An Interpretive Summary of the May 27, 2005 Delta Action 8 Workshop

Held in
Stockton, California

by
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For
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Introduction

On May 27, 2005 the California Bay-Delta Authority's Science Program sponsored a workshop to examine the purpose and results of US Fish and Wildlife Service (USFWS) studies to evaluate the effects of pumping by the Central Valley Project (CVP) and State Water Project (SWP) on survival of juvenile Chinook emigrating through the Sacramento-San Joaquin Delta during winter. (See attachment 1 for the list of attendees.) These studies, called "Delta Action 8", originated in an October 1996 proposal by the USFWS's Anadromous Fish Restoration Plan (AFRP) group for nine actions intended to increase protection of juvenile Chinook salmon in the Delta. The workshop was convened specifically to review plans for 2005 and 2006 Delta Action 8 (DA 8) studies, although discussion at the workshop explored some broader issues.

The DA 8 studies have been conducted to assess the potential benefits to juvenile Chinook of reducing the ratio of export flow to Delta inflow (the E:I ratio) from 65% to 35% during November 1 through January 31. (The E:I ratio is currently 35 % from February 1 through the end of May each year.) Delta Action 9 would implement the 35% E:I ratio, should DA 8 studies show that the reduction would benefit emigrating salmon. The USFWS has not requested that DA 9 be implemented, nor did the 2004 OCAP Biological Opinion contain a requirement that the 35% E:I ratio be in place during winter.

Our approach is to describe some of the basic structure of the DA 8 studies condensed from the material Brandes (USFWS) submitted as background for the workshop (see http://www.delta.dfg.ca.gov/jfmp/patfiles.asp. for all the background material), briefly summarize the discussion and provide some comments on the overall approach. Finally we reach some conclusions and recommendations based on the written material, discussions at the workshop, and our experience working with the results of these studies. Our report is supplemented by two attached reports (attachments 2 and 3) prepared by two scientists familiar with conducting and/or analyzing juvenile salmon survival studies – Russell Perry (USGS, Biological Resources Division – Cook, Washington) and Ken Newman (University of St. Andrews, Scotland) – who were invited to the workshop specifically to offer oral and written comments on the study approach and results.

Our purpose in preparing this summary is to promote continued discussion and analysis of the effects of SWP and CVP pumping on the survival of juvenile Chinook as they move through the Delta. Together with the very comprehensive background material compiled by Brandes and the thoughtful comments by Perry and Newman, this summary should help provide the basis for decisions by the agency managers about future salmon survival studies in the Delta. Among the decisions to be made will be whether to continue DA 8, and coded wire tag (CWT) release/recapture studies in general, and, if so, in what format. The key to making this decision will be to develop management questions and to propose studies that can realistically be expected to address them.

Readers will note that this is not simply a summary of the DA 8 workshop. In keeping with a recommendation by Johnnie Moore, the CALFED Lead Scientist, regarding our role as science advisors in workshops supported by the Science Program, we have included our thoughts and recommendations on what we have learned and where we might go. We recognize that the DA 8 studies are conducted by the USFWS using a mix of Interagency Ecological Program (IEP) and Central Valley Project Improvement Act (CVPIA) funds. (IEP funds some of the sampling at Chipps Island and the ocean fisheries and the CVPIA b2 funds tagging and the remainder of the Chipps Island sampling as well as data analysis and reporting.) The Calfed Bay-Delta Program is a member of the IEP and also has funded specific studies dealing with juvenile Chinook salmon survival.

This summary report is intended mainly for the Calfed Lead Scientist, workshop attendees, and others familiar with the Sacramento –San Joaquin Delta and Central Valley Chinook. Interested readers can find a more complete description of the system and the general study techniques in Brandes and McLain (2001).

Experimental Approach

The following contains a brief description of the DA 8 experimental approach, mostly extracted from the background material. Experiments have been conducted during most late fall/early winter periods from 1993-4 through 2004-5. The overall management question to be addressed by DA 8 studies was:

Should the inflow/export ratio be reduced to 35% between November 1 and the end of January to protect juvenile Chinook salmon emigrating through the Delta at that time?

