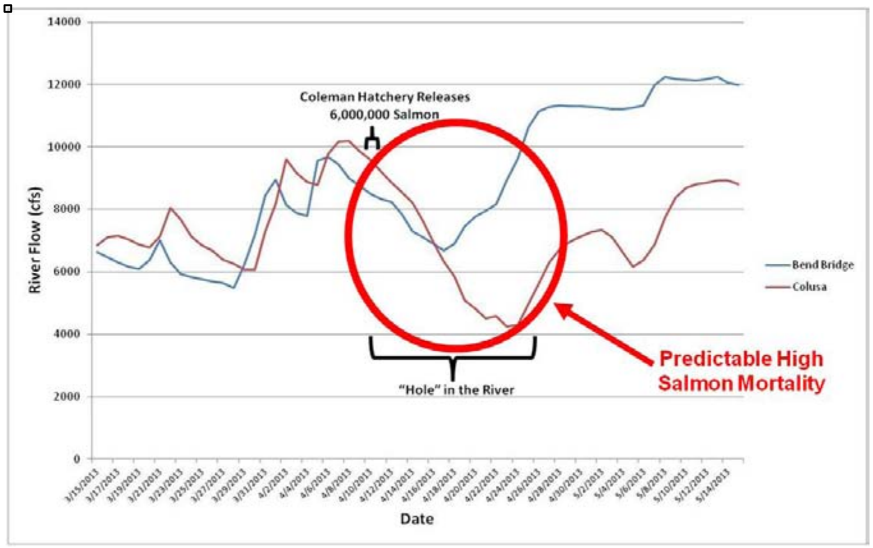

Figure 41. Timing of the release of approximately 6,000,000 juvenile fall-run Chinook salmon from Coleman National Fish Hatchery into Battle Creek on the upper Sacramento River in 2013 and Sacramento River flows downstream of the hatchery at Bend Bridge and Colusa.

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[32] Meeting between the USFWS, CDFW, and the Golden Gate Salmon association on February 14, 2014, Sacramento, CA.

Figure 42. Stomach contents of a striped bass caught by an angler in the middle Sacramento River after the CNFH fish release. Most of the contents are assumed to be numerous fall-run Chinook salmon.

In another example of purported adaptive management, the 2011 USFWS BA states:

> "Releases of late-fall Chinook and steelhead from Coleman NFH are timed to coincide with high flow events in Battle Creek and the Sacramento River."

The rationale for doing so is that releasing the larger-sized hatchery salmonids in the upper Sacramento River could have deleterious impacts on wild salmonids if the river is low and clear:

> "Based on the body size of hatchery-origin late-fall Chinook salmon, size ranges of natural-origin salmonid stocks, and predator-prey size constraints (i.e., prey less than half of predator length), hatchery-origin late-fall Chinook could potentially consume natural-origin fall, spring, and winter Chinook juveniles following their release from Coleman NFH." (USFWS 2011)
>
> "Releases [of juvenile late-fall Chinook into Battle Creek] are conducted over the course of one or two days and are timed to coincide with high flow and turbidity events, which promote rapid emigration and afford protection to out-migrating juveniles by discouraging predation."
>
> "The timing of late-fall Chinook releases are scheduled to coincide with winter storm events."

The 2014 water year turned into a near record-breaking drought and provided an excellent opportunity for USFWS to exhibit adaptive management principles in the CNFH late-fall Chinook releases. If the year's hydrologic conditions were normal, Sacramento River flows and turbidity would be naturally high during January due to tributary accretions and the USFWS strategy of releasing the late-fall-run Chinook in the upper river may be justified. However, this year's unique drought situation resulted in very unfavorable environmental conditions for late-fall salmon released into Battle Creek. In recognition in advance of the adverse impacts not only on the hatchery fish, but primarily on wild salmon stocks rearing in the river downstream of the hatchery, a recommendation was made for the USFWS to transport the fish downstream of the hatchery to the middle Sacramento River where survival would likely be higher and deleterious impacts on wild fish would be ameliorated (Vogel 2014). However, the recommendation was not adopted and no response was even provided by the USFWS. Subsequently, despite the supposed implementation of adaptive management for hatchery releases and the probable impact on wild fish in the river, including the endangered winter-run Chinook, threatened spring-run Chinook, and threatened steelhead, the USFWS released 750,000 large, juvenile hatchery late-fall Chinook into Battle Creek. Those fish experienced unseasonably low flows and extremely clear water. Many of those juvenile salmon were likely unnecessarily eaten by larger predaceous fish and birds after release from the hatchery. However, most importantly, the release of 750,000 late-fall-run Chinook salmon in the upper river likely adversely impacted the endangered winter-run, threatened spring-run, threatened steelhead, and fall-run Chinook salmon. Because the watershed had not yet experienced heavy precipitation events and high river flows that would stimulate large-scale wild salmonid emigration, it is likely that the majority of wild fish still remained rearing in the upper Sacramento River at that time. Releasing high numbers of large-sized hatchery salmon directly into the heart of the rearing grounds of wild salmon undoubtedly caused competition, displacement, and predation. The problem could have been avoided by transporting the fish to a location downstream of the hatchery to decrease the mortality while simultaneously reducing the ultimate straying rate compared to releases even farther downstream. It does not appear that the late-fall salmon releases were adaptively managed.

In yet another opportunity for the USFWS to exhibit adaptive management during this drought year, the releases of juvenile steelhead could also have been managed to avoid adverse impacts on wild salmonids rearing in the river. As stated in the USFWS BA:

> "However, interactions between salmonids from Coleman NFH and natural-origin salmonids in the Sacramento River are potentially greatest for hatchery-origin steelhead because of their comparatively larger body size, a general tendency for piscivory at the time of release, and a proclivity for adopting alternate life-history patterns (e.g., residualization).
>
> "Based on the size of hatchery-origin steelhead, size ranges of natural origin salmonid stocks, and predator-prey size constraints (i.e., prey less than half of predator length), hatchery-origin steelhead could potentially capture and consume young-of-the-year fall, spring, and winter Chinook juveniles."
>
> "Juvenile steelhead are released into the mainstem Sacramento River at Bend Bridge (RM 258) in January" [to minimize combination and predation on wild salmon].

> "Environmental conditions common in the Sacramento River during January likely reduce predation by hatchery-origin steelhead. Steelhead are released from Coleman NFH during early-January, a time of year when winter storm bring high flows, elevated turbidities, and cool water temperatures."

Despite the foregoing statements, the USFWS nevertheless released the entire production of steelhead at Bend Bridge (as they have traditionally done year after year), except now in very low, and clear water thereby violating the agency's original premise. Here again, the USFWS could have released the hatchery steelhead production farther downstream from Bend Bridge (which is within the heart of the primary rearing grounds for wild salmonids) to minimize deleterious impacts on wild fish in the low, clear water, but did not adaptively manage their release procedures.

In this final example of CNFH fish releases using so-called adaptive management, winter-run Chinook salmon from the satellite facility at Livingston Stone Hatchery at the base of Shasta Dam are released with the following USFWS strategy:

> "Releases [of juvenile winter-run Chinook into the upper Sacramento River at Redding] occur generally around late January or early February; however, actual release timing may occur outside of this target window in order to time the release of winter Chinook juveniles to coincide with a high flow and high turbidity event."

The first significant precipitation events of 2014 were clearly predicted by weather forecasts and increased river flows were predicted on CDEC. However, as shown in Figure 43, the USFWS released the winter-run Chinook *after* the precipitation events in the upper Sacramento River at a location where river flows were very low and clear. The river farther downstream was high and turbid. If the USFWS had adaptively managed the fish releases, the winter-run could have been released just a few days earlier and just downstream of some nearby tributaries where accretions increased mainstem flows and turbidity. Adverse impacts to this year's hatchery winter-run Chinook outmigrants likely occurred. Again, adaptive management was not employed.

