The Effects of Environmental Water Account Actions on Salmonids in 2001 -2004

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In the first four years of implementing the Environmental Water Account, the timing and extent of EWA actions for Chinook salmon has varied considerably. Uses include SWP/CVP export reductions in the winter months when winter run and spring run Chinook juveniles are present in the Delta and in the spring months, including the VAMP period, when spring run and fall run juveniles are emigrating. The purpose of this paper is to describe some methods for estimating the benefits to Chinook salmon from the pumping curtailments using EWA water and to present the results of applying those methods to the first four years of the EWA. Upstream actions and their effect on salmon also are described.

Many of the individual actions taken for salmon have been justified in part by the presence and expected benefits for steelhead, delta smelt, and other species. Except to compare the take of steelhead to the reconsultation take level, no analysis of steelhead benefits has been done. Effects of EWA uses on delta smelt will be described in a separate paper.

EWA used for salmon and steelhead

The primary use of EWA for Chinook salmon and steelhead was for pumping curtailments at the SWP and CVP diversions in the Delta to reduce the entrainment and increase the survival of emigrating juvenile fish.

Table 1 shows the amount of EWA water used during the winter months (prior to April 15) for salmonids and for the combination of salmonids and delta smelt, during the VAMP period (mid-April to mid-May when the focus is on protecting delta smelt and salmon and helping to carry out the VAMP experiment), and for the post VAMP period (late-May and early June when the focus is on delta smelt and late migrating fall run Chinook juveniles).

In the upstream area, EWA water augmented stream flow when released from a reservoir to the source river for transfer through the Delta, mostly during the summer months, but also in relatively small amounts in the fall 2001 on the lower American River (20 taf) and Merced River (~25 taf). On other occasions EWA water was released in very limited amounts when it could not be recovered in the Delta (~5.5 taf on the lower American River in the fall 2002).

River level outlet releases which bypasses the powerhouse were made at Folsom Dam in 2001 and 2002 in order to access the last cold water in the reservoir and reduce water temperature in the river downstream for holding and spawning salmon. In each case some power generation was lost. In 2001 the EWA used power credits accrued during earlier export pumping curtailments to pay for the foregone generation. In 2002, money in the EWA budget was used to buy replacement power. EWA water was not involved in either case.

Effects of EWA actions on salmon in the Delta

The effects of EWA actions in the Delta for Chinook salmon will be described as

- the resulting take compared to the reconsultation level of take specified in NOAA Fisheries OCAP Biological Opinions,
- the reduction in take compared to the no-action case,
- the change in survival compared to the no-action case using survival metrics estimated using several different models

<u>Actual “take” of listed salmonids compared to the reconsultation level</u>

Winter run Chinook salmon

Figure 1 depicts the loss of winter run Chinook at the SWP/CVP from 1993 -2004 compared to the level of loss authorized in the incidental take statement in the NOAA Fisheries Biological Opinion for the OCAP. Exceeding this level requires a mandatory re-initiation of ESA consultation with NOAA Fisheries (reconsultation level). The level is set as a percentage of the Juvenile Production Estimate (juveniles arriving at the Delta, JPE) which is calculated annually using an estimate of adult abundance and a set of biological factors and survival rates for subsequent life stages. The reconsultation level, set at one percent of the JPE, was exceeded by a small amount in 1994. The reconsultation level was changed to two percent of the JPE in 1995 because new genetics information indicated that only about half of the winter run size Chinook were genetic winter run. Use of the size criteria to characterize juvenile salmon as winter run continued, however, the original Fisher length criteria were modified in 1996 for use in the Delta.

Winter run take slightly exceeded the reconsultation level in 1996, then was below that level from 1997 through 2000. In 2001, the first year with the EWA in place, the loss of winter run reached nearly three times the reconsultation level despite over 200 taf of EWA actions in January - March 2001. Loss would have been greater without the EWA (see estimate below). Ultimately the JPE for that year was re-examined and a revised JPE was calculated using the number of spawning winter run determined from a carcass survey. The carcass survey provided a better estimate than that obtained by extrapolating from partial counts of adult salmon at Red Bluff Diversion Dam. The new estimate of spawner abundance was higher, which in turn yielded a higher JPE. The actual take of 20,000 juvenile winter run would have been about 40% of a revised reconsultation level associated with the larger spawning population.

