Review of CALFED 2001-02 Environmental Water Account (EWA) Implementation

2002 EWA Review Panel

1. Introduction

The second meeting of the EWA Technical Review Panel (Panel) of the Environmental Water Account (EWA) convened on October 21–22, 2002 at the Sheraton Hotel in Sacramento, California. Under its charge (Appendix 1) from CALFED's Lead Scientist, the Panel was asked to ".. to provide a balanced and constructive evaluation of EWA implementation in 2002, with the goal of making recommendations for future implementation." The thirteen members of the Panel are listed in Appendix 2.
This summary report provides our conclusions and recommendations concerning the results of the second year of the EWA. Written documents that described the second year's activities were distributed to the Panel and reviewed prior to the Panel meeting. At the meeting, oral presentations by both management and agency participants and stakeholders provided important additional information that supplemented the written documents. Following the public sessions, the Panel met, discussed the presentations and documents received, and developed the outline and basis for this report.

In last year's report, the Panel devoted considerable attention to institutional issues focused on the concept of "flexibility", as well as to the scientific issues inherent to the EWA. This year, after two years of EWA operation, it is clear that there are three major aspects to EWA:

1. Consistent with CALFED's fundamental principles, the stated overarching goal of the EWA is to use water to provide general ecological benefits including, but not limited to, helping restore populations of fish species of concern, i.e. salmon and Delta smelt.
2. The particular goal of the EWA is to operate so as to limit take at the pumps of fish species of concern to levels agreed upon by the Management Agencies (MAs), the water project operators and their contractors, and other stakeholders including environmental constituencies.

3. Achieving either goal is contingent on being able to purchase, move and store any water that is intended for EWA use.

While the report below addresses all three issues, and highlights a number of noteworthy successes of the operation of the EWA, the weakness of the linkage between (1) and (2), i.e. the sparseness of scientific data and analyses supporting the ecological significance of reducing take is of major concern to the Panel. We are aware that take limitations are based on MA implementation and interpretation of the Endangered Species Act, and so are not to be dismissed lightly. In the end, the choice of focusing on take may be one of policy rather than of science.

If the EWA focuses its strategy solely on minimizing take, then the science/engineering effort needs to be focused on understanding what conditions, operations and aspects of fish behavior/biology lead to entrainment. From an engineering standpoint, this points to formulating and solving an optimization problem, albeit one that already entails many constraints besides those of simply minimizing take. Perhaps more importantly, this approach also requires that *all* of the available tools be used in making decisions. In particular, explicit integration of recent advances in understanding and modeling Delta hydrodynamics with the needed elements of fisheries biology will be essential to more effectively using the EWA to protect fish species.

However, 2001-02 operation of the EWA showed that EWA actions might also be used to accomplish the larger ecological goal of improving the Delta ecosystem for fish beyond simply reducing take through improvements to spawning habitat that might be expected when reservoir releases charged to EWA are used to manipulate river temperatures and flow rates. If this proves to be valuable then modeling and management efforts will necessarily include an additional upstream component. The Panel notes that this upstream habitat focus is a major element of the CALFED Ecosystem Restoration Program (ERP), and so finds that this use of EWA assets is entirely consistent with CALFED's founding principles.

Thus, to best use EWA assets, we must be able to assess the relative value of different actions that might be taken, i.e., pumping curtailment, reservoir releases, and gate closures, to fish populations. This requires that we understand and put these actions into a ecological, and, ideally, a population context. The Panel appreciates that this is a major undertaking; nonetheless, we view its as being essential to the long-term success of the EWA. We describe below steps that might be taken by CALFED under the auspices of the EWA to tackle this problem.

In the short term, a focus on reducing take, albeit with some well designed experiments used (as in 2001-02 to a limited extent) to improve understanding of what might be possible besides pumping curtailment, seems appropriate. Accordingly we suggest (§4.2.1) an integrated modeling study that we feel must be a high priority action for CALFED and the EWA.

The third aspect of EWA, that is the ability to purchase, move, and store water is also problematic. While the performance over the past year has been more than satisfactory, there is a great risk that EWA lacks both the resources and flexibility to respond to extreme events. In terms of funding and staffing, the EWA is being asked to do more with less, stretching its ability to cope even with normal circumstances. Moreover, EWA lacks the capability to carry over funds and to store water from one year to the next. It is not certain that as infrastructure is added to the Delta water system, additional storage will be set aside for EWA. Staffing recommendations made by the committee last year have yet to be followed, and additional skilled personnel are increasingly essential.

Last year's Review Panel report also discussed adaptive management. The Panel continues to advocate strongly an experimental approach to resolving scientific uncertainties through both system level and field experiments. We believe that this is simply good science. The results from such experiments can be a very effective basis for modifying management strategies, as demonstrated by CALFED's progress in modifying Delta Cross Channel operations. Various factors, including the lack of a common understanding and definition of "adaptive management", have led us to minimize use of the term while continuing to vigorously support well-designed experimental approaches to reduce uncertainty at all levels.

The main body of the report is organized into the following sections: Positive findings; The EWA's five biggest issues; Science strategy for the EWA and the CALFED science program; Continuing constraints on EWA flexibility; and Summary.

2. Positive Findings: What's Good about EWA 2002

The second year of implementation of the Environmental Water Account (EWA) showed many signs of improvement and progress. The Review Panel received a substantial record of activities and accomplishments from CALFED and associated stakeholders prior to the workshop. Although the lead time was short for the most careful review of all material, the Team noted that, in the aggregate, the material showed a real and substantial effort to analyze and summarize the program in a timely manner. Such effort is critical to refining and improving decision-making as the EWA evolves, and it is a requisite in establishing the record for judging the effectiveness of the EWA.

Once again the EWA completed a difficult schedule of water purchase, storage, allocation, and carry-over to meet environmental requirements, and did so in a year of below average runoff. There is good evidence that the water acquisition program has learned well. Those working on the water acquisition element have presented a solid rationale for dealing with future anticipated bottlenecks in storage, transfer, accumulating debt, and buying ahead.

Through a combination of an improved biological model of winter run chinook salmon juvenile production, actual runoff characteristics, and EWA allocations, the program did not exceed authorized take limits under the Endangered Species Act and remained below the “high concern” warning levels for all other species. The EWA program also deployed some water this year to upstream uses that resulted in positive results for several species not directly related to reducing salvage at the pumps. The American River action of releasing colder reservoir water (and bypassing power generators) to improve conditions for salmon spawning was particularly noteworthy. This action highlighted not only an opportune decision, but also more efficient and effective inter-agency cooperation that has allowed leveraging of EWA assets.

In spite of funding limitations and uncertainties, the various state and federal agencies worked collaboratively on studies and decision-making. As noted by panelists at the workshop: “the EWA has brought about a fundamental change in the level of cooperation among agencies”. In the opinion of one participant: “ no one wants to return to the old way of doing business”. These are important institutional changes that should yield dividends for both water management and environmental improvement in years to come. The most immediate sign of improvement has been a reduced level of conflict, and in the words of another stakeholder, a more effective means of channeling competition.

The EWA program organized two effective workshops during the year that dealt directly with science findings, data needs, and population trends for salmon and Delta smelt. There were many references to the hypotheses underlying tests and observations, as well as the presentation of conceptual models for guiding research. This context was much more in evidence than in materials reviewed by the Panel last year. The documentation for these workshops was good and the importance, application, and strengths of findings generally were clearly displayed for the Panel (and others), and showed a higher, more rigorous level of science than last year. The Panel also noted that several of the key findings presented at the workshops had been incorporated in the EWA program for 2002. Chief among these was a refined Juvenile Production Estimate (JPE) for winter run Chinook salmon (as called for in our report last year). A much improved estimate of spawning adults, based on carcass counts, and an empirically determined sex ratio for the run, were important factors in the refinement. Missing, as noted in Panel review materials, was incorporation of uncertainty in the JPE; however, we noted that there are plans to incorporate this element in next year‘s JPE. Decision trees for both salmon and Delta smelt were substantially refined and consolidated (in the case of salmon) compared to last year. It is obvious that the use of decision trees is more than an exercise and is performing a critical function of making the entire process more transparent.

The results from the Delta smelt workshop in particular showed a major improvement in research direction and development of findings immediately relevant to Bay-Delta improvement. The workshop summary was encouraging not only for its display of a short- and long-term research strategy, but also for showing an effective interaction among researchers.

Documentation of benefits to fish from EWA took a more formal direction in the report “The use of the Environmental Water Account...2001–2002” prepared for the CALFED Lead Scientist. We encourage continued development of this approach; in particular, attempts to quantify benefits of Delta actions as well as those upstream or beyond the Delta (see later sections of our report). In future issues of such a report, we recommend the agencies highlight the benefits at the beginning.

In summary, we found substantial improvement in several aspects of the EWA program and a good documentation of the events and progress made in 2002. The organizations and individuals are commended for these results.