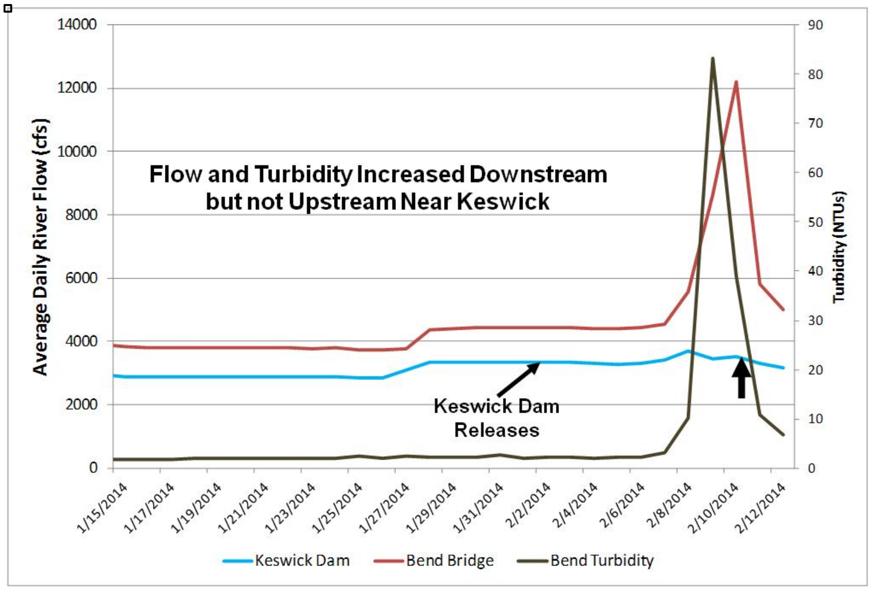

Figure 43. Release timing of juvenile winter-run Chinook salmon in the upper Sacramento River at Redding downstream of Keswick Dam (vertical pointer), Keswick Dam releases (daily cfs) and Sacramento River daily flow (cfs) and turbidity at Bend Bridge gauge 39 river miles downstream of the fish release location.

In summary, as can be seen from these foregoing recent, prominent examples, there has been a strong, consistent legacy in the Central Valley and Delta of *not* implementing adaptive management for the protection of fishery resources, even for relatively simple actions. Why would the BDCP be any different? The BDCP is far more complex and expansive than the examples provided. Again, the BDCP is entirely reliant on so-called adaptive management to attempt correction of deficiencies in the plan after it is implemented. Recent experience indicates otherwise and statements in the BDCP documents lack reliability. The BDCP must be rewritten to clearly articulate specifically how true adaptive management would be implemented during the program and describe all site-specific actions and feasible remedial counter-measures to demonstrate that the BDCP would not fail in this regard.

References

Afentoulis, V. and A. Schultz. 2014. Efficacy test of a tag designed to signal when a fish has been consumed. Abstracts of the California-Nevada Chapter of the American Fisheries Society, 48th Annual Conference. March 27 - 29, 2014. Sacramento, CA

Buchanan, R.A., J.R. Skalski, P.L. Brandes, and A. Fuller. 2013. Route use and survival of juvenile Chinook salmon through the San Joaquin River Delta. North American Journal of Fisheries Management 33:216-229.

California Department of Fish and Wildlife. 2010. California salmonid stream habitat restoration manual. Fourth Edition. Prepared by: G. Flossi, S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. Appendix S: Fish Screen Criteria. http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp

California Department of Water Resources. 2012. 2011 Georgiana Slough non-physical barrier performance evaluation project report. Sacramento, CA. September 5, 2012.

CH2M HILL. 2002. Fish protection evaluation and monitoring program, 2001 Annual Report. Prepared for Glenn-Colusa Irrigation District. April 2002.

Coulston, P. 1993. Clifton Court Forebay predator/predation control. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. Autumn 1993.

Cummins, K., C. Furey, A. Giorgi, S. Lindley, J. Nestler, and J. Shurts. 2008. Listen to the river: an independent review of the CVPIA Fisheries Program. Prepared for the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service. December 2008. 51 p. plus appendices.

Delaney, D., P. Bergman, B. Cavalo, and J. Melgo. 2014. Stipulaton study: Steelhead movement and survival in the South Delta with adaptive management of Old and Middle River flows. Report prepared for the California Department of Water Resources. February 2014.

Fish Facilities Technical Team. 2011. Technical memorandum of the Bay Delta Conservation Plan Fish Facilities Technical Team. July 15, 2011. 65 p.

Fisher, F.W. 1981. Long term swimming performance of juvenile American shad, *Alosa sapidissima*, and Chinook salmon, *Oncorhynchus tshawytscha*. California Department of Fish and Game. Anadromous Fisheries Branch. Administrative Report No. 81-2. March 1981. 14 p. plus appendices.

Hallock. R.J. and F.W. Fisher. 1985. Status of winter-run Chinook salmon, Oncorhynchus tshawytscha, in the Sacramento River. California Department of Fish and Game, Anadromous Fish Branch Report. January 25, 1985.

Hankin D., D. Dauble, J.J. Pizzimenti and P. Smith. 2010. The Vernalis Adaptive Management Program (VAMP): Report of the 2010 Review Panel, Delta Science Program, May 13.

Hestir, E.L., D.H. Schoellhamer, T. Morgan-King, and S. Ustin. 2010. An observed step change in river Delta turbidity following 1982-1983 El Nino floods. Abstract of the American Geophysical Union Fall Meeting 2010.

Holbrook, C.M., R.W. Perry, and N.S. Adams. 2009. Distribution and joint fish-tag survival of juvenile Chinook salmon migrating through the Sacramento – San Joaquin River Delta, California, 2008. U.S. Geological Survey, Open-File Report 2009-1204, Reston, Virginia.

Interagency Ecological Program. 1993. Clifton Court Forebay. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. Winter 1993.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California. Salmon in Estuaries. pp. 393-411.

Lindley, S.T., C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, D.L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope, P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook collapse? July 2009. NOAA-TM-NMFS-SWFSC-447. 60 p. plus appendices.

Lund, J.R., E. Hanak, and B. Gray. 2011. Adaptive management means never having to say you're sorry. Californiawaterblog.com. July 21, 2011.

MBK Engineers. 2014. Report on Review of Bay Delta Conservation Program Modeling. June 2014.

McLain, J.S. and G.C. Castillo. 2009. Nearshore areas used by Chinook salmon fry, *Oncorhynchus tshawytscha*, in the northwestern Sacramento – San Joaquin Delta, California. San Francisco Estuary and Watershed Science. December 2009. 12 p.

Michel, C.J. 2010. River and estuarine survival and migration of yearling Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*) smolts and the influence of environment. Master of Arts thesis. University of California, Santa Cruz. December 2010. 120 p.

Miranda, J., R. Padilla, J. Morinaka, J. DuBois, and M. Horn. Release site predation study. California Department of Water Resources. May 2010. 169 p.

Moyle, P. B. 2002. Inland Fishes of California. Revised and Expanded. Berkeley, CA: University of California Press. 502 p.

National Marine Fisheries Service. 1997. Fish screening criteria for anadromous salmonids. Southwest Region. January 1997. 10 p.

Nobriga, M. L., and F. Feyrer. 2007. Shallow-Water Piscivore-Prey Dynamics in California's Sacramento–San Joaquin Delta. *San Francisco Estuary and Watershed Science* 5(2):1–13.

Odenweller, D.B. and R.L. Brown. 1982. Delta fish facilities program report through June 30, 1982. FF/BIO 4ATR/82-6. IESP Technical Report 6. December 1982. 90 pp.

Perry, R.W. 2010. Survival and migration dynamics of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin River Delta. Ph.D. Dissertation. University of Washington, Seattle, WA.

Perry R.W., J.R. Skalski, P.L. Brandes, P.T. Sandstrom, A.P. Klimley, A. Ammann, B. MacFarlane. 2010. Estimating survival and migration route probabilities of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta. North Am J Fish Manage 30:142–156.

Perry, R.W., P.L. Brandes, J.R. Burau, A.P. Klimley, B. MacFarlane, C. Michel, and J.R. Skalski. 2012. Sensitivity of survival to migration routes used by juvenile Chinook salmon to negotiate the Sacramento – San Joaquin River Delta. Environ. Biol. Fish.

Petrovich, A. Jr. 1997. Memorandum from A. Petrovich Jr., Deputy Director, California Department of Fish and Game (CDFG) to CDFG Division Chiefs re. CDFG revised fish screening criteria. April 14, 1997. 10 p.

