Science and the Environmental Water Account: Reflections Following the 2004 EWA Workshop

By
Randall Brown and Wim Kimmerer

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CALFED Science Program
Johnnie Moore, Lead Scientist

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Introduction

The Environmental Water Account (EWA) is an integral part of the CALFED program, implemented to protect and restore sensitive and listed fish species including winter and spring Chinook salmon, steelhead rainbow trout, and delta smelt. The EWA also has the goal of helping maintain and improve water supply reliability from the Sacramento-San Joaquin Delta (Delta). CALFED agencies began the EWA in 2000 as a four-year "experiment" to determine:

- If sufficient environmental water could be acquired and stored within the limits of the available funds and other acquisition methods – the EWA assets.
- If the resource agencies could develop and implement a process that allocated EWA assets in a manner that not only protected target fish species, but also helped assure water supply reliability.

Year four of the EWA experiment ended officially on September 30, 2004. The implementing agencies [US Bureau of Reclamation (USBR), US Fish and Wildlife Service (USFWS), NOAA Fisheries, California Department of Water Resources (DWR), and Department of Fish and Game (DFG)] have agreed on terms of a Memorandum of Understanding (MOU) that will extend the EWA for an additional three years. Although the MOU terminates on December 31, 2007 (the end of CALFED's Phase I), the EWA is a critical component of a set of proposed CALFED long-term actions called the Delta Improvement Package. We therefore believe that, whatever happens in the next 3 years, pressure will be on to extend EWA indefinitely. It behooves us (the Science Program and the agencies) to begin preparing the scientific basis for the long-term EWA.

Over the EWA's four year trial period the Science Program has sponsored a series of annual workshops to summarize the EWA actions and highlight some of the technical issues associated with allocation of EWA water (see for example Brown and Kimmerer 2002 and Kimmerer and Brown 2003 on the CALFED web site). On September 8 and 9, 2004 the annual EWA workshop took a retrospective look at the EWA – from the thinking that led to its formation to its performance during its first four years. The objectives of the 2004 workshop were:

- To examine the first fours years of the EWA and assess its operations and benefits to fish populations and the water community.
- To attempt to place the relative contribution of the EWA in the broader scheme of fish protection and restoration [including the Central Valley Project Improvement Act (CVPIA), Ecosystem Restoration Program (ERP), regulatory standards, etc.]
- To identify scientific questions and information needs that must be considered when designing the structure and function of a long-term EWA.

This document is our interpretation of some of major points that came out of the 2004 workshop. We do not summarize any of the presentations, for three reasons. First, Kristen Honey's excellent notes (posted on the CALFED website) provide a detailed picture of the presentations and discussion at the workshop. These notes have been checked for accuracy by both of us as well as some of the speakers, and are intended to capture some of the discussion as well as the highlights of presentations themselves. Second, we have found that people cite our reports on previous workshops for work other

people have done, and believe this is inappropriate; they should cite the original authors who, naturally, need to get their work in print. Third, we wanted to take a step back and consider where things stand with the scientific aspects of EWA, particularly with regard to a long-term EWA. Thus, in contrast to previous such summaries, we take a much broader view, drawing not only on materials presented in the workshop but our own opinions and experiences. This work also benefited by discussions with Larry Brown, Zach Hymanson, and others.

This report focuses mainly on biological issues to reflect our combined expertise, but also to emphasize the topics that require, and have received, the most scientific attention. The other aspects of EWA (principally water acquisition, water management, and agency coordination) seem to be progressing smoothly, and there is little doubt that EWA will continue to be able to buy, move, and use water if it has the funds. By contrast, there is considerable uncertainty about the biological benefits of EWA.

