UPDATE OF CALFED ALTERNATIVE EVALUATION FOR CENTRAL VALLEY SALMON SURVIVAL

Final- September 24, 1998

Introduction

On June 25, 1998 the Diversion Effects on Fish Team (DEFT) completed a draft report entitled "Diversion Effects on Fish: Issues and Impacts." That report included an appendix describing in some detail the results of analyses of effects on salmon prepared by a subteam of DEFT. DEFT was instructed by management to pursue additional work on possible alternatives for consideration by management. The purpose of this draft is to summarize the additional work done by the salmon subteam.

The principal elements of the additional salmon-related work are:

- Consider whether various technical criticisms of the earlier analyses warranted changes in the original analyses.

- Identify potential additional alternatives for through-Delta conveyance which would provide better conditions for fish than Alternatives 1 and 2, described in CALFED's Phase II report, and evaluated in the June 25, 1998 draft report.

- Evaluate the effects of any new alternative on salmon originating from the Sacramento, San Joaquin, and East-side tributary basins. The team's original analyses on the three Delta Alternatives in the June 25, 1998 draft included only salmon from the Sacramento and San Joaquin watersheds. While the fall chinook salmon runs in the Eastside tributaries are small, they are both locally important and reflect needs in the Delta different from other runs. In order to evaluate the effects of a new alternative on salmon originating from the East-side tributaries, it was necessary to assess existing conditions and Alternative 1 as well. Alternative 2 and 3 were not scored for the East-side tributary stock in either the original or this additional analyses.

- Provide an assessment of the overall benefits of the CALFED program on salmon . The June 25, 1998 report considered only effects within the Delta and Suisun Bay of the CALFED alternatives for actions within the Delta. For salmon, the additional task involves integrating the effects of CALFED actions upstream from the Delta, with effects of Delta actions, and actions on harvest regulations.

Terry Mills of the CALFED staff and Joe Miyamoto of East Bay Municipal Utilities District were added to the Salmon Team to add expertise on upstream CALFED actions and East-side tributaries. This was essential to completing the broader assignment.

Technical Concerns About Original Analysis

The Salmon Team is aware of three primary technical concerns. No changes to the original document were made based on these concerns. The salmon team's response to these concerns are as follows:

1. Salmon are guided by salinity in the salinity gradient during their migration to the ocean. We agree that this is well substantiated in the literature. One manifestation of it probably is the rapid migration of salmon smolts from Suisun Bay to the Golden Gate demonstrated in studies done during the early 1980s.

Use of salinity as a cue does not necessarily indicate any relationship between survival and the location of the salinity gradient. Salmon presumably make a transition from cuing primarily on flow to cuing on salinity as they migrate downstream to the ocean, and the location of where that transition takes place may not be related to survival. Analyses of the survival of marked salmon smolts, however, indicate that survival may be related to the location of the salinity gradient.

Regardless, the major consideration in our evaluation is that the salinity gradient is in approximately the same location in each alternative, so salinity cues are not a probable cause of differences among alternatives. (One qualification on this conclusion is we understand that the operations studies for the CALFED alternatives did not take into account the degree to which salinity intrusion associated with reverse flows may differentially affect exports. That might mean that in real operations some differences in the salinity gradient would exist, but we doubt that they would be enough to negate our conclusion.)

2. The relationship between flow and survival in the lower Sacramento River is not valid. We agree that the original analysis we made was based on an invalid interpretation of information. We have analyzed other information in an attempt to determine whether a relationship between flow and survival exists. There are indications that such a relationship exists, but the information is far from definitive. We have not had sufficient resources and time to examine the information exhaustively. The ongoing evaluation of the information should be completed and the topic reconsidered based on the full evaluation.

Meanwhile, at the very least, our initial evaluation is more uncertain than we indicated in the June 25 report. The salmon team considered responses ranging from concluding that flows are not a significant consideration to leaving the impact assessment unchanged. The majority of the team decided, given the time constraints, to let the analysis stand as in the original report, while a minority believe the original report should be changed to indicate significantly less impact for flow below Hood. If flows have less effect on salmon survival in the lower Sacramento River than we have assumed, the negative effects of diverting water at Hood would be less and the scores for Alternatives 2 and 3, and to a lesser extent for Scenario A, would increase for Sacramento basin salmon.