3. THE EWA'S FIVE BIGGEST ISSUES

3.1 Expanding responsibilities with limited water resources

The EWA is at risk of faltering under the weight of inflation of its tasks. As originally conceived in the Record of Decision (ROD), EWA was to take its place among a diverse set of tools that had been developed to assure ecosystem protections and improvements in different ways and with different levels of security. The EWA thus assumed a regulatory baseline of "Tier 1" water that included water dedicated for environmental uses by section 3406b(2) of the Central Valley Project Improvement Act. Today, the EWA is expected to fulfill not only its own role with fewer resources than envisioned, but also the EWA is supposed to fill the gaps created by limitations of the other tools such as the b(2) water.

As discussed below, the EWA has never enjoyed the full complement of water resources contemplated by the ROD. In 2002, moreover, the EWA received only 60% of the monies it expended in 2001. EWA's budget fell from $67.5 million to $40.8 million. Due to the luck of favorable hydrology as well as an astute purchasing strategy, the EWA was able to acquire all of the water that it needed for the 2002 year within its limited budget. Modeling exercises run by EPRI Solutions and the Natural Heritage Institute, however, indicate that the in many years the net cost of acquiring sufficient water to meet EWA goals is likely to exceed the current budget.

Although its budget has dropped, the EWA today is expected to cover more environmental needs than the ROD originally contemplated. The EWA was designed to operate in conjunction with a number of other environmental tools. However, a number of these tools have been weakened or have yet to fully develop. In 2002, in particular, the EWA was used to make up for reductions in b(2) water allocated by the Central Valley Project Improvement Act but reduced by the *Wanger* court decision. There is a serious question whether the EWA can continue to meet its own goals and also act as a backstop for other environmental programs in future years. In effect, the EWA is carrying the burden of protecting fish without the promised additional resources, while no additional burden is being placed on water users. The equity established between serving the users and full protection of the ecosystem in the ROD may be eroding.

Future actions may further burden the EWA. CALFED, for example, is moving toward increasing the maximum Delta pumping rate allowed from 6,000 to 8,500 cfs by 2003. While it was reported to the Panel that some gaming exercises were reassuring about the extent of the burden on fisheries the increased pumping would impose, the details of these exercises were not made available to the Panel, although it also was reported that the increase will lead to greater volatility. Concern remains therefore that the increases in Delta pumping may place added stress on fisheries that the EWA will be expected to address. Settlement of Phase 8 of the Bay/Delta Water Rights Hearings also may increase exports, creating negative impacts that the EWA will be expected to mitigate.

Without supplemental resources, the ability of the EWA to meet its objectives will be reduced if these additional, unfunded burdens are added to its responsibilities. Thus, it is critical that actions that may increase the pressure on the EWA also be linked to additional water assets for the EWA. This might well take the form of in-kind mitigation. As infrastructure is added to the Delta water system, for example, a portion of the infrastructure could be dedicated to the EWA. Similarly, if regulatory changes increase the amount of water exports that are permitted from the Delta, a portion of the supplemental water could be provided to the EWA as offsetting mitigation.

3.2 Better Integration

CALFED includes exciting and innovative programs to protect living resources and their habitats at the scale of an entire ecosystem, a scale of resource protection at which we have limited experience. Successes and failures of CALFED will yield important lessons for guiding ecosystem-scale resource management elsewhere. The infusion of science within CALFED is a reason for optimism that CALFED programs will be successful. However, in this early evolutionary phase of rapid learning by trial and error, CALFED has not yet found institutional mechanisms to easily integrate science and operations across its programs. This organizational inability to easily integrate across programs was apparent from written materials and oral presentations provided as part of the Panel review of the EWA.

The science-based strategy of EWA, itself, is evolving rapidly. From early emphasis on species protection by operational actions geared solely to reduce direct mortality at export pumps, EWA staff have broadened their conceptual basis to include consideration of other processes that influence species sustainability. Examples of these other processes are indirect mortality of fish related to pump operations and aspects of life history of fish related to flow, such as water temperature in spawning habitats upstream of the Delta. We view this broadened conceptualization of the problem within the EWA as positive.

However, we are concerned by the apparent disconnect between the EWA and other programs conceived and funded to protect species and their supporting habitats. For example, the CALFED Ecosystem Restoration Program (ERP) has many biological goals identical to the EWA -- e.g., protection or recovery of endangered/threatened species. The ERP was conceived to reach these goals through habitat creation and management; the EWA was created to reach these goals with targeted flow manipulations. Sustainability and recovery of threatened species are dependent upon both habitat quality and quantity and flow manipulations, so the most rational approach toward species protection is through tight integration of all management actions, including those targeting habitat and those targeting flows. The success of EWA actions will be strongly dependent upon, and interconnected with, changes made by the ERP and other programs that modify conveyance structures, tidal gates, or operational regulations. A particular challenge of integration stems from the multiple, and sometimes conflicting, objectives within the CALFED system. For example, Delta Cross Channel Gate operations can sometimes have two conflicting goals: fish protection and water quality. Currently the goals are set according to a hierarchy; water quality operations superceding fish operations. Unfortunately, infrastructure does not currently exist to optimize both operations in a real-time environment.

Although we are reluctant to recommend creation of another layer of bureaucracy within CALFED, we view the need for programmatic integration as critical. Therefore, we encourage the CALFED Science Program leadership to search for an institutional mechanism to enhance communication among all programs designed to manage living resources, leading toward a strategic plan in which all actions (including habitat creation, flow manipulation, barrier emplacements, gate operations, and new pumping regulations) are considered as an integrative approach to living-resource management. A strategic plan should include consideration of the feedbacks between, and synergistic effects among, different management actions that, today, are treated as quasi-independent approaches toward meeting biological goals. We believe that the integrated effect of all actions directed toward species management could be different from the sum of the effects of individual actions. It is vital to the success of CALFED that this perspective be developed within the organization. One institutional solution could be creation of an office of programmatic integration within the CALFED Science Program. Another would be to accomplish this through appropriate managerial action.

3.3 More scientific analysis and synthesis to provide a better foundation for management.

Having, or at least developing, a sound scientific basis for decisions about the use of EWA resources is essential to the success of the program. During the first two years of the EWA, the principal (but not the only) means for deciding whether or not to use EWA water has been the decision trees developed by the MA staff. As noted above, the Panel was provided this year with copies of the decision trees for salmon for 2000-01 and 2001-02. These provide very specific criteria for initiating closure of the DCC or of curtailing export pumping. While these criteria may in fact be appropriate and well supported by MA experience with the system, it was hard for us to determine, based on the materials provided or from the presentations, exactly how those criteria were derived. While some of the supporting evidence for the decision trees is given in documentation from the 2001 EWA review (see especially Appendix 1 from White et al 2001), without a clear synthesis it is not possible for us to fairly assess the extent to which existing science supports the current formulation of the decision trees. Accordingly, the Panel recommends that the criteria and underlying information used to develop the decision tree be clearly stated so that their basis can be evaluated.

Generally, the major issues that we raised last year concerning the need to analyze and synthesize existing data, as well as to make use of existing modeling tools, are still relevant . Large volumes of data are being collected by the various monitoring programs, yet agency staff do not have sufficient time available to them to do more than superficial analysis of trends. For example, Wim Kimmerer, one of the EWA science advisors, pointed out in his presentation that the enormous data set derived from 43 million marked hatchery fish has yet to be fully and effectively analyzed. Another example is the apparent under use of the DWR particle tracking model (PTM), which has the capability of modeling the passive transport of organisms in the Delta and has been working for several years. Yet, it is not clear to the Panel the role, if any, played by these models in formulation of the decision trees and in EWA decision-making. At the very least, results from such a model could serve to provide a null hypothesis about how flow affects fish distributions, as well as providing a first estimate of the spatial extent of the zone of influence of the pumps. We describe below a plan for using a model like the PTM for the explicit purpose of refining the decision trees.

Finally, the single largest issue of scientific "uncertainty" that needs addressing is the ecological significance of take at the pumps. What does it mean to salmon and smelt populations to lose some fraction of the production of immature stages of fish each year?

3.4 Measures of performance

The Panel recommends that EWA define the measures that will be used to evaluate the biological performance of EWA actions. The Panel recognizes that, to some stakeholders, significant reduction in conflict among water users is a sufficient performance measure to evaluate the success of EWA. While the Panel understands the importance of conflict reduction among stakeholders, the Panel also feels that the issue of biological measures of performance needs to be resolved. Various stakeholders have very different ideas about how the biological benefits of EWA actions should be measured. In the first year of the EWA program, biological performance focused almost entirely on numbers of ESA listed fish species taken at the pumps relative to take limits. This is clearly a useful quantitative measure; however, the Panel notes that the benefit of the EWA can also be expressed in other measures. Indeed some actions do not affect fish numbers directly, but have quantifiable ecological benefits. The American River action of releasing colder reservoir water for spawning salmon is one such example. In principle, reducing water temperature improves fish survival, but expressing the impact directly in terms of percent survival or the equivalent number of adults saved requires numerous assumptions. The Panel sees value in establishing common measures, even though they are derived through assumption-based estimations. Additionally the Panel encourages the EWA to formally, and to the degree possible quantitatively, define measures associated with all actions. The Panel is concerned that some stakeholders consider the take-limit performance measure the sufficient biological measure, while other participants would also include more population-based measures. We note that common population-level measures are of value across the spectrum of stakeholders. The environmentalists expect EWA to help the fish populations, and water-users want to know the dollars spent to save each fish. The biological measures of performance need to be defined to avoid conflict over the issue of biological benefits of the EWA. Additionally, the future evaluation will be facilitated by clearly defining now the relevant biological measures of benefit.