Poytress, W.R. and F.D. Carrillo. 2012. Brood year 2010 winter Chinook juvenile production indices with comparisons to juvenile production estimates derived from adult escapement. Report prepared for California Department of Fish and Game, Ecosystem Restoration Program, and the U.S. Bureau of Reclamation. Final Annual Report. U.S. Fish and Wildlife Service. March 2012. 35 p.

Romine, J.G., R.W. Perry, S.V. Johnson, C.W. Fitzer, S.W. Pagliughi, and A.R. Blake. 2014. Identifying when tagged fishes have been consumed by piscivorous predators: application of multivariate mixture models to movement parameters of telemetered fish. Animal Biotelemetry 2:3.

San Joaquin River Group Authority. 2011. 2010 annual technical report on implementation and monitoring of the San Joaquin River agreement and the Vernalis Adaptive Management Plan. Report to the State Water Resource Control Board. February 2011.

Smith, L.S., and L.T. Carpenter. 1987. Salmonid fry swimming stamina data for diversion screen criteria, Final Report to Washington State Departments of Fisheries and Wildlife.

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enchanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2):325-333.

Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001. California's Yolo Bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8): 6 - 16.

Sommer, T.R., W.C. Harrell, and M.L. Nobriga. 2005. Habitat use and stranding risk of juvenile Chinook salmon on a seasonal floodplain. North American Journal of Fisheries Management 25:1493-1504.

Swanson, C., P. S. Young, J. J. Cech Jr., M. L. Kavvas, and G. A. Aasen. 2004a. Fish treadmill-developed fish screen criteria for native Sacramento-San Joaquin watershed fishes. Final Report prepared for the Anadromous Fish Screen Program Cooperative Agreement No. 114201J075.

Swanson. C., P. S. Young, and J. J. Cech, Jr. 2004b. Swimming in two-vector flows: Performance and behavior of juvenile Chinook salmon near a simulated screened water diversion. Transactions of the American Fisheries Society 133:265–278.

U.S. Bureau of Reclamation. 2006. Fish protection at water diversions. A guide for planning and designing fish exclusion facilities. Water Resources Technical Publication. April 2006. 480 p.

U.S. Fish and Wildlife Service. 2011. Biological assessment of artificial propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: program description and incidental take of Chinook salmon and steelhead. Prepared by the USFWS Red Bluff Fish and Wildlife Office and the USFWS Coleman National Fish Hatchery Complex. July 2011. 346 p. plus attachments.

Vincik, R. and F.H. Bajjaliya. 2008. Timing, composition, and abundance of juvenile salmonid emigration in the Sacramento River near Knights Landing, October 2002 – July 2003. Calif. Dept. Fish Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program. 29 pp.

Vogel, D.A. 1989. Tehama-Colusa Canal Diversion and Fishery Problems Study. Final Report. U.S. Fish and Wildlife Service Report No. AFF/FAO-89-06. April 1989. 33 p. with appendices.

Vogel, D.A. 1982. Evaluation of the 1981-82 operation of the Tehama-Colusa Fish Facilities. U.S. Fish and Wildlife Service Report. Fisheries Assistance Office. January 28, 1982. 24 p.

Vogel, D.A. 1983. Evaluation of the Tehama-Colusa Fish Facilities. Cal-Neva Wildlife Transactions 1983: 20 – 25.

Vogel, D.A. 1989. Tehama-Colusa Canal Diversion and Fishery Problems Study. Final Report. U.S. Fish and Wildlife Service Technical Report No. AFF/FAO-89-6. April 1989. 33 p. plus appendices.

Vogel, D.A. 2001. Delta Cross Channel juvenile salmon radio-telemetry pilot study results in 2000. Presentation at the Interagency Ecological Studies Program Science Conference in Asilomar, California on March 1, 2001.

Vogel, D.A. 2001. Juvenile Chinook salmon radio-telemetry study in the northern Sacramento-San Joaquin Delta, January – February 2000. Contract report for the U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. May 2001. 34 p. plus figures and appendices.

Vogel, D.A. 2002. Delta Cross Channel juvenile salmon radio-telemetry study results in 2001. Presentation at the Interagency Ecological Studies Program Science Conference in Asilomar, California on February 27, 2002.

Vogel, D.A. 2002. Juvenile Chinook salmon radio-telemetry study in the southern Sacramento-San Joaquin Delta, December 2000 – January 2001. Contract report for the U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. June 2002. 27 p. plus figures and appendices.

Vogel, D.A. 2003a. Migratory behavior of radio-tagged juvenile salmon in the vicinity of the Delta Cross Channel in response to local hydrodynamic conditions. Abstracts of the CALFED

Science Conference, 2003 and presentation on January 16, 2003. Advances in Science and Restoration in the Bay, Delta and Watershed. January 14 – 16, 2003. Sacramento, CA.

Vogel, D.A. 2003b. Migration patterns of Chinook salmon smolts in the north, central, and south Delta using radio telemetry: Results of research performed in 2000-2002. Abstracts of the CALFED Science Conference, 2003 and presentation on January 15, 2003. Advances in Science and Restoration in the Bay, Delta and Watershed. January 14 – 16, 2003. Sacramento, CA.

Vogel, D.A. 2004. Juvenile Chinook salmon radio-telemetry studies in the northern and central Sacramento-San Joaquin Delta, 2002 – 2003, Final Report. Contract report for CALFED, administered by the National Fish and Wildlife Foundation. Natural Resource Scientists, Inc. January 2004. 188 p.

Vogel, D.A. 2005. The effects of Delta hydrodynamic conditions on San Joaquin River juvenile salmon. Natural Resource Scientists, Inc. Report submitted to the California State Water Resources Control Board. May 2005. 18 p.

Vogel, D.A. 2006b. 2006 Vernalis Adaptive Management Program pilot study to monitor the migration of juvenile Chinook salmon using acoustic telemetry. Report to the Vernalis Adaptive Management Program Biology Committee. Natural Resource Scientists, Inc. November 2006.

Vogel, D.A. 2006a. Evaluation of acoustic telemetry equipment for monitoring juvenile Chinook salmon. Report prepared for the California Department of Water Resources. Natural Resource Scientists, Inc. March 2006. 56 p.

Vogel, D.A. 2006b. Advances in studying Chinook salmon smolt migration in the Delta using acoustic telemetry. Abstracts of the 4th Biennial CALFED Science Conference 2006 and presentation on October 25, 2006. Making Sense of Complexity: Science for a Changing Environment. October 23 – 25, 2006. Sacramento, CA.

Vogel, D.A. 2007. Technical memorandum to participating agencies in the 2007 Vernalis Adaptive Management Program concerning high fish mortality near Stockton, California. Natural Resource Scientists, Inc. May 20, 2007. 5 p.

Vogel, D.A. 2007. Use of acoustic telemetry to evaluate Chinook salmon smolt migration and mortality in California's Central Valley and Delta. Abstracts of the 137th Annual American Fisheries Society Conference and presentation on September 3, 2007. Thinking Downstream and Downcurrent: Addressing Uncertainty and Unintended Consequences in Fish and Fisheries. San Francisco, September 2 – 6, 2007.

Vogel, D.A. 2008. Pilot study to evaluate acoustic-tagged juvenile Chinook salmon smolt migration in the northern Sacramento – San Joaquin Delta, 2006 – 2007. Report prepared for the California Department of Water Resources. Natural Resource Scientists, Inc. March 2008. 43 p.

Vogel, D.A. 2008a. Surveys of water diversions in the Sacramento River - 2008. Report prepared for the Anadromous Fish Screen Program, U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. December 2008. 14 p. plus 27 GB database.

Vogel, D.A. 2008. Biological evaluations of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station, 2002 – 2007. Final Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. April 2008. 48 p.

Vogel, D.A. 2009. Concept for a temporary behavioral fish barrier at the head of Old River. Proposal to the California Department of Water Resources. January 5, 2009. Natural Resource Scientists, Inc. 6 p.

Vogel, D.A. 2010. Technical memorandum to the Vernalis Adaptive Management Program Biology Committee on 2008 striped bass tagging. Natural Resource Scientists, Inc. March 26, 2010. 11 p.