3. Net flows are not as significant as we estimated. The point has been made that net flows diminish in relation to tidal flows as one proceeds down the estuary and are only a small fraction of tidal flows in much of the estuary. Particle tracking model results indicate travel times of several weeks under some conditions from locations downstream of the Old-Middle River complex to the pumping plants. We acknowledged in the original report that net flows are often small in relation to tidal flows, as our critics contend, but we believe significant effects are associated with net flows. The appearance of juvenile salmon from the Sacramento basin at the south Delta diversion facilities requires some mechanism to account for these salmon departing from their migration route to the ocean. Response by salmon to net flows toward the south Delta is a plausible explanation.

As common sense and particle tracking studies indicate, the higher the export rate the larger the area within the influence of the pumps becomes. The area of influence also depends on the magnitude of freshwater flow. Particle tracking studies are available for exports ranging up to 8,000 cfs, and indicate that at high exports and low flows, the San Joaquin River downstream of the Mokelumne is within the area of short-term influence of the pumps.

The operations studies for the CALFED alternatives indicate that average monthly exports will exceed 8,000 cfs in 8 of the 12 months. Hence, about half of the time in those months export rates will exceed the largest exports examined in particle tracking model studies. Therefore, we have not evaluated the full range of potential impacts. In both our original analysis and the current evaluation, we included in our considerations that downstream migrant salmon are most abundant during the months when average exports are less than 8,000 cfs.

After reviewing this information, we believe that the third paragraph on page A-3 of the June 25, 1998 DEFT Report accurately describes our perception of the significance of net flows and is valid. Hence, we stand by our original analysis.

Identification of an additional alternative for through-Delta conveyance

DEFT identified one additional alternative, Scenario A, with through-Delta conveyance, which was thought to provide better conditions for fish than Alternatives 1 and 2, described in CALFED's Phase II report, and evaluated in the June 25, 1998 draft report. Within the Delta, Scenario A involves:

- Additional habitat restoration measures to be undertaken during Stage 1 (the first 7 years after approval of CALFED's preferred alternative), described in the DEFT white paper, Analysis of Phase I Delta Habitat, 10 September 98.

- The following structural actions:
  1) a 2,500 cfs fish screen for the CVP intake,
  2) a 6,000 cfs fish screen at the intake to Clifton Court Forebay,

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3) an operable barrier at the head of Old River, and
4) a 2,000 cfs screened channel from Hood to the Mokelumne River.

- The following operational actions:
  1) lower E/I ratios from November through June, and
  2) maintaining X2 at the 1962 level of development from February through June.

Analysis of Effects of the CALFED Program on Salmon in the Eastside Tributaries

Methods

Evaluation scores were developed for existing conditions and alternative 1. The criteria in the June 25, 1998 draft DEFT report was used as the basis to score the alternatives.

In general, the scores for the East-side tributaries were derived from the scores for either the Sacramento or San Joaquin River with adjustments made to account for higher levels of entrainment exposure relative to Sacramento River fish. The modifier for Sacramento entrainment impacts was changed from a four to a two for the Eastside tributaries to give this score a higher weighting. This adjustment was made on the basis of the differences in coded wire tag recoveries of Sacramento (1 %) and Mokelumne origin (3 - 5 %) salmon smolts at the export pumps. There was some disagreement in the group relative to the weighting of this factor between the three stocks. Some felt the Mokelumne group should not have a modifier because entrainment could be greater on the Mokelumne than on the San Joaquin stocks because of the additional lifestages and time period stocks are affected from the Mokelumne. Others felt the modifier for the East-side streams should be larger (2) than that on the San Joaquin (1) and less than that on the Sacramento (4).

The modifiers themselves should not affect comparisons within a stock between alternatives. Comparisons of total scores between stocks is somewhat problematic because different categories of environmental and operational variables were used to score each river system.

In scoring entrainment and interior Delta related impacts, the following life stages were assumed to be present: fall-run chinook salmon fry (December to March), fall-run chinook salmon smolts (April to June) and fall-run chinook salmon yearlings (October to December).

For all alternatives and existing conditions, a negative score was assigned for the installation of a barrier at the head of Old River. The barrier would have the effect of diverting more Eastside tributary salmon towards the export pumps than if the barrier was not in place. The barrier at the head of Old River was assumed to be removed after the month of May.

Impacts from agricultural diversions were not scored until April when the irrigation season was assumed to begin.

Temperature related impacts were identified in the Delta, but no differences were assumed between the baseline or any of the alternatives.

No score was assigned for Delta Cross Channel operations for the Eastside tributaries because this parameter was used to represent the percentage of Sacramento-origin salmon that enter the interior Delta. Any changes to the survival of East-side tributary salmon from the Delta Cross Channel operations would be reflected in the flow distribution parameter in the interior Delta survival scores.