Although all four Chinook races may reside in or move through the Delta during November - January, much of the management emphasis has been on protecting listed winter Chinook smolts and spring Chinook yearlings. Since it was not possible to obtain wild winter or spring Chinook test fish, the USFWS chose to use late-fall surrogates from the Coleman National Fish Hatchery (CNFH). The CNFH typically rears about one million late-fall Chinook, which are coded-wire tagged before release. Production fish are released below the hatchery in Battle Creek. Other tagged hatchery late-fall Chinook have been released as test fish – either as surrogates for spring run (upstream releases) or as surrogates for winter and spring run in the DA 8 studies. About 300,000 late-fall Chinook have been allocated each year to the DA 8 studies, although in some years the number was reduced because of fish losses in the hatchery. Also, in two years, test fish were used in studies of the Delta Cross Channel and there were no DA 8 studies. (See attachment 6 for a more complete description of using late-fall Chinook as surrogates in DA 8 studies.)

The test fish were trucked to various release sites in the Delta, with the sites selected to yield indices of survival of juvenile Chinook salmon that travel by different routes through the Delta, and therefore may be exposed in various degrees to the effects

of SWP and CVP pumping in the south Delta. Since these survival values are indices rather than absolute survival estimates, ratios of survival indices from different release points are used to infer environmental influences on survival, especially those due to export pumping.

Some of the key release sites are shown in Figure 1 (From Brandes background material.) For the DA 8 studies, two important release sites have been:

- Georgiana Slough – Fish released in Georgiana Slough (GS) are assumed to remain within the interior Delta and thus must use a longer migratory pathway to the ocean. Fish entering this slough are also expected to be more exposed to the direct effects of project pumping than fish released at the Ryde site described below. Hydrodynamic data have indicated that flow in GS is unidirectional towards the San Joaquin River.
- Ryde – Fish released at this site are assumed to migrate directly down the lower Sacramento River, and are therefore not exposed to the effects of export pumping. Thus, the ratio of survival of fish released at Georgiana Slough to that of fish released at Ryde are intended to provide information about survival in the interior Delta, and therefore the effects of

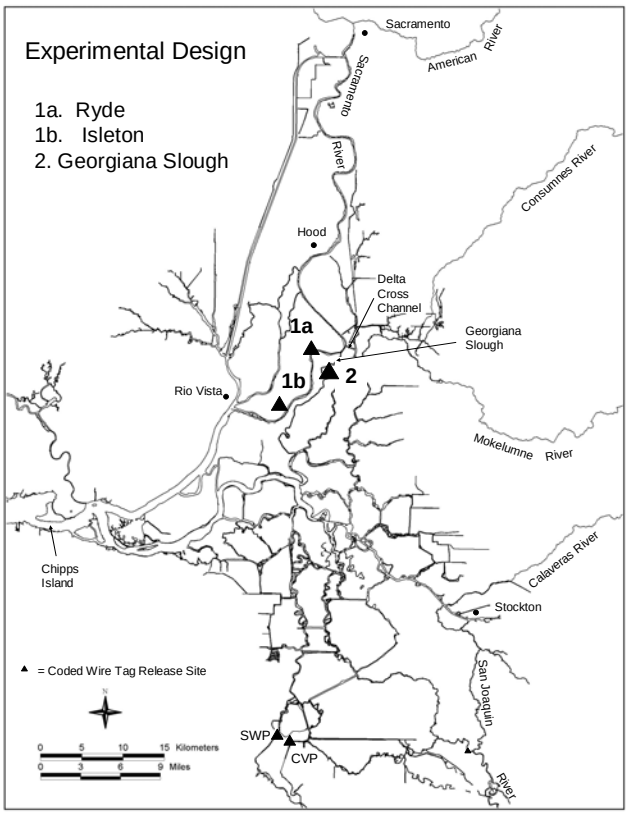

Figure 1: Experimental design for Delta Action 8

pumping.

Additional release sites have included:

- Near Sacramento – This site is at the upstream edge of the Delta. Fish released there have to traverse the entire system and recoveries of tagged fish provide an over-all index of through-Delta survival. This survival can change depending on internal Delta conditions that may affect salmon survival such as flow, flow splits at junctions, and whether the Delta Cross Channel is open or closed.
- Vorden – This site downstream of Sacramento was used to estimate the effects of the Cross Channel and Georgiana Slough when compared to Ryde releases and to estimate the effects of passage through Steamboat and Sutter sloughs when compared to Sacramento releases.
- Sherman Island – These releases were to provide estimates of absolute survival to Chipps Island.
- Near Port Chicago - This site is below the Delta and below the Chipps Island tag recovery site (see below). The assumption is that this site provides an overall control for ocean recoveries for evaluating survival from other locations

Tagged fish were recovered at four locations:

