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SJR Technical Report
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Comments pertaining to the "Scientific Basis for Developing Alternate San Joaquin River Delta Inflow Objectives" described in the State Water Resources Control Board's October 29, 2010, *Draft Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*

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On behalf of

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December 6, 2010

Comments pertaining to the "Scientific Basis for Developing Alternate San Joaquin River Delta Inflow Objectives" described in the State Water Resources Control Board's October 29, 2010, *Draft Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*

This document presents comments, submitted on behalf of the San Joaquin River Group Authority (SJRGA), regarding the *Draft Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives* prepared by the State Water Resources Control Board (SWRCB) on October 29, 2010. Comments are limited to sections within "Chapter 3. Scientific Basis for Developing Alternate San Joaquin River Delta inflow objectives."

Due to the short review period, we did not have sufficient time to thoroughly review all documents identified in the State Water Resources Control Board's (SWRCB) *Draft Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives* (Draft Report 2010). Instead, we focused our review on a number of key documents pertaining to two main topic areas and provide comments on key concepts related to those areas.

Two main topic areas:

(1) Flow Effects on Salmon Survival and Potential Flow Recommendations According to the Draft Report

The Draft Report (2010) presents the concept of flow effects on salmon survival in two sections (Section 3.4 Fall-Run Chinook Salmon Inflow Needs, Page 48; and Section 3.6 Analyses of Flow Effects on Fish Survival and Abundance, Pages 49-58) and identifies potential flow recommendations in one section (Section 3.7 Previous Flow Recommendations, Pages 58-60). Our comments regarding these elements are presented first under the heading "Flow Effects on Salmon Survival and Potential Flow Recommendations According to the Draft Report" and are organized into three sections that consist of several issue statements identifying key points that were either not adequately addressed or not considered within the Draft Report. Supporting information follows each issue statement, but is not all-inclusive due to time constraints.

(2) Functions Supported by Spring Flows According to the Draft Report

The Draft Report (2010) presents the concept of functions that are supported by spring flows in two sections (Section 3.5 Functions Supported by Spring Flows, Page 48; and Section 3.8 Importance of the Natural Flow Regime, Pages 60-65). Our comments regarding these elements are presented second under the heading "Functions Supported by Spring Flows According to the Draft Report" and are organized into 8 sections that consist of several issue statements, which identify key points that were either not adequately addressed or not considered within the Draft Report. Supporting information follows each issue statement, but is not all-inclusive due to time constraints.

Summary

Overall, the Draft Report (2010) is a poorly referenced document, filled with errors and assumptions, with little scientific basis to support its conclusion that more flow is needed to increase San Joaquin Basin salmon runs. We describe many issues in our comments that follow but key points include:

- The natural flow regime concept, used as basis for the justification that higher spring flows are needed, is not applicable to such a highly, physically altered system as the Delta.
- Flow does not explain low Delta survival of juvenile Chinook observed since 2003, so more flow is unlikely the solution.
- Establishing flow criteria to achieve *doubling* of historical abundance is not warranted because historical abundance has little to no relevance following the Delta regime shift that occurred in about 2000-2001.
- The Draft Report (2010) relies on three studies to determine flow effects on salmon survival and to identify potential flow recommendations. These studies used inappropriate statistical models, which do not represent the best available science.
- The underlying studies used to model the so-called relationship between flow and salmon abundance and survival were misinterpreted and inappropriately applied.
- The majority of the functions of spring flows identified in the Draft Report (2010) are not pertinent to the location and/or time period that was the focus of the SWRCB Draft Report (2010). Additionally, no evidence was presented to support the functions, or to explain the mechanisms by which the increased spring flows may lead to changes in salmonid abundance or survival.
- Lack of consideration of any alternatives to increasing spring flows to increase salmon survival, such as restoring Delta native fish habitat and decreasing predation by suppressing predator populations.
- The Delta is a highly altered environment that contains primarily non-native fish, some of which have been identified as major stressors on salmon populations by the National Marine Fisheries Service and others.
- Additional flows, in absence of increasing Delta juvenile rearing habitat and reducing predation, will not provide measurable benefits in juvenile salmonid survival. Instead of trying to increase salmon abundance and survival using flow, we recommend the SWRCB immediately implement a predator suppression program that is widely recognized as necessary for restoring salmon and trout populations, and that will not conflict with other beneficial uses of water.
- Predator suppression has been proven to substantially increase salmonid smolt survival in the Columbia River Basin and it is likely that similar results could be achieved in the lower San Joaquin River and South Delta. De-regulating freshwater introduced sportfish harvest would be an immediate, cost-effective, easy to implement, and effective way to increase juvenile salmon survival.

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Flow Effects on Salmon Survival and Potential Flow Recommendations According to the Draft Report

This section addresses the following elements that the Draft Report (2010) used as the basis for determining flow effects on salmon survival and for identifying potential flow recommendations:

- California Department of Fish and Game (DFG) Salmon Survival Model
- Anadromous Fish Restoration Program (AFRP) Doubling Goal Analysis
- The Bay Institute (TBI) and Natural Resources Defense Council (NRDC) Logit Analysis

The Draft Report cites these studies as mounting evidence for their flow recommendations, however, these pieces of evidence are essentially equivalent because they all (1) rely on the same baseline data (yearly escapement/recruitment estimates in different forms and average spring flows at Vernalis), and (2) present results based on variations of the same linear/logistic regression modeling approach that does not represent the best available science. For example, one of the findings by Judge Wanger in the litigation regarding the smelt biological opinion was that the federal government did not use the best available science (The Consolidated Delta Smelt Cases, No. 09-407; E.D. Cal. May 27, 2010). In that case, a life cycle model was considered the best available science. Similarly, the VAMP Independent Review Panel also strongly recommended that the SWRCB consider smolt survival "in the larger context of the entire life cycle of the fall-run Chinook" (Dauble et al. 2010). However, none of the studies cited in the Draft Report have considered life cycle models for salmon even though these models exist for Central Valley salmonids (Noble 2008, Noble et al. 2008). In addition to noting that the SWRCB ignored better tools, such as life-cycle models, our comments relating to the three elements cited by the Draft Report are summarized under the next general issue statement followed by twelve (12) DFG Model Issue, two (2) Reference Issue, one (1) AFRP Doubling Goal Analysis Issue, and four (4) TBI/NRDC Analysis Issue statements.

Flow does not explain low survival of juvenile Chinook observed in the South Delta since 2003, so more flow is unlikely the solution.

South Delta survival has been low since 2003. During this period, even flood flows of approximately 10,000 cfs and 25,000 cfs during outmigration in two years (2005 and 2006) did not increase survival to anywhere near levels when flows were moderately high (5,700 cfs) in 2000. It is unclear why smolt survival between 2003 and 2006 has been so low (SJRGA 2007), but these unexpectedly low Smolt survival observations during 2003-2006 were far lower than historical data. Models based on historical data that do not accurately represent recent conditions (such as Newman 2008 and others) should not be used to predict future scenarios (VAMP Tech. Team 2009).

Establishing flow criteria to achieve doubling of historical abundance is not warranted because historical abundance has little to no relevance following the Delta regime shift that occurred in about 2000-2001 (Bennett and Moyle 2010).

There have been major, anthropogenic changes to the Delta ecosystem resulting in a regime shift in about 2000-2001. To some degree, these changes are irreversible (Bennett and Moyle 2010) and likely preclude the ability to meet or exceed historical abundances. These changes have led biologists to conclude that "Delta policies relying on historical abundances as baselines, or targets for restoration of desired species have little relevance in this new regime" (Bennett and Moyle 2010). Efforts to increase the abundance of native species, such as anadromous salmonids, should therefore focus on what is achievable under current altered (or feasibly restored) conditions.

DFG Salmon Survival Model has consistently been found to be inadequate and should not be used

In March 2005, DFG provided comments to the State Water Board essentially stating the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta ("Bay-Delta") SJR spring Vernalis flow objectives were not adequate for the long-term protection of fall-run Chinook salmon beneficial uses in the SJR. DFG subsequently submitted flow recommendations based on version 1.0 of its Salmon Survival Model (DFG 2005). The DFG Model v1.0 used simple linear regression to determine relationships of interest. It was formally peer reviewed and, along with informal reviews, most reviewers indicated that there were substantial flaws in the methodology. DFG subsequently revised the model through two iterations and submitted the most recent Model v1.6 to the State Water Board in May 2009 with the acknowledgement that further refinements were to be made in version 2.0. The status of this latter revision is unknown.

The DFG Model v 1.6 was referenced, among other models, in the SWRCB's *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem* and again in the Draft Report. The latter notes a possible trigger flow, a minimum required to start making a difference in salmon survival. The DFG model is inconsistent with this possibility. It is also inconsistent with a discussion by McBain and Trush (2002) of the benefits of having low flow years, which allows riparian vegetation to grow. Rather, the DFG Model v1.6 supports the conclusion that more flow all the time is better, which is untenable.

Statistical Basis of DFG Model is Not Sound and Any Recommendations Based On Their Findings Do Not Represent The Best Available Science

The Draft Report (2010, pages 58-59) states the "relationships between flow at Vernalis and Chinook salmon abundance presented by DFG (2005a, Table 1)" indicate that the "most important parameters influencing escapement are spring flow magnitude, duration, and frequency, and that non-flow parameters have little or no relationship to escapement."

However, the 2005 version of the DFG salmon model was previously discredited by Pyper et al. 2006. Subsequently, several independent CALFED peer reviewers confirmed the model contained substantial flaws and recommendations for improving the model were provided. As a result, DFG developed a revised model (version 1.6) and submitted it to the State Water Board in May 2009 (DFG 2009). However, this newer version only contains partial revisions and the updates to the model remain inadequate to address many of the original problems that were identified.

The most recent version of the DFG model (DFG 2009) is still considered inappropriate for use by the SWRCB for a number of reasons, including the previously mentioned incomplete revisions and the lack of peer-review. Our comments, highlighting the problems with the statistical validity of the current DFG model, are summarized under the next 12 issue statements. Details regarding these statements are provided in Attachment 1.

DFG Model Issue 1. It is clear that in order to have a statistically sound model for escapement, one needs to incorporate environmental variables other than, or in addition to flow, such as dissolved oxygen, exports, and water temperature.

DFG Model Issue 2. The proposed simple linear regression model of escapement versus flow is inconsistent with the most recent data from 1999-2009, which shows a negative correlation between flow and escapement.

DFG Model Issue 3. The proposed model is inconsistent over different flow ranges. For example, when dividing the range of flow observations into 4 equally sized bins, one of the bins shows a negative correlation between flow and escapement.

DFG Model Issue 4. There are a small number of overly influential observations in the flow versus escapement data. For example, if one selects a moderately sized subset of these paired observations at random, the model fit varies widely and one frequently observes a negative correlation between flow and escapement.

DFG Model Issue 5. The Ecological Fallacy: The well-known phenomenon that averaging over subgroups (as has been done with the flow data) falsely inflates the strength of a linear relationship.

DFG Model Issue 6. Outliers are present in the flow versus escapement data.

DFG Model Issue 7. The residuals from the flow versus escapement model exhibit non-normality.

DFG Model Issue 8. Heteroscedasticity: The estimated errors in the flow versus escapement model exhibit a non-constant error rate.

DFG Model Issue 9. Nonlinearity is observed in the flow versus escapement data.

DFG Model Issue 10. The estimated errors in the flow versus escapement model exhibit dependence.

DFG Model Issue 11. The flow versus escapement model has a low R^2 value of around 0.27.

DFG Model Issue 12. The Regression Fallacy: That correlation implies causation.

Underlying Reports/Studies Have Been Inappropriately Applied

Reference Issue 1. Findings of studies cited as justification for the position that flow is the primary influence or limiting factor for salmon abundance, and additional flow is needed to improve protection, have been inappropriately applied and the statements are inconsistent with findings of the VAMP peer review. Furthermore, most of these studies rely on the same, or variations on the same data and approaches, that have already been determined inappropriate for setting policy recommendations and do not represent new or additional pieces of evidence for this position.

On Page 48, the Draft Report states that "1) additional flow is needed to significantly improve protection of fall-run Chinook salmon; and 2) the primary influence on adult escapement is flow two and a half years earlier during the juvenile rearing and downstream emigration life phase of the currently escaping adult population (AFRP 2005, DFG 2005a, DFG 2010a, Mesick 2008, DOI 2010)." These studies are largely based on the same linear regression approach repeatedly re-packaged by several authors, most frequently by Carl Mesick, DFG, and USFWS. Not surprisingly, the regressions indicate a correlation between flow at Vernalis and escapement 2 1/2 years later. However, the correlation does not imply causation (Lorden and Bartroff 2010 in Appendix 1), which limits the utility of this result. Specifically, the relationship suggests that flow may affect juvenile survival, but it does not imply a direct cause-effect relationship between juvenile salmon survival and flow, or that increasing flow will cause juvenile salmon survival to increase. Thus the findings of these studies have been inappropriately applied in the Draft Report.

It was this critical limitation, in conjunction with the need to address the limitations and biases associated with previous salmon smolt survival studies in the lower SJR and South Delta, that led to the development of the VAMP salmon smolt survival study (SJRTC 2008). VAMP was designed to gather scientific information that would fill the missing gaps in regard to the impacts of flow and export on salmon. Implementation of the VAMP has not been without challenges, and according to a recent peer review of the VAMP (Dauble et al. 2010), the relationships between survival and flows or exports remain unclear.

Understanding of the mechanisms driving juvenile salmon survival in the South Delta is not furthered by repeatedly reconstructing the flow vs. escapement regression. Undue emphasis has been placed on flow to the inappropriate and unjustified exclusion of other, possibly significant factors. This bias was recently noted during FERC proceedings regarding the operation of the New Don Pedro Project on the Tuolumne River. Specifically, FERC recently found that Mesick et al. (2007) "identifies Tuolumne River flows as having the greatest impact on juvenile Chinook salmon survival... however, they do not include any studies to ascertain the influence of other possible limiting factors, such as pumping at the state and federal water projects in the San Francisco Bay Delta, ocean conditions, and unscreened diversions in the Tuolumne River and in the Delta. In response to these concerns, we find that it may be inappropriate to focus on flow-related studies to the exclusion of other, possibly significant, limiting factors (FERC Order issued July 16, 2009)."

VAMP CWT studies were replaced in 2007 by acoustic telemetry studies, which provide more precise estimates of survival in multiple reaches. Findings to date have emphasized the need to investigate other factors that may affect smolt survival in the South Delta, in particular predation. The VAMP Peer Review (Dauble et al. 2010, page 11) found that "Although it is too soon to conclude that observed predation rates in these two years are "typical" rates of predation, ***it seems clear that identification and management of predation must be a future focus of studies and management activities*** [emphasis added]. It is conceivable that predation impacts on juvenile Chinook has increased due to the recent decline in other pelagic organisms that previously served as alternative prey for predators."

Reference Issue 2. Baker and Morhardt (2001) openly concluded that relationships with flow were still unresolved, but their findings were misinterpreted by NMFS (2009b).

Based on Baker and Morhardt (2001) and (NMFS 2009b), the Draft Report (2010, page 52) suggested that the relationship between flow and survival was "not well quantified," and the lack of relationship between flow and escapement was likely due to other factors, yet still based flow recommendations on these relationships. Baker and Morhardt (2001) noted a positive relationship between survival and flow, and between escapement and flow, especially at flows greater than 10,000 cfs. When only the data below 10,000 cfs were considered, there appeared to be no relationship between flow and smolt survival. Similarly, the relationship between flow and escapement, clearly positive when high flows were included in the analysis, disappeared if only flows below 10,000 cfs were considered and there was a substantial amount of scatter in the data. Baker and Morhardt (2001) highlighted that the regression of escapement on average flows 2.5 years prior to escapement assumes that the same number of smolts emigrate every year. Though this may a necessary simplification for the simple linear regression of escapement on juvenile flow conditions, future analyses should instead consider smolt outmigration abundance.

Baker and Morhardt (2001) also noted that there was a substantial gap in the data available for flow between 11,000 cfs and 18,000 cfs, and thus there was very little information available in this range of flows. Flows over 18,000 cfs represent periods when the tributaries are spilling from the dams and are essentially at flood stage; such conditions may be important to fish, but cannot be provided on demand by reservoir operators. Furthermore, in the nine years since Baker and Morhardt's analysis, there have been additional high flow (> 10,000 cfs) years. Instead of reinforcing the trend observed by Baker and Morhardt, these additional years of data result in more variation in escapement estimates at higher flows (i.e., observe both high and very low escapement estimates in high flow years).