The carcass survey has been used to estimate the spawning population and to calculate the JPE and reconsultation level since 2001. The actual loss of winter run has remained below the reconsultation level each year since 2001. No EWA actions have been taken exclusively for winter run Chinook protection since 2001 because the reconsultation limit has not been approached and adult abundance has increased substantially (between about 7,500 - 8,200 in 2001 -2003) from very low levels (~ 200-400 fish) in the early 1990s.

Spring Run Chinook salmon

For several reasons, the take management approach used for winter run Chinook has not been used for spring run Chinook. Instead, the authorized take level at the SWP/CVP for the spring run emigrating from the tributaries in the winter months is set at one percent of fish from any of several groups of tagged Coleman National Fish Hatchery late fall run Chinook (LFR) released in the upper Sacramento River in November – January. Table 2 shows the percent loss at the SWP/CVP of these groups of surrogates for spring run Chinook yearlings from 2001 – 2004 compared to the 1% reconsultation level established in the OCAP Biological Opinion. In the several years before the EWA, the 1 % take level had been exceeded several times (DWR, unpublished data). Loss of all surrogate groups was well below 1 % in 2001. Much of this loss occurred in late January through mid-March when 200 taf of EWA actions were being taken to reduce loss of winter run, reducing the number of tagged surrogates entrained at the SWP during this period. (We could estimate the change in loss of surrogates due to the EWA actions but have not done so. The reconsultation level probably would not have been exceeded in any case.) Loss of two groups of surrogates (December and January releases) approached but did not exceed the reconsultation level in 2002. In 2003, loss for both the December and January groups exceeded the reconsultation level. About 100 taf of EWA was used for pumping curtailments, 32 taf during December and 89 taf in January when the loss rate was the highest. In 2004 there were only two release groups used as surrogates. The loss of the January group exceeded the reconsultation level and consultation was reinitiated with NOAA Fisheries. However, no EWA actions were taken based on agency biologists' interpretation of the available information on the migration pattern and loss of tagged and wild fish, respectively.

The use of surrogates for spring run Chinook is being reevaluated. In the near future, genetic analysis of tissue samples will be available to help us identify spring run Chinook in the Delta and refine the approach to management of loss in the Delta. It is not clear that yearling spring run coming from Deer and Mill Creek in the fall are ready to immediately migrate to the Delta once they leave their natal tributary and enter the Sacramento River. Instead they may linger in the middle reach of the Sacramento River or migrate slowly downstream. Recoveries of tagged LFR released in November seem to indicate this latter type of behavior (Erin Chappell, EWA Workshop presentation, September, 2004). The spring run yearlings also tend to be emigrating from the tributary streams over a longer time period than originally thought. Each of the LFR groups may represent a part of the emigrating population, but if we are to continue to use surrogates, we need to determine how to use the information from all the surrogate groups for take management.

Steelhead

The number of steelhead salvaged is used as the measure of take instead of the number lost used for salmon because the factors needed to convert salvage to loss are not known for steelhead. Figure 2 shows the number of steelhead salvaged at the SWP/CVP fish facilities from 1998 -2004 and compared to the reconsultation level in the NOAA Fisheries OCAP Biological Opinion in the most recent years. Comprehensive marking of hatchery steelhead began in 1998, enabling the enumeration of naturally produced (unmarked) fish. The first take limit for the SWP/CVP was established in 2000 (range = 300-400) and salvage was close to the upper end of the range that year. The reconsultation level for steelhead was 4500 from 2001-2003; salvage was near that level in 2001 and would have exceeded it were it not for the 200 taf of EWA pumping curtailments in January – March. Steelhead salvage was well below 4,500 in 2002 and 2003 and would not have exceeded this level even without EWA actions. The reconsultation level was changed to 3,500 in 2004. Actual steelhead salvage in 2004 was about half that number without any EWA actions in the steelhead emigration season.

<u>Reduction in “take” compared to the no-action case</u>

Another way to measure the effect of EWA actions in the Delta is to estimate how many salmon were lost at the SWP/CVP compared to the no-action case. This analysis requires an assumption that the number of salmon in the exported water would be the same without an export curtailment as was observed during the periods of export curtailment and that other factors (screen efficiency, prescreen losses, etc) are not affected by changes in pumping rate. The number of fish saved from entrainment by each EWA action is estimated as:

Number of salmon saved = (number of salmon lost/acre foot)(acre feet to be pumped without the action – acre feet actually pumped during the EWA action)

For any salmon run or other designated group (i.e. “older juvenile Chinook”) the total number of fish saved from being lost at the SWP/CVP diversions is the sum of fish saved from all the actions taken when fish in that group were present.