- At the state and federal fish salvage facilities. Recovery of these tags provides an estimate of travel time from different release sites but the tag recovery information is not used in estimating survival.
- In mid-water trawling operations at Chipps Island. The USFWS takes ten 20-minute trawls on most days during the period when test fish are expected to be recovered. The catches are expanded by sampling time and estimated fraction of the water column sampled to yield estimated total catches of tagged fish.
- In the ocean fisheries. Off California, the DFG Ocean Salmon Project samples about 20% of the ocean catch, and collects heads of fish with clipped adipose fins (i.e., hatchery-reared fish). Similar programs operate in Oregon and Washington, with the majority of the DA 8 tags collected from the California and Oregon recreational and commercial fisheries.
- In the inland waters when the adults return to spawn. Heads from fin-clipped adult salmon are collected during spawning surveys and in the six Central Valley Chinook salmon hatcheries. Information from these freshwater tag recoveries is not used in estimating Delta juvenile salmon survival, mainly because the effects of straying by juvenile late fall Chinook released in the Delta are unknown. The inland tag recovery information can be used to obtain an idea of the straying of DA 8 test fish compared to similar fish released in Battle Creek below the hatchery.

Heads from the salvage facilities and the Chipps Island trawl are sent to USFWS offices in Red Bluff for tag extraction and decoding. The heads from fin-clipped fish collected in the ocean fisheries off California are sent to the DFG office in Santa Rosa for extracting and decoding. Adult heads collected from all streams and hatcheries except Battle Creek and Coleman National Fish Hatchery are sent to DFG in Santa Rosa. The USFWS handles all heads on Battle Creek and from the CNFH and Livingston Stone National Fish Hatchery.

The tag recovery data from the Chipps Island and fish salvage operations are stored on an internal USFWS data base and posted on the IEP website. Tag recovery data from the ocean fisheries and the adult inland recoveries are stored in the Pacific States Marine Fisheries Commission's Regional Mark Information System (RMIS) data base.

Per the Brandes background paper, the hypotheses being tested are:

- The ratio of the Georgiana Slough (interior Delta) survival index to that from Ryde/Isleton is inversely related to export flow.
- Survival through the Delta is higher with lower export flow.
- Survival is higher with lower export flow when the Delta cross channel is closed.
- Juvenile Chinook salmon diverted into Steamboat and Sutter sloughs have higher survival than those staying in the mainstem Sacramento River.

The major assumptions underlying the DA 8 studies – also from the Brandes background paper - are:

- Survival of fish released at Ryde is not affected by export flow.
- Survival of fish released downstream of Sherman Island /Port Chicago is the same for all groups released in one experiment (released usually within 1 day of each other).
- Survival of upstream release groups is the same as downstream groups once the upstream groups reach the downstream location. Thus, the only difference in survival is due to effects occurring during migration from the upstream location to the downstream location.
- There is an equal probability of capture of all groups at Chipps Island (after correcting for sampling effort) and in the ocean fisheries.

As explained by Brandes the following procedures are used to obtain the survival estimates, ratios and ocean recovery rates.

The survival index to Chipps Island is calculated by the following formula:

*S = # recovered/((# released) * (fraction of time * fraction of area sampled))*

The fraction of time sampled is calculated based on the number of minutes sampled between the first and last recovery at Chipps Island divided by the total number of minutes during that period. The fraction of area sampled is the net width (30') divided by the width of the channel at Chipps Island (3900') and equals 0.007692.

The survival indices have been calculated for each tag code when more than one tag code is used within a group. Group survival is calculated by combining the recovery and release numbers and time sampled for two tag codes. The USFWS has used this group survival when calculating the Georgiana Slough/Ryde survival ratio. In 2003 and 2004 we also have reported mean survival (plus and minus two standard deviations) when comparing groups within a year. Although two tag codes have been used in these later years, they are still raised together in the same pond and trucked together thus they are not truly independent of one another.

The ocean recovery information is reported as ocean recovery rate, which is the expanded number recovered in the ocean fishery divided by the number released.

The survival ratio is simply the ocean recovery rate of the Georgiana Slough group divided by the Ryde group and is called a differential recovery rate. With the Chipps Island survival indices the ratio of survival is the survival index of the Georgiana Slough group divided by the survival index of the Ryde group.

A differential recovery rate was also calculated for the Chipps Island recoveries.