Vogel, D.A. 2010. Evaluation of acoustic-tagged juvenile Chinook salmon movements in the Sacramento – San Joaquin Delta during the 2009 Vernalis Adaptive Management Program. Final Report. Natural Resource Scientists, Inc. March 2010. 63 p. Available at: http://www.sjrg.org/technicalreport/2009/2009-VAMP-Tagged-Salmon-Report.pdf

Vogel, D.A. 2010a. A synthesis of 22 telemetry studies to evaluate Chinook salmon smolt migration and mortality in California's Sacramento – San Joaquin Delta. Abstracts of the Bay – Delta Science Conference and presentation on September 28, 2010. September 27 – 29, 2010. Sacramento, CA

Vogel, D.A. 2011. Insights into the problems, progress, and potential solutions for Sacramento River basin native anadromous fish restoration. Report prepared for the Northern California Water Association and Sacramento Valley Water Users. Natural Resource Scientists, Inc. April 2011. 154 p. Available at: http://www.norcalwater.org/wp-content/uploads/2011/07/vogel-final-report-apr2011.pdf

Vogel, D.A. 2011. National Marine Fisheries Service Biological Opinion. California Water and Environmental Modeling Forum. Technical Briefing Series: Background and Technical Basis for the Biological Opinions. Presentation on September 7, 2011. Sacramento, CA. Available at: http://www.cwemf.org/workshops/BOWorkshop/DVogelBOPres.pdf

Vogel, D.A. 2011. Evaluation of acoustic-tagged juvenile Chinook salmon and predatory fish movements in the Sacramento – San Joaquin Delta during the 2010 Vernalis Adaptive Management Program. Natural Resource Scientists, Inc. October 2011. 19 p. plus appendices. Available at:
http://www.sjrg.org/technicalreport/2010/2010_Predator_Tagging_Study_by_NRSInc.pdf

Vogel, D.A. 2012. Insights into the problems, progress, and potential solutions for Sacramento River basin native anadromous fish restoration for consideration in the Bay-Delta Water Quality

Control Plan Update. Workshop 2: Bay-Delta Fishery Resources (Anadromous Salmonids). Written submittal on behalf of Glenn-Colusa Irrigation District, Sacramento Valley Water Users, and Northern California Water Association. Natural Resource Scientists, Inc. September 14, 2012. 53 p. plus attached exhibits.

Vogel, D.A. 2012. North/Central Delta salmon outmigration study, 2008 – 2009: Predator fish tagging and mobile telemetry survey results. Technical report prepared for the California Department of Water Resources. Natural Resource Scientists, Inc. December 2012. 43 p. including appendix.

Vogel, D.A. 2013. Evaluation of fish entrainment in 12 unscreened Sacramento River diversions, Final Report. Report prepared for the CVPIA Anadromous Fish Screen Program (U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation) and Ecosystem Restoration Program (California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, NOAA Fisheries). Natural Resource Scientists, Inc. July 2013. 153 p.

Vogel, D.A. 2014. Letter to the U.S. Fish and Wildlife Service providing concerns and recommendations for the release of Coleman National Fish Hatchery late-fall-run Chinook salmon into Battle Creek. January 6, 2014. 3 p.

Vogel, D.A., K.R. Marine and J.G. Smith. 1988. Fish passage action program for Red Bluff Diversion Dam: Final report on fishery investigations. U.S. Fish and Wildlife Service Report No. FR1/FAO-88-19. October 1988. 77 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Report prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.

Vogel, D.A. and K.R. Marine. 1995. 1994 biological evaluation of the new fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Natural Resource Scientists, Inc. February 1995. 77 p. plus appendices.

Williams, J.G. 2012. Juvenile Chinook salmon (Oncorhynchus tshawytscha) in and around the San Francisco estuary. San Francisco Estuary and Watershed Science 10(3). October 2012.

EXHIBIT 1

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Education

M.S., 1979, Natural Resources (Fisheries), University of Michigan
B.S., 1974, Biology, Bowling Green State University

Experience

Dave Vogel specializes in aquatic resource assessments and resolution of fishery resource issues associated with water development. His 39 years of work experience in this field includes large-scale assessments in river systems, lakes and reservoirs, and estuaries, mostly associated with restoration of western United States fishery resources. He has designed and conducted numerous projects to determine fish habitat criteria and population limiting factors leading to development and implementation of innovative measures to increase fish populations. Mr. Vogel has worked on California's Central Valley fishery resource issues for the past 33 years. During the 1980s he served as the U.S. Fish and Wildlife Service's (USFWS) Project Leader in northern California and was responsible for expanding a one-person office in Red Bluff into a large-scale, fishery research facility. In this regard, he directed research on Sacramento River basin salmon and steelhead populations and successfully developed measures to increase fish runs.

Dave Vogel has extensive experience in the design and evaluation of large fish screening facilities. He was the project leader of a major evaluation on fish entrainment into the 2,700 cfs Tehama-Colusa Canal and Corning Canal diversions which lead to the design and installation of state-of-the-art fish screening and fish bypass facilities. Mr. Vogel was a key individual in the development of the biological criteria and associated bioengineering design for those facilities. As a member of multi-agency groups which have developed the concepts and designs of new screening facilities, he is thoroughly familiar with modern-day fish screen technologies. Dave Vogel was the Principal Investigator in a study of fish entrainment at the largest unscreened agricultural diversion in Oregon and developed the conceptual design that ultimately led to a fish screen and bypass facility on the A-Canal in the Klamath Irrigation Project. Mr. Vogel also served as the Principal Scientific Investigator for biological evaluations of the largest riverine diversion in the Central Valley at Glenn-Colusa Irrigation District's (GCID) pumping facility and worked on the bioengineering designs of the retrofits for the old and interim screens and ultimate final 3,000 cfs fish screen facility. On behalf of state and federal agencies and GCID, he developed and implemented the pre- and post-project biological evaluations. This multi-year program involved extensive testing of the new fish screens and bypass systems using fish mark-recapture techniques as well as radio- and acoustic-telemetry, electrofishing, angling, juvenile and adult fish traps, direct underwater SCUBA observations, underwater hand-held videography, surface-deployed underwater videography, surface observations, and extensive use of a dual-frequency identification sonar camera. Additionally, he evaluated the new associated Sacramento River gradient facility by capturing, tagging and monitoring the telemetered movements of adult green and white sturgeon at the site, as well as examining the relative distribution, abundance, and habitats of predatory fish over many years. Dave Vogel has conducted many dozens of underwater inspections of large fish screens, evaluating biological performance, juvenile salmon and predatory fish behavior, characteristics on sedimentation, screen seals, debris loading, and water velocities. Much of his work has led to improved fish screen designs elsewhere.

Dave Vogel has served as a Principal Scientific Investigator for 22 research projects in the north, central, and south Sacramento – San Joaquin Delta. He was the first scientist to successfully employ miniaturized radio- and acoustic-telemetry technology to evaluate juvenile salmon migratory behavior, migration pathways, and survival. He also developed breakthroughs on use of the technology to detect predation on salmon. He served on the Delta Cross Channel Work Team as the principal scientist evaluating the movements of juvenile salmon at the Delta Cross Channel and Georgiana Slough using both radio- and acoustic-telemetry methods. Mr. Vogel was also a Principal Scientific Investigator for the Vernalis Adaptive Management Program from 2006 through 2010 and developed innovative field and analytical techniques toward the end of the program (https://sites.google.com/site/vamp2009team/). He recently conducted four research projects on the behavior and movements of predatory fish in the Delta. Based on his extensive field experience, he has acquired a highly specialized knowledge of the Delta, including fish habitat characteristics, migratory pathways utilized by salmon and fish mortality by reach, juvenile salmon and predatory fish behavior, site-specific sources of fish mortality, and Delta hydrodynamic conditions. He has used a Natural Resource Scientists, Inc. DIDSON™ sonar camera extensively throughout the Delta to study fish habitats, water diversions, agricultural siphons, waste water treatment outfalls, artificial and natural in-channel structures, and predator/prey interactions.