Existing Conditions

Existing conditions have negative impacts on East-side tributary salmon fry, smolts, and yearlings primarily from entrainment, interior delta flow distribution, and predation-related losses. The score for the month of June was adjusted to reflect avoidance of Delta impacts due to the Mokelumne River trap and truck program during June in dry and critically dry water year types.

Alternative 1

The new fish screens at the Clifton Court forebay intake would reduce entrainment and predation losses of Eastside tributary salmon. Increased exports from October through December would entrain a greater number of yearling salmon and may offset some of the benefits to smolts from the new fish screens at Clifton Court Forebay.

The score for this alternative was also improved by the cumulative benefits from the Common Programs. The CalFed Ecosystem Restoration Program proposes moderate increases in existing shallow-water habitat by creating areas where inundation of vegetation occurs more frequently. Predatory fish would also be attracted to the shallow-water habitat during the months of March through June. Overall, the creation of shallow-water habitat would probably result in a net benefit to juvenile salmonids, especially to salmon fry and presmolts, because it would provide food and escape cover. These benefits are expected to accrue from January through March for shallow-water habitat and from January through June for increased food supply.

Screens on Delta agricultural diversions from the common program would also reduce entrainment losses of salmon smolts during April through June. Salmon fry would not be at risk because the irrigation season does not begin until April.

Evaluation of new Delta conditions (Scenario A)

The Team evaluated in-Delta consequences of Scenario A based on the habitat, structural, and operational assumptions described above, and model runs describing the consequences of the operational measures on Delta hydrology. (The model runs for Scenario A used the 1995 level of

demand for water, which is the same level of demand used for Existing Conditions in the original analysis. The estimated 2020 level of demand was used in evaluations of other alternatives in the original analysis. As a result of using the 1995 level of demand, the Scenario A evaluation is biased somewhat towards overestimating environmental benefits in relation to the other CALFED alternatives.)

The month-by-month analyses for the Sacramento, Eastside tributaries, and San Joaquin runs are presented in Appendix 1, Tables 1, 2, and 3 of this report. As mentioned earlier, the total scores on each of the matrices from the different river systems should not be directly compared with each other because different categories of environmental and operational variables were used to score each river system. The best way to use the scores is to compare various alternatives within a given river system.

Our evaluation of Scenario A, without new storage, yielded summary scores of +2 or +3 for the three geographic runs included, corresponding to an expectation of small to moderate increases in abundance (see Summary Matrix in June 25, 1998 report and Table 1 in this report).

For the Sacramento runs, the primary positive features were reduced entrainment losses in the south Delta associated with reduced exports from December through June and improved interior-Delta survival associated with improved flows in the same months. Those benefits were partially offset by exposure of downstream juvenile and upstream adult migrants to the Hood diversion, generally as described for Alternative 2, but to a substantially lesser degree. The overall result was a total score of -20, which is slightly higher than the score for any other alternative (see Appendix A, Table 2 of June 25, 1998 report, and Table 2 of this report). The difference, however, is not sufficient to warrant a summary score for Scenario A higher than +2, the score given for Alternatives 1 and 3 in the June 25 report.

For the San Joaquin runs, decreased exports and improved flow conditions lessened entrainment losses and improved interior Delta survival, resulting in a total score of -20. This total is similar to Alternative 2 and substantially less than for Alternative 3 (see Appendix A, Table 3 of June 25 report, and Table 2 of this report). The resulting summary score for Scenario A is +3, the same score given for Alternative 2, one unit higher than Alternative 1, and one unit less than Alternative 3.

For the East-side Tributaries, the scores for entrainment showed an improvement over Alternative 1 to reflect more restrictive E/I ratios under the Scenario A alternative. Scores for interior Delta flow distribution showed an improvement similar to the San Joaquin River scores. The resulting total score of -14 is half of the Alternative 1 total (Table 2). The summary scores show a one-unit improvement for Delta-related actions between Alternative 1 and Scenario A (from +2 to +3).

The San Joaquin River total score includes three units of improvement to account for more positive flow in the Central Delta with the 2,000 screened diversion at Hood ($1/5^{th}$ of the

improvement attributed to a diversion of 10,300 cfs into the interior Delta in Alternative 2). No similar adjustment factor was used for the East-side tributaries because the operation of this facility is not viewed as a positive measure for these fish because these flows would divert more fish into the Mokelumne South Fork where they would be more vulnerable to entrainment losses at the export pumps.