The net effect of EWA management must also take into account any periods when the EWA caused pumping to be higher than in the no-action case and salmon entrainment would have been higher as well. This occurs when the EWA agencies allow pumping to exceed the allowable export:inflow standard in order to gain water for the EWA as well as when the SWP pumps b(2) water and half of it goes to the EWA In the first four years, one or the other of these conditions has occurred at least once in every month except May and July and, where applicable have been included in estimating the effect of EWA on SWP/CVP loss. This aspect of the analysis is relatively straightforward when examining changes in loss, but is more difficult to account for in estimating changes in survival (see later section).

The results of EWA actions in January – March 2001 provides the clearest example of the reduction in salmon loss. The calculation was done for winter run Chinook as characterized by the Delta length-at-date criteria (size curves). Actual loss for the season was about 20,000 winter run size Chinook. It was estimated that without the 200 taf of EWA actions, the loss would have been about 26,000 salmon, hence the EWA actions saved about 6,000 juvenile winter run from being entrained, a 23% reduction in loss. Loss of 20,000 juveniles represented about 6% of the winter run JPE for that year or about three times the reconsultation level of 2%. Recall, however, that the JPE was later revised upward when recalculated using adult abundance from the carcass survey data. Estimated loss was 0.08% of the revised JPE or about 40% of the revised reconsultation level.

We know that in the Delta during the winter months there are salmon that are not winter run but are in the winter run size range and these are counted as winter run when loss is determined. This means that the impact of winter run loss at the SWP/CVP is overstated when it is described by the loss of winter run size salmon as a percentage of the number of juvenile winter run reaching the Delta calculated from the abundance of spawning winter run (JPE). Another way to assess the loss of these winter run size salmon is as a percentage of the number of fish in this same size range that are estimated to pass Chipps Island in the western Delta as they emigrate from the Delta. This comparison of SWP/CVP loss to the number of salmon successfully emigrating from the Delta may be more meaningful than a comparison to the JPE from a population perspective. The comparison is not for a discrete run (e.g. winter run), but it does provide a context for assessing the impact of pumping on all the juvenile Chinook in a given size range that are being affected by conditions in the Delta at the time. In

2001, the 20,000 winter run size salmon lost at the SWP/CVP was about 10% of the number estimated of winter run size salmon that migrated past Chipps Island during the same season. Without any EWA action in the winter of 2001, loss may have been 13% of that out-migrant population.

This result suggests that SWP/CVP loss of salmon can have a substantial effect on older juvenile Chinook, which includes winter run size and larger fish. In the past we have not attempted any in-season comparisons of salmon loss relative to successful out-migrant salmon abundance to assess the risk to the out-migrating population. Such an approach may be useful in the future.

In the years since 2001, few actions have been taken during the winter months just to reduce salmon entrainment and in no case was the loss per acre foot of water pumped as high as in the winter 2001. Consequently, the number of older juvenile salmon saved from entrainment by EWA actions to help one or a combination of fish species (salmon, steelhead and delta smelt) resulted in much smaller net changes in salmon entrainment. In 2002, only 243 salmon were saved but an additional 60 were lost during pumping to obtain EWA water (flexing the Export:Inflow standard), for a net reduction in entrainment loss of 183 older juvenile salmon. In 2003, 675 salmon were saved and 230 were lost during extra pumping to gain EWA water for a net change in entrainment loss of 445 older juvenile salmon. EWA had essentially no effect on older juvenile salmon entrainment in 2004 because no EWA actions were taken prior to mid-April and no older juvenile salmon were seen at the SWP/CVP during the only EWA curtailments (the VAMP and post VAMP periods). A minor amount of extra pumping to reduce EWA debt in San Luis Reservoir (202 acre feet) was done in March at the CVP, potentially increasing the entrainment of older juvenile salmon by one fish.