NMFS also cites Baker and Morhardt (2001) as the basis for a positive linear relationship starting at 5,000-6,000 cfs. NMFS based this assertion specifically on Figure 11 in Baker and Morhardt (2001), but this was not Baker and Morhardt's conclusion (as summarized above). The Technical Memorandum for the OCAP-BO (NMFS 2009b) promulgates the 4:1 Vernalis:Export ratio. The 5,000-6,000 cfs recommendation is based on this ratio, instead of flow itself. This determination is arbitrary and capricious, because, although science supports a ratio of exports to SJR flow of more than 2:1, it does not support any specific ratio greater than 2:1. (*Consol. Salmon Cases*, 713 F.Supp.2d 1116, 1136 (2010)). A flow of 1,500 cfs was deemed, by NMFS, as the minimum export flow for human health and safety, but this was not equivalent to a biological explanation (*Id.* at 1165 fn 17). Although a margin of error would have been scientifically justified, it was not justified within the record (*Id.* at 1165 fn 19).

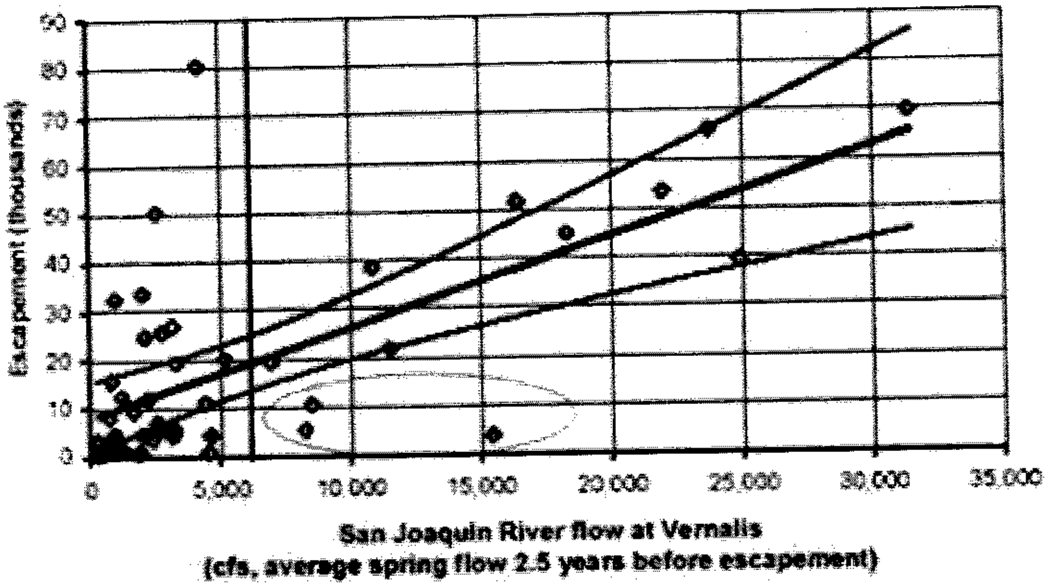

Figure 11 Total escapement to San Joaquin tributaries, 1951 through 1996, and spring flow in the San Joaquin River at Vernalis 2.5 years earlier. Fitted regression line and envelope of 95% confidence region for fitted line are shown.

Finally, Baker and Morhardt (2001) represent yet another example of use of general linear models to predict survival and escapement based solely on flows. This approach and any inferences made from the results of this approach (and similar approaches) are subject to the same criticisms (too simplistic, not considering other important factors, violation of statistical assumptions underlying the model, and averaging over variable flows) as DFG's models (Lorden and Bartroff 2010 in Appendix 1). For example, we noted that 5,000 cfs is also the minimum Vernalis flow above which Baker and Morhardt (2001; Figure 8) demonstrated a marked upturn in the SJR-Old River flow split. Exports are also a factor, however, and can make a difference in a flow split from 60 (the minimum) to nearly 80 percent. The VAMP Final Report did not address the possibility of a specific relationship between the SJR-Old River flow split, but it did identify a significant drop in survival rates if salmon were allowed into Old River. These, and other factors known to have an affect on survival and recruitment, need to be incorporated into models along with information on flow magnitude and variation.

AFRP Doubling Goal Analysis Found To Be Inadequate and Does Not Represent The Best Available Science

AFRP Doubling Goal Issue 1. The approach taken by the AFRP (2005) has not been peer-reviewed and is subject to many of the same criticisms as analyses conducted by DFG. In other words, their findings are not based on the best available science, do not represent new or additional pieces of evidence for the

effects of flow on survival, and are therefore inappropriate for setting management recommendations.

The streamflow recommendations for doubling salmon production presented in AFRP (2005) are based on salmon production models attributed to Mesick (2005). We were unable to find this particular reference; however, the AFRP (2005) outlines the approach used by Mesick (2005).

The AFRP (2005) appears to have utilized a linear regression model to assess the affects of average spring flows at Vernalis (April-May) on recruitment in each of the tributaries to the SJR. This approach is very similar to what has already been presented by DFG (2005a and 2009). The primary difference is in the specification of the dependent variable; in AFRP (2005) the dependent variable used to parameterize the regression equations was recruits per spawner (Draft Report 2010, page 59). The AFRP (2005) recommendations are based on salmon production models for each of the three main tributaries (the Merced, Tuolumne, and Stanislaus rivers) that are based on regression analyses of recruits per spawner and April through May Vernalis Flows. Note that their analysis also limited the period under study to the April-May time period in order to specifically target smolts and to target the time period when water temperatures begin to increase.

Using simple linear regression to predict fish abundance from average spring flow at Vernalis is the same approach taken by DFG in their escapement model. This method is clearly flawed (Lorden and Bartroff 2010 in Appendix 1), and predictions made using this method are not acceptable or based on the best available science. The use of linear regressions to assess these effects is too simple an approach given the clear importance of other environmental factors (e.g., temperature), the tendency for other factors to be correlated with each other, and other violations of simple linear regression that were not addressed in the AFRP report (Lorden and Bartroff 2010 in Appendix 1). Also, here, as in DFG's analysis and in TBI/NRDC's analysis (discussed in next section), the model only included average spring flows, which may mask biologically important variations in flow (Lorden and Bartroff 2010 in Appendix 1).

Flows deemed necessary for doubling salmon production were then estimated using the linear production models described above, as follows (Draft Report 2010, page 59):

> The model combines the above individual recruitment equations to estimate the flows needed at Vernalis during the February through May period to double salmon production in the SJR basin. The flows (Table 2, AFRP 2005) recommended at Vernalis range from 1,744 cfs in February of critically dry years to a maximum of 17,369 cfs in May of wet years and generally increase from February through May to mimic the natural flow regime (natural peak flow in May). Estimates of flows needed on each tributary to double salmon production range from 51 to

> 97 percent of unimpaired flow; with a greater percentage of unimpaired flow needed in drier years than wet years (AFRP 2005).

Due to the fact that this estimate is based on flawed production models, the results are invalid. It should also be noted that the AFRP Doubling Goal Analysis has not been peer-reviewed.

TBI/NRDC Logit Analysis Found To Be Inadequate and Does Not Represent The Best Available Science

TBI/NRDC Logit Analysis Issue 1. The approach taken by The Bay Institute and Natural Resources Defense Council (TBI/NRDC) is subject to many of the same criticisms as analyses conducted by DFG (DFG 2005a and DFG 2009), and therefore their findings are not appropriate for setting management recommendations.

The logit analysis approach taken by the TBI/NRDC (Exhibit 1, 3, 2010) is too simplistic because it ignores other ecological variables known to be important and correlated with flow, such as temperature. In their analysis, TBI/NRDC used a generalized linear model in the form of a logistic regression for binomial dependent variables (i.e., logit model). The dependent variable reflected either positive population growth or negative population growth as estimated by a cohort return ratio (CRR), i.e., the ratio of number of fish that returned to spawn in a given year to the number of fish that spawned several years earlier. The independent variable was average spring flow (March-June) as measured at Vernalis. The TBI/NRDC analysis claims they used the CRR to control for initial population sizes, but their analysis still consists only of a single generalized linear model applied to DFG's GrandTab escapement data and average spring flow at Vernalis.

There are myriad other ecological factors, or interactions between factors, that are likely to impact this analysis (Lorden and Bartroff 2010 in Appendix 1). If any other potential ecological factors are correlated with spring flow, the results of TBI/NRDC's regression may be misinterpreted due to multicollinearity. For example, in years of high spring flows, winter flows are also usually high and vice versa. Any positive relationship between winter flow and escapement could exaggerate the perceived relationship between spring flow and escapement, because the positive effects would be inseparable. The regression analysis also used only average spring flows, which may mask biologically important variations in flow. For example, there is clearly variation that has not been explained by flow thresholds determined in this analysis. The TBI/NRDC analysis found that average spring flows less than 5,000 cfs were associated with negative population growth in 66% of years. In other words, at average spring flows less than 5,000 cfs, population growth did not decline in over a third of the years. To begin to address these issues, TBI/NRDC could have included other variables as covariates, used stepwise regression to arbitrate among models with multiple covariates, or used model selection criteria to arbitrate among a set of competing models that included different arrangements of other covariates.

There are additional statistical weaknesses in TBI/NRDC's analysis, as there does not appear to be evidence that the data used in this analysis meet the assumptions of generalized linear models. For example, if data are autocorrelated, the model may appear to have more predictive ability than it really does. Other potential problems not addressed include heteroscedasticity, non-normality of residuals, and non-linearity as addressed by Lorden and Bartroff (2010 in Appendix 1). Finally, the report does not provide any evidence of model validation to support TBI/NRDC's use of this approach.

TBI/NRDC Analysis Issue 2. The State Water Board based their flow recommendations partially on TBI/NRDC's (Exhibit 1, 3, 2010) flow recommendations. TBI/NRDC's flow recommendations were inferred from an analysis that has already been determined flawed (i.e., DFG 2009).

The State Water Board bases flow recommendations on TBI/NRDC's findings (State Water Board 2010, page 60), as follows:

> Based on abundance to prior flow relationships, TBI/NRDC estimates that average March through June inflows of 10,000 cfs are likely to achieve the salmon doubling goal (TBI/NRDC 2010a and b).

In Exhibit 3, TBI/NRDC (2010) state that this recommendation is based on "the abundance to prior flow relationship" (page 17, Exhibit 3) as described in the quotation below (page 17 Exhibit 3):

> In order to determine San Joaquin River flows into the Delta that would support abundance of fall run Chinook salmon, we analyzed the relationship between Vernalis flow and the absolute abundance of San Joaquin River Chinook salmon. We also evaluated the relationship between flows and floodplain inundation on the lower San Joaquin, particularly between Vernalis and Mossdale, and between flows and water temperature.
>
> Our analysis of the effects of Vernalis flows on abundance showed that, in general, springtime flows that are less than 5000 cfs (average March-June) correspond to escapement numbers that are less than 10,000 fish (Figure 8). Average springtime flows of greater than 10,000 cfs appear necessary to produce annual escapements that meet the doubling objective.

TBI/NRDC's analysis of the effects of average spring flows at Vernalis on abundance (i.e., escapement from DFG's GrandTab) 2.5 years later is based on a simple linear regression model with an R^2 of 0.39 (presented in Figure 8 of Exhibit 3; page 16).

Not only is this a low R^2 value, indicating that the independent variable (average spring flow) is a poor predictor of the dependent variable (escapement), but these are the same (or very similar) data and the same analysis used by DFG (2009), hence the similarly low R^2 (0.27 for the DFG model). Thus, this analysis has the same problems as the DFG analysis and is subject to the same criticisms, such as overly influential data points and violation of regression assumptions (Lorden and Bartroff 2010 in Appendix 1).

TBI/NRDC Analysis Issue 3. The wording used in the discussion of TBI/NRDC's results could lead to misinterpretation as it seems to suggest that there is a proven causal relationship where there is not.

The squared correlation coefficient (R^2) value of a regression typically indicates the proportion of explained variance, which may be interpreted as a measure of the strength of the relationship; it does not, however, imply causality. The Draft Report (2010) misinterprets the TBI/NRDC's results by using verbiage that suggests the results of this analysis are causal, instead of correlative. SWRCB claims that the TBI/NRDC analysis demonstrates that lower flows "resulted in" population declines, and flows of a certain level "produced" different outcomes for population growth (Technical Report 2010, page 60), as follows:

> TBI/NRDC found that average March through June flows of 5,000 cfs or greater resulted in positive population growth in 84 percent of years and flows less than 5,000 cfs resulted in population decline in 66 percent of years. TBI/NRDC found that flows of 6,000 cfs produced a similar response to the 5,000 cfs or greater flows, and flows of 4,000 cfs or lower resulted in significantly reduced population growth in only 37 percent of years.

However, as mentioned previously (Lorden and Bartroff 2010 in Appendix 1), regression relationships, even with relatively high r^2 values, do not imply causality.

TBI/NRDC Analysis Issue 4. Based on TBI/NRDC's results, the Draft Report (2010) claims that 5,000 cfs may represent an important minimum flow threshold for salmon survival and that flows of 10,000 cfs are "likely" to double salmon production. There is no quantification or explanation for how confident the proposers are regarding the likelihood that this flow will reach the salmon doubling goal.

The Draft Report makes the following claim on page 60:

> The TBI/NRDC analysis suggests that 5,000 cfs may represent an important minimum flow threshold for salmon survival on the SJR. Based on abundance to prior flow relationships, TBI/NRDC estimates that average March through June inflows of 10,000 cfs are likely [emphasis added] to achieve the salmon doubling goal (TBI/NRDC 2010a and b).

The TBI/NRDC authors provide no explanation for how confident they are that 5,000 cfs is a necessary minimum flow and that 10,000 cfs will reach the salmon doubling goal. Since the modeling approach that they used has already been found to be flawed, it is likely that confidence intervals (if they were generated) would not be useful. Future model estimates (based on appropriate methodology) for salmon production should include confidence intervals to allow decision-makers to understand the likelihood of modeled flows producing the desired effect and to understand the range of possible outcomes. For example, very wide confidence intervals would indicate that there is substantial uncertainty in the estimates, requiring more data and more appropriate models.

Functions Supported by Spring Flows According to the Draft Report

The Draft Report (2010, page 48) indicates that

> freshwater flows during the late winter and spring period provide several ***functions*** [emphasis added] that affect juvenile fall-run Chinook salmon survival and abundance as they move downstream through the Delta. [These functions are as follows:]
>
> (1) …cue to trigger migration of smolts…;
> (2) …facilitate transport of fish downstream…;
> (3) …improve migration corridor conditions…;
> (4) …improved rearing habitat within a few days of emergence…;
> (5) …increased and improved edge habitat (generally inundated areas with vegetation) …;
> (6) …increased and improved food production…;
> (7) …increased turbidity and more rapid flows may reduce predation…;
> (8) …maintenance of channel habitat…;
> (9) …transport of sediment, biota, and nutrients…;
> (10) …reducing temperatures…;
> (11) …increasing dissolved oxygen levels…; and
> (12) …reducing contaminant concentrations.

We examined these functions, along with other factors that were not considered by the State Water Board, based on their relevancy to several different topic areas as follows:

(1) fry and smolt outmigration (functions # 1-3);
(2) salmonid rearing habitat (functions # 4-7);
(3) physical transport and geomorphology (functions # 8-9); and
(4) water quality (functions # 10-12).

Fry and Smolt Outmigration

According to the Draft Report (2010), fry "generally begin migrating in the early spring", and "late winter/early spring, increased flows provide improved transport downstream for salmon migrating as fry." Additionally the Draft Report (2010) states that, there are three functions of late winter and spring flows that affect smolt outmigration including "later in the season, higher inflows function as an ***environmental cue to trigger migration*** of smolts and ***facilitate transport of fish*** downstream, and ***improve migration corridor conditions*** (DOI 2010)" [Emphasis added; Page 48]. Our comments regarding the factors influencing fry and smolt outmigration that were both considered, and not considered, by the Draft Report are summarized under the next ten (10) Outmigration Issue statements.

Outmigration Issue 1. The Draft Report (2010) erroneously identifies that fry migration occurs in early spring and does not take into account the influence of turbidity on fry survival.

The report describes fry migration from the tributaries as occurring in the early spring and specifically during early flow events. This description is unnecessarily vague and confusing. The timing of fry migration from the San Joaquin tributaries is well documented by historical and ongoing outmigration monitoring efforts (USFWS 2006, Fuller 2008, Palmer and Sonke 2008, SJRGA 2008, FISHBIO 2009, SJRGA 2009, Palmer and Sonke 2010) and is described as occurring during January-March with peak migration in February. Referring to this timing as "early spring" is confusing since the first day of spring is March 20 and most fry have emigrated by this time. The timing of fry migration would more appropriately be described as occurring during winter.

While it is clear from recent and historical outmigrant monitoring efforts (i.e. current rotary screw traps, and Mossdale trawls in the 30's and 40's) that winter run-off events can cue fry migration from tributaries to the San Joaquin River, this is a tributary function and very little is known about the factors influencing fry survival once they reach the South Delta. The Draft Report acknowledges that cueing migration is a tributary function on page 48 stating that "delays in precipitation producing flows may result in delayed emigration which may result in increased susceptibility to ***in-river*** [emphasis added] mortality from predation and other poor habitat conditions (DFG 2010d)." But, the Draft Report fails to mention that these run-off events consist of both increased flows and elevated turbidity, and decoupling these functions is difficult. Flows from run-off events can be simulated with reservoir releases, but turbidity cannot, and the cue to migrate does not appear to be as strong in response to managed high pulse flows in absence of turbidity (FISHBIO, unpublished data).