Experimental Variables

As with most large field studies, several variables may affect the outcome. Some of these variables were controllable and others were not. In terms of control, the desired state would be that experimental conditions would be stable at least from time the fish were released until most of the fish were recovered at Chipps Island. The following seem to be important variables that fall into these two categories, although analytical emphasis was on export flow:

Controllable – To a considerable extent, the USFWS could control the time of release, the release location, and the numbers of fish that were released, although release date and numbers of fish were somewhat dependent on hatchery operations. To a large extent the Service could control sampling effort, however weather and take limits for delta smelt could affect sampling. The position of the Delta Cross Channel gates can be largely be controlled and the FWS selected the closed position to minimize the number of experimental variables, although in 1999 the gates were opened during the experiment because of concerns over water quality in the interior Delta. By reviewing tide tables, and releasing fish on specific tidal phases, the effects of tidal currents on fish movement (and recovery) can be evaluated.

Uncontrollable – Some of the major experimental variables could not always be controlled to the extent needed to ensure that the studies would yield definitive results addressing the management question driving the studies. Some of the more important non-controllable variables were:

- Freshwater flow - Inflow to the Delta varies with natural hydrology and with reservoir operations to meet flood management, instream flow, and other

regulatory requirements, and to allow for export pumping from the Delta. Providing a specific, stable flow is difficult, particularly in late fall/early winter for the ~3-week tag recovery period.

- Export pumping – In principle pumping by the State and federal water projects should be controllable, at least for a few weeks. In practice, this has not been the case because the projects must adjust their pumping to meet unanticipated changes in hydrology, demand, Delta conditions, etc. In addition, it has proven difficult to test the full range of pumping levels that is needed for adequate statistical power, particularly the lower pumping levels.
- Export/Inflow ratio - As one might expect, since pumping and flow cannot be controlled, the E:I ratio cannot be controlled. In fact, the USFWS quickly dropped the attempt to control this ratio and focused on pumping rates alone.
- Water temperature – There is considerable inter-annual variation in water temperature and, to a lesser extent, variation on weekly and geographic scales; variation in water temperature may affect the survival of hatchery fish released after several hours of transit (the "shock effect").
- Condition of test fish – Although naturally produced test fish would have been preferable to hatchery fish, this was not practical. The late-fall Chinook from the CNFH were to be at the migratory stage and all releases groups (from various raceways) were assumed to be of comparable quality. A less important assumption is that test fish were generally of similar quality from year to year.
- The regulatory climate – Although not often considered an experimental variable, the regulatory and management climate can affect variables such as pumping. For example, when DA 8 studies were first proposed, there no Environmental Water Account (EWA), Data Assessment Team, or Water Operations Management Team. The EWA related activities now provide the opportunity of the fish agencies to request the cross channel gates to be closed for up to 45 days during October through January and to reduce exports if this action would benefit sensitive fish species – thus effectively changing the export:inflow ratio for a short period. The regulatory and management climate can affect the type of management question being asked and the type of study one would need to address it.

Results

Brandes documented the results of the DA 8 extensively in her background report and supporting figures and tables found at http://www.delta.dfg.ca.gov/jfmp/patfiles.asp.

In the background report, Brandes presented results from all the releases; however, her presentation and the discussion focused on the comparison of survival from Ryde and Georgiana Slough releases, which included the bulk of the data. As summarized by Brandes, the overall results from this comparison were:

The ratio of the Georgiana Slough survival relative to the Ryde survival (or recovery rate in the ocean fishery) is correlated to mean combined exports at the State

Water Project (SWP) and Central Valley Project (CVP) for the three days after the Georgiana Slough release. The relationship using the ocean information and only 11 data points is statistically significant ($p<0.05$). The ocean information for the last three releases is not yet available. The relationship using the same 11 points for the Chipps Island survival ratios is also significant at $p < 0.05$. The slope of the two lines are not different indicating their relationship to exports is similar. The intercept of the regression lines are significantly different – indicating that the ocean index is predicting a higher ratio at any one flow.

Discussion by attendees

Instead of going through the discussion point by point, we have chosen to summarize it into several bullets organized around major issues. Although the workshop was originally aimed at obtaining ideas on what to with DA 8 studies in 2005 and 2006, it quickly became apparent that there were some general issues associated with these studies and these issues could affect the future of DA 8 and other salmon survival studies in the Delta. Note that the issues listed below are not necessarily in order of importance or the timing of the discussion at the workshop. It should also be kept in mind that the discussion points are based on notes taken at the workshop by the authors. Finally, the issues are not entirely discrete – that is there is overlap among them. We do not link specific speakers with specific issues but want to thank Bryan Manly, Tina Swanson, Brad Cavallo, Steve Cramer, Ken Newman, and Russ Perry for their contributions to the discussion. These participants were particularly valuable in that they understand the issues but were not directly involved in conducting or analyzing the DA studies.