The Panel firmly advocates the use of a life cycle basis for biological measures of performance. Life cycle analyses would enable the various EWA actions to be expressed in a common metric, such as population responses in adult-equivalents, recruitment rates, and total egg production (as a measure of spawning stock). Life cycle analyses would also allow for measures of performance that reflect the stochastic nature of fish population dynamics. For example, a possible life cycle-based measure might be the increased likelihood (probability) that EWA actions improved salmon or Delta smelt recruitment. A life cycle approach would not only provide a basis for evaluating the benefits of the wide variety of past and ongoing EWA actions on the population level, but would also be useful for planning future EWA actions. An example of the usefulness of life cycle analyses for evaluating EWA actions is that the benefits of upstream actions to improve spawning habitat can be combined with, and compared to, other actions such as increased river flow in the Delta. Life cycle analyses can also aid in planning by providing a method for determining which actions would generate the most biological benefits.

The Panel understands that this recommendation entails a significant amount of effort, both intellectually and people labor. The Panel feels strongly that EWA needs to formally define measures of performance appropriate for evaluating the biological benefits of EWA. Otherwise, EWA might experience a new form of conflict in the future; conflict focused on whether EWA produced sufficient biological benefits to justify EWA continuing into the future as it presently exists.

3.5 Resource Constraints

To a large extent our critique of the current operation of the EWA points to the important constraints imposed on the EWA due to a shortage of key resources including funding for water purchases, necessary water assets such as storage capacity, and personnel to carry out needed analyses.

3.5.1 Water Constraints

An adequate water supply remains essential to the long-term success of the EWA. Risk is inversely related to the size of the EWA's water supply. As the size of EWA's water supply drops, the EWA must make increasingly risky management decisions and the probability increases that the EWA will not be able to mitigate a potential take , potentially forcing a renewed conflict between water deliveries and compliance with the ESA. As we emphasized in last year's report, moreover, the EWA provides a valuable opportunity for experimentation that could lead to improved protection of fish species, at a potentially lower regulatory cost. Given the EWA's currently limited water assets, combined with the reduction in b(2) water, however, management agencies are understandably reluctant to use the scarce EWA resources for experimentation. The EWA, in short, is an innovative program with tremendous potential, but can achieve its full potential only with adequate water resources.

As discussed earlier, modeling exercises have cast doubt on whether the EWA consistently can meet even its basic goal of covering needed export cuts with a budget of only $40.8 million (the total state and Federal budget for 2002). Models run by EPRI Solutions and the Natural Heritage Institute (NHI) indicated that there is a 25 percent probability that EWA will incur more than $42 million in net costs (water acquisition costs minus sales of surplus water and reimbursement of electricity credits and facility fee credits) to cover export cuts in any given year.

These results emphasize not only the importance of adequate funding but also of providing EWA with greater temporal flexibility. The EPRI/NHI models indicate that the *average* net cost of meeting the EWA's goals may be as low as $23 million. Given the EWA's current deficit of long-term storage capacity, the EWA is unable to carry over large quantities of water from one year to the next and unable to demand full compensation for surplus water on the open market (because purchasers recognize that the EWA has limited options). How costs and credits for electricity and facilities will be handled also remains to be worked out in a manner that reflects the full benefits that may be provided by the EWA.

Given the importance of temporal flexibility, the lack of storage capacity continues to plague effective operations of the EWA. As the SWP filled the San Luis Reservoir in the Spring of 2002, EWA water in the reservoir became at risk of spilling. After investigating various options for EWA's water, a portion of the water was used to reduce SWP exports (providing some environmental benefits to the Bay-Delta ecosystem, but fewer benefits than if the water could have been stored and used at a later time) and a portion was exchanged at a 2:1 rate with south-of-the-Delta contractors. The long-term viability of the EWA will require the creation of adequate storage capacity for the EWA.

Absent strong temporal flexibility at the moment, the EWA's Tier III resources also remain important. In the Panel's 2001 report, the Panel emphasized the importance of providing adequate Tier III resources in at least the early years of the EWA. Earlier this year, CALFED agencies agreed to an interim protocol providing that Tier III resources would be a "fail-safe device" that the EWA should not "rely upon … in its planning or operations." The funding of Tier III in 2001-2002 was a valuable improvement. It also is important, however, that the conditions for using Tier III be sufficiently flexible that the EWA is not forced to make overly conservative water allocations early in the fish season, under-serving winter-run salmonids in order to preserve water for later release when Delta smelt need protection. CALFED agencies should use existing gaming data and studies, if they have not done so already, to examine whether the current Tier III rules are sufficiently flexible and, at the same time, should continue to work toward a permanent protocol that provides the EWA with adequate operational flexibility in those years when Tier II water proves inadequate.

3.5.2 Maximizing Available Water Resources

Given the limited funding available to the EWA for water purchases, CALFED must continue to work to maximize what the EWA can achieve within its budget constraints. Three measures are particularly important. First, as emphasized earlier, CALFED must ensure that all federal and state environmental water programs, including the EWA, work as an integrated unit in meeting environmental needs. A number of programs can help in meeting the goals of the EWA, just as the EWA in its operations can help in meeting other environmental goals. These programs include b(2) water, the Environmental Water Program (EWP), and the CVPIA Water Acquisition Program (WAP), as well as perhaps various state and Federal dry-year transfer programs. EWA personnel recognize the value of greater integration with these programs and, in a number of instances, already have taken these programs into account in their decisions on both acquisitions and uses of water. More active integration, however, can be achieved, and it is not clear that the other water programs have been fully receptive to increased integration. The EWP, in particular, may be able to help reduce the current burdens shouldered by the EWA. Although a 2001 briefing paper of the EWP listed a number of important means by which the EWA and the EWP could work together in the acquisition and use of water resources, much more progress can be made toward such integrated operations. As suggested above, direct involvement by CALFED management may be needed to ensure that the programs are properly integrated and achieve synergistic use of the limited resources available to each of the programs.

Second, the EWA should continue to look for opportunities to achieve multiple goals through single management actions. The EWA, as observed earlier, made impressive strides in 2001-2002 toward managing its releases of upstream water to provide in-stream fish benefits, both in increased flow and reduced water temperature. Maximizing such opportunities in the future will require even closer coordination between those involved in water acquisitions and those involved in management decisions (so that water acquisitions can be made to the extent possible with such coordination opportunities in mind) and between the EWA and other Federal, state, and local entities. Although the Panel was impressed with the current level of coordination, representatives of the management agencies suggested that greater coordination was both possible and valuable.

Finally, the EWA must work to further expand the market for its water acquisitions and sales, to look for new forms of water transactions that can stretch its limited budget, and to use forecasts and modeling tools to ensure that funding is used efficiently. In 2001-2002, the EWA developed a more efficient strategy for water acquisitions, moving away from the predominantly south-of-the-Delta approach contemplated in the ROD. Partly as a result, the EWA did a very good job in 2001-2002 of maximizing the quantity of water acquired (reducing the average price per acre foot by approximately a third, from $179 to $118). Given the current size of the market and the EWA's limited storage options, however, the EWA still encountered significant constraints in managing its water supplies. Both Federal and state water agencies may be able to help the EWA overcome these constraints by helping to locate and develop new acquisition markets for the EWA. The EWA also should study whether it could make even better use of hydrologic forecasts and financial tools in making real time decisions on the acquisition, sale, and exchange of water. Although effective water marketing inevitably relies on qualitative judgments and personal marketing skills, quantitative tools can be as valuable here as they can be in managing how the water is later used.

In developing and implementing its water acquisition strategy, the EWA also must give thought to how its acquisition operations will influence the evolution of water markets in California. In a short period of time, the EWA has become one of the major players in the California water market, particularly north of the Delta. The processes through which the EWA examines the broader social implications of its water acquisition strategy will reflect upon whether the CALFED embodies more open, transparent, and participatory water resources decision-making in California.

3.5.3 Personnel

Advancing the scientific basis of the EWA necessitates spending money on analyses. Both this report and our previous report lay out a number of specific analysis tasks that the Panel feels could substantially improve the EWA, and strengthen its scientific credibility. The MAs responded to our suggestions to the best of their abilities, and did succeed in making one important improvement to the basis for EWA actions, namely a major change in the JPE. Unfortunately, for the most part, they were unable to act on the majority of issues we raised because of a lack of staff. This lack of staff has two aspects: (1) lack of time dedicated for synthesis and basic analysis of data collected as part of ongoing monitoring; (2) insufficient expertise in crucial areas like fish population ecology and modeling. We distinguish between these two elements of human-resource limitations.