<u>Change in Delta survival of Sacramento River basin salmon</u>

Models based on relationships derived from mark-recapture experiments conducted by the US Fish and Wildlife Service with coded wire tagged juvenile salmon (Models 1, 2 and 4) or from SWP/CVP loss data and catch per unit effort data in trawling at Sacramento and Chipps Island (Model 3) were used to estimate the change in Delta survival for winter run size salmon attributable to EWA pumping curtailments.

Models 1 and 2 are based on the results of experiments with paired release groups of late-fall run Chinook in Georgiana Slough and in the Sacramento River at Ryde during the winter months (Figure 3). Model 1 relates the Georgiana Slough:Ryde survival ratio to exports during the 17 days after salmon are released and includes data from 1993-1998. Model 1 model was originally shared with the panel in the 2001 Agency Salmon Biologist's report (Figure 4). Model 2 also uses the Georgiana Slough:Ryde survival ratio but uses exports during the first three days after fish are released and includes data from experiments in 1993-2003 (Figure 5). The relationships in Models 1 and 2 have relatively low r^2 values and are statistically significant at $p < 0.10$. Model 1 is used to assess the change in survival for fish emigrating into the Delta during February and March while model 2 is applied to salmon migrating into the Delta from mid-November through mid-April. In each model the relative number of fish migrating into the Delta each day is based on catch data from the Sacramento trawl with a 2-day lag. Both models calculate survival for the portion of the population migrating each day and add up the daily results for the no action case and with the EWA pumping curtailments, respectively.

Model 3 predicts survival changes from Sacramento to Chipps Island from a relationship between a survival index and the SWP/CVP loss for the season Figure 6). This relationship has a relatively low r^2 and is statistically significant at $p < 0.10$. The survival index is the average Chipps Island CPUE for winter run size Chinook divided by the average CPUE for winter run at Sacramento. Loss is the total loss for winter run size Chinook for the season. Data are from 1993-1994 through 2002-2003. One complication is that two different sets of size curves were used to characterize juvenile salmon as winter run at the three sampling location. Fisher curves were used to identify winter run and estimate their survival through the Delta using catches at Sacramento and Chipps Island and Delta curves were used to characterize fish as winter run at the SWP/CVP.

Model 4 uses the relationship of several environmental factors to survival through the Delta developed by Ken Newman (2003) from experiments conducted by the Fish and Wildlife Service where fall run tagged juvenile salmon were released in the north Delta and western Delta and recovered at Chipps Island and in the ocean fishery (Figure 7). Factors in the equation include river flow, river temperature, export pumping rate, turbidity, salinity and Delta Cross Channel gate position. Cramer et al. (2004) used this relationship as the Delta survival component in their Winter Run Chinook Salmon Integrated Modeling Framework model and this model component was used to compute survival values for the no- action and EWA curtailment cases. Average Sacramento River flow at Freeport and combined SWP/CVP pumping rate from December 1 – April 15 for the no-action case and the EWA case were used. For this analysis both model runs used actual DCC gate operations, 58 degrees for water temperature (a no-effect level), the default value for turbidity, and salinity predicted from a flow relationship.

Table 3 shows the changes in the survival metrics computed using the four models for 2001-2003. The biggest changes in the survival metrics from all the models are in 2001 when the most EWA (>200 taf) was used for pumping curtailments during the winter run migration season. Models 1, 2 and 4 showed increases of 0.01 to 0.03 survival metric units, representing increases ranging from about 1.4% to 4.5% from the no-action case. Model 3 predicts a much lower survival metric for the no-action case and an increase of 0.08 units, an increase of about 28% from the no-action case.

The results for 2002 show the combined effects of 67 taf of targeted EWA action, 38 taf of pumping curtailment in March that occurred because there was EWA water stored in San Luis Reservoir (not an action requested by the EWA Management Agencies), and 76 taf of extra pumping to obtain water for the EWA by flexing the E:I standard. The net result is a reduction in the survival metrics from models 1 and 2 and a small increase in the metric from model 4 (Table 3). As noted above, this result is likely due to the disparity between the temporal pattern of salmon vulnerability as described by Sacramento trawl catch for the modeling and the assumed (and hopefully accurate) pattern of vulnerability as determined from SWP/CVP and Chipps Island data that has been the basis for most EWA decisions. Whether or not this result is accurate or spurious due to input assumptions, it points out the fact that there is a downside to fish survival when pumping is increased to get water for the EWA and reminds us that the concept of the EWA is basically one of shifting pumping from the most harmful times to other times in order to reduce adverse effects to fish overall. The estimate of benefit was higher using the loss/survival relationship.