Mr. Vogel served as Task Manager on numerous projects for the U.S. Bureau of Reclamation (USBR), Mid-Pacific Region, to define interrelationships of fishery resources and water project operations. He developed a life history guide for salmon in California's Central Valley to improve interagency coordination and communication concerning fishery and water resource management. He also assessed techniques to estimate the annual run sizes of the endangered winter Chinook salmon to recommend improved methodologies to enhance population restoration. He was the Task Manager for the original Biological Assessment of the federal Central Valley Project and the principal author of biological portions of the original Biological Assessment for the USBR's Klamath Project. Dave Vogel served as the Task Manager to assess options for the disposition of the Tehama-Colusa Fish Facilities. Recently, under contract for the USBR, Mr. Vogel completed a comprehensive in-river survey of all the unscreened water diversions in the Sacramento River between Verona and Red Bluff using a DIDSON® sonar camera and an Acoustic Doppler Current Profiler.

Mr. Vogel has participated in various work teams to evaluate numerous proposed projects in the Delta. He has served on the CALFED Integration Panel and other committees to evaluate and recommend ecosystem restoration projects. He also worked on the Bay/Delta Oversight Committee's technical team. He has been involved with evaluations of proposed water projects and facilities in the Delta using particle tracking model results and other analytical tools.

Dave Vogel has strong expertise in designing and implementing multifaceted projects to sample entrainment of juvenile fish in small, medium, and large unscreened water intakes. Recently, Mr. Vogel has been serving as the Principal Scientific Investigator on behalf of the State/federal Anadromous Fish Screen Program for multi-year evaluations of fish entrainment in unscreened diversions on the Sacramento River. He is an expert in the design and fabrication of complex fish sampling equipment for installation and operation at challenging field sites capable of withstanding powerful hydraulic forces and heavy debris loading. He personally builds the structures using metal inert gas welding, plasma cutting, and oxyacetylene.

He is an expert SCUBA diver possessing standard, advanced, and research diver world-wide recognized certifications. He is a professional underwater videographer and his footage has been shown on nationwide, prime-time televisions shows, instructional videos, and environmental documentaries. He is a voluntary member of the Tehama County Search and Rescue Team for recovery of drowning victims in northern California rivers and reservoirs. Based on this training and experience, Dave Vogel developed innovative underwater survey techniques to map riverbed substrates on the Sacramento River in deep, swift water. He and his dive team mapped Sacramento River salmon spawning habitats in the three-mile reach downstream of Keswick Dam and in the vicinity of numerous Sacramento River bridges.

Dave Vogel is very knowledgeable of provisions of the federal Endangered Species Act (ESA) having served on the original National Marine Fisheries Service's Winter-Run Chinook Salmon Recovery Team and the U.S. Fish and Wildlife Service's Endangered Lost River Sucker and Shortnose Sucker Working Group. He developed the framework for the original winter-run Chinook salmon restoration program and has worked on projects associated with the endangered monk seal, threatened green sea turtle, bald eagle, and other species. He has given public presentations to a wide variety of groups concerning the ESA including Congressional testimony on three separate occasions. He frequently works on ESA consultations and permitting associated with threatened and endangered fish.

Mr. Vogel previously worked for the U.S. Government in the USFWS's Fishery Research Division and the Fishery Resources Division. He received the "Fishery Management Biologist of the Year" award for six western states and numerous outstanding and superior achievement awards. He served as Chairman of the USFWS SCUBA Diving Control Board for six western states during an eight-year period. Mr. Vogel designed and conducted evaluations of Federal and state fish hatcheries to improve their effectiveness. He was Chairman of the Sacramento River Steelhead Trout Technical Committee for six years. He also developed and directed numerous projects to improve the survival and contribution of hatchery salmon and represented the USFWS on the California Department of Fish and Game's Salmon Smolt Quality Committee during the 1980s.

Mr. Vogel frequently serves as a volunteer for environmental issues. He serves on the Board of Directors for the Fishery Foundation of California. Dave Vogel was a member of the California

4th Senatorial Environmental Advisory Committee and has provided presentations to California legislative committees on several occasions. Mr. Vogel served as a peer reviewer for the Interim and Final reports of the National Academy of Sciences' National Research Council Klamath Committee (Interim Report: Scientific Evaluation of Biological Opinions on Endangered and Threatened Fish in the Klamath River Basin; Final Report: Endangered and Threatened Fish of the Klamath River Basin: Causes of Decline and Strategies for Recovery). He has given many formal presentations on environmental issues to diverse organizations.

Dave Vogel's clients have included municipal, county, state and federal agencies, water districts, water user organizations, universities, Indian tribes, private landowners, engineering and environmental consulting firms, the timber industry, watershed conservancies, resource conservation districts, law firms, and non-governmental environmental organizations. He is presently working for the Golden Gate Salmon Association and northern California water districts to develop a salmon re-building program for the Sacramento River basin in concert with state and federal agencies and non-governmental organizations.

Selected Primary Authored Reports

Vogel, D.A. 1978. Population estimation of the 1977- 78 winter steelhead run to the Lake Washington watershed. U.S. Fish and Wildlife Service and Muckleshoot Indian Tribe. Olympia, Washington. October 1978.

Vogel, D.A. 1979. Distribution and movement of 1976 Port Susan coho stocks. U.S. Fish and Wildlife Service and Tulalip Indian Tribe. Olympia, Washington. July 1979.

Vogel, D.A. 1980. Instream flow recommendations for fishery resources in the major rivers and streams on the Wind River Indian Reservation, Wyoming. U.S. Fish and Wildlife Service. Lander, Wyoming. October 1980. 85 p.

Vogel, D.A. 1982. Evaluation of the 1981-82 operation of the Tehama-Colusa Fish Facilities. U.S. Fish and Wildlife Service Report. Fisheries Assistance Office. January 28, 1982. 24 p.

Vogel, D.A. 1982. Preferred spawning velocities, depths, and substrates for fall Chinook salmon in Battle Creek, California. U.S. Fish and Wildlife Service, Fisheries Assistance Office. November 18, 1982. 8 p.

Vogel, D.A. 1983. Evaluation of the Tehama-Colusa Fish Facilities. Cal-Neva Wildlife Transactions 1983: 20 – 25.

Vogel, D.A. 1984. Data on daily entrainment for fry and juvenile Chinook salmon into the Tehama-Colusa (Dual-Purpose) and Corning Canals, California, January 1982 through December 1983. March 1984. U.S. Fish and Wildlife Service Report No. FR1/FAO-84-1. 27 p. plus appendices.

Vogel, D.A. 1984. Evaluation of the 1982-83 operation of the Tehama-Colusa Fish Facilities. July 1984. U.S. Fish and Wildlife Service Report No. FR1/FAO-84-2. 9 p.

Vogel, D.A. 1984. Fish passage action program for Red Bluff Diversion Dam. Annual progress report. December 1984. U.S. Fish and Wildlife Service Report No. FR1/FAO-85-4. 72 p. plus appendices.

Vogel, D.A. 1985. Fish passage action program for Red Bluff Diversion Dam. Annual progress report. October 1985. USFWS Report No. FR1/FAO-86-5. 53 p. plus appendices.

Vogel, D.A. 1987. Estimation of the 1986 spring Chinook salmon run in Deer Creek, California. U.S. Fish and Wildlife Service. Fisheries Assistance Office. Report No. FR1/FAO-87-3. January 1987. 10 p.

Vogel, D.A. 1987. Tehama-Colusa Canal Diversion and Fishery Problems Study. U.S. Fish and Wildlife Service Technical Report No. FR1/FAO-87-9.

Vogel, D.A. 1987. Estimation of the 1986 spring Chinook salmon run in Mill Creek, California. U.S. Fish and Wildlife Service. Fisheries Assistance Office. Report No. FR1/FAO-87-12. May 1987. 9 p.

Vogel, D.A. 1989. Tehama-Colusa Canal Diversion and Fishery Problems Study. Final Report. U.S. Fish and Wildlife Service Technical Report No. AFF/FAO-89-6. April 1989. 33 p. plus appendices.

Vogel, D.A. 1989. Sacramento River salmon restoration. Sacramento Valley Landowners Magazine. Pp. 10 – 13.

Vogel, D.A. 1990. Important biological considerations of the proposed Shasta Dam water temperature control device. Congressional briefing paper. October 1990. 9 p.