The question of whether it is desirable/effective, in terms of production, to cue fry migration from the tributaries has not been resolved, and the Draft Report presents no discussion or information regarding the potential positive and negative effects of moving fry into the lower SJR and South Delta. There is also no discussion of how many fry move, the percentage of fry to smolts, the contribution of fry to escapement, or quantitative analysis of how functions in the South Delta relate to fry survival. Management has long focused on smolts, with the belief that fry are lost in the Delta and do not contribute to adult escapement. This belief appears to have been based on conclusions drawn from coded-wire tag (CWT) studies during 1980-1987 (Brandes and McLain 2001) on the Sacramento River, a system that differs greatly from the San Joaquin River in hydrology and runoff patterns, and on the interpretation of relationship between spring SJR flow and escapement.

While the Sacramento CWT studies indicated that survival of fry released in the Sacramento River near the edge of the Delta was an order of magnitude lower than for smolts, this information was not interpreted in the context of the relative abundance of fry and smolt outmigrants. Studies were reinitiated in 2000 and each year paired groups of fry were released on the Sacramento River just below the Red Bluff Diversion Dam (RBDD) and in the North Delta at Clarksburg (USFWS 2006, USFWS 2007). The index of survival was calculated for each release group by dividing the number of expanded ocean recoveries by the number released. Although release groups are not directly comparable, the ocean recovery rates for fry between 2001 and 2003 are much lower than for smolts during the same time period (USFWS 2007). However, similar to previous studies, the ocean recovery rate for fry released just below RBDD was much greater than the rate for the fry released in the North Delta, demonstrating that estimates of fry survival can vary greatly by release location. While it may appear from these low survival rates that fry may not contribute to adult escapement, it is important to consider that the abundance of fry outmigrants leaving the tributaries is often much greater than the abundance of smolts (Williams 2001, Pyper and Justice 2006), and that the survival of fry leaving the Sacramento River through the North Delta will not necessarily be comparable to that of fry passing through the lower San Joaquin River and South Delta.

The disregard for fry contributions may have been falsely attributed to the belief that increased spring flows lead to increased smolt survival, because high winter flows are often followed by high spring flows, which affect the same brood. Until recently, the possibility that fry may contribute to escapement has been speculative. However, results published this year from otolith microchemistry analyses of fish which emigrated during 2003 and 2004 revealed that samples were comprised of individuals that emigrated as parr (mean = 48%), followed by smolts (32%) and fry (20%; Miller et al. 2010). Since these proportions are based on entry into brackish waters of the Bay, rather than the transition from tributary to Delta, then the parr (or smolt) percentages above may also include fry (or parr) that migrated out of the tributaries and reared in the Delta. In light of the fact that any of the *smolts entering the Bay* may represent fry or parr migrants from the tributaries, the percentage of *fry leaving the tributaries* that contribute to the escapement is likely higher than 20%. Regardless, based on 2003 and 2004, which were below normal (BN) and dry (D) years, information suggests that fry may contribute even under low Delta outflow conditions.

Outmigration Issue 2. The Draft Report (2010) erroneously identifies that spring flows in the South Delta serve as cues to migration, and provides no evidence that 'triggering migration' provides any measurable benefit to either juvenile survival or adult return rates.

As stated in the Draft Report (2010, page 34), "[t]he focus of this review is on SJR flows at Vernalis. . . Other SJR flows, including tributary flows, will be the focus of future State Water Board activities"(page 34). In general, smolts are rearing in the tributaries; therefore, any migration cues associated with flow would occur above Vernalis, which is outside the geographical extent of the State Water Board's review.

Although juvenile Chinook migration out of the upper tributaries is ***temporarily*** stimulated by *changes* in flow, long duration pulse flows do not "flush" fish out of the tributaries. Juvenile migration from the tributaries typically begins in January and nearly all juveniles migrate out of the tributaries by May 15 (i.e., 95-97% prior to May 15; SJRGA 2007-2010; Deas et al. 2004; Demko et al. 1999, 2000a, 2000b, 2001a, and 2001b; FISHBIO 2007; Fuller et al. 2006-2007; Fuller 2005; Palmer and Sonke 2008-2009; SPCA 2001; Watry et al. 2008). The Draft Report fails to mention that juvenile Chinook migration from the tributaries can be triggered by a ***decrease*** in flow just as easily as by an increase in flow, and that the stimulatory effect is short lived (i.e., a few days) and only affects fish that are ready to migrate (Kjelson et al. 19981, Demko et al. 2001a, 2000a; Demko and Cramer 1995, 1996). Although the Draft Report (2010) does note that migration can be stimulated by a variety of factors, including "inherited behavior, habitat availability, flows, competition for space and food, water temperature (Jones and Stokes 2005), increasing turbidity from runoff, and changes in day length," none of the non-flow factors or their relative influence for stimulating migration were considered while developing flow recommendations. While flow pulses are one factor that can influence the initial migration movements, it is one of a complex suite of interacting factors.

Outmigration Issue 3. The Draft Report (2010) does not present any evidence that higher spring flows "facilitate transport," or present any potential mechanisms by which "facilitation" could be measured.

The term "facilitate transport" is undefined in the Draft Report (2010) and is too vague to evaluate adequately. Although the Draft Report cites DOI's comments to the State Water Board (DOI 2010) for this function, there is no reference to "facilitate transport" anywhere in the DOI (2010) text. Therefore, it is unclear by what mechanisms spring flows facilitate transport of smolts, what the benefits are, and how the benefits may be influenced by factors such as flow level, duration, turbidity, etc. Without a more detailed description of mechanisms by which juvenile Chinook allegedly benefit from higher spring flows in the South Delta, we cannot provide a thorough assessment.

Nonetheless, the Draft Report (2010) may be suggesting that increased flows result in increased velocity, which may lead to decreased juvenile salmonid travel time through the region, thus 'facilitating transport'. A reference was cited by the Draft Technical Report from an early USFWS exhibit to the State Water Board (USFWS 1987) in support of the hypothesis that increased San Joaquin River flows are positively related to smolt migration rates, "with smolt migration rates more than doubling as inflow increased from 2,000 to 7,000 cfs." However, the original reference does not specify how and when these data were gathered and analyzed. Presumably these data are part of the work conducted by the USFWS as part of the Interagency Ecological Program for the Sacramento-San Joaquin Delta (IEP). As in other documents related to these IEP and other early studies, data have often been misinterpreted, or there were factors not considered such as the potential for different sized fish to be released (different sized fish behave differently giving the appearance that migration rates were influenced by flows).

In 2001, four years after the 1987 USFWS exhibit, this hypotheses regarding flow and migration rates was already in question as evidenced by Baker and Morhardt (2001) which stated that

> "initially it seems intuitively reasonable that increased flows entering the Delta from the San Joaquin River at Vernalis would decrease travel times and speed passage, with concomitant benefits to survival. The data, however, show otherwise."

Baker and Morhardt (2001) examined the relationship between mean smolt migration times from three locations (one above and two below the Head of the Old River to Chipps Island) and San Joaquin flow (average for the seven days following release) and found no significant relationships at the 95% confidence level, and a significant relationship at the 90% confidence level for only Old River releases.

Although flows were not found to facilitate transport, there was evidence of an increase in smolt migration rate with increasing size of released smolts (Baker and Morhardt 2001), which again highlights the limitation of the "black box approach" and emphasizes a need for a better understanding of the mechanisms underlying the relationship of survival and flow.

This increase in migration rate with increasing size may be explained by the one factor that definitely helps facilitate the transport of salmon through the Delta: the salmon itself. Juvenile salmonids are actively swimming, rather than moving passively with the flow, as they migrate towards the ocean (Cramer Decl., Case 1:09-cv-01053-OWW-DLB Document 167, Peake McKinley 1998), and the movements of juvenile salmonids depend on their species and size, water temperature and local hydrology, and many other factors (Cramer Decl., Case 1:09-cv-01053-OWW-DLB Document 167). Baker and Morhardt (2001) provide an example of a study which compared the speed of smolt passage to that of tracer particles (particle tracking model - PTM), "in which 80% of the smolts were estimated to have been recovered after two weeks, but only 0.55% of the tracer particles were recovered after two months." According to documents filed in the Consolidated Salmon Cases (Cramer Decl., Case 1:09-cv-01053-OWW-DLB Document 167), simulations of PTM were compared to actual mark and recapture CWT data for Chinook salmon released at Mossdale on the San Joaquin River, and it was found that smolts traveled to Chipps Island 3.5 times faster than the modeled particles, with a significant difference in the time to first arrival (df=76, T=9.92, p<0.001).

In recent years, VAMP has used acoustic tags to monitor smolt outmigration survival, therefore more detailed travel times have been estimated for the various SJR and South Delta reaches. Results have generally shown short travel times between reaches, suggesting active swimming. In 2009, the average travel times were reported for each reach, and all were under 2.5 days (SJRGA 2009). For example, the average travel time between Lathrop and Stockton was only 2.29 days.

In addition, while modeling suggests that velocities at the Head of Old River may increase by about 1 ft/s with an additional 6,000 cfs San Joaquin River flow, the model predicts little to no change in velocity (<0.5 ft/s) at other stations in the South Delta (Paulsen et al. 2008 in Appendix 2). Thus, increased flows may increase velocity near the boundary of the Delta, but do not substantially increase velocity through the Delta.

Outmigration Issue 4. The term "improve migration corridor conditions" is poorly defined; no specifics on how higher inflows will "improve" the corridor for fish, or how those improvements will provide measurable benefits to juvenile Chinook.

The statement "improve migration corridor conditions" is vague and the supporting citation (DOI 2010) does not specifically reference the function. The Draft Report (2010) does not present any analysis or interpretation of how spring flows "improve" migration corridors, or what metrics could be used to judge an improvement.

Outmigration Issue 5. Research over the last decade has demonstrated that the Head of Old River Barrier (HORB) is an important factor influencing juvenile Chinook survival in the SJR, yet this aspect of the HORB does not appear to factor into the Draft Report (2010) flow considerations.

Although the Draft Report (2010 page 51) mentioned that the HORB has shown "survival is improved via the barrier because of the shorter migration path, but also because it increases the flows down the main-stem SJR (Brandes and McLain 2001)" and that the majority of flow enters the Old River instead of continuing downstream in the San Joaquin when the HORB is not installed, the lack of a barrier is not considered. Due to delta smelt concerns, it is unlikely that the HORB will be installed during the spring salmonid outmigration period, which will reduce the migration suitability for salmonids regardless of tributary flows.

A non-physical barrier (Bio-Acoustic Fish Fence = BAFF) is currently being tested, but it is unclear how this will affect survival of migrating fish. The BAFF was designed to prevent fish from entering the Old River without deflecting flow down the SJR, since it is the reduced flow that was the concern for Delta smelt. During the first two years, results have been inconclusive. In the first year of installation, 2009, the BAFF was effective at discouraging fish from entering the Old River, and when the BAFF was operating, the deterrence rate was 81.4% (Bowen et al. 2009). However, there was evidence of high predation associated with a scour hole just past the HOR. DIDSON monitoring documented large schools of predatory fish holding near the barrier's infrastructure. Striped bass were seen swimming in looping patterns displaying patrolling behavior throughout the HOR area. The final report stated that "[t]he predation rate was so high in fact that the Protection Efficiency was not statistically different between barrier off and barrier on. The data suggest that much of the gains accomplished by the BAFF's deterrent of smolts is offset by the predators in the scour hole." In 2010 the configuration of the BAFF was changed to guide fish away from the scour hole. At the OCAP Review meeting in early November (2010) Mark Bowen presented the 2010 results. This year, the deterrence rate declined, but the protection efficiency was much higher (43.1%). Bowen hypothesized that the higher flow rates (higher water velocity) in 2010 lead to faster transit times (Chinook travel speeds) and less opportunities for predators to encounter prey, thus increasing protection efficiency. However, higher water velocities and travel speeds also meant the fish approached the barrier at a much faster rate and had less time to respond to the BAFF. Since it appears that an alternative to the non-physical HORB will likely be installed in the future, additional studies are necessary to understand how the BAFF affects fish outmigration behavior and survival.

Outmigration Issue 6. The Draft Report (2010) incorrectly assumes higher flows will reduce predation by "displacing" non-native species.

Non-native species have become more abundant than native species in the South Delta (Figure 1). According to the Draft Report (2010),

> seasonal flow events may be beneficial for native species in the south Delta by... displacing nonnative species (Marchetti and Moyle 2001), and by providing suboptimal spawning and rearing conditions for some non-native species (Marchetti and Moyle 2001, Brown & Ford 2002)(Feyrer and Healey 2003).

However, there is evidence that striped bass (*Morone saxatilis*) are also positively associated with higher river flows (Feyrer and Healey 2003). Therefore, while an increase in spring flows could benefit native species such as tule perch (*Hysterocarpus traski*) and Sacramento sucker (*Catostomus occidentalis*), it would also benefit a predator of salmonids, the striped bass.

Outmigration Issue 7. Despite overwhelming evidence that predation by striped bass and other non-native predators are the major threat to salmon and steelhead

survival, the Draft Report (2010) does not consider that reducing predation may benefit salmon more than increasing flows.

Several studies have documented that non-native predator species, especially striped bass, prey upon juvenile salmon in the Sacramento-San Joaquin complex (Shapovalov 1936, Stevens 1966, Thomas 1967, Pickard et al. 1982, Merz 1994, Gingras 1997, Nobrigra and Feyrer 2007, Miranda et. al. 2010), and, to a lesser extent, on steelhead (Edwards 1997, Figure 3). Statistical models have examined the effects of striped bass predation on winter-run Chinook salmon extinction risk and predicted that increased predation by striped bass would substantially impact this endangered population (Lindley and Mohr 2003). According to DFG (2009), there are roughly one (1) million adult striped bass in the Delta and their abundance remains relatively high despite curtailment of a stocking program in 1992 (DFG 2009). This estimate does not account for Age 1 and Age 2 striped bass, which were estimated by Hanson (2009a) as part of a bioenergetic analysis to be 4,796,850 and 1,199,212 fish, respectively. Based on this bioenergetic analysis, Hanson (2009a) concluded that

> striped bass predation is a major cause, if not the greatest cause, of mortality to juvenile winter-run and spring-run Chinook salmon in the Delta system.

Despite these findings, other studies have reported low rates of predation by non-native species in the Central Valley (Edwards 1997, Nobriga and Feyrer 2007, Tucker et al. 1998) or argued that removing specific non-native predators (i.e., striped bass) simply makes room for other predators to proliferate (Nobriga 2009). However, in concert with extensive habitat loss (Yoshiyama 2001) and serious declines in salmon stocks, even low levels of predation on salmonid early life stages are suspected to contribute to the decline of California's native fisheries and should be addressed through non-native predator reduction (Rea 2010).

Outmigration Issue 8. The Draft Report (2010) ignored evidence that striped bass in the San Joaquin River and South Delta prey on juvenile Chinook to such an extent that they significantly reduce the number of Chinook returning to the San Joaquin Basin.

High predation losses at the State Water Project (SWP) are particularly detrimental to San Joaquin Chinook salmon populations since over 50% of juvenile salmon from the San Joaquin travel through Old River on their way to the ocean, exposing them to predation at Clifton Court Forebay (CCF) and causing substantially reduced survival. Predation rates in CCF are as high as 66-99% of salmon smolts (Gingras 1997; Buell 2003; Kimmerer and Brown 2006). Striped bass are generally associated with the bulk of predation in CCF since their estimated populations have ranged between 30,000 and 905,000 (Healey 1997; Cohen and Moyle 2004); however, studies indicate that six additional invasive predators occur in the CCF (i.e., white catfish, black crappie, largemouth bass, smallmouth bass, spotted bass, redeye bass) with white catfish being the most numerous, having estimated populations of 67,000 to

246,000 (Kano 1990). Yoshiyama et al. (1998) noted that "[S]uch heavy predation, if it extends over large portions of the Delta and lower rivers, may call into question current plans to restore striped bass to the high population levels of previous decades, particularly if the numerical restoration goal for striped bass (2.5 to 3 million adults; USFWS 1995; CALFED 1997) is more than double the number of all naturally produced Central Valley Chinook salmon (990,000 adults, all runs combined; USFWS 1995)." In 2005, Churchwell and Hanson (2006) presented results of a pilot investigation of predation on acoustically tagged steelhead (ranging from 221-275 mm) and estimated that 22 of 30 (73%) were preyed upon. Nobriga and Feyrer (2007) state:

> Striped bass likely remains the most significant predator of Chinook salmon, *Oncorhyncus tschawytscha* (Lindley and Mohr 2003), and threatened Delta smelt, *Hypomesus transpacificus* (Stevens 1966), due to its ubiquitous distribution in the Estuary and its tendency to aggregate around water diversion structures where these fishes are frequently entrained (Brown et al. 1996).