1. The relevance of DA 8 study results to management questions associated with the effects of water project pumping on the survival of juvenile Chinook salmon moving through the Delta. There are some important subsets of this issue:
    a. The specific management questions being addressed by DA 8 studies.
    b. If the management questions have been identified (for example, should we go to DA 9?) whether the studies provide the information needed to address that question.
    c. The fraction of Chinook salmon that enter Georgiana Slough under different flow and gate operational conditions.
    d. Issue c above leads to the larger question of salmon smolt movement through the Delta and which pathways they use under different conditions.
    e. The overall survival of juvenile Chinook salmon through the Delta and the effects of pumps on this survival. The GS survival is a component of this survival but because of issue c above its importance is unknown, and the DA 8 studies cannot provide the information needed to assess the relative importance of this component. Therefore the study design is incomplete with regard to its original purpose.
    f. Biological versus statistical significance. Are we spending too much time on improving the r-square values while ignoring the broader biological questions of the population level effects of fish losses in GS that can be tied to pumping?

g. Are the past coded wire tag studies using fall run relevant to winter and spring run questions? Stated another way, do DA 8 studies increase our overall understanding of salmon survival through the Delta?

2. The usefulness of Chipps Island Trawl data. This issue centered mostly around capture probability versus estimating survival, although there was concern about the low number of recaptures.
3. Variables to use in relating GS survival to pumping. Bryan Manly provided analyses that indicated water temperature was an important variable affecting survival of fish released in GS and found only a weak relation with pumping (Attachment 4). Discussion of that issue did not suggest a mechanism for a temperature effect in winter. Several questions were associated with the lag period used to average flow conditions; Brandes used 3 days which gave the best fit, but some questioned the justification for that period.
4. What more do we need in the way of DA 8 data points? Put another way, how long are DA 8 studies expected to continue? Kimmerer proposed that data points at the lower and upper ends of the pumping range would be more helpful than points in the middle of the range, which provide almost no new information.
5. The assumptions necessary to conduct and analyze DA 8 studies. The concern was that too many of the assumptions have not been adequately tested and verified.
6. The use of late-fall hatchery fish as surrogates for winter and spring Chinook. Several questions were raised about the suitability of hatchery fish to mimic the behavior and survivability of wild fish.
7. Subsequent straying of adult late-fall experimental fish released as juveniles in the Delta. As documented by USFWS Coleman National Fish Hatchery staff (mentioned briefly in attachment 6), the test fish stray at a much higher rate that those released at the hatchery. Test late-fall Chinook released in the Delta are now being found in all of the larger Central Valley streams (Brown 2006, see Table 1 for some data from American River and Nimbus Hatchery) where they are not endemic. Since about one-third of the CNFH late-fall production has been dedicated to these tests, this high straying rate can affect the hatchery's production and mitigation goals.

Table 1. Combined expanded tag recoveries from the American River and Nimbus Fish Hatcheries in 2003 and 2004. (Data extracted from PSMFC mark information data base, as reported in Brown 2006.)

Tag origin by hatchery	**2003**	**2004**
CNFH*	265	247
Feather River Hatchery	1506	160
Merced Fish Hatchery	351	305
Mokelumne Fish Hatchery	409	963
Nimbus Fish Hatchery	7149	3008

*All CNFH tags were from DA8 experimental releases

Comments by the outside experts

Perry and Newman submitted written comments and recommendations following the workshop (attachments 2 and 3). Everyone should read and consider the very thoughtful comments from both experts. The following is a brief summary of what we take from the reports.

Overall **Russ Perry's** recommendation appeared to be to continue DA 8 studies (or at least CWT mark-recapture studies) as part of a broader study design that incorporated additional technology, such as acoustic tags. This recommendation is supported by the following passage extracted from Perry's report:

This example shows that to estimate the effects of water exports on survival of the population, we need to know 1) the proportion of fish passing each route, 2) survival rates of fish using each route, and 3) the effects of water management actions (exports and operation of the Delta Cross Channel) on survival rates and the proportion of fish passing each route.

One major drawback of the Coded Wire Tag (CWT) survival study is that it can not address the complex processes that likely affect the overall survival rate of the population of winter run juvenile Chinook salmon. What became clear through discussions at the workshop was that survival rates of juvenile salmon will likely depend heavily on the pathway (or route) of fish through the Delta.