Vogel, D.A. 1991. Chapter in *California's Salmon and Steelhead: The Struggle to Restore an Imperiled Resource.* Alan Lufkin, ed. University of California Press. p. 124-134.

Vogel, D.A. 1992. Assessment of the fish passage facilities at Lake Lodi in the Mokelumne River. Report prepared for East Bay Municipal Utility District, Oakland, California. Vogel Environmental Services. 42 p.

Vogel, D.A. 1992. Resolving Environmental Issues in the Environmental Age. Chapter in *Achieving Consensus on Water Policy in California.* Edmund G. "Pat" Brown Institute of Public Affairs, California State University, Los Angeles. p. 137-147.

Vogel, D.A. 1992. Preliminary assessment of potential factors limiting populations of the Lost River sucker, *Deltistes luxatus*, and Shortnose sucker, *Chasmistes brevirostris*. Report prepared for the Klamath Water Users Association. Vogel Environmental Services. July 1992. 27 p.

Vogel, D.A. 1992. Reconnaissance-level survey of anadromous salmonid habitat in Little River, California. Report prepared for Louisiana-Pacific Corporation. Vogel Environmental Services. August 1992. 61 p.

Vogel, D.A. 1993. Chinook salmon rearing in the Central Valley. Notes and selected abstracts from the "Workshop on Central Valley Chinook Salmon". University of California, Davis. January 4 – 5, 1993.

Vogel, D.A. 1993. Initial Ecosystem Restoration Plan for the Upper Klamath River Basin with Focus on Endangered Species Recovery and Water Management Improvements. Vogel Environmental Services. January 1993. Report prepared for the Klamath Water Users Association, Klamath Falls, Oregon. 83 p.

Vogel, D.A. 1993. Need for updating fish protection facilities for anadromous and resident stocks in the West Coast of North America. Proceedings of the American Fisheries Society Bioengineering Symposium, Portland, Oregon. August 30 - September 3, 1993. 6 p.

Vogel, D.A. 1994. Evaluation of streambed substrate in anadromous salmonid spawning habitat in Little River, California, 1993. Report prepared for Louisiana-Pacific Corporation. Vogel Environmental Services. January 1994. 43 p.

Vogel, D.A. 1994. Considerations on the use of fish survival indices as a tool to develop fish and wildlife standards in the Sacramento - San Joaquin Delta. Testimony presented on behalf of Delta Wetlands to the California State Water Resources Control Board. Natural Resource Scientists, Inc. July 14, 1994. 16 p

Vogel, D.A. 1994. Proposed operations of the Delta Cross Channel gates to protect downstream-migrant Chinook salmon based on real-time monitoring in the Sacramento River. Written testimony presented on behalf of Delta Wetlands to the California State Water Resources Control Board. Natural Resource Scientists, Inc. October 7, 1994. 8 p.

Vogel, D.A. 1995. Losses of young anadromous salmonids at water diversions on the Sacramento and Mokelumne rivers. Report prepared for the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. Natural Resource Scientists, Inc. January 1995. 34 p.

Vogel, D.A. 1997. Measurements of total phosphorus and water temperatures in various springs, rivers, streams, and canals in the Wood River Valley, Oregon. Natural Resource Scientists, Inc. March 1997. 31 p.

Vogel, D.A. 1997. Preliminary investigation on fish entrainment into the A-Canal on Upper Klamath Lake. Natural Resource Scientists, Inc. Report to the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service. August 1997. 54 p.

Vogel, D.A. 1998. Riverine habitat monitoring data in the Glenn-Colusa Irrigation District's oxbow bypass channel on the Sacramento River. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. 55 p.

Vogel, D.A. 1998. Preliminary assessment of streambed substrate for salmon spawning in Stony Creek, California. Natural Resource Scientists, Inc. Report prepared for the Orland Unit Water Users and Tehama-Colusa Canal Authority. February 1998. 15 p.

Vogel, D.A. 1998. History and status of the lower Mokelumne River fishery resource. Report prepared for East Bay Municipal Utility District and submitted to the California State Water Resources Control Board. June 1998. 46 p.

Vogel, D.A. 2000. Fish monitoring in the vicinity of the future Glenn-Colusa Irrigation District gradient facility on the Sacramento River, 1998 - 1999. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. September 2000. 29 p. plus appendices.

Vogel, D.A. 2001. Juvenile Chinook salmon radio-telemetry study in the northern Sacramento-San Joaquin Delta, January – February 2000. Contract report for the U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. May 2001. 34 p. plus figures and appendices.

Vogel, D.A. 2002. Juvenile Chinook salmon radio-telemetry study in the southern Sacramento-San Joaquin Delta, December 2000 – January 2001. Contract report for the U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. June 2002. 27 p. plus figures and appendices.

Vogel, D.A. 2002. Juvenile steelhead/rainbow trout (*Oncorhynchus mykiss*) surveys in Los Trancos Creek, March - May 2002. Report prepared for Stanford University. Natural Resource Scientists, Inc. September 2002. 13 p. plus appendices.

Vogel, D.A. 2002. Assessment of Klamath River water temperatures downstream of Iron Gate Dam during September and October 2002. Report prepared for the Klamath Water Users Association. Natural Resource Scientists, Inc., Red Bluff, CA. December 2002. 20 p.

Vogel, D.A. 2003. Fish monitoring in the vicinity of the Glenn-Colusa Irrigation District Sacramento River gradient facility, 1998 – 2001 (pre- and post-construction). Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. February 2003. 45 p. plus appendices.

Vogel, D.A. 2003. Salmon rearing habitats in the main stem Klamath River. Report prepared for the Klamath Water Users Association. Natural Resource Scientists, Inc., Red Bluff, CA. February 2003. 36 p.

Vogel, D.A. 2003. Merced River wing dam gravel monitoring, 2000 – 2002. Final Report to the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. Natural Resource Scientists, Inc. and Merced Irrigation District. March 2003. 39 p.

Vogel, D.A. 2003. 2002 biological evaluation of the fish screens and gradient facility at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. October 2003. 27 p.

Vogel, D.A. 2003. Evaluation of a proposal for hydraulic salmonid egg deposition. Report prepared for the U.S. Bureau of Reclamation. Natural Resource Scientists, Inc. October 2003. 36 p.

Vogel, D.A. 2003. Merced River Water Temperature Feasibility Investigation: Reconnaissance Report. Contract report prepared for the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. Natural Resource Scientists, Inc., Red Bluff, CA. December 2003. 89 p.

Vogel, D.A. 2003. Assessment of anadromous salmonid habitat in the Lower Bear River, California. Unpublished report prepared for South Sutter Water District. Natural Resource Scientists, Inc. December 2003. 33 p. plus appendices.

Vogel, D.A. 2004. Juvenile Chinook salmon radio-telemetry studies in the northern and central Sacramento-San Joaquin Delta, 2002 – 2003, Final Report. Contract report for CALFED, administered by the National Fish and Wildlife Foundation. Natural Resource Scientists, Inc. January 2004. 188 p.

Vogel, D.A. 2005. 2003 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. January 2005. Natural Resource Scientists, Inc. 37 p.

Vogel, D.A. 2005. Klamath fishery science. The Water Report, Issue No. 11. January 15, 2005.

Vogel, D.A. 2005. 2004 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. May 2005. Natural Resource Scientists, Inc. 24 p.

Vogel, D.A. 2005. Evaluation of adult sturgeon migration at the Glenn-Colusa Irrigation District gradient facility on the Sacramento River during 2003. Report prepared for the multi-agency Technical Oversight Committee. May 2005. Natural Resource Scientists, Inc. 14 p.

Vogel, D.A. 2005. The effects of Delta hydrodynamic conditions on San Joaquin River juvenile salmon. Natural Resource Scientists, Inc. Report submitted to the California State Water Resources Control Board. May 2005. 18 p.

Vogel, D.A. 2005. Assessment of adult anadromous salmonid migration barriers and holding habitats in the Upper Yuba River, Technical Appendix. Report prepared for the CALFED Upper Yuba River Study Program. 34 p.

Vogel, D.A. 2005. Fishery Resources Chapter for the Western Tehama County Watershed Assessment. Natural Resource Scientists, Inc. Prepared for VESTRA and Tehama County. 57 p.