The solution to this problem is straightforward, but will cost money. The Panel recommends that CALFED support targeted post-docs, university faculty, or other distinguished scientists to work on specific problems central to EWA. We note in passing that a review of research projects that CALFED ERP is funding (or has recommended for funding) shows few projects that specifically address EWA issues. The list we present in §4 below, as well as the variety of analytical tasks we outlined last year, provide a concise list of important problems for these external researchers. We envisage this following the model the I.E.P. recently implemented following review of their Bay Program by their Science Advisory group. In that case, post-docs were funded to work with specific university researchers in collaboration with agency staff. Given that time is of the essence, ideally this would mean targeting specific researchers to serve as principle investigators as well as mentors and advisors to post-docs and students. An alternative approach is CALFED Science Fellows program in which CALFED itself is currently engaged in collaboration with Sea Grant. In either case, it is essential given the 2004 deadline for EWA that CALFED's current difficulties with contracting be resolved. Practically, funding for these activities could be included in the ERP, or more directly by using a fixed percentage of EWA funds, e.g. 5%, to pay for the very specific tasks we describe below. In any case, the Panel feels strongly that these critical research activities will have the best chance for success if they significantly incorporate the efforts of scientists and engineers outside the MAs and PAs.

4. Science strategy for the EWA and the CALFED Science Program

4.1 Overview

In his opening address, CALFED Director Patrick Wright listed five big challenges to the EWA. He listed first the challenge to develop a strong scientific foundation. Members of the EWA Review Panel agree that EWA's ultimate success at protecting living resources is dependent upon development of science-based tools built from (incomplete) mechanistic understanding of the environmental controls on the population dynamics of target species. The scientific process includes both new discovery (either from creative analyses of existing data or new research) and application of that discovery to design strategies for maximizing the biological benefits of each operational action.

The science need of EWA is large because the challenge of species sustainability is complex. Institutional obstacles (including agency reluctance to share data, constraints on hiring and contracting, weak linkages between CALFED programs having common goals, funding limitations—see §5) can retard progress toward effective science-based management tools. In consultation with EWA staff, we present here six avenues of new scientific investigation, all critical to the success of EWA at meeting its biological objectives. Of these, the panel all agreed that the first action, a study aimed at understanding Delta Smelt entrainment at the pumps, was the highest priority. The order of presentation of the other studies does not reflect any particular priority. Some of these avenues can be pursued with existing information; others require new studies. For each high-priority scientific topic, we suggest a general approach and describe how each investigation can be incorporated into management tools. We suggest mechanisms to implement each investigation, recognizing that specific guidance is most helpful to the CALFED Science Program as its leaders search for creative approaches to overcome institutional obstacles. To increase the potential for success of each investigation, we strongly encourage independent scientific review at critical milestones in these investigations.

Finally, we are aware that any of the proposed activities described below will have significant implications for current IEP programs and staff. It is clear that for any of these programs to go forward, explicit IEP participation is vital. We urge the CALFED chief scientist to immediately initiate discussions with IEP management concerning integration of EWA and IEP programs in order to help address EWA's science needs.

4.2 Specific examples

4.2.1 Science Challenge #1: To determine the combinations of physical conditions in the Delta (flow, transports, temperature) that give rise to 'entrainment events' of Delta smelt.

Relevance to EWA: A primary biological objective of EWA is to reduce take of Delta smelt and Chinook salmon at the SWP and CVP pumps in the south Delta. Incidental take of both species is highly variable, and the underlying mechanisms of that variability are not known.

Approach: This question can be answered by combining analyses of existing data with simulations using a hydrodynamic-transport model of the Delta. Data include historic measures of the distribution and abundance of Delta smelt (primarily from IEP programs including Real Time Monitoring), flow, stage, and water quality. Phase I could include independent (a) statistical analyses of Delta smelt distribution and (b) model development (including options for behavior of transported particles), leading to Phase II in which model simulations are conducted to test hypotheses emerging from the data analysis. The ultimate goal is a set of rules to define, mechanistically, those combinations of flow, water temperature, and Delta smelt dynamics that lead to large events of entrainment at the export pumps.

Implementation: This investigation could be accomplished as a team study including, for example: (1) a full-time team leader (either a non-agency scientist supported by contract or an agency scientist given sufficient time and independence to complete this study) responsible for study design, data analysis, synthesis of data and simulations, and development of rules to guide management actions; (2) an IEP-agency employee (1/4 time) with knowledge of Delta smelt population biology and data sources; (3) an IEP-agency employee (1/4 time) with knowledge of flow and water-quality data; (4) an EWA-agency employee (1/4 time) to assist with study design and application of emerging rules into tools; (5) a senior scientist/engineer to guide model development (~ 1/8 time); and (6) a full time scientist/engineer (e.g. postdoc or agency employee) to develop the hydrodynamic/transport model and conduct simulations. This project could be completed in 3 years and would require about 3 FTE.

Tool Development: The goal of this study would be a mechanistic basis for operational actions geared to reduce take of Delta smelt, implemented as refinements in the EWA decision tree for actions to protect this species.

4.2.2 Science Challenge #2: What are the growth and mortality rates, habitat use, and movement patterns of juvenile Chinook salmon within the Delta?

Relevance to EWA: Recent analyses by EWA-agency scientists suggest that out-migration of early-stage Chinook salmon is a function of their movement into and rearing within the Delta. If this hypothesis is correct, then EWA actions could be geared specifically to alter these movements. However, the potential outcomes of specific actions are unknown because of knowledge gaps about how the Delta functions as a transit route and source of indirect mortality to Chinook salmon and how export pumps modify those functions. Initial studies on indirect mortality rates caused by pumping range between 0 and 10%. The higher range is derived from the work of Brandes' presentation in the 2002 Salmonid Workshop (Brown and Kimmerer 2002, Table 5 p 36) and the lower range is derived from Newman and Rice (2002). Using estimates of direct take at the pumps, which range between 1 and 2%, the indirect mortality associated with pumping may range between 0 and 10 times the direct pump take. Refining the relationship between the indirect and direct mortality is important to assess the value of directing EWA water to pump reductions or using the water for competing uses including water quality maintenance, delta smelt protection, and actions taken upstream in the tributaries. Additionally, understanding juvenile transit and habitat use within the Delta is important to the design of the Delta pump and cross channel gate operations. Ultimately, better information on how juvenile salmon respond to Delta operations will allow more efficient use of EWA water for improving fish survival.

Approach: Because of the complexity of assessing salmon mortality in the Delta, the Panel envisions partitioning the work into three phases: Phase #1 involves compilation and further analyses of the existing data to resolve discrepancies in Delta and river mortality estimates. This is followed by a workshop to evaluate the findings of the analysis and then the creation of a habitat team to implement the findings. Phase #2 begins the development of a Fish Tracking Model that has application to a number of the Science Challenges for salmon and smelt. Phase # 3 addresses, what the Panel believes, is the need to develop a new and powerful monitoring program that can measure growth and mortality on a spatially explicit scale in the rivers and Delta. Although the description outlined here is based on PIT tag technology, the Panel recommends that CALFED consider other technologies before embarking on a program.

The Panel suggests that the problem of assessing growth and mortality be treated in much the same way as an essential fish habitat (EFH) issue and use the guidelines recommended by the National Marine Fisheries Service for resolving EFH questions. As such, level 4 data that includes not only estimates of differential habitat usage and relative abundance, but also habitat-specific estimates of differential survival and biomass production (indexed by the ratio of growth to mortality) under a variety of flow conditions will be required. There are many good examples in the fisheries literature that describe studies of this type in estuaries, albeit that they may not be specific to juvenile salmon.

Approach in Phase #1 Analysis of available data

The Panel notes that, as suggested in the First Annual Review, the managers have made progress in quantifying the direct and indirect impacts of pump operations on fish mortality. Based on tagging data extending back to 1978 the analyses focused on the timing of fish migration through the Sacramento River and the effects of pump operations on water quality and fish entrainment into the Delta. The analyses reached a variety of conclusions, some of which were in agreement while others were not. The Panel believes the uncertainties need to be resolved and the estimates of impacts improved.

To address the impacts of pump and cross channel gate operations on fish a rigorous statistical analysis needs to be conducted that will build on the initial work of Kjelson, Greene and Brandes (1989) and White et al (2002). The hypothesis presented by A. Low on the factors affecting the annual variability of winter chinook take at the pumps needs to be further developed with a more rigorous analysis. The companion analysis by P. Brandes (presented at the 2002 Salmonid Workshop, Brown and Kimmerer 2002, Table 5, p. 36) on the indirect mortality attributed to the pumps also needs further development. In particular, the quasi-likelihood model (QLM) applied by Newman and Rice (2002) is probably an appropriate technique to explore the effects of gate operations and pump exports on fish in the Delta.

Approach in Phase #2 Development of a Fish Tracking Model

The effect of Delta operations on fish can also be studied with individual-based models in which fish movement is simulated in terms of the contributions of hydraulics and fish behavior. As noted in the First Annual Review, such models should be valuable for evaluating the potential significance of water export schedules and channel operations across a spectrum of ecological and hydrological goals. An initial individual- based model can be developed by ascribing rudimentary fish-like behavior to the particles in the particle tracking model (PTM) maintained by the Modeling Support Group of the Department of Water Resources. An initial fish tracking model (FTM) would be calibrated with fish movement data obtained from the recent radio tag studies conducted in the Delta. Additionally, mortality could be included in the FTM from the results of the QLM analysis in Phase #1. The FTM model could in turn be used to generate fish recapture data for analysis in the QLM. In this way the ability of the QLM methodology to extract known mortality rates under a variety of environmental conditions and data error structures can be explored with the pseudo data generated from the FTM.