Similarly, predators congregate around the numerous smaller underwater structures in the lower San Joaquin River and South Delta including bridge pilings, barriers, and pump platforms (Hanson 2009b, Miranda 2010, Vogel 2010).

Outmigration Issue 9. Recent San Joaquin Basin VAMP studies support high predation rates by striped bass on Chinook salmon in the lower San Joaquin River and South Delta.

In 2006 and 2007, the first two years of an acoustic tag monitoring study were conducted to evaluate survival of salmon smolts emigrating from the San Joaquin River through the South and Central Delta (SJRGA 2008). In 2006, results indicated that without the, "Head of Old River Barrier in place and during high-flow conditions many (half or more) of the acoustic-tagged fish, released near Mossdale, migrated into Old River."

In 2007, a total of 970 juvenile salmon were tagged with acoustic transmitters and were detected by a combination of receivers including mobile tracking and stationary detections. Mobile tracking found that 20% of released fish (n=192) were potentially consumed by predators at three "hotspots" located near Stockton Treatment Plant (n=116), just upstream of the Tracy Fish Facility trashracks (n=57), and at the head of Old River flow split downstream of Mossdale (n=19). Stationary detections indicated an average 45% loss, potentially attributable to predation, that does not account for losses at the largest "hotspot" at Stockton Treatment Plant, nor in the greater Delta past Stockton and Hwy 4.

In 2008 and 2009, it became apparent that the issue of predation could greatly affect the estimates of smolt survival through the South and Central Delta. First, some tagged smolts were showing 'predator-like behaviors', which lead researchers to believe that these tags were actually predators that had consumed the tagged smolts (SJRGA 2009; Vogel 2010a; Vogel 2010b and Buchanan et al. 2010 in Appendix 3). As a result, several alternative data analysis approaches were designed in order to minimize any bias in the survival estimate associated with predation (SJRGA 2009). When both "smolt type" and "predator type" detections were included in the survival model, survival was estimated to be 0.34 (95%CI=0.29-0.57), which was much higher than the survival estimate based on smolt only detections of 0.06 (95%CI=0.04-0.10). Secondly, during the pilot study of the BAFF to prevent fish from entering the Old River, researchers found that many of the fish that passed the barrier and stayed in the SJR were apparently eaten by predators at the large scour hole downstream of the HORB (Bowen et al. 2009). Predation rates at the barrier ranged from 11.8 to 40% (mean=27.5%). These two key results of the recent acoustic telemetry studies highlight the potential management implications of ignoring the issue of predation on study fish, and the importance of developing new telemetry technology that can differentiate a tag in a live fish from a tag in a consumed fish (Vogel 2010a; Vogel 2010b and Buchanan et al. 2010 in Appendix 3).

Outmigration Issue 10. The Draft Report (2010) ignored the fact that the overwhelming majority of predation on juvenile Chinook is the result of non-native predators that were intentionally stocked by DFG, and whose abundance can be reduced to minimize the impacts on Chinook.

Most of the non-native fish species (69%) in California, including major predators, were intentionally stocked by DFG for recreation and consumption beginning in the 1870's (Figures 5 and 6). All of the top predators responsible for preying on native fish are currently managed to maintain or increase their abundance. Historically, the Delta consisted of approximately 29 native fish species, none of which were significant predators. Today, 12 of these original species are either eliminated from the Delta or threatened with extinction, and the Delta and lower tributaries are full of large non-native predators such as striped bass that feed "voraciously" throughout long annual freshwater stays (McGinnis 2006). Lee (2000) found a remarkable increase in the number of black bass tournaments and angler effort devoted to catching bass in the Delta over the last 15 years. According to Nobriga and Feyrer (2007), "largemouth bass likely have the highest per capita impact on nearshore fishes, including native fishes," and "shallow water piscivores are widespread in the Delta and generally respond in a density-dependent manner to seasonal changes in prey availability." The impacts of the two recent invaders—spotted bass (*Micropterus punctulatus*) and redeye bass (*M. coosae*)—remain undetermined; however, redeye bass "devastated the native fish fauna of the Cosumnes River basin" (Moyle *et al.* 2003 as cited by Cohen and Moyle 2004). Black crappie were responsible for a high level of predation during a 1966/67 DFG study with as many as 87 recognizable fish removed from the stomach of a single crappie, and counts of 40 to 50 were common. Most of the fish were undigested; hence, they were not in the stomachs for very long. Therefore, an individual crappie could presumably eat several times the observed number in one day, perhaps 100 or 150 fish; while, the average numbers for striped bass could be 200 to 300 fish, on the conservative side.

Agencies along the West Coast are beginning to recognize the significance of predation on ESA listed salmon runs. In the Columbia River Basin, there is a Northern Pikeminnow Sport Fishery program that rewards anglers for catching predatory pikeminnows. The pikeminnow reduction program was estimated to reduce potential predation to 40% of pre-program levels in 2009 (Porter 2009).

In California, the Sacramento Bee (Weiser 2010) reported that DFG has been aware of some of the direct effects of non-native predation on native species for over a decade:

> A 1999 report by Fish and Game estimated stripers may eat as much as 6 percent of some salmon runs. Evidence uncovered by the lawsuit indicates state officials have known for years that it may be a bigger problem, according to documents the coalition obtained as part of the lawsuit.
>
> "Last night a chill ran down my spine imagining that Delta smelt go extinct ... while we have done nothing proactive to address predation by striped bass," Marty Gingras, supervising biologist for Fish and Game's Bay Delta Region, wrote in a February 2007 e-mail. "I'm again thinking we should propose revising the striped bass policy to consider them a 'weed' like pigs or a similar pest."
>
> The e-mail was labeled "Confidential" and sent to Gingras' boss, Chuck Armor, who replied, "I share your concern."
>
> In a subsequent deposition, the coalition's attorney pressed Gingras to estimate how many juvenile salmon are eaten by striped bass. Because no one knows for sure, he gave a range of 5 percent to 25 percent.

The Department of Water Resources is also now examining the effects of predation on salvaged fish that are released into the Delta at specific release sites, to determine how to alter practices to increase the survival of salvaged salmonids (Miranda et al. 2010).

Earlier this year, in a letter addressed to the President of the California Fish and Game Commission, the Sacramento Area Office NMFS Supervisor (Rea 2010) stated,

> The public draft recovery plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead has identified non-native predation as a key factor contributing to the precarious status of these species (see executive summary page 2; pages 4, 19, 36, 48, and 157 in the main document, and pages 33-35 and 40 in Appendix B)...NMFS has concluded that striped bass predation on salmon and steelhead is an important stressor warranting action. . .

> Actions to address stressors such as Delta water withdrawals and ocean harvest are being taken. We believe it is necessary to address the full range of stressors if we are to recover these species, including a concentrated effort to reduce predation by non-native species.

And, in a recent editorial in the Sacramento Bee (McCamman 2010), the director of DFG stated that

> many other factors may be addressed in the Bay-Delta Conservation Plan planning effort, including wastewater discharge and its effect on nutrients in the Delta, agricultural and urban storm runoff, and the role of introduced plant and animal species, including ***predatory fish species such as black bass and striped bass*** [emphasis added].

From these examples of predator suppression programs, evaluations into local predation potential (i.e., salvage release sites), and recent quotations by various state and federal agencies, it is clear that natural resource managers and biologists along the West Coast recognize the role of predation as an important stressor on ESA listed salmon runs. It is also apparent that predation is a stressor that can be successfully reduced, as evidenced by a predator suppression program in the Pacific Northwest (Porter 2009).

Salmonid Rearing Habitat

The Draft Report (2010) makes numerous references to the potential benefits of increased SJR flows, including the inundation of floodplain and associated riparian habitat and its effects on growth and survival of outmigrating anadromous salmonids. While the Draft Report (2010) lists a wide variety of potential benefits from floodplain inundation, this review will focus only on the potential effects on outmigrating Chinook salmon and steelhead.

The Draft Report (2010) specifically states that increased flows and inundation of floodplains and associated vegetation will directly benefit anadromous salmonids by providing increased overhead shading and instream cover, greater protection from larger piscivorous predators, warmer early-season water temperatures, and increased production of fish food organisms – all of which are expected to produce faster growing juveniles that may exit the Delta sooner than smaller individuals and enjoy greater survival. Our comments regarding these assertions are provided in the following ten (10) Rearing Habitat Issue statements.

Rearing Habitat Issue 1. Historical floodplain locations, and presumably functions, between the Sacramento River and San Joaquin River not directly comparable.

Historically, the Sacramento River and the SJR basins both possessed vast areas of floodplain habitat that was annually inundated by high winter and spring streamflows, each encompassing areas up to 1,000 mi^2 or more (TBI 1998). However, most of the

SJR basin floodplains existed in the upper basin upstream of the Merced River, and relatively little floodplain habitat occurred in the lower SJR until entering the Delta (TBI 1998, Figure G6). This is in contrast to the Sacramento River Basin, where the majority of historical floodplain existed in the lower river downstream of present day Hamilton City (TBI 1998, Figure G4).

Rearing Habitat Issue 2. As evidence of the benefits of floodplain habitat to salmonids, the Draft Report (2010) improperly relies on generic literature reviews (not actual research studies), data collected outside the United States, and two locations (Sacramento River Yolo Bypass and Cosumnes River Preserve) in California that share little resemblance or characteristics with SJR habitat.

The majority of the citations listed in the Draft Report (2010) are simply other literature reviews, often based on data from other continents. The bulk of California-specific information used to support these expected benefits come from studies conducted in two locations: the Sacramento River Yolo Bypass and the Cosumnes River Preserve. Whereas both of these locations have produced evidence supporting increased growth of migrant juvenile Chinook salmon, the Yolo Bypass is vastly different than floodplain areas surrounding the SJR or the South Delta, and the Cosumnes River Preserve is a very small wetland/river system that has provided a limited amount of comparable data. Also, the historic runoff patterns in these areas, and thus the inundation durations and timing, were likely very different than run-off patterns in the San Joaquin Basin.

Rearing Habitat Issue 3. Evidence of improved growth of juvenile Chinook conducted on the large, flat, relatively shallow floodplains of the Yolo Bypass and Cosumnes Preserve are not directly applicable to the SJR Basin and South Delta, and should not be used to infer similar benefits of floodplain habitat in the SJR and South Delta.

TBI (1998; Figure 7) described the SJR channel below the Merced River as a highly sinuous pattern of rapid channel meander migration with a rich complex of oxbow lakes, backwater sloughs, ponds, and sand bars. This is in contrast to the wide, flat floodplain areas surrounding the Sacramento River. When flooded, the Yolo Bypass, which is the source of most data emphasizing floodplain benefits to salmon, is characterized as a wide, shallow, slow-moving water body that is comparatively warmer and more productive than the adjacent Sacramento River (Sommer et al. 2001a, 2004). Although the Yolo Bypass studies do not emphasize the occasional flooded pond habitats, some such habitats do exist but generally were found to be less productive for juvenile salmon than were the shallower cultivated areas (Feyrer et al. 2004). Likewise, the limited studies in the Cosumnes River Preserve found that growth of juvenile Chinook was slower in flooded pond areas than in the adjacent flooded pastures and woodlands (Jeffries et al. 2008).

The Yolo Bypass studies have revealed that it is the large expanse of shallow (mostly <1 m), slow velocity (mostly <0.3 mps) water that yields increased productivity of fish food organisms and increased growth of juvenile Chinook salmon (Sommer et al. 2001a,b). Inundated floodplains in the SJR, by contrast, are likely to be more comprised of deeper water, due to the natural confinement of the adjacent lowlands and to the frequent presence of oxbow features. Floodplains within the SJR are also likely to be swifter than floodplains in the Yolo Bypass, and may not provide any food or cover when they are inundated (Figure 8). Consequently, the amount of habitat suitable for juvenile Chinook, which strongly prefer shallow, slow-velocity habitat, may be limited to a relatively small portion of the inundation zones described in an analysis by Campbell et al. (2010).

Although the majority of historical floodplain habitat has disappeared in both basins, the Sacramento River still supports large areas of periodically inundated, shallow water floodplains in the Sutter Bypass (~15,500 acres) and the Yolo Bypass (~60,000 acres). Historically, the South Delta was similar to the Yolo Bypass; however, extensive (mechanical) channel modifications have changed the shallow tidal marsh environment in ways that cannot be re-established by flow management. Instead, habitat restoration is required to improve conditions, which can then be followed by evaluations to determine whether managed flows influence the functionality of restored habitats.

Rearing Habitat Issue 4. No studies of salmonid use of floodplain habitat have ever been conducted in the lower SJR or South Delta and increasing flows could lead to increases in juvenile stranding.

The oxbow channel features characteristic of the lower SJR may not provide ideal rearing habitat for outmigrating salmonids. Flooded oxbows are likely to result in significant stranding of juvenile salmon. In the Yolo Bypass, where ponds are relatively rare and the Bypass is gradually sloped into a parallel toe drain, the incidence of stranding was not described as being significant, yet over 120,000 Chinook may have been stranded during that study (Sommer et al. 2005). Besides the obvious and potentially significant impact of stranding within the numerous SJR oxbows, the presence of high densities of piscivorous fish in the perennial oxbows would likely result in heavy mortality of juvenile salmonids that entered the flooded oxbow areas (see Rearing Habitat Issues #5 and #9 below).

Rearing Habitat Issue 5. The Draft Report (2010) does not provide any evidence that increased flows will increase floodplain habitat in the SJR.

From Vernalis to Mossdale (11 river miles), the SJR has a defined low flow channel. From Mossdale downstream (60 river miles), there is no defined low flow channel, as the water elevation goes bank to bank.

A recent assessment of potential floodplain habitat in the SJR downstream of the Merced River showed progressively less floodplain inundation in the downstream direction over a streamflow range of 1,000-25,000 cfs (cbec 2010 in Appendix 4, Figures 9-11).

At a flow of 16,000 cfs, which represents approximate bank-full flow in the SJR downstream of the Stanislaus River and is 2-3X bank-full flow in the mainstem downstream of the Merced River, the estimated amount of inundated floodplain ranges from a maximum of 6,884 acres between the Tuolumne and Merced rivers, to a low of 908 acres from the Stanislaus River downstream to Mossdale (cbec 2010 in Appendix 4, Table 5). In the Stanislaus to Mossdale reach (17 river miles), the extent of inundated floodplain only exceeds 2,000 acres at the maximum modeled flow of 25,000 cfs.

Although the range of alternative flows are not specified in the Draft Report, 60% of unimpaired flows will exceed 10,000 cfs under many wet years, but proposed release flows during dry years will likely be much lower. The cbec (2010 in Appendix 4) analysis shows that virtually no floodplain is inundated at flows <5,000 cfs; whereas, further gain in floodplain acreage declines above 15,000 cfs (cbec 2010 in Appendix 4, Figure 14). Much of the inundated floodplain habitat at intermediate flows are associated with oxbow features, many of which appear to retain water year-round and are known to be predatory fish habitat.

Because the lower SJR is more constrained by elevated valley topography than is the Sacramento River (TBI 1998), the estimates of floodplain inundation conducted by cbec (2010 in Appendix 4) may suggest relatively greater habitat for outmigrating salmon than is actually available because inundation areas are likely to be deeper and swifter than those preferred by salmon.

Rearing Habitat Issue 6. The Draft Report (2010) does not provide any evidence that increased flows will increase floodplain habitat in the South Delta.

While the cbec analysis (cbec 2010 in Appendix 4) did not extend farther into the Delta than Mossdale, conventional wisdom is that the extensive levee systems in the Delta severely constrain all flows within narrow corridors (except for flooded islands), and therefore the potential functions associated with floodplain inundation are not applicable to the South and Central Delta waters.

Rearing Habitat Issue 7. The Draft Report (2010) incorrectly and without evidence asserts that floodplain habitat improvements that benefit Chinook will also benefit steelhead.

Steelhead smolts characteristically utilize deeper and faster microhabitats than do juvenile Chinook, and steelhead are not known to rear as fry (or as smolts) in floodplain habitats to any great degree (Hartman & Brown 1987, Swales & Levings 1989, Brown 2002). Steelhead, in contrast to Chinook, typically rear to smolt size in upstream rearing habitats and only pass through the lower SJR and South Delta during outmigration as smolts.

The Draft Report states that "tidal marsh areas allow steelhead juveniles to grow faster, which in turn requires a shorter period in freshwater before smoltification occurs" (pg 45). While studies support the use of small coastal estuaries by steelhead and increased growth opportunities therein (Bond 2006, Hayes et al. 2008), steelhead in the San Joaquin Basin generally do not enter the lower SJR or South Delta as fry and are not expected to utilize these areas for rearing. Also, there is little remaining tidal marsh in the Delta and, to our knowledge, none occurs in the lower SJR and South Delta.