The CWT survival study estimates only one component of the "big picture" – survival rates of fish using Georgiana slough relative to those using the mainstem Sacramento River below Ryde/Isleton. Missing from this picture are survival rates through other routes (e.g., Steamboat/Sutter Slough and the Delta Cross Channel) and the proportion of the population passing through each route. Even if survival rates of fish in the Central/Southern Delta are negatively related to exports, exports may have a small affect on survival of the population if a low proportion of fish pass into the Central/Southern Delta.

We recognize the possible problems associated with extracting statements out of context and again urge you to read the entire report.

Ken Newman offers 21 recommendations for next steps. By our informal count, 13 of the recommendations deal with new approaches to analyzing the existing information, 6 suggest new approaches to consider if DA 8 studies were to continue, and 2 suggest that acoustic tagging studies would complement mark-recapture studies. Newman provides background information to support each recommendation. Newman's overall recommendation seems to be to continue DA 8 with modifications to help resolve some of the issues associated with the study design. He also seems to advocate the use of acoustic technology that may answer some of the questions that cannot be answered by CWT mark-recapture methods. For this latter point, see specifically Suggestion 4, Section 6.4 on page 17 of his comments.

Kimmerer and Brown's comments and recommendations on proceeding with DA 8 studies.

Near the end of the discussion period, Zach Hymanson proposed the following decision tree to help organize the group's thinking on how to proceed. We believe his points should be kept in mind as we plan for future Delta salmon survival studies.

Should FWS continue to pursue the Delta Action 8 (DA 8) Experiments? This is the question Zach posed to all attendees at the workshop. He also identified several possible options given a yes or no answer to the question.

If yes, then plausible options identified during the course of the workshop included:

1. Continue doing the experiment and incrementally modify the experimental design to refine the information obtained. This option assumes aggressive and complete analysis of all data collected through the DA 8 experiments.

2. Continue doing the experiment and expand the experimental array to concurrently complete other associated studies (e.g., try to quantify movement patterns and the various sources of mortality occurring in the Delta) and incorporate other technologies (e.g., radio tagging) to enhance our understanding of salmon behavior and movement.

If no, then plausible options identified during the course of the workshop included:

1. Stop all fieldwork but fund a thorough analysis of the existing data and associated information (Newman and Manly proposed some additional analyses). These analyses would likely include simulation modeling to help refine assumptions. The results of these analyses would undergo peer review and would serve as the basis to identify remaining questions and the experiments needed to address those questions.

2. Stop the existing DA 8 experiments and instead put all efforts into determining, as accurately as possible, the proportion of emigrating salmon going into the interior Delta.

3. Summarize and synthesize existing information and take this information to agency managers to see if: a) they want to continue to fund DA 8 experiments, b) if they are ready to make a decision on DA 9, or c) they have other ideas or concerns.

4. Abandon DA 8 experiments altogether.

Below we discuss what we conclude has actually been learned from this series of studies. We also discuss some issues that have been raised regarding the experimental approach and analysis. In general data have been analyzed through regressions of

survival indices or ratios on environmental variables. We focus here on the ratio of survival indices at Georgiana Slough to Ryde and their relationship to export flow. Newman (Attachment 2) provides detailed commentary on the statistical approach; we focus mainly on some other experimental issues.

Relevance to the original question: Survival of juvenile Chinook salmon emigrating through the Delta is the mean of survivals of salmon migrating down each pathway, weighted by the proportion that take each pathway. The original question related to survival through the Delta, not through a particular pathway. Thus, the DA8 experiment as actually conducted provides only a piece of the answer, and it will be a small piece if relatively few fish actually use the Georgiana Slough pathway. There appear to be no plans to determine the fraction of fish taking different pathways; thus, the results of the DA8 experiments conducted to date have little context regarding the question of overall juvenile salmon through Delta. .

Comparing the survival indices from 2002, 2003 and 2004 provides an example of how we should put Georgiana Slough survival in perspective (data from the Brandes background report):

Survival Index to Chipps Island by release location

Year	Sacramento	Ryde	Georgiana Slough
2002	0.515	0.397	0.017
2003	0.412	0.282	0.079
2004	0.58	0.59	0.19

Taking these data at face value, survival from Sacramento to Chipps Island in these 3 years appears better or equal to that from Ryde to Chipps Island. Since survival of Georgiana Slough releases was much lower than for either Sacramento or Ryde releases, one possible conclusion is that few of the fish released at Sacramento entered Georgiana Slough. It isn't clear however, that the Sacramento and Ryde indices are statistically distinguishable.