For all salmon runs, the team considered whether the substantial benefits attributed to habitat restoration in the original report should be changed. A majority of the team concluded that they should not. The primary issue continues to be uncertainty over the degree to which shaded riverine aquatic habitat will be rehabilitated along the Sacramento system portion of the Delta. Although the DEFT habitat report states that such habitat "should" be restored to the extent "practicable," the salmon team is concerned about the uncertainty denoted in the description, which seems warranted by historical levee maintenance practices and estimated costs of habitat restoration in the north Delta.

Table 1. Summary of evaluation of Scenario A.

Alternative	Sacramento River Salmon	San Joaquin River Salmon	Eastside Tributary Salmon
Scenario A Without Storage	Score +2 -Interior Delta survival improved in relation to Alternative 1 by better flows and reduced exports -improvement partially offset by reduced flows below Hood, juvenile entrainment losses at Hood screen, and the barrier to adult migration. If created along the migration route, as suggested may occur in Scenario A, SRA habitat would improve salmon survival during rearing and migration.	Score +3 -Lower exports improve survival at south Delta screens -Improved flow conditions in interior Delta improve survival	Score +3 -Lower exports improve survival at south Delta screens -Improved flow conditions in interior Delta improve survival -Improvement partially offset by the flow patterns from the 2,000 cfs diversion into Snodgrass Slough that would divert more fish into the Mokelumne South Fork where entrainment losses would be expected to be higher.

Table 2: Comparison of total matrix and summary scores between two Delta Alternatives; Alternative 1 and Scenario A, for salmon from the Sacramento, San Joaquin, and Eastside Tributary systems..

	Alternative 1 Matrix Score	Summary Score	Scenario A Matrix Score	Summary Score
Sacramento River System	-23	+2	-20	+2
San Joaquin River System	-35	+2	-20	+3
Eastside Tributaries	-28	+2	-14	+3

Assessment of Upstream Actions

CALFED staff provided the team with a list of upstream actions expected to take place during Stage I implementation of the CALFED program, and a list of actions expected during the remainder of the CALFED program. Both sets of actions were evaluated to estimate the value they would have for salmon at maturity of the habitat. The evaluations are described in detail in Appendix 2 and summarized here.

Benefits were estimated separately for many runs in various parts of the Central Valley system and then summarized by races of salmon for major portions of the system (Table 3). Scores were assigned using the following criteria:

- +1 or +2 Upstream improvements in stream habitat quality and function likely **will not** increase chinook salmon production within the stream sufficiently for CALFED, through its system-wide program, to achieve its salmon recovery goal.

- +3 through +5 Upstream improvements in stream habitat quality and function **may** increase chinook salmon production within the stream sufficiently for CALFED, through its system-wide program, to achieve its salmon recovery goal.

- +6 and +7 Upstream improvements in stream habitat quality and function **likely will** increase chinook salmon production within the stream sufficiently for CALFED, through its system-wide program, to achieve its salmon recovery goal.

Table 3. Comparison of benefits of upstream actions proposed to be implemented during Stage 1 with the upstream benefits to be implemented throughout the CALFED Program for various runs of Chinook salmon.

Salmon Run	Stage 1 Upstream Actions	Long-term Upstream Actions
Sacramento Fall Run	+3	+6
San Joaquin Fall Run	+3	+4
Spring Run	+4	+6
Late-fall Run	+5	+6
Winter Run	+5	+6
Eastside Tributaries	+4	+6

The analysis indicates that in most cases substantially greater benefits can be expected from the subsequent implementation of actions on the long-term list than from the Stage 1 actions. The combined benefits of the Stage 1 and long term actions receive scores associated with high recovery potential for upstream actions, except for San Joaquin fall-run salmon.

An Assessment of Harvest Management Actions

The next step in the analysis was to estimate benefits for harvest actions.The Harvest Management Team concluded that over the next seven years new regulations will warrant a +6 score for salmon, indicating the regulations are likely to be sufficient to achieve CALFED recovery goals. We used that value in our analysis.

Integration of Delta, Upstream, and Harvest Management Actions

It was necessary to weight the importance of each of the three components; the Delta, Upstream (both for Stage 1 and long-term actions), and Harvest regulations to determine the likelihood of recovery. After testing for sensitivity within the range of weighting factors the team considered reasonable, the team adopted the weighting factors indicated in Table 4. These factors reflect the team's judgement that Delta conditions are more important for salmon from the San Joaquin system than for those from the Sacramento system, reflecting their more direct exposure to the export system under today's conditions.