The typical lack of rearing by fry or smolt steelhead in lower river floodplains is illustrated by an abundance of literature from the Pacific Northwest, and by the rare observation of steelhead in either the Yolo Bypass or the Cosumnes River floodplains. Moyle et al. 2007 focused on the Preserve and surrounding habitats and did record the presence of *O. mykiss* in an adjacent mainstem reach in 3 of 5 years of sampling, and in the floodplain itself in one year. However, the rarity of *O. mykiss* in floodplain habitats led the authors to conclude that this species was an "inadvertent user" that was not adapted for floodplain use, and was further assumed to have been "carried onto the floodplain by accident". Thus, the available data from California supports conclusions from northwestern states and suggests that outmigrating steelhead smolts do not require, and would be unlikely to reside within, inundated floodplain habitat even if it was available in the lower SJR.

Rearing Habitat Issue 8. There is no evidence that higher flows will increase the amount of instream cover via flooding of riparian vegetation, particularly since the banks of the lower San Joaquin River and South Delta are intentionally maintained with minimal vegetation for flood control.

The Draft Report (2010) states that higher flows will increase the amount of instream cover by flooding riparian vegetation, which will benefit juvenile rearing, but no evidence was presented that higher flows will increase flooded riparian vegetation, or that this would benefit fish. The lower SJR is a confined channel with levees on both sides that consist largely of steep rip-rapped banks with limited to no vegetation (e.g. trees and large shrubs) and intentionally maintained in this denuded state for flood control purposes (Figure 9). Expecting high flows to create floodplain and riparian habitat in the lower SJR and South Delta without extensive long-term restoration and shift in flood control policies is highly unrealistic.

Rearing Habitat Issue 9. Evidence indicates that higher flows in the San Joaquin River may improve habitat for non-native predators (e.g., largemouth bass) and increase potential for Chinook predation.

Numerous papers have described the invasion and establishment of non-native species in the Central Valley, including the SJR and Delta (Saiki 1984, Brown 2000, Moyle 2002, Feyrer & Healey 2003, Nobriga at al. 2005).

In the Delta, the primary piscivorous species are the Sacramento pikeminnow, the striped bass, and the largemouth bass (Nobriga & Feyrer 2007). Although all three species are considered sight feeders, the largemouth bass is not considered a pelagic, open water species like striped bass, but rather more of an ambush predator closely associated with shallow, instream structure (Nobriga et al 2005, Nobriga & Feyrer 2007). Studies have shown that ambush predators are more efficient at capturing prey in complex habitat and in turbid conditions than are more open-water predators (Greenberg et al. 1995). Studies in the Delta have also confirmed that largemouth bass are highly piscivorous and opportunistic predators, and they appear to switch from invertebrate prey to fish prey at a smaller size than do pikeminnows and striped bass (Nobriga and Feyrer 2007). Largemouth bass and other centrarchid predators (e.g., green sunfish, crappie) in the Delta are also closely associated with dense instream cover and other elements characteristic of sloughs and oxbows (Grimaldo et al. 2000, Feyrer & Healey 2003).

Unlike the Delta and SJR, the Sacramento River is not known to harbor significant numbers of largemouth bass, but does contain abundant pikeminnows and striped bass. The findings that the Yolo Bypass presents a refuge from large predators is probably a result of the more open-water, pelagic nature of those two species, which are less likely to invade shallow, cover-rich habitats such as the inundated fields of the Yolo Bypass. In contrast, the largemouth bass throughout its range appears to show strong preference for shallow, cover-rich habitats (i.e. invasive aquatic weeds), which are extremely abundant in the South Delta (Figure 10). As a result, the Delta has become a world-class fishery for largemouth bass and is the host of dozens of bass tournaments, including the major national bass-fishing organizations. Although most attention is devoted to the Delta waters, largemouth bass are also very abundant in the SJR (Saiki 1984, Brown 2000), probably due to the low gradient, generally slow velocities, presence of numerous oxbow ponds, and abundance of submerged riparian and aquatic vegetation (mostly invasive aquatic weeds).

A graphic illustration of this fact took place this summer when a major national bass tournament was held in the Delta (**http://www.bassfan.com/news_article.asp?id=3645**). At that June tournament, two boats easily bested a field of over 100 top bass anglers by leaving the greater Delta and boating upstream into the lower SJR where they fished in a barely connected oxbow pond and proceeded to catch daily limits of largemouth averaging over four pounds, including fish up to seven pounds. Although only perennial oxbow ponds can harbor such heavy populations of large bass, numerous permanent ponds are present within the SJR "floodplain", and the SJR itself contains an abundance of bass.

The point of the preceding arguments is that the SJR and any associated floodplain habitat may provide abundant habitat for the highly piscivorous largemouth bass, especially in slow velocity areas such as oxbow ponds. Although flooding riparian vegetation has the potential to slightly increase refuge habitat for juvenile salmonids from open-water predators such as pikeminnows and striped bass, this will also increase habitat for shallow, cover-oriented predator species such as largemouth bass, and thus may serve to increase predation on salmonids.

Rearing Habitat Issue 10. The Draft Report does not provide any evidence that outmigrating Chinook smolts are food limited during their 3-15 day migration through the lower SJR below Vernalis and the South Delta.

The Draft Report (2010) purports that increased flows in the early spring will improve food production for early spring salmon rearing (p. 60):

> These early spring flows also provide for increased and improved edge habitat (generally inundated areas with vegetation) and food production for salmon remaining in the river to rear during the early spring.

The Draft Report (2010) provides evidence that, in other systems, unregulated rivers have more and better food resources that regulated rivers (p. 63). However, the report does not provide any evidence that increasing flows in an already highly degraded system has the capability to return primary and secondary production quantity and quality to its pre-regulated state. Furthermore, the Draft Report (2010) does not define how it would measure changes in food production (quality or quantity) or the mechanisms thought to drive food production in response to short-term increases in flow.

The Draft Report (2010) also does not explain temporal and spatial scales under consideration for food production. Based on acoustic VAMP studies in 2008, Holbrook et al. (2009) found that smolts took 3-15 days (median 6-9 days) for migration through the lower San Joaquin and South Delta, so the need for food production over such a short duration is questionable. Increases in primary and secondary production that occur due to restoration or changes in management likely occur over longer periods of time, rather than that targeted by short-term pulse flows. Spatial scale is important too, as impacts to food resources are generated at different rates and via different processes depending on where they are located in the river continuum.

Physical Habitat and Transport

The Draft Report (2010) states that "higher inflows of various magnitudes during the spring support a variety of functions including ***maintenance of channel habitat*** and ***transport of sediment, biota, and nutrients*** [emphases added](Junk et al. 1989)." These concepts are based on mechanisms that occur in unmodified, relatively pristine, large river-floodplain systems that do not apply to the highly modified and channelized San Joaquin River system occurring downstream of Vernalis, which is supposed to be the focus of the Draft Report. The Draft Report (2010) also presents several ideas regarding the "Natural Flow Regime" concept as follows [emphases added]:

(1) "Specific ecosystem attributes that a more ***natural flow regime*** should improve include: 1) support of native fish communities; 2) support of the natural food web; 3) habitat connectivity; 4) fluvial hydrogeomorphological processes; and 5) improved temperatures." (Page 61)

(2) "Using a river's ***natural flow regime*** as a foundation for determining ecosystem flow requirements is well supported by the current scientific literature (Poff et al. 1997, Tennant 1976, Orth and Maughan 1981, Marchetti and Moyle 2001, and Mazvimavi et al. 2007). In addition, major regulatory programs in Texas, Florida, Australia and South Africa have developed flow prescriptions based on the natural flow regime in order to enhance or protect aquatic ecosystems (Arthington et al. 1992, Arthington et al. 2004, NRDC 2005, Florida Administrative Code 2010), and the World Bank now uses a framework for ecosystem flows based on the natural quality, quantity, and timing of water flows (Hirji and Davis 2009). Poff et al. (1997) describes the ***natural flow regime*** as the "master variable" that regulates the ecological integrity of rivers." (Page 60)

Our comments regarding assertions related to the functions of high flows and to the natural flow regime are provided in the following six (6) Physical Habitat Issue and two (2) Physical Transport Issue statements.

Physical Habitat

Physical Habitat Issue 1. The physical habitat for Delta fishes has been substantially reduced and altered, which has led to invasive species expansions.

Diverse habitats historically available in the Delta have been simplified and reduced by development of the watershed (Lindley et al. 2009), and 95% of tidal wetlands were lost to levee construction and agricultural conversion since the mid 1800's (Williams 2006). Major change in system includes loss of shallow rearing habitat (Lindley et al. 2009).

Current habitat structure benefits introduced predators more than natives (Brown 2003). The proliferation of non-native aquatic weeds, such as *Egeria densa* (Brazilian waterweed), has increased habitat and abundance of largemouth bass and other invasive predators (Baxter et al. 2008; Figure 10). The area near the CVP intake has significant amounts of *E. densa* (Baxter et al. 2008). *Egeria* has strong influence on results of habitat alterations as different fish communities are found in its presence (Brown 2003)

Physical Habitat Issue 2. The Draft Report (2010) cites the 'Flood Pulse Concept' by Junk et al. (1989) in support of the assertion that higher flows provide maintenance of channel habitat and transport of sediment, biota and nutrients; however, this concept was developed for large, pristine river-floodplain systems and is <u>not applicable</u> to the present-day lower San Joaquin River and South Delta.

The Draft Report (2010) states that "higher inflows of various magnitudes during the spring support a variety of functions including ***maintenance of channel habitat*** and ***transport of sediment, biota, and nutrients*** (Junk et al. 1989)". These physical transport and geomorphological functions are attributed to the 'Flood Pulse Concept' described in Junk et al. (1989), which is a concept based on the authors' experience in unmodified, relatively pristine, rain-fed (rather than snow fed), large river-floodplain systems in the neotropics, Southeast Asia and Upper Mississippi River and in published literature, that is predicated upon the relationships between a river channel and its floodplain. Junk et al. (1989) describe how the "[l]ength, amplitude, frequency, timing, and predictability of the flood pulse determine occurrences, life cycles, and abundances of primary and secondary producers and decomposers," emphasizing the importance of the *natural flow regime* in maintaining the dynamic equilibrium of river-floodplain systems. However, as described previously in this document, the physical habitat characteristics of the SJR floodplain areas are very different from those in the rivers described in Junk et al. (1989), therefore the "Flood Pulse Concept" is not applicable to the highly altered and leveed lower San Joaquin River and South Delta.

Physical Habitat Issue 3. Significant changes have occurred that have altered the historic "natural" physical habitat conditions in the San Joaquin River and South Delta.

In its natural state the South Delta could have been described as pristine, large river-floodplain systems. Although the natural San Joaquin River lacked the extensive, depressed flood basin habitat of the lower Sacramento River (which extended ~1,000 square miles), it consisted of a network of oxbow lakes, backwater sloughs, tule marshes, ponds, and sand bars bordered the river downstream of Merced (Bay Institute 1998). The SJR's natural flow meandered through the floodplain habitat and formed short (~6ft) natural depositional levees along the river banks (Bay Institute 1998). In the San Joaquin Basin, wetlands (tule marshes) existed alongside the sloughs, though not to the degree of the Sacramento River, and their extent depended upon the precipitation and runoff. During floods in the SJR, flood waters spread out from the river channel over the floodplain sloughs and marshes along the river. TBI (1998) also reported that approximately "150 square miles of land above the Head of Old River were subject to frequent inundation, and the entire region became a reservoir of slowly moving waters during floods (Rose et al. 1895, Hall 1880)."

Before development, the Sacramento and San Joaquin Rivers drained into a complex, extensive tule-dominated marsh and tidal wetland. "[T]he swamp was alternately inundated and exposed as a result of changes in tides, precipitation, and discharge from the lowland rivers" (Bay Institute 1998). Intertidal wetlands that dominated the South Delta were made up of pools, lakes, open waters, mud flats, and subtidal waterways, and this habitat diversity was reflected in the varied plant assemblage (Bay Institute 1998). The historic South Delta was similar to the present day Yolo Bypass, in that it offered shallow, slow moving areas of water that likely provided similar rearing benefits to outmigrating Chinook fry.

However, the lower San Joaquin River and South Delta presently bears little resemblance to the delta system described above; the natural channels are now narrow and deep with steep, armored sides (levees), which constrain the meanders to the established channels (Figures 11 & 12). These channels are often choked with non-native water weeds (Figure 13), which provide habitat for non-native predators. Mechanical alterations to the lower San Joaquin and South Delta have greatly reduced any of the habitats previously mentioned (i.e., oxbow lakes, backwater sloughs, tule marshes, ponds, and sand bars), significantly altering the habitat which native species historically used.

Physical Habitat Issue 4. References were improperly cited in support for the natural flow concept.

The Draft Report (2010) states that "[u]sing a river's natural flow regime as a foundation for determining ecosystem flow requirements is well supported by the current scientific literature (Poff et al. 1997, Tennant 1976, Orth and Maughan 1981, Marchetti and Moyle 2001, and Mazvimavi et al. 2007)." However, This statement is either not supported by most of the cited references or the cited references are not directly applicable to the hydrology and ecology of the San Joaquin River. The methods of Tennant (1976) and Orth and Maughan (1981) are 30-35 years old (not "current") and both studies recommend a percentage of average annual flow in six-month periods, which is not a "natural flow regime". Orth and Maughan (1981) concluded that "This method should be useful for preliminary instream flow assessments in Oklahoma." Where more detailed instream flow studies are available, their method would be superseded. Marchetti and Moyle (2001) evaluated native and non-native fish populations in Putah Creek, which is below a major reservoir and does not have a remotely "natural" flow regime. They compared fish population structure and distribution during drought years (when the stream was often dry due to riparian pumping by the UC Davis Russell Ranch) to those during wetter years when the stream did not go dry, so extrapolating their conclusions to the San Joaquin River system is not reasonable or relevant. The Mazvimavi et al. (2007) study used a method developed for the "climatological, physiographic and hydrological conditions similar to some basins in South Africa" (which are not in the least similar to the San Joaquin River), and also only recommended a percentage of average annual flow (not a natural flow regime).

The article by Poff et al. (1997) titled "The Natural Flow Regime: a paradigm for river conservation and restoration" does recommend that managed river flow regimes should mimic components of natural hydrology. Implementation of the natural flow paradigm, however, has been sporadic, lacking in standards, and linked to the specific objectives of river management, which are rarely defined and currently absent in the San Joaquin River. Where the authors recognize that full flow restoration is not possible, they recommend reproducing geomorphic processes that may result in the desired ecological benefits (Poff et al. 1997). They do not recommend natural flows (or a percentage thereof) either in a vacuum or as an end in itself, but as a "foundation for determining ecosystem flow requirements."

Furthermore, a series of "major regulatory programs" were cited as having developed flow prescriptions based on the natural flow regime "to enhance or protect aquatic ecosystems," however, all of these papers reference river systems with completely different hydrologic regimes than the San Joaquin River. These systems are generally in rainfall dominated watersheds, which experience extreme natural flow fluctuation, or else the flow prescriptions were intended for use in highly complex, virtually unstudied ecosystems. The San Joaquin River contains relatively few aquatic species (in comparison to the southeastern U.S., eastern Australia, South Africa, and tropical Africa and Asia), and, like most California rivers, is typically managed for either salmonids or other listed endangered species. The habitat needs of California species are subject to intense research and their habitat needs are relatively well known, which allows for direct species restoration through flow management in lieu of a catch-all "nature-knows-best" flow management.

Physical Habitat Issue 5. The natural flow paradigm assumes that channel formation and maintenance is directly influenced and modified by flow, which is generally true under natural conditions; however, leveed rivers can be nearly independent of flow.

Poff et al. (1997, page 770), identify "five critical components of the ["natural," i.e., unaltered by humans] flow regime that regulate ecological processes in river ecosystems: the magnitude, frequency, duration, timing, and rate of change of hydrologic conditions (Poff and Ward 1989, Richter et al. 1996, Walker et al. 1995)." The authors also recognize that most rivers are highly modified and allude to the possibility that restoration of a natural flow regime may be limited "depending on the present extent of human intervention and flow alteration affecting a particular river (Poff et al. 1997, Page 780)." The natural flow paradigm assumes that channel form is directly influenced and modified by flow, which is generally true under natural conditions (a potential exception being a bedrock controlled channel); however, the morphology of a highly engineered river (e.g., levees) can be practically independent of flow (Jacobson and Galat 2006). In such a system, flow-related factors like timing of floods, water temperature, and turbidity may be managed; but, in absence of a "naturalized morphology, or flow capable of maintaining channel-forming processes, the hydrologic pulses will not be realized in habitat availability."

With minimal floodplains remaining due to land use changes, higher flows do not necessarily provide the channel maintenance that would occur under natural conditions.

In these leveed systems, true channel mobilization flows are not possible because of flood control. In some instances, higher flows can actually result in increased detrimental incision in upstream tributary areas like the Stanislaus River where existing riparian encroachment is armored and cannot be removed by high flow events, which limits "river migration and sediment transport processes" (Kondolf et al. 2001, page 39). In addition, the ability to provide a more natural flow regime is hampered by "urban and agricultural developments that have encroached down to the 8,000 cfs line," which effectively limit the highest flows to no more than the allowable flood control (i.e., 8,000 cfs) (Kondolf et al. 2001, page 46) Also, in the case of the Stanislaus River, there is limited opportunity to provide mechanical restoration of floodplains due to private landowners and flood control. As mentioned previously in instances where flood pulses can no longer provide functions such as ***maintenance of channel habitat***, Poff et al. (1997) states, "mimicking certain geomorphic processes may provide some ecological benefits [e.g., gravel augmentation, stimulate recruitment of riparian trees like cottonwoods with irrigation]."