Vogel, D.A. 2006. Evaluation of acoustic telemetry equipment for monitoring juvenile Chinook salmon. Report prepared for the California Department of Water Resources. Natural Resource Scientists, Inc. March 2006. 56 p.

Vogel, D.A. 2006. 2005 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. May 2006. 40 p.

Vogel, D.A. 2006. 2006 Vernalis Adaptive Management Program pilot study to monitor the migration of juvenile Chinook salmon using acoustic telemetry. Report to the Vernalis Adaptive Management Program Biology Committee. Natural Resource Scientists, Inc. November 2006.

Vogel, D.A. 2007. Technical memorandum to participating agencies in the 2007 Vernalis Adaptive Management Program concerning high fish mortality near Stockton, California. Natural Resource Scientists, Inc. May 20, 2007. 5 p.

Vogel, D.A. 2007. 2006 biological evaluation of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. June 2007. 24 p.

Vogel, D.A. 2007. A feasibility investigation of reintroduction of anadromous salmonids above Crocker-Huffman Dam on the Merced River. Report prepared for the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. Natural Resource Scientists, Inc. December 2007. 110 p. plus appendices.

Vogel, D.A. 2008. Pilot study to evaluate acoustic-tagged juvenile Chinook salmon smolt migration in the northern Sacramento – San Joaquin Delta, 2006 – 2007. Report prepared for the California Department of Water Resources. Natural Resource Scientists, Inc. March 2008. 43 p.

Vogel, D.A. 2008. Biological evaluations of the fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station, 2002 – 2007. Final Report prepared for the multi-agency Technical Oversight Committee. Natural Resource Scientists, Inc. April 2008. 48 p.

Vogel, D.A. 2008. Evaluation of adult sturgeon migration at the Glenn-Colusa Irrigation District gradient facility on the Sacramento River. Final Report prepared for the multi-agency Technical Oversight Committee.. Natural Resource Scientists, Inc. April 2008. 33 p.

Vogel, D.A. 2008. Evaluation of unscreened diversions, 2007 – 2008. Report prepared for the Anadromous Fish Screen Program, U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. December 2008. 38 p. plus six appendices.

Vogel, D.A. 2008. Surveys of water diversions in the Sacramento River - 2008. Report prepared for the Anadromous Fish Screen Program, U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. December 2008. 14 p. plus 27 GB database.

Vogel, D.A. 2009. Concept for a temporary behavioral fish barrier at the head of Old River. Proposal to the California Department of Water Resources. January 5, 2009. Natural Resource Scientists, Inc. 6 p.

Vogel, D.A. 2010. Technical memorandum to the Vernalis Adaptive Management Program Biology Committee on 2008 striped bass tagging. Natural Resource Scientists, Inc. March 26, 2010. 11 p.

Vogel, D.A. 2010. Evaluation of acoustic-tagged juvenile Chinook salmon movements in the Sacramento – San Joaquin Delta during the 2009 Vernalis Adaptive Management Program. Final Report. Natural Resource Scientists, Inc. March 2010. 63 p.

Vogel, D.A. 2010. Evaluation of fish entrainment in three unscreened Sacramento River diversions, 2009. Report to the Anadromous Fish Screen Program, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service. Natural Resource Scientists, Inc. March 2010. 40 p. plus appendices.

Vogel, D.A. 2011. Evaluation of fish entrainment in seven unscreened Sacramento River diversions, 2010. Report prepared for the Anadromous Fish Screen Program, CALFED Ecosystem Restoration Program, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, NOAA Fisheries, and the California Department of Fish and Game. Natural Resource Scientists, Inc. February 2011. 77 p. plus appendices.

Vogel, D.A. 2011. Insights into the problems, progress, and potential solutions for Sacramento River basin native anadromous fish restoration. Report prepared for the Northern California Water Association and Sacramento Valley Water Users. Natural Resource Scientists, Inc. April 2011. 154 p.

Vogel, D.A. 2011. Evaluation of acoustic-tagged juvenile Chinook salmon and predatory fish movements in the Sacramento – San Joaquin Delta during the 2010 Vernalis Adaptive Management Program. Natural Resource Scientists, Inc. October 2011. 19 p. plus appendices.

Vogel, D.A. 2012. Evaluation of fish entrainment in nine unscreened Sacramento River diversions, 2012. Report prepared for the Anadromous Fish Screen Program, CALFED Ecosystem Restoration Program, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, NOAA Fisheries, and the California Department of Fish and Game. Natural Resource Scientists, Inc. January 2012. 97 p. plus appendices.

Vogel, D.A. 2012. Insights into the problems, progress, and potential solutions for Sacramento River basin native anadromous fish restoration for consideration in the Bay-Delta Water Quality Control Plan Update. Workshop 2: Bay-Delta Fishery Resources (Anadromous Salmonids). Written submittal on behalf of Glenn-Colusa Irrigation District, Sacramento Valley Water Users, and Northern California Water Association. Natural Resource Scientists, Inc. September 14, 2012. 53 p. plus attached exhibits.

Vogel, D.A. 2012. North/Central Delta salmon outmigration study, 2008 – 2009: Predator fish tagging and mobile telemetry survey results. Technical report prepared for the California Department of Water Resources. Natural Resource Scientists, Inc. December 2012. 43 p. including appendix.

Vogel, D.A. 2013. Evaluation of fish entrainment in 12 unscreened Sacramento River diversions, Final Report. Report prepared for the CVPIA Anadromous Fish Screen Program (U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation) and Ecosystem Restoration Program (California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, NOAA Fisheries). Natural Resource Scientists, Inc. July 2013. 153 p.

Vogel, D.A. 2014. Evaluation of the effectiveness of a potential fish deterrent device on a Sacramento River water diversion. Report prepared for the CVPIA Anadromous Fish Screen Program (U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation). Annual Report. Natural Resource Scientists, Inc. January 2014. 22 p. plus appendices.

Vogel, D.A. and K.M. Clemens. 1982. An evaluation of the contribution of Chinook salmon produced at the Tehama-Colusa Fish Facilities to the ocean fisheries and upper Sacramento River escapement (brood years 1973 – 1977). U.S. Fish and Wildlife Service Report. September 27, 1982. 7 p.

Vogel, D.A. and K.R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Report prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.

Vogel, D.A. and K.R. Marine. 1992. An assessment of the appraisal study of options for improving fish passage at Red Bluff Diversion Dam. Report prepared for the Tehama-Colusa Canal Authority. Vogel Environmental Services. 29 p.

Vogel, D.A. and K.R. Marine. 1994. Lower Mokelumne River Fisheries Monitoring Program, Evaluation of the downstream migration of juvenile salmon and steelhead in the lower Mokelumne River and the Sacramento - San Joaquin Delta (January through July 1993. Technical Report prepared by Vogel Environmental Services for East Bay Municipal Utility District, Oakland, California. April 1994. 59 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1994. Preliminary assessment of increased Klamath River flows for salmon during the late summer and fall of 1994. Report prepared for the Klamath Water Users Association. Natural Resource Scientists, Inc.. November 1994. 36 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1995. 1994 biological evaluation of the new fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Natural Resource Scientists, Inc. February 1995. 77 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1995. 1995 evaluation of juvenile Chinook salmon transport timing in the vicinity of the new fish screens at the Glenn-Colusa Irrigation District's Sacramento River pump station. Natural Resource Scientists, Inc. Prepared for Glenn-Colusa Irrigation District, Willows, California. November 1995. 34 p.

Vogel, D.A. and K.R. Marine. 1995. A technical memorandum on 1995 predation evaluations near the GCID Sacramento River pump station. Natural Resource Scientists, Inc. Prepared for Glenn-Colusa Irrigation District, Willows, California. December 1995. 17 p.