The approach we used to integrate benefits for the various races and runs of salmon to achieve a weighted score incorporating the Stage 1 upstream actions, Scenario A for Delta conditions and Harvest Actions involved 5 steps:

1) evaluate both the Stage 1 and long-term actions for each tributary by race of salmon,
2) combine all tributary scores into average scores for upstream actions (Stage 1 and long term) by race and geographic area (Tables 5 and 6),
3) multiply the average scores for upstream actions by the appropriate weighting factor (see Table 4),
4) multiply the summary scores for Delta Scenario A and harvest management actions by the appropriate weighting factors (see Table 4),
5) calculate averages of the 3 weighted scores resulting from steps 3 and 4 for each race and geographic area (Tables 5 and 6).

Table 4. Weighting factors for various types of actions for use in computing overall effects of CALFED actions on salmon populations.

Type of Action	Sacramento System Salmon	San Joaquin System Salmon	Eastside Tributary Salmon
Upstream Actions	0.5	0.4	0.4
Delta Actions	0.3	0.4	0.4
Harvest Actions	0.2	0.2	0.2

Table 5. Details of Integration of Benefits over All CALFED Actions for Scenario A and Stage 1 Upstream Actions

Salmon Run	Stage 1 Upstream Actions	Delta Actions	Harvest Management Actions	Weighted Average
Sacramento Fall Run	+3	+2	+6	+3
San Joaquin Fall Run	+3	+3	+6	+4
Spring Run	+4	+2	+6	+4
Late Fall Run	+5	+2	+6	+4
Winter Run	+5	+2	+6	+4
East-Side Runs	+4	+3	+6	+4

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Table 6. Details of Integration of Benefits over All CALFED Actions for Scenario A : Upstream Actions include all actions over the life of the CALFED Program.

Salmon Run	All Upstream Actions	Delta Actions	Harvest Management Actions	Weighted Average
Sacramento Fall Run	+6	+2	+6	+5
San Joaquin Fall Run	+4	+3	+6	+4
Spring Run	+6	+2	+6	+5
Late Fall Run	+6	+2	+6	+5
Winter Run	+6	+2	+6	+5
East-Side Runs	+6	+3	+6	+5

The same approach was used to evaluate the integrated benefits for each of the other CALFED alternatives, using the scores from the Summary Matrix for salmon on page 14 of the June 25, 1998 DEFT report. The weighted averages using the Stage 1 and full list of actions for implementation in Stage 1 and in the long-term for salmon from the Sacramento, San Joaquin, and East-side Tributary Systems are shown in Tables 7, 8 and 9, respectively. They indicate that the overall benefits of CALFED actions, as currently envisioned, will ultimately be greater for salmon from the Sacramento System and East-side tributaries than for those from the San Joaquin, and that much of the difference will be due to the relative effectiveness of actions upstream from the Delta implemented after Stage 1.

Table 7. Sacramento system: Comparison of Benefits Integrated over CALFED Actions Upstream of the Delta, both Stage 1 and Long-term actions, in-Delta, and Harvest Management for Salmon.

Alternative	Stage 1 Upstream Actions, plus Delta and Harvest Actions	All Upstream Actions, plus Delta and Harvest Actions
Alternative 1 Without Storage	+3	+5
Alternative 2 Without Storage	+2	+4
Alternative 3 Without Storage	+3	+5
Scenario A Without Storage	+3	+5

Table 8. San Joaquin system: Comparison of Benefits Integrated over Actions Upstream of the Delta, both in Stage 1 and in the Long term, in-Delta, and Harvest Management for Salmon.

Alternative	Stage 1 upstream, plus Delta actions plus Harvest actions	All upstream actions plus Delta Actions plus Harvest actions
Alternative 1 Without storage	+3	+4
Alternative 2 Without Storage	+4	+4
Alternative 3 Without Storage	+4	+4
Scenario A Without Storage	+4	+4

Table 9. East-side tributaries: Comparison of Benefits Integrated over Actions Upstream of the Delta, for both Stage 1 and Long-term, in-Delta, and Harvest Management for Salmon. Alternatives 2 and 3 were not evaluated for the Eastside tributaries.

Alternative	Stage 1 upstream, plus Delta actions + Harvest actions	All upstream actions plus Delta Actions plus Harvest actions
Alternative 1 Without Storage	+4	+4
Scenario A Without Storage	+4	+5

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