In 2003, the model results reflect 121 taf of fish actions (about half for salmonids and half for delta smelt and salmonids) and increased pumping to obtain 60 taf of water for the EWA, resulting in little or no net change in the four survival metrics (Table 3).

In 2004 there were no EWA actions and no extra pumping for the EWA prior to the beginning of the VAMP period in mid-April. Survival has not been computed for the no-action case (Table 3).

These model results indicate that only small changes in juvenile salmon survival can be accomplished through relatively minor SWP/CVP pumping curtailments using the EWA. Models 1 and 2 indicate it is possible that the positive effects of EWA actions could be more than offset by the adverse effects of increased pumping for the EWA at other times. A key to whether the output of these models is realistic is the assumption about when the salmon are present and being affected by project operations in the Delta. Model 1 and model 2 both use catch in the Sacramento trawl to describe the daily pattern of juvenile salmon input to the model. It is apparent from many years of sampling at Sacramento, Chipps Island and the SWP/CVP fish facilities that some salmon migrate into the Delta and exit the Delta within a short period of time (nearly coincident peaks in catch at all three locations). Other salmon migrate into the Delta and remain there for weeks or months before resuming downstream migration. Fish exhibiting the latter behavior may be relatively immune to the effects of pumping until they resume their migration. Decisions on Delta Cross Channel gate operations and some decisions on EWA pumping curtailments were based on data from sampling upstream of the Delta. However, most decisions to do EWA pumping curtailments or to do extra pumping to obtain water for the EWA were based on variation in salmon (or other fish) numbers at the SWP/CVP fish facilities, which corresponds closely to catch patterns for salmon at Chipps Island. For these reasons, it may be more realistic to characterize the timing of fish migration, and hence vulnerability to the effects of pumping, using the catches in trawling at Chipps Island instead of at Sacramento as in Model 1 and 2. Additional refinement of this input assumption and numerous other aspects of salmon survival modeling will be necessary to improve the realism of the models and our confidence in them.

Change in Delta survival of San Joaquin River basin salmon

The Vernalis Adaptive Management Plan has been investigating the role of San Joaquin River flow and export pumping on the Delta survival of salmon emigrating from the San Joaquin River tributaries with a barrier in place at the head of Old River. The San Joaquin River Group adds flow in the tributaries and thus to the San Joaquin River and southern Delta (measured at Vernalis) for 31 days from mid-April to mid-May. Concurrently the SWP and CVP reduce their combined pumping to achieve one of the several flow/export combinations in the experimental design matrix. The only EWA role is to accomplish some of the reduction in SWP pumping that produces the VAMP combined SWP/CVP export pumping rate. Survival of hatchery smolts released for the VAMP experiment is characterized by the combined differential recovery rate (CDDR) for pairs of release groups recovered at locations in the western Delta. The regression equation for CDDR’s (the measure of survival) versus Vernalis flow/export pumping rate for 5 years of VAMP experiment results (1994, 1997, 2000-2002) (Figure 8) was used to estimate survival for two conditions: 1) “without VAMP” flows and exports (flow:export = 1:1) but with the head of Old River barrier and 2) with the VAMP conditions (also including the HOR barrier). The difference is an estimate of the effect on smolt survival of the VAMP flow/export conditions in 2000-2004. We recognize that the multi-year VAMP experiment is in the middle of implementation, the results are preliminary and consequently so is this assessment.

The application of this regression model indicates VAMP conditions, including increased river flow and flow:exports in the range of about 2:1 to 3:1, result in a 60 to 100 percent increase in survival from the 0.10 survival predicted with the HOR barrier but without VAMP flows and exports (San Joaquin River flow at Vernalis and SWP/CVP export rate would be equal) (Table 4). The EWA action contributes only partly to this survival increase because the EWA is responsible for only part of the reduction in combined SWP/CVP exports. Adding river flow and reducing pumping probably work in combination to produce these differences. Recall that the effect on survival of the HOR barrier which blocks most fish from entering the head of Old River (a direct path to the CVP and SWP diversions) is present in both cases.