Approach in Phase #3 Development of a fish tracking system

The Panel believes that efficient management of EWA water over a range of objectives will required more detailed information on the movement, survival, and growth of salmon and smelt than can be obtained with the existing technology. Ultimately, many individual fish will have to be tracked on a routine basis over many years. The Panel recommends that future juvenile salmon tagging studies use PIT tag technology. Standing for Passive Integrated Transponder tags, the staple-sized PIT tags (23 mm, 0.6 g) are implanted in juvenile fish as they begin their migration. Each tag is unique and identifies an individual fish. Stationary detectors on fish traps or mobile detectors deployed from boats can read the tags as the young fish migrate and when the adult fish return to spawn. The tagging system thus gives the rate of migration of individual fish and how many fish survive as they move from one life stage to the next or from one location to the next. Furthermore, by measuring the weight of fish recaptured at traps the growth rate of individual fish can be determined.

Implementation:

Implementation Phase #1. Analysis of existing data

Because this issue is complex and is coupled, in part, to predation as a source of mortality in the Delta, Phase 1 of Science Challenge #2 would be a worthy topic of discussion for the upcoming CALFED predation workshop that is planned for this spring. As such, CALFED should make every effort to ensure that all of the tagging data obtained to date are analyzed and made available to workshop participants. This may require that CALFED contract a biostatistician to work with agency personnel and the science advisors to compile and analyze these data. In addition, a habitat team, perhaps with its core in the IEP, then should be identified to act in response to the findings of the workshop. A least two members of the habitat team should be independent scientists from outside the EWA "family". Details of the studies recommended during the workshop, and the manpower needed to execute the studies, will emerge as a product of the workshop. The same habitat team could also be used to define studies in Clifton Court Forebay (See Science Challenge # 4).

Analysis of available data for the workshop will require the following personnel: (1) A project leader – PhD level biostatistician (1/6 FTE); (2) One post-doc level biostatistician to carry out the analysis, data preparation and prepare a final report (1 FTE); (4) An agency fisheries biologist to advise on the analysis (1/6 FTE). This project (1 1/3 FTEs) will take 1 year to complete.

Implementation Phase #2. Fish Tracking Model

The Panel notes the addition of fish behavior to the Particle Tracking Model has been identified as a future task of the Department of Water Resources' Modeling Support Group. The Panel encourages the EWA to establish a cooperative agreement with the group for the development of a FTM that meets the needs of the EWA. The Panel also recommends that the development of a FTM include a workshop with participants that include people who specialize in organism movement models (e.g., SWARM, NMFS), the scientist that radio tracked fish in the Delta, the Water Resources Model Support Group, the habitat team discussed above, and outside scientists.

Development of a FTM will require the following personnel: (1) A project leader – PhD level modeler/biologist familiar with individual-based models in fish ecology (1/6 FTE); (2) A representative of the Department of Water Resources' Modeling Support Group (1/6 FTE); (3) One post-doc level modeler to develop the FTM (1 FTE); (4) A biostatistician to carry out the analysis on the QML model with the FTM generated data (1/2 FTE). (5) An agency fisheries biologist to advise on the model requirements (1/6 FTE). This project (2 FTEs) will take 2 years to complete and the model could be up and running in less than a year.

Implementation Phase #3 Development of a PIT tag tracking system

A PIT tag tracking system can be implemented through an individual project or across the entire CALFED program providing real-time information for programs involving salmon. The system has three elements, tagging, detection, and data management. Fish can be tagged in the pre-smolt rearing habitat, at hatcheries, or at fixed traps in the rivers. A relatively comprehensive coverage of fish movement and mortality in the Delta could be obtained with 10 to12 detector sites. Pit tag detectors deployed in the SPW and CVP salvage facilities would give managers real-time internet accessible information on the percent of individual stocks taken by the pumps on a minute-to-minute basis. A trap and PIT detector at the entrance to Clifton Court Forebay would allow estimation of the residence time and mortality of fish in the Forebay (See Science Challenge # 4). PIT tag detectors at the smolt monitoring trap in the Sacramento and San Joaquin rivers would provide information on the instantaneous passage of individual salmon stocks through the rivers and survival from release to the detection sites. A number of mobile and fixed detectors could be operated throughout the Delta to characterize fish migration timing and survival in specific channels. Finally, with detectors located near Chipps Island, survival, travel time, and growth between Chipps Island and the upstream detector and release sites could be calculated.

The cost of a PIT tag system depends on its extent. Each PIT tags cost $2.25 and handheld detectors cost a few hundred dollars. Thus, a system operated by a single investigator to say characterize the survival of a specific stock through a single river reach may cost a few tens of thousand of dollars and 0.5 FTE. However, a basin wide system would PIT tag several hundred thousand fish each year. An effort of this magnitude will require new infrastructure including mobile tagging teams, a regional datacenter, and a number of fixed and mobile detection sites. Such as system would require 2 to 4 FTEs plus seasonal employees to tag fish. A PIT tag project on the Columbia River tags and tracks 500,000 fish annually for a cost of $1.75 million. Installation of the system could also cost several million dollars and would take several years to implement. However, because of the value of a basin wide PIT tag system, it would be appropriate to fund the effort as a separate CALFED program. The Panel recommends a multistage evaluation of the utility and costs of implementing a PIT tag monitoring program in the Delta. Several pilot studies would be performed first to determine the technical feasibility and to gauge the costs of scaled-up versions.

Tool Development: Phase #1 would use the existing tag data in a rigorous analysis to evaluate the effects of environmental conditions and Delta operations on fish mortality in the Sacramento River and the Delta. A companion to the analysis would be a dataset of the available tag data and all relevant environmental data. These data can be used in habitat suitability models to express changes in flow as changes in fish habitat quality and quantity. Habitat suitability analyses have a long history of application, are intuitive to understand, relatively easy to implement (given the correct people), and well accepted by the fisheries and ecology communities. Development of habitat suitability models that will permit evaluation of how changes in EWA water management operations can affect habitat quality and quantity for fishes within the delta.

Phase #2 would develop the FTM to study in detail the effect of environmental conditions and Delta operations on salmon migration and mortality. The tool would also have application for evaluating Delta smelt entrainment events (Science Challenge #1) and the effect of cross channel gate operations on salmon migration and Delta salinity (Science Challenge # 5). The FTM would also provide valuable information for the selection of PIT tag detector locations.

In Phase # 3 a fish tag tracking system would be developed for monitoring the effects real-time Delta operations and environmental conditions on fish movements, growth, and survival. The tag system could also provide information for other questions such as the effect of reservoir operations on river temperature (Science Challenge 6), fish passage and stranding. The information from a tag system would also be critical for calibrating habitat suitability models.

4.2.3 Science Challenge #3. To develop a quantitative synthesis of the life cycle of delta smelt and Chinook salmon.

Relevance to EWA: Quantitative synthesis of the Chinook salmon and Delta smelt life cycles will enable EWA to put “take at the pumps” into a ecological, and perhaps even population, context. There are many possible combinations of when and where to use EWA water. A full life cycle approach will enable better decisions on how to get the most *ecological* benefits from alternative ways to use EWA water.

Approach: The life cycles of Chinook salmon and Delta smelt can be synthesized using site-specific data for the populations of interest, and from studies on these and related species in other systems and from laboratory studies. Existing data should be mined before new data are collected. The first step would be to qualitatively describe the life cycles of each species in detail. Sketching out the life cycles qualitatively is not difficult, and the workshops to date provide a good start. The challenge is the second step of making each of the life cycles quantitative. Specifying the growth, survival, and duration of each life stage, and how environmental and biological variables affect these vital rates, will require a significant and coordinated effort. These types of efforts usually are iterative, with each iteration resulting in a more refined and improved life cycle. Once a quantitative life cycle is assembled, computing metrics such as adult equivalents and relative changes in recruitment, and formulating full-blown matrix projection population dynamics models, become possible.

Implementation: Development of the life cycles would be best accomplished using a small team of scientists for each species, with each team having a designated leader. A leader is required to ensure that there is one person who has the responsibility and resources (funding) to construct the life cycle. Workshops would be held with the specific goal of developing the life cycles. A rough estimate of the effort involved for each species would be: (1) half-time support for the team leader (likely a non-agency scientist supported by contract); (2) 20% support for each of 4 to 5 individuals (IEP- or EWA- agency employees and academic scientists) hand-picked based on their knowledge of the species and system; (3) funds to conduct workshops. Development of the life cycles to a point they can be used by EWA for predictions of ecological benefits could be achieved in 1 to 2 years and would require about 3 FTEs per species. Further development of the quantitative life cycles in models of population dynamics would involve a moderate amount of additional effort.