> ***Physical Habitat Issue 6. In absence of floodplain connectivity, the functions attributed to higher "pulse flows" <u>cannot</u> be achieved as described by the Flood Pulse Concept (FPC) (Junk et al. 1989; Junk and Wantzen 2003).***

Under natural conditions, the San Joaquin River was a river channel connected with its floodplain. Flood pulses in the winter and spring would have provided the functions identified by Junk et al. (1989) and by Junk and Wantzen (2003). However, anthropomorphic changes in the lower river (e.g., levees), particularly below Vernalis (the focus of the Draft Technical Report), have substantially reduced this floodplain connectivity and the region is can no longer be considered a "large river-floodplain system." As described previously in this document, the extent of inundated floodplain in the Stanislaus to Mossdale reach only exceeds 2,000 acres at the maximum modeled flow of 25,000 cfs (cbec 2010 in Appendix 4).

Physical Transport

> ***Physical Transport Issue 1. According to Junk et al. (1989) the transport of sediment, biota, and nutrients is directly related to the floodplains of a river-floodplain complex; the majority of the floodplain in the lower San Joaquin River has been eliminated and any remaining floodplain is isolated behind levees.***

Junk et al. (1989) originally proposed the FPC, stating "that the pulsing of the river discharge, the flood pulse, is the major force controlling biota in river floodplains. . . We postulate that in ***unaltered large river systems with floodplains*** in the temperate, subtropical, or tropical belt, the overwhelming bulk of the riverine animal biomass derives directly or indirectly from production within the floodplains and not from downstream transport of organic matter produced elsewhere in the basin." According to Junk and Wantzen (2003), the FPC:

> focuses on the lateral exchange of water, nutrients and organisms between the ***river channel <u>and</u> the <u>connected</u> floodplain***. It considers the importance of the hydrology and hydrochemistry of the parent river, but focuses on their impact

> on the organisms and the specific processes in the floodplain. Periodic inundation and drought (flood pulse) is the driving force in the river-floodplain system. The ***floodplain** is considered as an **integral** part of the system*. . . [emphases added]

As mentioned previously there are many assumptions of the FPC that are likely not met in the South Delta and lower San Joaquin River, including "a large part of the primary and secondary production occurs in the floodplain, whereas the river is mainly the transport vehicle for water and dissolved and suspended matter" (Junk and Wantzen 2003). Based on statements above, the "maintenance of channel habitat and transport of sediment, biota, and nutrients" is directly related to the floodplains of a river-floodplain complex, which has nearly been eliminated from the lower San Joaquin River and its tributaries (cbec 2010 in Appendix 4; Williams 2006). Junk et al. (1989) recognized that this might be the case in altered systems stating, "[o]f course, former floodplains now behind manmade levees will remain isolated from the river, assuming no long-term changes in flood stages or flood protection policy."

Physical Transport Issue 2. The transport of sediment, biota, and nutrients differs between the large river-floodplain systems described by Junk et al. (1989), and the anthropogenic, leveed river channels of the South Delta.

During natural processes, sediments would have been brought downstream from the upper tributaries, but now, the numerous dams on tributaries limit natural sediment inputs such as gravels (Schoellhamer et al. 2007). Further, many human activities such as mining, urbanization and agriculture have increased erosion and the supply of fine river sediments (Schoellhamer et al. 2007).

Additionally, according to Schoellhamer et al. (2007), the present day modified system, "would tend to transport more sediment to the Delta because 1) the flood basins were a sink for fine sediments, and 2) the leveed channels will experience greater bed shear stress because more flow is kept in the channel. . . It follows that levee setbacks and floodplain restoration would tend to decrease sediment supply to the Delta by promoting floodplain deposition along upstream reaches."

In the SJR, sediments would normally have been deposited and exchanged between floodplains and the river channel, but they now travel through areas of the South Delta where no floodplain exists. Sediments that stay in suspension and are transported in the water column can have negative effects in the South Delta, through reduced light (and photosynthesis), which can reduce primary production and impact the South Delta food web. Most of the sediment supplied to the Delta is now episodic, through large flood pulses from the Sacramento River. Any sediment inputs into the South Delta from the SJR are the result of increases in suspended sediments in response to run-off events and are generally not associated with managed flow pulses (SJRG 2004).

Water Quality

The Draft Report states, "Higher inflows also provide better water quality conditions by reducing temperatures, increasing dissolved oxygen levels, and reducing contaminant concentrations." Our comments regarding these assertions are provided in the following two (2) Water Temperature Issue, six (6) Dissolve Oxygen Issue, and four (4) Contaminant Issue statements.

Water Temperature

Water Temperature Issue 1. The Draft Report provides no evidence or citation to demonstrate a need to decrease water temperatures in the Delta for salmonids.

The Draft Technical Report states, "Higher inflows also provide better water quality conditions *by reducing temperatures*, increasing dissolved oxygen levels, and reducing contaminant concentrations" (Emphasis added; pages 48-49, 60-61), however no evidence is provided to support the implicit claim that Delta temperatures for juvenile salmonid rearing and migration need to be reduced or maintained through June. The Draft Technical Report also does not specify temperature objectives for Chinook salmon in the Delta or discuss the biological significance of the existing thermal regime relative to a regime with "reduced" temperatures, assuming they could be achieved.

Seven day average daily maximum temperatures are generally ≤20°C (68°F) at Vernalis through May 15, and nearly all juvenile salmonids migrate from the San Joaquin Basin prior to May 15, with <3-5% migrating after May 15 (SJRGA 2007-2010; Deas et al. 2004; Demko et al. 1999, 2000a, 2000b, 2001a, and 2001b; FISHBIO 2007; Fuller et al. 2006-2007; Fuller 2005; Palmer and Sonke 2008-2009; SPCA 2001; Watry et al. 2008). Water temperatures up to 22.8°C were found to have <u>at most</u>, a slightly negative effect on juvenile salmon survival (Newman 2008), and studies evaluating the relationship between growth and temperature of Central Valley Chinook found no difference in growth rates between 13-16°C (55-61°F) and 17-20°C (63-68°F) (Marine 1997), suggesting that reducing water temperatures would not be expected to enhance growth rates of juvenile salmon rearing in the Delta.

Water Temperature Issue 2. The Draft Report provides no evidence or citation to support the statement that higher inflows will decrease water temperatures in the Delta.

Flows have little if any effect on spring water temperatures in the Delta (AD Consultants and others 2009), and by the end of May, water temperatures at Vernalis range between 65°F and 70°F regardless of flow levels between 3,000 cfs and 30,000 cfs (SRFG 2004). Average monthly flows and average maximum water temperatures recorded at Vernalis during 1973-2006 illustrate that water temperatures can only be reduced by increasing flows up to approximately 3,000-5,000 cfs (Figure 14).

Increasing flows beyond this point does not result in further reduction in water temperatures.

The restoration of the San Joaquin River upstream of the Merced River will have future implications to flow and temperature management that were not considered in the Technical Report.

Dissolved Oxygen

Dissolved Oxygen Issue 1. Existing dissolved oxygen concentrations do not prevent juvenile salmon and steelhead migration.

The Draft Technical Report states, "Higher inflows also provide better water quality conditions by reducing temperatures, ***increasing dissolved oxygen levels***, and reducing contaminant concentrations" (Emphasis added; pages 48 & 49), however the report does not provide any references or further discussion to support this statement.

Dissolved oxygen issues have been studied and discussed for over a decade in the San Joaquin River, particularly since 1998 when the State Water Resources Control Board (State Water Board) placed the San Joaquin River Deep Water Ship Channel (DWSC), located downstream from the City of Stockton, on the Clean Water Act (CWA) Section 303(d) list. The State Water Board then established a Total Maximum Daily Load (TMDL) that has been implemented since 2005, which established several measures to reduce excess net oxygen demand including "Actions Addressing Sources of Oxygen Demanding Substances and their Precursors," and "Actions Addressing Non-Load Related Contributing Factors" (i.e., DWSC geometry and reduced flows through the DWSC). Concerns have focused on June through October, which is primarily outside of the February to June period covered by the Draft Report (2010).

Since improvements at the City of Stockton Regional Wastewater Control Facility (RWCF) were complete in 2007, there have been few instances during the February through June period when dissolved oxygen has declined below 5 mg/L. There were a few 1-2 day periods in June 2008 and June 2009 and a seven-day period in May 2009 where DO declined to as low as 4.7. It is unlikely that these DO levels would prevent juvenile salmonid migration, particularly those in June since there are few juveniles migrating during that period (i.e., <3-5% after May 15; SJRGA 2007-2010; Deas et al. 2004; Demko et al. 1999, 2000a, 2000b, 2001a, and 2001b; FISHBIO 2007; Fuller et al. 2006-2007; Fuller 2005; Palmer and Sonke 2008-2009; SPCA 2001; Watry et al. 2008). Also, the duration of occurrences when DO was below 5 mg/L was very short and the levels were not far below 5 mg/L and nowhere near the EPA national recommended 1-day minimum which is 4 mg/L (EPA 1986), indicating that few individuals would be exposed and potential impacts are likely to be minimal, if any. In addition, there is no evidence from smolt survival experiments that juvenile salmon survival is correlated with existing dissolved oxygen concentrations. (SRFG 2004; SJRGA 2002 and 2003).

Dissolved Oxygen Issue 2. Potential for low dissolved oxygen (DO) concentrations are primarily limited to the Deep Water Ship Channel (DWSC) during June through October and are primarily a result of altered channel geometry, with some contribution from loads of oxygen demanding resources and reduced flows.

The DWSC, starting at the Port of Stockton where the San Joaquin River (SJR) drops from 8-10 feet deep to 35-40 feet deep, is a major factor in DO depletion below the existing water quality objectives. The critical reach of the SJR DWSC for low DO problems is approximately the seven miles just downstream of the Port to Turner Cut. (Lee and Jones-Lee 2003, page viii).

The highest frequency that DO declines below 5.0 mg/L in the DWSC (at Rough and Ready Island gage [RRI]) occurs from June to October (CVRWQCB 2005, pages 20-21), a time with minimal impacts to both juvenile (see Dissolved Oxygen Issue 1) and adult (adult lifestage not covered in the Draft Report [2010]) salmonids. It appears that declines in DO have occurred less often after September 2007 due to reductions of ammonia discharged from the City of Stockton's Regional Wastewater Control Facility (RWCF)(RRI data from California Data Exchange Center).

According to CVRWQCB (2005, pages 27-28),

> Numerous studies over the last several years have provided significant data and information on the causes of the DO impairment. Most of these studies were peer-reviewed in June 2002 by an independent science panel and summarized or referenced in the Synthesis Report (Lee and Jones-Lee, 2003). CVRWQCB has concluded from these studies that the three main contributing factors to the DO impairment are as follows:
>
> - The DWSC geometry impacts various mechanisms that add or remove dissolved oxygen from the water column, such that net oxygen demand exerted in the DWSC is increased.
> - Loads of oxygen demanding substances from upstream sources [RWCF and others] react by numerous chemical, biological, and physical mechanisms to remove dissolved oxygen from the water column in the DWSC.
> - Reduced flow through the DWSC impacts various mechanisms that add or remove dissolved oxygen from the water column, such that net oxygen demand exerted in the DWSC is increased.

The DWSC is primarily responsible. If the DWSC did not exist, there would be few, if any, low-DO problems in the channel (Lee and Jones-Lee 2003, page ix).

Algae/oxygen demands that are discharged by Mud and Salt Sloughs to the SJR continue to develop in the SJR, ultimately leading to greatly elevated planktonic algal chlorophyll *a* and BOD concentrations and loads at Mossdale. At times, 50 to 80 percent of the Mossdale loads of BOD originate from the Mud and Salt Slough discharges to the SJR and the SJR upstream of Lander Avenue (Lee and Jones-Lee 2003, page xiii). The westside tributaries (except Mud and Salt Sloughs), such as Los Banos Creek, Orestimba Creek and Spanish Grant Drain, have been found to contribute a small part of the oxygen demand load and chlorophyll *a* to the SJR that ultimately are present in the SJR at Mossdale.

Wastewater discharges and stormwater runoff from the large municipalities in the SJR watershed upstream of Mossdale are not normally major sources of oxygen demand that cause DO depletion in the DWSC during the summer and fall months (Lee and Jones-Lee 2003, page xiv).

The eastside rivers (Tuolumne, Stanislaus and Merced) have been found to discharge high-quality Sierra Nevada water to the SJR which has low planktonic algal content and oxygen demand, and are not a major source of oxygen demand contributing to the low DO problem in the DWSC (Lee and Jones-Lee 2003, page xiii).

There are substantial municipal and agricultural diversions of SJR water upstream of the DWSC. These diversions decrease the amount of SJR flow through the DWSC (Lee and Jones-Lee 2003, page xiv).

Examination of the SJR at Vernalis flows during 2002 and 2003 shows that the low flows of the SJR through the DWSC were not due to low SJR at Vernalis flows, but were due to diversion of most of the SJR flow at Vernalis down Old River for export through the CVP and SWP (Lee and Jones-Lee 2003, page xv).

Dissolved Oxygen Issue 3. Dissolved oxygen concentrations in the DWSC are influenced by Delta exports, but can be ameliorated by installation of the Head of Old River Barrier (HORB).

Lee (2003, page 4) states that SJR flows through the DWSC "less than about 500 cfs can (and generally does) lead to DO concentrations below the water quality objective," which applies year-round. Low flow levels generally occur as a result of exports in absence of the HORB and "it is also now clear from the 1999 to present data [i.e., 2003] that, if the SJR at Vernalis flow had been allowed to largely pass through the DWSC before export from the Delta [i.e., the HORB was in place], the low-DO problems and the fish kill that occurred in February 2003 would not have occurred" (Lee 2003, page 5).

The Head of Old River Barrier (HORB) is installed to improve DO levels in fall but, since 2007, it has not been installed during the spring because of delta smelt concerns. The inability to operate the HORB during the spring when juveniles salmonids are migrating precludes managing DO with flow.

South Delta water exports artificially change the flows in the South Delta, which, in absence of the HORB, results in a higher proportion of the San Joaquin River going through Old River. These Old River diversions can "significantly reduce the SJR flow through the DWSC, thereby directly contributing to the low-DO problem in the DWSC" (Lee and Jones-Lee 2003). As an example of what can occur, South Delta exports from mid-January through mid-February 2003 led to very low SJR flow through the DWSC (less than 200 cfs, even though there were flows of at least 1,500 cfs at Vernalis). These low flows were related to severe low-DO problems in the DWSC that led to a fish kill (Lee and Jones-Lee 2003, page xv).

ICF (2010 Page ES-1) states that a 2-3 mg/L increase in dissolved oxygen has been observed with the HORB in place since 2000. Additional info in # 6.

Dissolved Oxygen Issue 4. There is no evidence that higher flows dilute oxygen-depleting substances from upstream sources, and previous published papers have identified that the relationship between flow and DO is complex.

Although the idea that San Joaquin River flows greater than 2,000 cfs could dilute oxygen-depleting substances and transport them quickly through the DWSC was presented by Jones and Stokes (2004), Lee (2005) clarified that

> the dilution of oxygen demand applies only to city of Stockton ammonia; it does not apply to upstream-derived algal oxygen demand. Under conditions of ***elevated flows***, the loads of oxygen demand to the DWSC is ***increased*** [emphasis added].

Van Nieuwenhuyse (2002) indicates the relationship between flow and DO is complex and that increasing net flow (1) reduces hydraulic residence time, (2) increases natural aeration but also increases the amount of artificial aeration required to achieve a unit increase in DO, (3) increases the loading rate of algal biomass or other organic matter from upstream, and (4) may merely displace the most DO-depleted zone of the ship channel a few miles or less downstream of its usual position near Rough and Ready Island.

According to Van Nieuwenhuyse (2002, pages 16 and 17), modeling indicated that within the range of flows considered (i.e., estimated monthly average values from 1983-2001, page 5),

> the beneficial effects of decreased residence time are more than offset by the increased amount of artificial oxygenation required to raise DO in the ship and by the negative effects associated with increased loading of algal biomass or other oxygen-consuming material from upstream. This finding has important management implications.
>
> As a management action, the "boost flow" alternative ("D" in Table 5) called for maintaining Q_{vern} at its historical median level (the "2-year return flow in Jones & Stokes 2001). In a dry year (say, Q_{vern} at its 10th percentile value), this management action would require the release of

> some 500,000 ac-ft of stored water from eastside tributaries (or the equivalent amount of auxiliary pumping via Grant Line Canal) just for the months of June through October. And yet, the average improvement in CDOD would be only 20% over the "No Action" alternative (Table 5). Such a modest return on such a large investment would make little ecologic or economic sense and would presumably be challenged under the "waste not" doctrine of California water law. More modest levels of flow enhancement may, however, prove beneficial if combined with other management actions.