Improvements in survival accrue only to smolts migrating while these conditions are in place. Trawling at Mossdale on the San Joaquin River downstream from the confluence of the three main tributaries indicates that in most years a substantial proportion of the salmon smolts (58-76 percent) migrate from the San Joaquin River basin during the 31-day VAMP period and benefit from the VAMP conditions (Figure 9). However, in 2000 only 31% of smolts moved downstream into the Delta during the VAMP period, with roughly equal proportions migrating before and after the VAMP. This indicates that migration timing can vary, the out-migration period can be 3-4 months long, and a very large proportion of smolts may migrate outside the month-long VAMP period. These proportions include only those salmon emigrating as smolts and does not account for salmon that may come into the Delta earlier as fry and may or may not still be in the Delta.

After the VAMP period, typically the flow in the San Joaquin River at Vernalis decreases, export pumping increases and the HOR barrier is removed (due to concern for its potential adverse effect on delta smelt in the southern Delta). From 2001-2004 export pumping has been curtailed at or close to the VAMP period export rate for about two weeks primarily for delta smelt. In 2001 -2004 between about 7 and 17 percent of the smolt out-migration occurred during this post-VAMP period action. Effects of reduced pumping on the later migrating smolts were not analyzed.

Upstream actions

EWA-related actions upstream of the Delta have included increasing river flow by releasing water from reservoirs, usually at a time when the water could be re-diverted in the Delta for the EWA and used to repay EWA obligations to SWP/CVP. Releases of water for transfer through the Delta took place mostly in the summer months (July-September) because that is when the EWA had some dedicated pumping capacity. Primary sources have been the Yuba and American rivers. Increased summer flow in the lower reach of the Yuba River provides lower water temperature which can increase the amount of habitat suitable for over-summering steelhead for as long as the water transfer continues and lower temperature persists. How this may affect habitat for and the distribution of juvenile steelhead has been considered and is being investigated.

Water purchased on the American River has typically been released to the lower river in the fall to augment low river flow. In October–November 2001, a total of 20,000 acre feet of EWA water was released during several intervals, in conjunction with use of b(2) water, to maintain flows during this period. Assumed benefits of the increased flow include providing more riffle habitat for juvenile steelhead, reducing water temperature for rearing steelhead and adult salmon and providing more space for holding salmon.

From November 10-26, 2001 about half of the 1000 cfs being released from Folsom Dam (through Lake Natoma) to the lower American River was from the river level outlet at Folsom Dam, bypassing the powerhouse. This action had no EWA water costs; lost CVP power was replaced and accounted against power credits accrued by the EWA during earlier Delta pumping curtailments. Based on a comparison to modeled temperature without the bypass, after the three days for the effect of the cold water release to propagate through Lake Natoma, the blending of powerhouse and river level outlet releases resulted in a reduction of about 3 degrees F in the Nimbus Dam release temperature and of about 1.5 degrees F 13 miles downstream at Watt Avenue. The bypass was discontinued when the benefits ended because the cold water supply in the lower strata of Folsom Lake was exhausted. Due to the bypass/blending action the temperature of water released to the lower river at Nimbus reached 60 degrees F about 10 days earlier and 56 degrees F about 4 days earlier than modeling of the no-action case indicated. From field observations, pre-spawning mortality was estimated to be more than 60 percent of the run. Although effects on salmon mortality and spawning success have not been quantified, it is assumed that pre-spawning mortality would have been higher without earlier cooling provided by the action. Cooler water was provided to the Nimbus Hatchery as well as the river, minimizing temperature effects on hatchery operations.

The EWA bought 25 TAF on the Merced River in 2001 and released it between October 16 and November 11, 2001 in coordination with releases of water purchased with CVPIA and State funds pursuant to the San Joaquin River Agreement. The water provided a short term attraction flow of 700 cfs (base flow 85 cfs) and then a spawning flow of 425 cfs (base flow 220 cfs) which was then sustained at 400 cfs by a combination of base flow and SJRA water. This action was for fall run Chinook salmon. Attraction flow is intended to facilitate the upstream migration of adult Merced River fall run Chinook through the San Joaquin River main stem and into the Merced River. Higher flows during the spawning period are intended to provide more habitat area suitable for salmon spawning. The effects on these flow changes on salmon production have not been quantified.