Tool Development: The result of this study would be a full life cycle basis for evaluating the ecological and population benefits of alternative EWA operations. An example of how the life cycles could be used would be to use the life cycles to compare the ecological benefits (e.g., number of adult equivalents) of using water to benefit upstream spawning versus reducing take of young-of-the-year individuals at the pumps, and comparing both of these to fishing mortality effects. Many other examples could be envisioned. The process of assembling the life cycles will also provide information on designing specific future studies to fill in the critical gaps in our knowledge. The resulting life cycle tool could be coupled with the EWA decision trees, so that short-term and long-term ecological responses could be incorporated into the gaming.

4.2.4 Science Challenge #4: To determine the magnitude of predation mortality in Clifton Court Forebay, including elucidation of whether losses through the bay differ by species and vary as a function of prey density.

Relevance to the EWA: Fish losses attributable to the actions of the pumping plants are numerically dominated by the multiplier (assumed 75% mortality scaled by the number salvaged) used to account for predation losses as juvenile fishes traverse Clifton Court Forebay. While others have concluded that studies to date are adequate to estimate the magnitude of these losses, the aforementioned studies are difficult to obtain, many were done prior to dramatic recent changes in the biomass of some of the potential predators, and may not be species specific. As such, the conclusion that these studies are adequate appears to the Panel to be unjustified, especially given the importance of the predation multiplier used to inflate estimates of take at the pumps. In many ways, this multiplier may be among the most critical of all numbers used to evaluate the near-term success of EWA actions.

Approach: There may be many ways to approach this challenge, but to do it correctly will require new research initiatives that will need to be well funded to be successful. It is time to begin to think outside the box. Among those approaches that should be considered include field sampling and laboratory study programs designed to: 1) quantify predator biomass and species composition on, at a minimum, a seasonal time scale; 2) quantify predator diets and growth rates on a similar time scale; 3) estimate the parameters necessary to develop simple bioenergetics models for the major predator species; and, 4) quantify prey biomass as it enters and exits the mouth of the Forebay.

These combined data, once available, could be used to predict prey demand on a daily basis, balanced against the estimate of prey biomass entering the Forebay. In a more simple approach, it may be possible to measure flux of prey fish biomass across the mouth of the Forebay, and to use releases of tagged prey fish at the mouth of the Forebay, to develop a simple ratio of biomass entering the bay to that leaving the bay at the pumps, under a variety of flow conditions and prey fish densities. Sampling efforts should be designed to focus both on juvenile salmon and delta smelt, including those smelt less than 20 mm where possible. The first of the two approaches will require a more rigorous field effort, but this may be justified given the importance of understanding the true magnitude of predation mortality in the Forebay. As such, predator biomass can be determined by using hydroacoustics coupled with some net sampling to ground truth predator species composition, and to collect specimens for diet analysis. Recent advances in hydroacoustic technology permit accurate sampling in shallow water. Prey biomass flux across the Forebay mouth also can be measured using stationary hydroacoutics or acoustic Doppler profilers, again with some net sampling to ground truth species composition.

Attention should be paid to the possibility that not all of the prey that enter the Forebay get eaten or end up at the pumps, thus recognizing the potential for prey to move both in and out of the Forebay. Estimation of bioenergetics parameters for predator species is based upon relatively standard techniques and is well described in the literature. If the major predators of interest turn out to be striped bass and largemouth bass as some have suggested, bioenergetics models already exist for these species and would simply have to be adapted for use in the Forebay. In the latter approach, prey flux can be determined as above, but supplemented with releases of tagged prey to directly estimate losses in the Forebay under a variety of flow conditions, times of the year, and prey densities. Rates of salvage then could be related to prey flux and the other variables in a predictive model of losses in the Forebay. It is possible, for example, that when prey densities are very high, predators in the Forebay become satiated, thus reducing cumulative losses to predation during those days. The opposite may be true when only small numbers of prey are entering the Forebay on any given day. Unfortunately, the methods describe above probably will not work well for larval delta smelt; it is difficult to estimate of the numbers of smelt entrained by routine sampling of ichthyoplankton in the pump intakes.

Implementation: As with several of the other science challenges, the first step in addressing this challenge is to compile and synthesize those studies that have addressed this issue in the past, specifically to judge their relevance to the species of importance to the EWA. If past studies did not address Chinook salmon and Delta smelt predation specifically, or are inadequate to account for potential time-specific changes in predator biomass or composition, then they may be grossly inadequate to develop a predation multiplier that can be used with confidence. CALFED currently is planning to convene a predation workshop, and one major goal of this workshop will be to evaluate the adequacy of previous studies to address EWA needs. Another goal of the workshop will be to define new studies, perhaps much different than the ones described above, that address predation both in Clifton Court Forebay, as well as the role of predation in determining the quality of nursery habitat in the delta. Predation is a complex issue and measuring predation rates is difficult. A predation team, perhaps with its core in the IEP, should be identified to act in response to the findings of the workshop. A least two, and preferably more, members of the predation team should be independent scientists from outside the EWA "family". Details of the studies recommended during the workshop, and the manpower needed to execute the studies will emerge as a product of the workshop.

Tool Development: Independent of the approach used, the results of these efforts would permit dynamic, species-specific estimation of predation losses in the Forebay. Even a crude estimate that allowed rates to be adjusted for ambient conditions would be more useful than the fixed multiplier that is currently being used, and may result in changes in our perception of the effectiveness of EWA actions that are as large as those that occurred when the method of calculating the JPE was modified.

4.2.5 Science Challenge #5 Optimizing Delta Cross Channel Gate Operations

Relevance to EWA: One of the most important decisions in Delta water management involves the operations of the Delta Cross Channel (DCC) Gate. Opening the gate allows Sacramento River water into the inner Delta and helps reduce the salinity of water exported from the Delta. However, an open gate also allows Sacramento River salmon smolts into the inner Delta with subsequent increased mortality from predation and take at the Delta pumps. Simply closing the gate during the migration alleviates the problem to fish but causes the Delta salinity to increase. In 1999, a gate closure to meet the fish objectives resulted in high Delta salinity. As a result of the ensuing conflict, CALFED scientists initiated an integrated cross channel research program to study how fish, flows, and water quality interact in and around the cross channel. However, while this study has provided considerable information, the management of the system, and in particular management to optimize fish actions within the constraints of water quality, can be further improved with a coordinated real-time decision program.

The need for coordinated real time management to meet the competing objectives for fish and water quality was also evident in the 2001-2002 season. On Nov. 21 2001,the gate was initially closed in accordance with the Knights Landing index catch reaching the gate closure level. The catch dropped below the closure level for the next 4 days and then increased dramatically. However, 8 days after the initial closure the gate was reopened to mitigate an unexpected increase in Delta salinity. Five days later the gate was closed to mitigate the threat of inner Delta flooding resulting from a storm. In retrospect it appears that initially the gate was closed 4 to 5 days prior to the chinook run reaching the cross channel and was then reopened as the run reached the channel. With a more efficient decision process the initial gate closing may have been delayed which may have alleviated the need to open the gate for salinity control during peak of the migration. Improved gate operations may be especially critical in drought years when the fish migration patterns are atypical and the Delta is more susceptible to salinity intrusion.

Approach: To improve the DCC gate operations it is necessary to accurately predict fish passage at the DCC and salinity intrusion into the delta and the information for these predictions needs to be integrated into the real-time gate operations. Developing a prediction system involves three tasks. The first task is to improve smolt passage predictions. Currently the DCC gate is closed within 24 hr of when the smolt catch, collected 40 to 50 miles upstream, exceeds a Catch Index level. As revealed in 2001-2002 smolt migration season, this method may not accurately predict the run timing at the cross channel. Improving this prediction requires two steps. First, the passage prediction at the Knights Landing index site needs to be improved. The goal is to predict the timing and shape of the entire run using information derived from the pattern of the early arrivals at the index site. Such algorithms developed for Columbia River smolts match the early passage numbers against the historical pattern to predict the entire run pattern (Townsend et al. 1996, Connor et al. 2000). These algorithms could readily be adapted to the Sacramento River. The second step of the first task is to predict the migration of the run from the index site to the DCC. Here again, algorithms that predict the migration rate of Columbia River smolts using river flow and fish length should be useful (Zabel and Anderson 1997, Zabel 2002). The second task is to model in real time the impacts of gate operations and river flow on Delta salinity. Here, the California Department of Water Resources Delta Simulation Model II (DSM2) plus the efforts of the DCC research program provide a foundation for developing a real time prediction of delta salinity. The third and final step is to integrate the fish passage and salinity models into a management system that predicts in real-time the probable impacts of gate operations on fish immigration into the inner Delta and the Delta salinity.

Because situations will inevitably arise in which the gate is open during fish passage, it is worthwhile to explore possible methods to keep juvenile salmon from entering the DCC. The DCC research group has considered screening the delta but has identified engineering and behavioral problems with physical screens. As an alternative approach, several Panel members suggested using lights to modify passage behavior. Research has shown that migrating juvenile salmon are attracted to artificial lights (Nemeth and Anderson 1992). However the response depends on the background level, the light spectrum, and the light level to which the fish were adapted prior to encountering artificial light. In principle however, it is possible that a series of attraction lights across the entrance of the DCC, coordinated with the tidal cycles, could inhibit the entrainment of juvenile salmon into the delta. The hypothesis is that switching light on during the flood tide and off on the ebb tide would rectify the fish passage through the channel. In the flood tide the fish would orientate to the light instead of being swept into the cross channel, and on the ebb, with the lights off, they would follow the flow down the Sacramento River. If this hypothesized response reduces fish entrainment into the cross channel it could be an effective supplement to pump reductions in the south delta.