More recent modeling by Jassby and Van Nieuwenhuyse (2005, Page 1) indicates

> over the recent historical range (1983–2003), wastewater ammonium and river phytoplankton have played a similar role in the monthly variability of the dissolved oxygen deficit, but river discharge has the strongest effect [assuming the HORB is in place]. Model scenarios imply that control of either river phytoplankton or wastewater ammonium load alone would be insufficient to eliminate hypoxia. Both must be strongly reduced, or reduction of one must be combined with increases in net discharge to the Ship Channel. Model scenarios imply that preventing discharge down Old River [i.e., with HORB in place] with a barrier markedly reduces hypoxia in the Ship Channel.

Also, Jassby and Van Nieuwenhuyse (2005, page 31) states that

> the model for dissolved oxygen contains lags of up to two months, representing the memory of loading in the recent past, which at least in principle could overwhelm any positive increment in current discharge. The scenario in which river discharge is restored to full natural flow resolves this question: the trade-off between early and late summer is reversed, but the net effect on frequency of hypoxia remains about the same. The barrier at the head of Old River appears to have much more importance for historical dissolved oxygen conditions than the difference between unimpaired and actual flows upstream of Old River.

All of these examples point to the complex interaction between flow and other factors, which indicates that setting a flow criteria is not the best approach for achieving a DO objective. Instead, the DO TMDL that is already in place provides the mechanism for achieving the DO objective.

Dissolved Oxygen Issue 5. Wastewater effluent from the City of Stockton Regional Wastewater Control Facility (RWCF) previously contributed 10-90% of oxygen demand load, but facility modifications have led to improvements.

According to Lee and Jones-Lee Synthesis report (2003), wastewater effluent discharges from the City of Stockton's RWCF were found to contribute between 10-

90% of the total oxygen demand load to the DWSC, where highest percentages were generally associated with high ammonia concentrations (>25 mg/L) discharged during low San Joaquin River flows through the DWSC. In 2002, the CVRWQCB approved a NPDES wastewater discharge permit (CVRWQCB Order No. 5-02-083) for the RWCF that limits the monthly average ammonia concentration in the effluent to 2 mg/L and the daily maximum to 5 mg/l. Three years later, the CVRWQCB assigned 30% as a waste load allocation for excess net oxygen demand to the RWCF (CVRWQCB 2005).

In order to meet the NPDES requirements, the "RWCF constructed enhanced wetlands and nitrifying biotowers which went into operation in 2006, with startup operations stabilized in 2007" (City of Stockton 2010). It is unclear exactly when these improvements became entirely functional but low DO (< 5 mg/L) was observed from June through September 2007. According to the CVRWQCB (2010), treatment upgrades at Lodi, Manteca, Stockton, and Tracy have "significantly reduced the oxygen demand on Delta waters" and that "since Stockton began removing ammonia, the extremely low dissolved oxygen events have not occurred." Although extreme low DO events have not occurred since September 2007, there have still been some instances where DO values have declined below the minimum of 5 mg/L at RRI, including a few instances during the February-June period of 2008 and 2009 (see # 5).

According to the City of Stockton (2010),

> since installation and startup of the new treatment facilities in 2007, (1) the current RWCF ammonia discharge has been reduced to 1/10th of the previous discharge, and (2) ambient ammonia levels in the receiving water have never exceeded the USEPA acute or chronic ammonia criterion and typically have not exceeded the USEPA acute or chronic criterion for freshwater aquatic life in the period prior to installation of the new nitrification facilities, with the exception of a brief period in early 2004.

The City of Stockton also maintains that there is a "lack of [any] current or historic impact[s] to beneficial uses due to ammonia levels in treated effluent from Stockton's RWCF." Most recently, discharge from their facility was found to be within water quality parameter limits set forth in their NPDES permit and did not result in mortality of tagged fish observed in the vicinity of the railroad bridge in May 2007 (RBI 2007), and it also did not result in any measurable negative impacts to juvenile Chinook salmon held adjacent to the RWCF outfall in net pens for 40 hours in 2009 (SJRGA 2010).

Dissolved Oxygen Issue 6. DO objective for DWSC is inconsistent with the United States Environmental Protection Agency's (EPA 1986) national standard.

The 5 mg/L water quality objective during the February to June timeframe is similar to the EPA's (1986) national water quality criterion for DO. However, the national criterion allows for averaging and for low DO concentrations to occur near the sediment water interface; whereas, the Basin Plan does not. There is no evidence to support this deviation from the national standard.

Contaminants

Contaminant Issue 1. The Draft Report provides no evidence or citation to support the statement that higher inflows reduce contaminant concentrations.

The Draft Report states, "Higher inflows also provide better water quality conditions by reducing temperatures, increasing dissolved oxygen levels, and ***reducing contaminant concentrations***" (Emphasis added; pages 48 & 49), however the report does not provide any references or further discussion to support this statement. The Draft Report may be inferring that higher flows would act to dilute already suspended contaminants. However, the influence of higher flows on contaminant concentrations is variable; dilution may occur in some instances but increases may occur in others (see Issue Statement 2).

Contaminant Issue 2. The Draft Report failed to mention that higher flows may also lead to increased suspended contaminant concentrations.

The Draft Report neglects to mention that high flows can also lead to increases in contaminant concentrations resulting form the resuspension of contaminants located in riverbed sediments. Contaminants in suspended sediments may affect the ecosystem differently from dissolved contaminants, since filter feeding organisms consume suspended sediments and organic material (allowing the contaminants in the sediments to enter into the food web) and may have longer residence times in the rivers and estuaries in comparison with water (Bergamaschi et al. 1997). Research has begun to focus on relationship between freshwater flow and contaminant transport to and through the Delta.

Although increased flows can result in reduced dissolved or suspended sediment concentrations of some contaminants, they can also lead to increased pesticide loading. In a study conducted just downstream of Vernalis, the USGS examined the concentrations of organic contaminants in surface water sites along the San Joaquin River and in the Old River before, during and after the VAMP month-long pulse flow (Orlando and Kuivila 2005)[1]. Of the 13 total pesticides detected, diazinon and three herbicides (metolachlor, simazine, and trifluralin) were found in every sample.

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[1] This study was done in conjunction with a caging study of salmon smolts conducted by University of California at Davis, which tested fish for acetylcholinesterase activity, DNA strand breaks, cytochrome P450 expression, and stress protein expression. This aspect of the study may help to clarify what effects the exposure to pesticides may have on juvenile salmon passing through the system. Unfortunately, the results of the salmon exposure study do not appear to be available (CalFed Bay-Delta Grant -Evaluation of the Decreased Survival of Chinook Salmon Smolts in Old River: Biological Responses to Toxicants).

Although it might be expected that the higher flows would dilute the contaminants, the results were mixed. Diazinon and Simazine were highest at SJR and OR sites before VAMP (4/2/01 and 4/6/01), showed intermediate values during the VAMP period (5/14/01 and 5/18/01) and then reached lowest values during the post-VAMP period (5/31/01 and 6/4/01). Metolachlor showed the opposite trend at SJR and OR sites and increased throughout the three periods. Trifluralin showed a peak during the VAMP period for most sites. Suspended sediments were highest in SJR during VAMP; however, the opposite was true for the Old River, suspended sediments were lower during VAMP compared to just before and after the VAMP period. This was likely influenced by the operations of the Head of the Old River Barrier (HORB), which was installed during the 2001 VAMP period. All six culvert slide gates were open from April 26 to May 26, allowing some water to pass into the Old River. Suspended sediment concentrations generally increase with increasing streamflow, but there are likely nonlinear relationships between streamflow, suspended sediment concentration, and contaminant concentration. Limited conclusions can be drawn from a study with such a narrow spatial and temporal scope, however it is clear that increased flows do not necessarily lead to reduced contaminant concentrations. Undoubtedly, more research is needed to clarify this process.

Furthermore, the relationship between flow and contaminants is not obvious above Vernalis. As summarized in the Background Report for the San Joaquin River Restoration Study (McBain and Trush, Inc 2002), while higher flows may dilute some contaminants, such as selenium, mercury and DDT, contaminants in the bottom sediments of the San Joaquin River could also be remobilized during higher flows.

> McBain and Trush (2002) found that "although water quality conditions on the San Joaquin River relating to conservative ions, (e.g., salt and boron), and some nutrients are likely to improve under increased flow conditions, it is unclear how these and other potential restoration actions will impact many of the current TMDL programs and existing contaminant load estimates. This is most true of constituents with complex oxidation reduction chemistry, and sediment/water/biota compartmentalization (e.g., pesticides, trace metals)…Perhaps the greatest risks to potential restoration actions within the San Joaquin River study reaches relate to uncertainties regarding remobilization of past deposits of organochlorine pesticides, i.e., DDT and mercury."

Contaminant Issue 3. It remains unknown whether, or to what extent, migrating salmonids may be affected by suspended contaminants.

It is generally recognized that contaminants can have a negative affect on aquatic ecosystems, however despite the extensive studies conducted in field of toxicology, the direct ('acute toxicity' leading to death; or 'chronic' or 'sublethal toxicity' leading to decreased physical health; NMFS 2009) and indirect effects (reduction of invertebrate prey sources, reducing energetically favorable prey species relative to less energetically profitable or palatable prey; Macneale et al. 2010) of pollutants on salmon in the wild are not well understood.

Despite concerns over the threat contaminants may pose to threatened and endangered salmonid species, little is known regarding the effects of these contaminants on the health and survival of juvenile Chinook salmon in the Delta and its tributaries (Orlando et al. 2005). In a small scale, pilot study of contaminant concentrations in fish from the Delta and lower San Joaquin Rivers, resident species were tested for some of the contaminants listed above, however no salmonid species were tested (Davis 2000). The study found that 11 out of 19 adult largemouth bass sampled exceeded the mercury screening values, with a general pattern of lower concentrations down stream in the SJR toward the central Delta. DDT concentrations were exceeded in 6 of 11 white catfish, but only 1 of 19 largemouth bass. All samples above the DDT screening value were obtained from the South Delta or lower San Joaquin River watershed, indicating that the South Delta is still influenced by historic DDT use in the San Joaquin River basin. Two of the listed organophosphate pesticides were measured; diazinon was not detected in any sample and chlorpyrifos was detected in 11 of 47 samples analyzed, but at concentrations well below the screening value. With regards to salmonids, however, it is important to consider that resident fish may experience chronic exposure to these chemicals, while outmigrating Chinook smolts pass through the South Delta in a relatively short period of time.

A study by Meador et al. (2002) focused on estimating threshold PCB concentrations for juvenile Chinook salmon migrating through urban estuaries. PCBs were a concern because they had been shown to alter thyroid hormones important for the process of smoltification. During smoltification salmonids tend to show declines in muscle lipids, the main lipid storage organ for salmonids, causing the PCBs to be redistributed to, and concentrated in, other organs (Meador et al. 2002). Results of this study indicate that tissue concentrations below 2.4 mg PCB g^{-1} lipid should protect juvenile salmon migrating through urban estuaries from adverse effects specifically due to PCB exposure. This does not take into account any affects of other contaminants likely to also be in estuarine waters such as the Delta.

Contaminant Issue 4. Bioaccumulation, rather than exposure to dissolved contaminants, is likely the main concern for migrating juvenile Chinook.

Pesticides in the water column may be dissolved contaminants or they may accumulate in suspended sediments associated with organic matter. Dissolved contaminants can be absorbed through the gills or skin and this uptake may show more variability than the other exposure routes depending on concentrations, temperature and stress (Meador et al. 2002). Contaminants that accumulate in riverbed sediments may be resuspended (Pereira et al. 1996), and enter the food chain through filter-feeding benthic or pelagic organisms, such as Corbicula clams. In turn fish, such as carp and catfish, that are bottom feeders consume filter feeding invertebrates (Brown 1997). This process leads to bioaccumulation of the contaminants up the food chain. Bioaccumulation, rather than exposure to dissolved contaminants, is likely the main concern for migrating juvenile Chinook (Meadnor et al. 2002). Factors that affect bioaccumulation include: variable uptake and elimination rates, reduced bioavailability, reduced exposure, and insufficient time for sediment–water partitioning or tissue steady state can affect (Meador et al. 2002).

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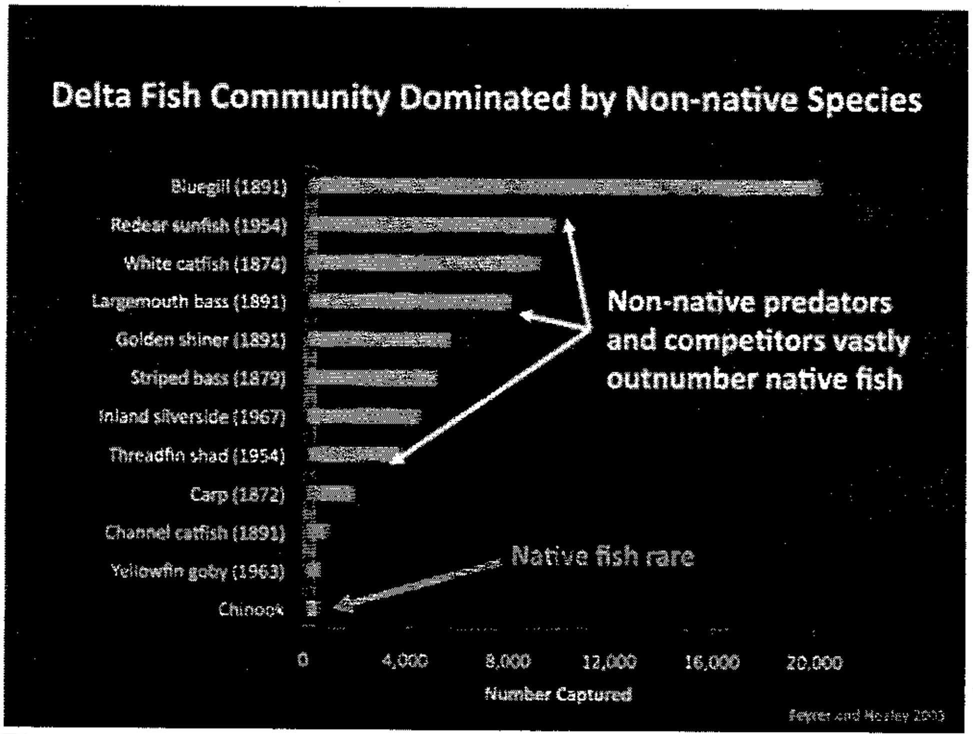


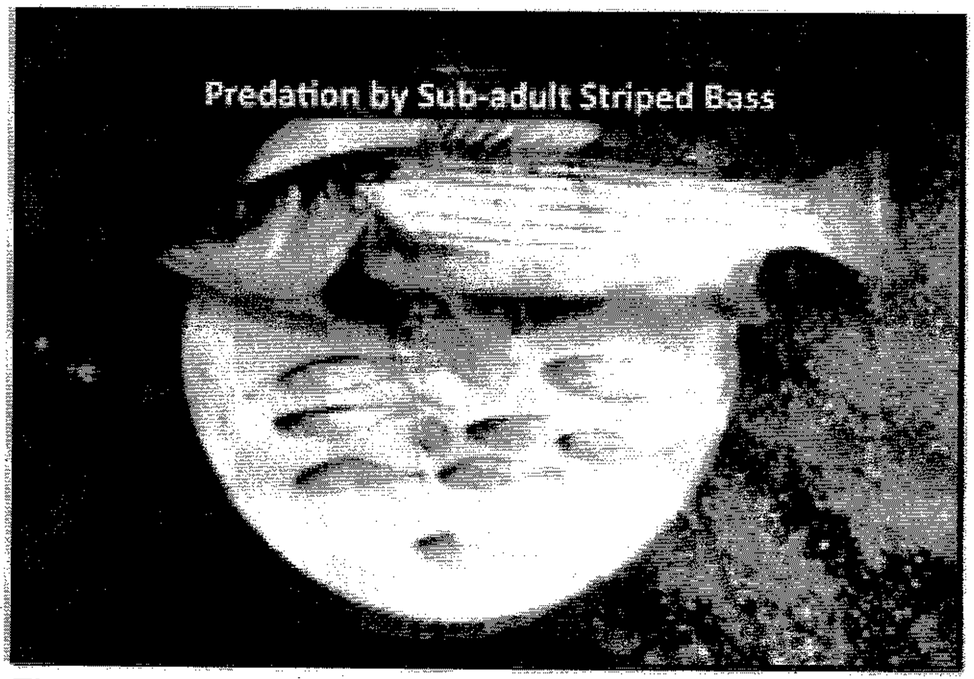
Delta Fish Community Dominated by Non-native Species

Non-native predators and competitors vastly outnumber native fish

Native fish rare

Feyrer and Healey 2003

Figure 1. The fish community of the South Delta is dominated by non-native species (Feyrer and Healey 2003).