Again in the fall of 2002, from October 25 through November 19, Folsom Dam river level outlet releases (about 49 degrees F) were blended with powerhouse releases to reduce water temperature in the lower American River which were not expected to decrease to 60 degrees F until mid- to late-November. River outlet release at Folsom Dam comprised between 20 and 33 percent of the total Nimbus release. With this action water temperature at Nimbus decreased to 60 degrees F on 10/28, about 12 days sooner than estimated from modeling the no-action case and to 57 degrees on 11/2. It fluctuated between 57 and 58 degrees F through November. Water temperature at Watt Avenue decreased from about 64 degrees F to 57 degrees F by 11/2 and fluctuated between 57 and 59 degrees F thereafter. Due to ambient air cooling water temperature from Nimbus Dam to Watt Avenue finally reached 56 degrees at the end of November. Conditions were not as adverse in 2002 as in 2001. Reservoir storage and the volume of cold water were both greater and 50 percent more water was being released to the river. Pre-spawning mortality was estimated to have been about 30 percent of the run, less than half that seen in 2001. Although not quantified, the bypass/blending operation was partly responsible for the lower mortality. Replacement power was provided using EWA funds.

In the first four years, very little EWA water purchased from upstream sources was released from the source reservoirs to improve habitat conditions in the river downstream without the expectation that it would be re-diverted for the EWA in the Delta.   EWA flow-related actions upstream were of minor magnitude, short duration and involved coordination with other sources of water to help cover a flow augmentation for a longer period. Flow/habitat models might be used to estimate the changes in habitat area for salmonid spawning or rearing, but extrapolating from increased habitat area to an increase in fish production is not straightforward. No attempt has been made to do this type of analysis.

Results of power bypass/blending on the lower American River were not quantified in terms of numbers of fish produced. Higher pre-spawning mortality of adult salmon on the lower American was observed in 2002 (67%) than in 2003 (30%) because conditions were worse to start with and the EWA action provided less improvement.

Note: A new water year (WY 2005) and EWA reporting period began on October 1, 2004. Habitat conditions for adult salmon and juvenile steelhead are less than satisfactory on the lower American River again this fall and, with little cold water remaining in Folsom Lake, another bypass/blending operation to access the small quantity of cold water left in the lake is anticipated, probably beginning in early November, 2004. Water purchased on the American River in 2004 is being held in Folsom Lake until more adult salmon are observed and releasing the water will help improve river habitat conditions for spawning. EWA mangers prefer that this water be pumped from the Delta for the EWA when it is released. However, we recognize that the later in the fall it is released, the chances that some or all of it will not be recovered in the Delta because the Delta goes from “balanced conditions” into “excess conditions” increase.

Summary/Conclusions

Regarding the use of EWA to reduce SWP/CVP take and avoid reaching the reconsultation levels for listed salmon and steelhead, in the first four years of EWA we have observed the full range of results. Most of the time the reconsultation levels of take for listed salmonids was avoided and in most instances would have been avoided without EWA actions. One exception is in 2001 when steelhead salvage almost reached the reconsultation level despite extensive January – March actions for which the primary rationale was the apparent exceedance of the reconsultation level for winter run Chinook.   In WY 2003, despite the use of 120 TAF of EWA, the percent loss exceeded the reconsultation level for two of the spring run surrogate groups. In 2004, no EWA actions were taken when spring run surrogate loss approached the reconsultation level and then exceeded it, because the agency biologists who examined the current information concluded that wild spring run salmon were not being unduly impacted. The concept of using surrogates for listed salmon is being re-evaluated.

Estimated changes in Delta survival from SWP/CVP pumping curtailments using the EWA for Sacramento basin salmon were for the most part relatively small. This is not surprising when the actions were small and brief. The most extensive actions (200 TAF) taken in January –March 2001 changed the various survival metrics estimated from three models by 1.5 to 4.5 percent. A fourth model, with perhaps the weakest underlying relationship, indicated a 28 percent increase. This is too wide a range of estimates for us to confidently define the benefit.

The small benefits of minor curtailments combined with the adverse consequences of increased pumping to obtain water for the EWA, could result in a small net benefit, no benefit, or potentially a detrimental impact. The net outcome is a function of the pumping reductions to help fish and the increases in pumping to obtain water for the EWA. These modeled outcomes also depend in part on how the timing of salmon presence and more importantly their vulnerability to export effects is represented. Some survival models used Sacramento trawl data to describe emigration timing. Other data such as SWP/CVP salvage or loss or Chipps Island trawl catches could be used. Data from all of these sources are considered when decisions are made to use EWA for salmon protection or to allow extra pumping to occur to get EWA water. Further analysis, including consideration of how the models are applied to assess EWA effects, is warranted.