Vogel, D.A. and K.R. Marine. 1996. Lower Mokelumne River Fisheries Monitoring Program, Evaluation of the downstream migration of juvenile salmon and steelhead in the lower Mokelumne River and the Sacramento - San Joaquin Delta (January through July 1994. Technical Report prepared by Vogel Environmental Services for East Bay Municipal Utility District, Oakland, California. July 1996. 66 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1997. Fish passage and stress effects on juvenile Chinook salmon physiology and predator avoidance abilities. Natural Resource Scientists, Inc. February 1997. 32 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1998. Lower Mokelumne River Fisheries Monitoring Program, Evaluation of the downstream migration of juvenile salmon and steelhead in the lower Mokelumne River and the Sacramento - San Joaquin Delta (January through July 1995. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. April 1998. 55 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1998. Lower Mokelumne River Fisheries Monitoring Program, Evaluation of the downstream migration of juvenile salmon and steelhead in the lower Mokelumne River and the Sacramento - San Joaquin Delta (January through July 1996. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. October 1998. 43 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1999. Lower Mokelumne River Fisheries Monitoring Program, Evaluation of the downstream migration of juvenile salmon and steelhead in the lower Mokelumne River and the Sacramento - San Joaquin Delta (January through July 1997. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. February 1999. 44 p. plus appendices.

Vogel, D.A. and K.R. Marine. 1999. Lower Mokelumne River Fisheries Monitoring Program, Evaluation of the downstream migration of juvenile salmon and steelhead in the lower Mokelumne River and the Sacramento - San Joaquin Delta (December 1997 through July 1998. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. September 1999. 43 p. plus appendices.

Vogel, D.A. and K.R. Marine. 2000. Lower Mokelumne River Fisheries Monitoring Program, Downstream migration monitoring at Woodbridge Dam during December 1998 through July 1999. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. March 2000. 38 p. plus appendices.

Vogel, D.A. and K.R. Marine. 2000. Lower Mokelumne River Fisheries Monitoring Program, Downstream migration monitoring at Woodbridge Dam during December 1999 through July 2000. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. November 2000. 41 p. plus appendices.

Vogel, D.A. and K.R. Marine. 2001. Assessment of salmon spawning gravel characteristics and quality, 1995 – 1997, Lower Mokelumne River Fisheries Monitoring Program. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. June 2001. 35 p. plus appendices.

Vogel, D.A., K.R. Marine, and J.G. Smith. 1987. Fish passage action program for Red Bluff Diversion Dam. Annual progress report. March 1987. U.S. Fish and Wildlife Service Report No. FR1/FAO-87-6. 56 p. plus appendices.

Vogel, D.A., K.R. Marine and J.G. Smith. 1988. Fish passage action program for Red Bluff Diversion Dam: Final report on fishery investigations. U.S. Fish and Wildlife Service Report No. FR1/FAO-88-19. October 1988. 77 p. plus appendices.

Vogel, D.A., K.R. Marine and J.G. Smith. 1990. A summary of evaluations of upstream and downstream anadromous salmonid passage at Red Bluff Diversion Dam on the Sacramento River, California, U.S.A. Paper presented at the *International Symposium on Fishways '90 in Gifu, Japan.* Proceedings p. 275-281. October 8-10, 1990.

Vogel, D.A. and H. Rectenwald. 1987. Water quality and water quantity needs for Chinook salmon production in the upper Sacramento River. Written testimony prepared for the State Water Resources Control Board 1987 Hearing Process on the San Francisco Bay/Sacramento – San Joaquin Delta Estuary. U.S. Fish and Wildlife Service and the California Department of Fish and Game. 37 p.

Vogel, D.A. and several co-authors. 1991. Assessment of options for excluding adult salmon from entry into the Colusa Basin Drain. Report prepared for Reclamation District 2047. CH2M Hill. September 1991. 19 p.

Vogel, D.A. and G. Taylor. 1987. Survey of the Chinook salmon spawning substrate in the Sacramento River from the Highway 273 bridge to Keswick Dam, July – August 1987. U.S. Fish and Wildlife Service. Joint report by the Fisheries Assistance Office and the Division of Ecological Services Office. 13 p.

Selected Co-Authored Reports

Dorratcague, D., D.A. Vogel, and B. Mitchell. 1999. Guidance Manual for the Fish Protection Evaluation and Monitoring Program. Glenn-Colusa Irrigation District Fish Screen Improvement Project. Montgomery Watson, Natural Resource Scientists, Inc., and Jones & Stokes Assoc. June 1999.

Giddings, J., L. Hall, Jr., K. Solomon, W. Adams, D. Vogel, L. Davis, and R. Smith. 1997. An ecological risk assessment of diazinon in the Sacramento and San Joaquin River basins. Novartis Crop Protection, Inc. Technical Report 11/97. Greensboro, North Carolina. 289 p.

Hallock, R.J., D.A. Vogel, R.R. Reisenbichler. 1982. The effect of Red Bluff Diversion Dam on the migration of adult Chinook salmon, *Oncorhynchus tshawytscha*, as indicated by radio-tagged fish. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 82-8. 47 p.

Johnson, S.I. and D.A. Vogel. 1981. Tehama-Colusa Fish Facilities Operational Plan. U.S. Fish and Wildlife Service Report. 27 p.

June, F.C., L.G. Beckman, J. H. Elrod, G.K. O'Bryan, and D.A. Vogel. 1987. Limnological and fishery studies on Lake Sharpe, a main-stem Missouri River reservoir, 1964 – 1975. U.S. Fish and Wildlife Service Technical Report 8, Washington, D.C.

Lindley, S.T., D.L. Erickson, M.L. Moser, G. Williams, O.P. Langness, B.W. McCovey, M. Belchik, D. Vogel, W. Pinnix, J.T. Kelly, J.C. Heublein, and A.P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Trans. Am. Fish. Soc. 140(1):108-122.

Marine, K.R. and D.A. Vogel. 1993. Lower Mokelumne River Fisheries Monitoring Program, Monitoring of the upstream spawning migration of Chinook salmon and steelhead during October through December 1992. Technical Report prepared by Vogel Environmental Services for East Bay Municipal Utility District, Oakland, California. June 1993. 40 p. plus appendices.

Marine, K.R. and D.A. Vogel. 1994. Lower Mokelumne River Fisheries Monitoring Program, Monitoring of the upstream spawning migration of Chinook salmon and steelhead during October through December 1993 and monitoring of the emigration of the 1993 fall release of yearling Chinook salmon from Mokelumne River Fish Installation during October 1993 through February 1994. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. December 1994. 49 p. plus appendices.

Marine, K.R. and D.A. Vogel. 1996. Lower Mokelumne River Fisheries Monitoring Program, Monitoring of the upstream migration of Chinook salmon and steelhead during October through December 1994. Technical Report

prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. November 1996. 58 p. plus appendices.

Marine, K.R. and D.A. Vogel. 1998. Lower Mokelumne River Fisheries Monitoring Program, Monitoring of the upstream migration of Chinook salmon and steelhead during September through December 1995. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. April 1998. 47 p. plus appendices.

Marine, K.R. and D.A. Vogel. 1999. Lower Mokelumne River Fisheries Monitoring Program, Monitoring of the upstream migration of Chinook salmon and steelhead during September 1997 through February 1998. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. February 1999. 44 p. plus appendices.

Marine, K.R. and D.A. Vogel. 1998. Lower Mokelumne River Fisheries Monitoring Program, Monitoring of the upstream migration of Chinook salmon and steelhead during September through December 1996. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. October 1998. 44 p. plus appendices.

Marine, K.R. and D.A. Vogel. 1999. Lower Mokelumne River Fisheries Monitoring Program, Upstream migration monitoring at Woodbridge Dam during August 1998 through March 1999. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. December1999. 48 p. plus appendices.

Marine, K.R. and D.A. Vogel. 2000. Lower Mokelumne River Fisheries Monitoring Program, Upstream migration monitoring at Woodbridge Dam during August 1999 through March 2000. Technical Report prepared by Natural Resource Scientists, Inc. for East Bay Municipal Utility District, Oakland, California. September 2000. 48 p. plus appendices.

Meyer, J.H. and D.A. Vogel. 1978. An examination of the smaller benthic invertebrates in Hylebos Waterway, Tacoma, Washington. U.S. Fish and Wildlife Service. Olympia, Washington. April 1978.

Wilkinson, C., R. Churchwell, D. Vogel. 2004. Yolo Bypass Experimental Fish Passage Project, 2003-2004 Interim Report. California Department of Water Resources, Division of Environmental Services, Fish Facilities Section. 19 p.