Implementation: Improved operations of the DCC gate to meet the dual goals of fish protection and salinity control will required a working team involving several CALFED programs. This work could be coordinated by the EWA management team with the support of the Drinking Water Quality Program, which would also benefit from more efficient gate operations. Expertise to develop the program is available, both within and outside of CALFED. The fish modeling could be based on existing models used to predict fish migration in the Columbia River system. It may be possible that modeling the effects of flow and gate operations on salinity can be conducted as part of the ongoing water quality monitoring program. Integration of the fish and salinity elements of the program could be coordinated by EWA managers. It is likely that a program could be made operational within a year with the equivalent of one FTE. Research on using light attraction devices to exclude fish from the cross channel would best be coordinated through the cross channel research program. The level of effort would depend on whether the fish monitoring can be conducted as part of the cross channel program. Installing an array of lights could be contracted to one of a number of companies with experience in this field.

Tool Development: The result of this effort would be a real-time integrated system to supplement or replace the existing gate operations of the EWA decision tree. Over time the gate operations algorithm would include pump operations and provide in real-time probabilistic predictions of the consequences of delta operations under multiple constraints. In essence, this Science Challenge is a specific example of the Panel's previous recommendation to develop a stochastic description of the impacts of Delta operations on fish.

4.2.6 Science Challenge #6: Are there reservoir management strategies to improve the availability of cold water for in-stream habitat enhancements?

Relevance to EWA: The use of cold water releases from reservoirs to rivers and streams is cited frequently in the CALFED ecosystem restoration plan as being important to spawning of salmonids. As seen in 2002, when EWA resources (water and power credits) were used to pay for releases of cold water from Folsom Reservoir, this can be accomplished with amounts of water that are within EWA's budget. In terms of the overall EWA goal of protection of salmonid populations, this may prove to be more valuable than pumping curtailment (subject to the results from work described as Science challenge #3). Although information about this aspect of management of the Bay-Delta system was not part of the EWA documentation, other than in the context of the Folsom action, it is clear that this is already an important topic to water management agencies who have recently invested large sums of money in temperature control structures in several reservoirs (e.g., Shasta).

Approach: Optimization of the production and release of cold water from reservoirs upstream of the Bay-Delta system requires the application of reservoir and stream temperature models to explore the range of possible outcomes of a given operational strategy or structural modification to a reservoir (e.g. a temperature curtain). Good models already exist to carry out this work. For example, the accuracy of stream temperature models may be primarily limited by available data rather than by model parameterizations. In a similar fashion, while the underlying physics is more complicated, reasonably sophisticated reservoir models (e.g. DYRESM – see Schladow 1992) exist that include state-of-the-art descriptions of vertical mixing, as well as of inflow and outflow dynamics. In any case, proper operation of temperature models, especially when they are used adaptively to guide operations, will necessitate improved data collection, i.e. continuous real-time temperature profile information in any reservoir for which this type of operation is planned. Moreover, to make best use of temperature models, and to understand their limitations, they must be calibrated using both detailed short-term data sets and less detailed long-term data sets. This may require that new field experiments, comparable in sophistication of recent USGS studies of Bay/Delta hydrodynamics, be carried out. We note that the USBR and UC Davis have carried out detailed reservoir studies in the context of evaluating the utility of temperature curtains.

While the required temperature modeling is relatively straightforward, given that there are other constraints on reservoir operation, a major portion of this activity will be the integration of temperature models with water system operational models like CALSIM.

Implementation: As a first step it would useful to convene a workshop with the goal of defining what opportunities might exist for using EWA water for coldwater releases. Participants in this workshop would include engineers currently involved in reservoir operations (including system level operations), fisheries biologists working on in-stream habitat requirements and spawning, and those who are doing temperature models of these systems. To ensure the best possible science, outside experts familiar with reservoir dynamics, fisheries aspects of in-stream habitats, and water resources optimization should be included. This workshop would result in a report detailing the possibilities for EWA actions involving reservoir releases (or lack thereof). This workshop will require a coordinator with scientific/engineering expertise in some or all (!) aspects of this problem (1/6 FTE), and an administrative assistant to make necessary arrangements (1/6 FTE).

If it turns out that significant opportunities do exist, then CALFED should go forward with a fairly directed project to produce validated, real--time temperature models for several critical reservoirs, possibly Folsom, Oroville, and Shasta (assuming these could be used for EWA purposes) This will require the following personnel: (1) A project leader – PhD level engineer familiar with reservoir dynamics and modeling (1/6 FTE); (2) An assistant project leader – PhD level engineer familiar with water resources system operations and optimization (1/6 FTE). (3) Two post-doc level modelers to do the reservoir modeling and model integration (2 FTE); (4) An agency engineer familiar with reservoir operations (1/6 FTE); (5) An agency engineer familiar with CALSIM (1/3 FTE); (6) A agency fisheries biologist to advise on temperature requirements (1/6 FTE); and (7) an agency provided field technician to maintain and operate any new temperature measuring systems needed for this work (1 FTE). This project (4 FTEs) will take 3 years to complete, although the reservoir models could be up and running in less than a year (depending on data).

Tool Development: Assuming that opportunities to use EWA water for reservoir releases continues to be an important management tool for EWA, then the outcome of the directed project would be models and approaches for evaluating reservoir operations with an eye towards producing cold water for salmonid spawning. Integration of reservoir/stream temperature models with CALSIM would be a significant enhancement of CALSIM's utility to managing California's water supply.

5. Continuing constraints on EWA flexibility

5.1 Impediments to inter annual carry-overs of debt and assets

As discussed earlier, temporal flexibility is absolutely critical to EWA's ability to adjust to changing hydrologic and biologic conditions. In 2002, EWA was able to creatively maximize flexibility within limits much more adroitly than occurred in 2001. The use of options to lease water was critical to the program's ability to adjust to changing circumstances. It was also important that EWA was able to enter into source shift arrangements which could be activated in the Spring before the low point in the San Luis Reservoir and returned to users in the Fall.

Impediments to desirable flexibility remain, however, and they must be addressed. The EWA lacks dedicated storage and ground water reserves that can be drawn upon anytime. At present, options must be signed long before the EWA officials know the likely water needs. EWA managers may be able to use long term climate forecasting to good advantage in anticipating water needs three weeks to six months into the future. Flexibility can be increased by pursuing longer term, multiple year arrangements with variable rates and deadlines. Arrangements with other agencies, including the CVP and the SWP, to purchase water in their service areas and to facilitate borrowing over multiple years would be helpful. Carry-over clauses that allow an asset to remain in place and be transferred in future years would increase effectiveness. It is important that the EWA be able to carry over assets in reserve accounts.

5.2 Problems associated with upstream actions

To a considerable extent the EWA has been Delta- centered and focused upon lowering the take of targeted fish species at the pumps. This bias is somewhat built into the EWA in the ROD that establishes fixed asset targets of 35 TAF coming from sources upstream of the Delta and 150 TAF coming from south of the Delta. This concentration of assets in the south imposes financial burdens on the EWA as imported water is more expensive, especially in dry years. As emphasized earlier, moreover, greater benefits to the ecosystem and fisheries may be possible via upstream actions with the same expenditure of water. Beginning in 2002, the EWA began to purchase more water upstream of the Delta than specified in the ROD and to employ the notion of functional equivalency. This strategy allowed the purchase of water at cheaper prices. It also facilitated upstream releases of water to sustain flows or to provide water at more appropriate temperatures for fish spawning. For example, the EWA was used to deliver colder water more beneficial to salmonid resources on the Lower American River at critical times. Delivery of cold water from the lower depths of reservoirs involved hydropower losses. In November 2001, the EWA invested power credits to release about 16 TAF of water to lower the temperatures of releases from Folsom Dam. The action also paid off in terms of encouraging public participation and building ties to local watershed associations.

While such upstream actions may be excellent investments, EWA is constrained by the availability of power credits or other resources and by competing demands for its water. Furthermore, water purchases upstream may be lost if storage capacity is scarce and EWA does not have secure pumping capacity to convey its water purchases across the Delta in all hydrologic conditions. In 2002, the EWA was pressed into making a 2 for 1 exchange because the only alternative was uncompensated spill of its water from the full San Luis Reservoir, in which EWA has no storage.