Any increase in juvenile salmon survival will contribute to the affected salmon population, absent density dependent mortality factors later life stages. What percent change in survival is sufficient to justify the use of EWA for any particular Sacramento basin salmonid population depends partly on the status and trend in the abundance of that population? Actions achieving a small increase in a small population may be more easily justified than a similar increase in a larger population. EWA managers have applied this idea and used less EWA for winter run Chinook in the last few years because their abundance is much greater than the perilously low levels of 10-15 years ago and is trending upward. If the trend were reversed, our approach could change too. The success of our approach to applying EWA to help spring run Chinook salmon in the Delta during the winter and spring months is not so clear, given our incomplete understanding of the timing and abundance in the Delta, relative to other runs, of individuals from the spring run Chinook populations.

We do not yet have the ability to identify individual salmon by run so it is not always clear which run, if any, predominates at various locations at any given time. The picture is least clear in the Delta. Until we can sort salmon in the lower Sacramento River and Delta better we will continue to have uncertainty about which runs are present and our decisions about whether or not to use EWA to help them will have to take this uncertainty into account. We also need to consider making in-season assessments about salvage/loss at the SWP/CVP of particular groups of salmon (e.g. older juveniles, specific runs if and when we can identify them) in relation to their abundance at other locations in the Delta (e.g. Chipps Island). This can provide us with an additional perspective on the potential importance of Delta losses for particular groups, besides that provided by comparing take to reconsultation levels, and help clarify when actions to reduce impacts may be needed.

Escapement of winter run Chinook and some tributary populations of spring run Chinook (Mill, Deer and Butte creeks) have been higher in the last few years. Many factors have contributed. Broad ranging efforts have helped increase the abundance these various fish populations (for example, temperature control for Shasta Dam releases, adult and juvenile fish passage at Red Bluff Diversion Dam, fish screens on main stem Sacramento River water diversions benefiting winter run Chinook; fish passage improvements through dam removal, ladder improvements and fish screens benefiting spring run and fall run on Butte Creek, and greater inland and ocean harvest restrictions affecting both winter rand spring run Chinook). Hydrology (affecting the inland and estuarine environments) and conditions in the ocean environment are two factors beyond human control that can have substantial effects on anadromous fish populations. The assessment of the value of EWA actions and decisions about future application of EWA assets have to be made in this greater and shifting context.

EWA actions have affected Delta pumping in winter months in three of the first four years. Even in 2001 when the most actions were taken, the modifications to project pumping were rather modest overall and in 2002 and 2003 EWA actions in the winter months were half or less of the 2001 actions. We can conclude that these actions made some contribution to the survival of juvenile salmonids and subsequent abundance of later life stages, particularly in 2001. The magnitude of these benefits for salmon and steelhead, relative to survival and abundance changes due to other factors, is uncertain.

Our sense of the degree to which export pumping may affect Sacramento basin salmon survival and the reduced urgency to achieve that level of effect given the somewhat improved status of the listed salmon runs has affected EWA decisions and resulted in less EWA being used for this purpose, including none used in 2004. These have been decisions based on the conditions existing at the time and do not represent rigid rules.

Population models like the one being developed by Cramer et al. (documentation provided separately to the panel) may provide us with a basis for comparing the benefits of the range of fish protection and restoration measures in the future.

Comparison of the EWA benefits with the benefits from the other factors we are manipulating requires that the effects of the other factors also be quantified. More comprehensive information on how some of the individual actions affect salmon will be needed to be developed.

The VAMP experiment is designed to investigate the influence of river flow and exports with the HORB in place on Delta survival of juvenile salmon from San Joaquin River tributaries. The experiment as planned has several years to run, so results are preliminary. Results in 2003 and 2004 are particularly perplexing. The pre-2003 results were used to assess effects of the flow (for which EWA has no part) and exports (for which EWA is used for only part). The combined VAMP condition appears to be beneficial for San Joaquin juvenile salmon survival. This use of EWA, which concurrently addresses concerns for delta smelt, will be continued so the VAMP experiment can be completed.