Expansion factors for recaptures at Chipps Island: The expansion factor should be the inverse of the fraction of the cross-section sampled, divided by the volume sampled and multiplied by the speed with which the fish move through the Chipps Island cross-section. This would give a flux of fish moving past Chipps Island. Instead, the expansion factor is the fraction of the cross-section sampled times the fraction of the time sampled. The tacit assumption behind this calculation, never stated, is that the fish move past Chipps Island at exactly the speed at which the net is towed through the water. This seems unlikely. Note that this problem does not apply to ocean recoveries. Also note that Brandes and Kimmerer continue to discuss this comment to determine how it should be handled.

Assumptions: Numerous assumptions of the approach are not met. Several of these are addressed in Attachments 2 and 3. The biggest problems seem to be:

- The time factor for recaptures at Chipps Island depends on the time between the first and last recapture; however, that time period depends on the number of fish actually migrating, since the more that are migrating the higher the chance of catching one or more fish on a given day. Therefore the time factor is biased in favor of the Ryde release group.
- Export flow, the key variable chosen for analyses, is too variable, causing ambiguity and forcing a choice about the appropriate averaging period. The period selected, 3 days, seems short relative to the time it takes for the fish to leave the Delta. The fact that this time period gives the best fit of survival ratio to export flow merely emphasizes the point that the averaging period should be chosen on the basis of fish behavior. As Pat pointed out, however, some of Dave Vogel's unpublished field data support the 3-day interval
- Nobody knows if naturally-reared fish, the ultimate concern of this exercise, behave anything like the hatchery-reared fish used in these experiments. It seems unlikely.

Conclusions and recommendations

We now have over 10 years of DA 8 studies. USFWS staff has done a remarkable job acquiring, transporting and releasing test fish, trawling at Chipps Island to recapture tagged fish and trying to make sense of Chipps Island and ocean tag recovery data. All this has been done in a constantly changing system. Below are some thoughts on where we are after this decade of intense effort, followed by a few recommendations on next steps.

What have we learned from DA 8 studies?

- The system is very complex and it is nearly impossible to have stable flows and pumping rates for more than a few days at a time.
- Juvenile salmon in Georgiana Slough do not survive nearly as well as those that remain in the mainstem Sacramento River.
- Results of the paired-release studies suggest that export flow may reduce survival of fish released in Georgiana Slough compared to those released at Ryde; however, this is based on a small number of points and the analytical summary presented at the workshop did not have time to go into the details of several methodological and statistical difficulties. (Perry and Newman do discuss these problems in their written comments – attachments 2 and 3.). Furthermore, Manly's analysis (attachment 4) showing a temperature effect on the survival ratio casts doubt on the interpretation of changes in survival ratio as depending only on export flow.
- Recaptures of tagged fish by Chipps Island trawling are low and thus there is little statistical power in analyses using these data. Using tag recoveries from the ocean fisheries increases the power. A corollary of this finding is that Chipps Island trawling is not a particularly useful component of the experimental

procedure. Chipps Island trawling may have benefits other than for this study and its continuation should be based on its value for all purposes.

- Test fish are straying to all Central Valley streams at much higher rates than have been found from upstream releases (above and in attachment 6). Since late-fall Chinook are not found in these streams, introducing these fish may have undesirable biological consequences.

What we have not learned from DA 8 studies?

- We know little or nothing more about the benefits of changing the E:I ratio to 35% during the November 1 through January 31 than we did in 1994. This is due principally to the incompleteness of the experimental design to answer the original question, although the low power of the analyses and ambiguity about the experimental conditions during the experiments contribute to this lack of conclusiveness.
- DA 8 studies have not increased our understanding of the overall effects of project pumping on overall survival of emigrating winter Chinook salmon through the Delta. The principal reason for this rather strong statement is the incompleteness of the design discussed above. In addition, there has been little attempt to assess the population-level impacts of changes in survival attributed to export pumping. Also, the focus of the analyses and discussions has emphasized statistical significance rather than biological importance.

Where should we go next?

Thinking about the future of juvenile salmon survival studies must be a collective effort, involving not only agency biologists but also stakeholders and technical specialists such as Russ Perry and Ken Newman. Although much of the management focus is now on the decline of several pelagic species resident in the estuary, juvenile Chinook salmon survival, and the effects of water project operations on this survival, is still important to managing the Central Valley system. We must point out that we don't have any magic bullets but do believe that a pause in the study program for some focused discussion will benefit not only the biologists and managers, but hopefuly even the fish.