5.3 Lack of program integration

The operations of other governmental water programs, and the degree to which those programs are operated in coordination with the EWA, affects the flexibility enjoyed by the EWA. As emphasized earlier, the EWA is part of a portfolio of tools for helping to restore the listed Delta fish species and for addressing other environmental problems faced by the Bay-Delta and related water systems. These programs include b(2), the Environmental Water Program (EWP), the Ecosystem Restoration Program (ERP), and the CVPIA Water Acquisition Programs (WAP). To the degree that these programs are cut back, delayed, or ineffective, stakeholders and policymakers may look to the EWA to pick up the slack. More importantly, careful coordination with these other programs can provide EWA with increased resources and greater flexibility in meeting its goals. A 2001 briefing paper issued by the EWP provides some examples of the benefits that program integration could provide. According to the briefing paper, the EWA and EWP could jointly acquire water assets of benefits to both of the programs or could engage in sequential purchases where, for example, the EWP could acquire water assets for its purposes and then, after accomplishing its goals, sell the water to the EWA. The EWA and EWP also might swap assets over time as conditions and information change the relative value of water resources to one or the other program.

The EWA generally manages its water with the other program operations in mind. The Panel, however, would have liked to have seen more evidence that the various programs are actively working together in acquiring and managing their water resources. In part, this reflects the programs' early stages of development. The EWP, for example, appears still to be in a planning stage and not to have spent any of its funding on water acquisitions. But the apparent lack of active integration also may reflect the natural tendency of separate programs to focus on their individual missions and to "protect" their individually owned resources. If so, CALFED management can play a valuable role either by creating an institutional structure to provide greater integration, or by providing the various programs with financial or other incentives to work more closely together. CALFED management also should encourage further study of the opportunities for coordination among the various water programs.

6. Recommendations and Summary

Half way through its projected initial lifespan, the EWA is a noteworthy experiment in environmental and resources management, both from a scientific standpoint, and from an institutional and regulatory standpoint. The tasks it is charged with, using flows to protect and enhance selected fish populations, and acquiring the water to provide those flows, are complex and difficult and entail many physical, biological, institutional and financial factors outside the control of the EWA. Overall, the Panel commends all the agencies and their staff who have been involved in this experiment for their diligence in attempting to realize the vision for EWA laid out in the CALFED ROD.

Nonetheless, the Panel finds that for the EWA to maximize its potential, several significant challenges will need to be overcome, most notably:

1. The growing burden of expectations placed on EWA in the face of reduced funding and increases in what it is expected to do.
2. Better integration of EWA into other CALFED restoration activities.
3. Scientific analysis and synthesis of available data must be improved to strengthen and make more rigorous the scientific underpinnings of EWA actions.
4. More focus on ecologically appropriate measures of biological performance, which would ultimately provide biological justification for the EWA. We remain convinced that take at the pumps must be understood in terms of its effects on fish populations if maximal use is to be made of the limited water EWA has available for fish protection.
5. Allocating sufficient resources to accomplish the stated goals of the EWA. This includes funds for water purchases, needed physical assets like storage capacity, and the people needed to carry out the observations, experiments, analyses, and modeling.

To move forward on EWA science issues, the Panel recommends that CALFED proceed with a sense of urgency to carry out directed actions to address the following critical issues:

1. Identification of the conditions that give rise to entrainment at the pumps.

2. Estimation of the growth and mortality rates, habitat use, and movement patterns of juvenile Chinook salmon within the Delta.
3. Development of a quantitative synthesis of the life cycle of delta smelt and Chinook salmon.
4. Determining how Delta Cross Channel operations might be optimized to reduce entrainment.
5. Determining if and how EWA water can be used to make reservoir releases that improve Salmon spawning habitat at critical times.

From an institutional standpoint the EWA needs additional flexibility in its ability to store water it acquires and must be better integrated with other CALFED elements like the Ecosystems Restoration Program.

Finally, the Panel requests that the CALFED chief scientist in consultation with EWA staff provide a formal, written response to this report to the Panel, especially delineating which of our recommendations can be acted upon this year and which actions are not feasible given contracting problems, staffing limitations, and whatever other factors may constrain changes in EWA implementation and evaluation. We believe that timely feedback to our review will help ensure that the EWA continues to progress towards meeting all of the objectives assigned to it by CALFED.

Acknowledgements

The Panel wishes to thank all of the agency staff, the EWA science advisors and others who contributed written materials concerning the 2001-2002 EWA, as well as those who made presentations at the October workshop. We also wish to thank CALFED staff, particularly Jessica Burton, for their hard work in handling the practical arrangements for the meeting with aplomb. Finally, we are grateful to Dr. Sam Luoma, the CALFED lead scientist for the opportunity to participate in the EWA process and for his efforts in clearly posing the Panel's charge.

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Appendix 1: Draft Charge for 2002 EWA panel (September 26, 2002):

CALFED's Lead Scientist has been assigned the responsibility to evaluate the Environmental Water Account (EWA) at the end of every water year. That evaluation is to be conducted by a standing panel of distinguished scientists who have not been involved in the process. The review will consider the overall concept of EWA and the plans, EWA actions (uses of water and actions to protect fish), and justifications for actions that took place during the year. At the end of four years, the panel will be asked to make recommendations about the implications of using the EWA strategy for the long-term for managing flows and/or changing pumping operations for environmental protection (especially protection of listed fish species), water supply reliability and water quality.

The goal of this second in the series of reviews review is to provide a balanced and constructive evaluation of EWA implementation in 2002, with the goal of making recommendations for future implementation. The review should also consider the outcomes and prospects/plans for the future described below with the goals to make recommendations about possible improvements in those. The panel is asked to be specific, where possible, about how to implement recommendations. Finally, we ask the panel to directly comment on responsiveness to last year's panel review and, if necessary, offer specific insights about how such responsiveness might be improved.

Annual Review Goals.
The panel is expected to convene each year over the four year life of the initial EWA "experience". The annual review will take place each year at the end of the water operations cycle but prior to the development of the next year's EWA plan. Where feasible, involvement of individual panel members in facilitating accomplishment of recommendation or otherwise participating in CALFED activities is encouraged, although not required. The second peer review panel meeting will be held October 21 – 22, 2002 .

The panelist's assignment will be to provide insights and an evaluative report on the progress of the Environmental Water Account. CALFED asks that the report be available by Dec. 5 for the meeting of CALFED agency oversight committee (Policy Group). The 2002 review will provide specific comment on and recommendations regarding:

- Responses to last year's recommendations from the review panel.
- Recap and interpretation of this year's EWA actions.
- Science issues that arose or were dealt with in 2002.
- Development of a strategy for improving the science underlying biological aspects of the management of water in the Delta.
- EWA's future: Decision points, implications of the changes in definition of environmental water, future EWA water purchasing strategies, converging events in the delta.
- Status of science for species and ecosystem; Potential use of models, and water allocation strategies from elsewhere in future management of California's water.
- Insights about information needs and recommendations for advancing knowledge in key areas, including performance measures and testing key working assumptions.

Two [sic 3] questions that were mentioned last year that continue to be of relevance are:

1. ***What factors limited or strengthened EWA effectiveness in satisfying the EWA?***

a. **–Available data?**

b. **–Biological/physical knowledge?**

c. **–Basis of management criteria?**

d. **–Effect of water diversion vs. other stressors?**

e. **–Institutional impediments?**

f. **–Enough water?**

g. **--Accounting; baseline; type of water year?**

2. ***opportunities to employ Adaptive Management or other alternative strategies?***
3. ***Could interconnections between water management and other aspects of CALFED be better considered?***

The EWA Standing Technical Panel

The panel will be comprised of an interdisciplinary group scientific experts who can bring a balance among the issues relevant to the EWA. Independent scientists are invited to participate who are experienced, have a history of leadership activities and who have a demonstrated ability to deal with complex issues in a balanced manner. The group will include some scientists with local expertise and some with relevant discipline knowledge but experience outside the Delta or Bay-Delta water issues. The range of disciplines needed is determined by the complex interconnections of ecology, hydrology, water supply/management and institutional characteristics of the EWA. External experience vs. direct experience (local) with CALFED issues are balanced.

Individual Criteria

•nationally and internationally recognized

•strong publication record and/or record of scientific leadership

•experience with program-level reviews of resource management and complex interagency programs

•track record of fair and unbiased, yet constructive criticism

•**Board Criteria**

•balance between local and outside experts

•range of expertise that spans program-wide scientific issues.

•continuity with existing Boards

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The range of disciplines needed is determined by the complex interconnections of ecology, hydrology, water supply/management and institutional characteristics of the EWA. External experience vs. direct experience (local) with CALFED issues are also must be balanced.

Appendix 2: EWA panel membership 2002

James Anderson - School of Fisheries, University of Washington

Edward Chesney, Louisiana Universities Marine Consortium

James Cloern – Water Resources Division, United States Geological Survey

James Cowan Jr. - Department of Oceanography & Coastal Sciences/Coastal Fisheries Institute, Louisiana State University

Donald Erman – Dept of Wildlife, Fish, and Conservation Biology, UC Davis

David Freyberg - Dept of Civil and Environmental Engineering, Stanford University

Helen Ingram - Dept of Politics and Society, UC Irvine

Stephen Monismith - Dept of Civil and Environmental Engineering, Stanford University

Pete Rhoades – (retired) Metropolitan Water District & South Florida Water Management District

Kenneth Rose - Department of Oceanography & Coastal Sciences/Coastal Fisheries Institute, Louisiana State University

Barton (Buzz) Thompson Jr.– School of Law, Stanford University