Predation by Sub-adult Striped Bass

Figure 2. Sub-adult striped bass prey on Chinook smolts. Photo source: Hayes, D. 2005. SWP and CVP Fish Protective Facilities. Predation Workshop. <u>http://science.calwater.ca.gov/pdf/workshops/SP_workshop_predation_Hayes_052805.pdf</u>

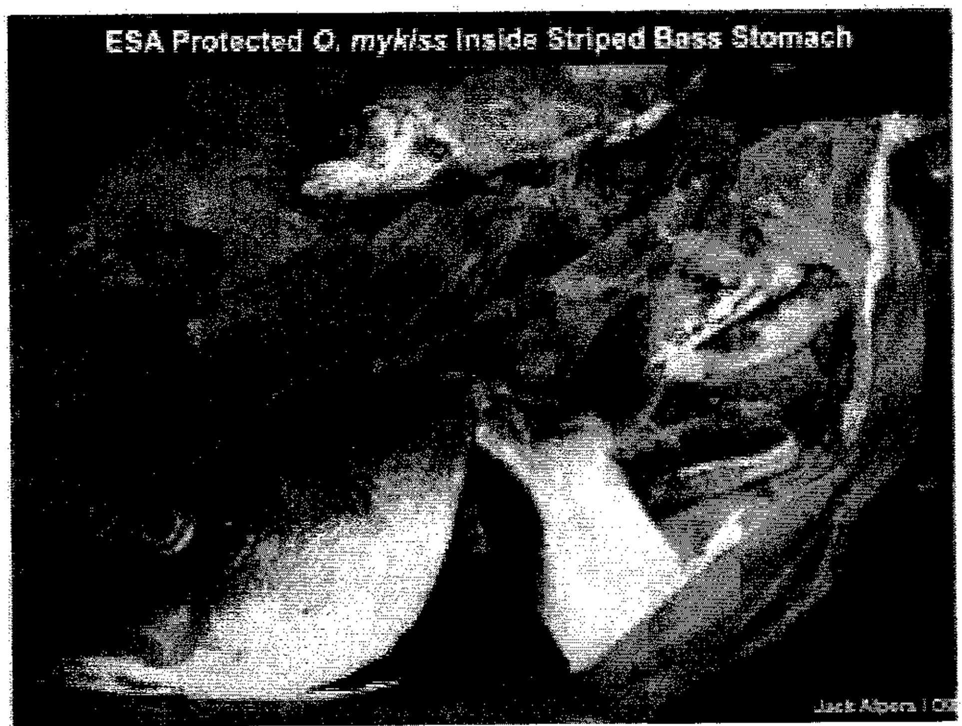


Figure 3. Striped bass in the Stanislaus River with an *O. mykiss* smolt in its stomach. Photo source: Jack Alpers (OID).

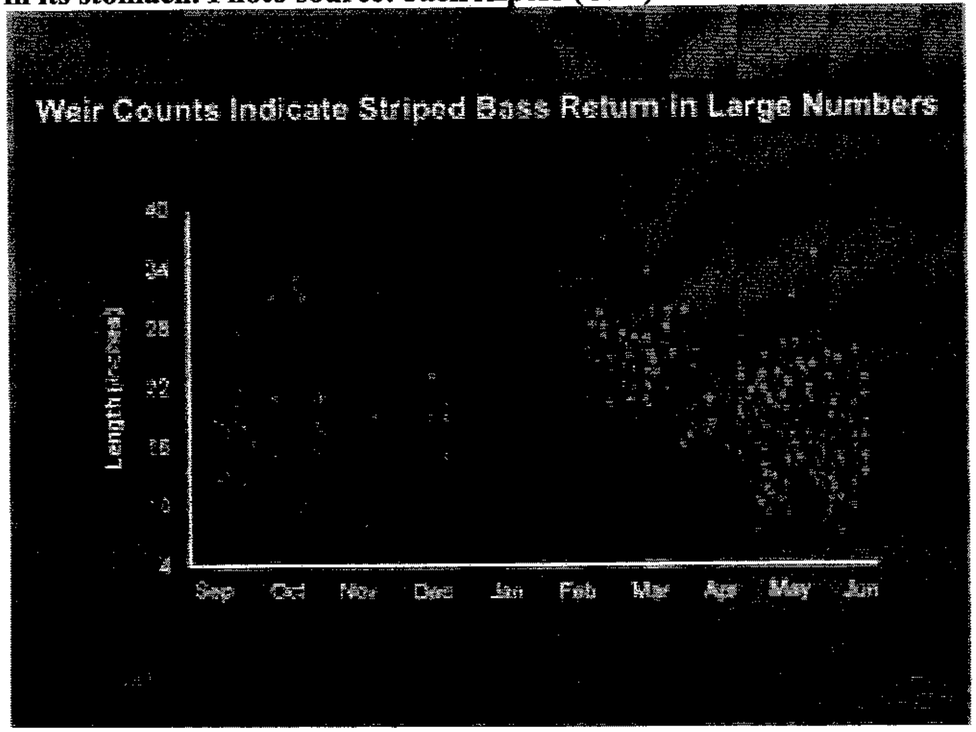
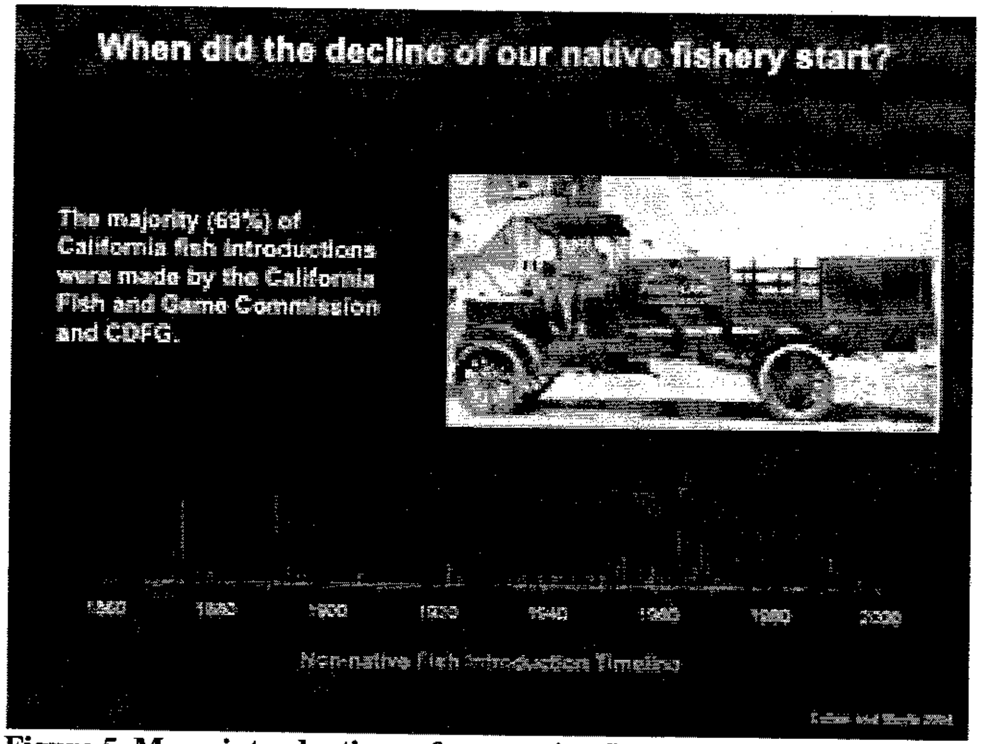


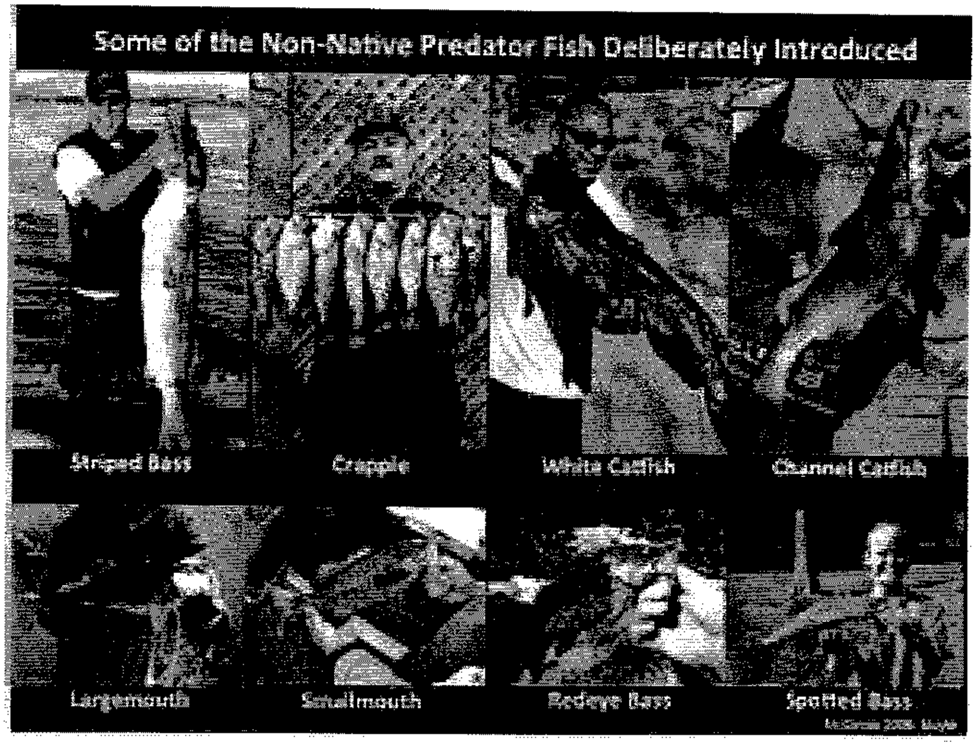
Figure 4. Large striped bass are present in San Joaquin River tributaries year round, with an increased presence in the spring (April-June). Data Source: Stanislaus River weir from 2003-2009 (n=378).



When did the decline of our native fishery start?

The majority (69%) of California fish introductions were made by the California Fish and Game Commission and CDFG.

Figure 5. Many introductions of non-native fish species have occurred intentionally over the last 150 years (Cohen and Moyle 2004).



Some of the Non-Native Predator Fish Deliberately Introduced

Figure 6. Several of the intentionally introduced sport fish species are predators.

Figure 7. The San Joaquin River contains a complex of oxbow lakes, backwater sloughs, ponds, and sand bars that become isolated when flow subsides.

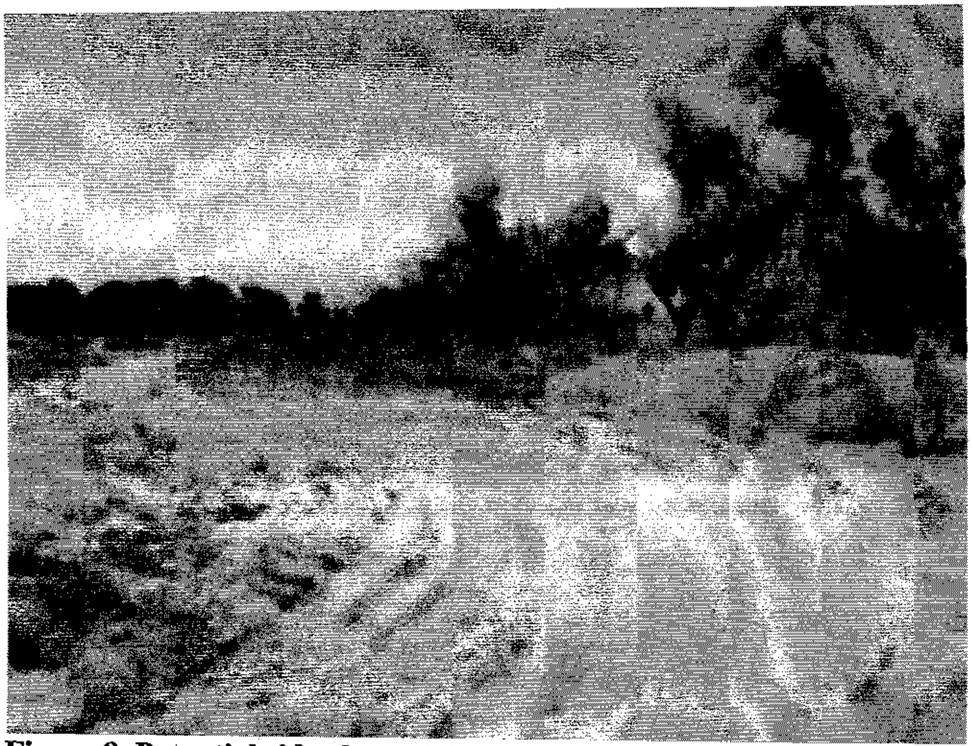


Figure 8. Potential side channel devoid of terrestrial vegetation. These channels may not provide food and cover for outmigration smolts when they become inundated.

Figure 9. An example of the steep, rip-rapped banks of the lower San Joaquin River with limited or no vegetation.

Figure 10. A bass angler fishes along the edge of a bed of aquatic vegetation in a slough in the South Delta. This habitat is often associated with largemouth bass.

Figure 11. The lower San Joaquin River is a confined channel with steep levees on both sides.

Figure 12. In some areas of the lower San Joaquin River, the steep levees have begun to erode.

Figure 13. A channel choked with non-native aquatic weeds.

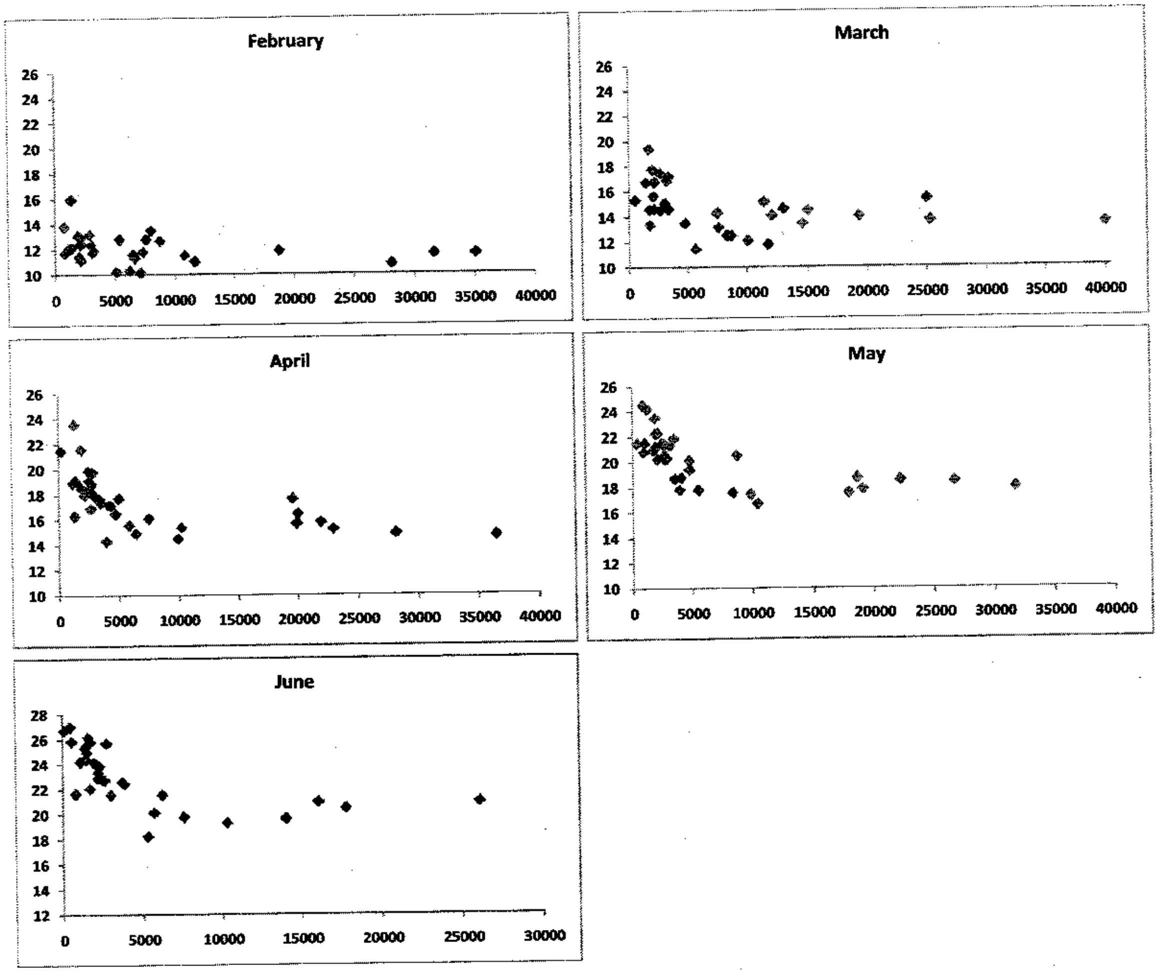


Figure 14. Monthly average flows (cfs) and average monthly maximum water temperatures (°C) at Vernalis, 1973-2006.