<u>We recommend the following specific actions be considered</u>:

1. Stop conducting DA 8 studies as they now stand. Design an alternative approach that will address the entire issue of Chinook survival through the Delta and the possible effects of water project operations. Some specific recommendations appear below. The general model should be that developed in the EWA program: interagency cooperation supplemented with Science Program and stakeholder input and outside review,

2. Thoroughly analyze and document the results to date. Brandes' background report is an admirable start in that the data seem to be all there. We suggest that Brandes use the suggested pause in the field program to work with a quantitative scientist to convert this information into a peer-reviewed

publication. This will force a focus on the assumptions, the limitations on interpretation of the results, and the statistical issues that Ken Newman raises. The recent CALFED Science Program PSP grant to the USFWS should meet this need

3. Develop a long-range study plan (minimum 5 years) according to the following approach:
   - This planning effort should be directed by a small group of agency biologists with support from others as appropriate. The planning group should consider working sessions that include a broader community of biologists, other scientists, and engineers convened to discuss technical aspects of the proposed program. We specifically recommend that Russ Perry. Dave Vogel, and Jon Burau be part of the discussions. Ken Newman and Bryan Manly, or other statisticians, should also be included.
   - These studies should be planned in the context of the current adaptive paradigm being used to manage Chinook salmon in the Delta – that is, the EWA-DAT-WOMT process and the 2004 NOAA Fisheries Biological Opinion on OCAP. The emphasis should be on reassessing the purpose of such studies and adapting them to current needs as identified in management questions. What additional data and information do we need to support the existing management model and assessing the benefits of actions to protect Chinook salmon? What are the important questions to be addressed?
   - Delta studies should be integrated with upstream studies as much as possible. For example, large numbers of late-fall Chinook salmon are released upstream. Can analyzing these data – survival to Chipps Island, the ocean fisheries, and escapement – be related to environmental variables in including Delta pumping?
   - The planning process should include updated quantitative models of our understanding of salmon migration and sources of mortality from emergence through the ocean and back again. Only with this sort of perspective will we will be able to assess the importance of survival in any particular geographic segment of their range or life history stage. The existing data could be used to conduct some simulation studies that examine the relative benefits of certain actions.
   - Consider holding specific technical workshops on new techniques (acoustic and radio tags, and PIT tags) to be considered for inclusion in the long range plan. At the workshop Steve Lindley described a new study he and his colleagues proposed to Calfed and which Calfed partially funded. (See attachment 5 for a brief description of the study.) Consider working with Lindley and his colleagues to mesh their study with specific mark recovery studies to address management questions.

Acknowledgment

We acknowledge the help of Pat Brandes, without whom the workshop would not have happened. She conducted the studies, analyzed the data and provided these analyses as background material for the workshop. Pat also reviewed an early draft of this report and provided several comments which we believe improved our report. We do not agree with Pat on the conclusions and recommendations but the discussion has been helpful – at least to us.

References

Brandes, PL and JS McClain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. Pages 39-138 in Contributions to the biology of Central Valley salmonids. RL Brown, editor, Calif. Dept. Fish and Game, Fish Bull. 179.

Brown, RL. 2006. Nimbus Salmon and Steelhead Hatchery - The first 50 years of Chinook culture with a note on steelhead. Final report to the Water Forum, Sacramento, CA.

Attachment 1 to DA 8 workshop summary report –
Attendance list

Name	Organization
Randy Brown	Calfed Science Program
Dan Odenweller	DeltaKeeper
Steve Cramer	SP Cramer and Associates
Russell Perry	USGS, BRD
Kevin Niemela	USFWS, Red Bluff
Tina Swanson	The Bay Institute
Bruce Oppenheim	NOAA Fisheries
Bryan Manly	West, Inc.
Steve Lindley	NOAA Fisheries
Wim Kimmerer	San Francisco State University
Ken Newman	University of St. Andrews
Zach Hymanson	Calfed Science Program
John Williams	Private Consultant
Jim White	Fish and Game
Russ Bellmer	USFWS – Stockton
Brad Cavallo	Water Resources
Nick Hindman	USFWS – Sacramento
Alice Low	Fish and Game
Tim Heyne	Fish and Game
Chuck Hanson	Hanson Environmental
Pat Brandes	USFWS – Stockton
BJ Miller	San Luis and Delta-Mendota Water Authority