EWA's purpose and goals

In his presentation at the 2004 workshop, Dave Fullerton correctly pointed out that the EWA was part of the CALFED package established to protect and restore listed species. The EWA grew out of a series of efforts, led mainly by the water contractors and environmental groups (the 3-way process and the Delta Accord), to move beyond the contentious take management process that was the *modus operandi* after the first biological opinions on Delta water project operations were issued in the early 1990s. The EWA was codified in the 2000 CALFED Record of Decision and was included in the suite of actions designed to provide ESA coverage to the water projects. As stated in a 9/23/04 memo from the USFWS to the USBR regarding re-initiation of consultation on the EWA,

*"Several components of the CALFED Program are designed to further the ESA. These programs are an **inseparable part** of the CALFED Program and include the Ecosystem Restoration Program (ERP), the Multi Species Conservation Strategy (MSCS), the Water Quality Program, a short term EWA and its operating principles, and implementation strategies including monitoring and adaptive management." (emphasis added)*

Based on the above, we propose that CALFED fish protection and recovery actions, including the EWA, be judged as an ensemble. We reach this conclusion because the EWA and the other programs provide required ESA coverage to Delta water project operations.

The decision to consider EWA and the other programs inseparable is a political decision, not a scientific one. This decision is based on the belief of the agencies that the package alluded to in the above quote will as a whole achieve ESA protection. Whether that belief will persist as new evidence is gathered remains to be seen. We suspect that if a long-term EWA is based on user fees, the users will demand a more detailed accounting of the benefits of EWA actions taken with their money.

Examining incremental benefits of EWA

The Science Program should continue to press for analysis of incremental benefits of EWA for the following reasons:

- A cost-benefit analysis of EWA, even if qualitative, would allow EWA assets to be used to maximum effect.
- A clear, complete analysis of the benefits of EWA would allow alternative measures to be considered, such as upstream actions that affect populations but not take at the pumps.
- When, in the future, costs and benefits of EWA are examined for a decision whether to continue the program, a clear analysis of the benefits will be most helpful.
- The longer EWA continues, and the more its costs are borne by users, the greater will be the pressure to account for EWA benefits separately from those of other programs.

Incremental benefits of EWA can be separated from those of other programs if these effects are additive. Consider the case of winter-run salmon migrating through the Delta and affected by EWA pumping reductions, as well as various other actions. Density dependence in winter-run salmon is probably weak because of the low population level, and if it occurred would probably occur during spawning. In that case there is no feedback between the size of the population and the fractional survival through the Delta, and the proportional effects of EWA are the same whether the population is large or small.

Suppose survival of winter-run Chinook salmon through the Delta is 50%, and that targeted EWA actions can increase this to 51%, or a 2% increase in survival (51/50 – 1). This means that there will be 2% more fish entering the ocean, being caught in the ocean, and escaping to the river, than there would have been without EWA. This increase can be compounded into the future as long as the 2% gain is realized in the Delta. Survival to the delta, or in the ocean, does not affect this calculation. We do recognize that the information needed to make the calculations has large, and largely unquantified, error bars: thus the EWA benefits will remain somewhat speculative.

A different situation may exist with delta smelt, since the stock-recruit relationship is either very weak or obscured by variability in the data. Thus, an action taken in late spring for juvenile smelt is unlikely to be reflected in higher abundance in fall, because of some (unknown) combination of variability in the population response and the measurements, and potential density-dependent feedback. Even if we were to achieve a stated percentage increase in survival of a particular life stage, there is no expectation that this increase would carry through even that generation, let alone future generations.

The current state of science in the EWA

Has EWA been a science-based program?

To answer this question requires a clear concept of what we mean by "science." Several alternative definitions seem to abound. First, science is seen by many as a body of knowledge, as in "best available science" (see Bisbal 2002 for a discussion of the ambiguity and inaccuracy of this term). Second, science is often perceived as a way of thinking about the world, a definition that people with scientific training use to describe themselves as scientists. Third, science is an approach to gathering knowledge. This

latter approach has certain elements including formation of theories (or conceptual models, in current CALFED parlance), development of hypotheses or alternative models, design and execution of studies to test hypotheses or models, or to determine model parameters, peer review of written results, and publication.

In almost no part of EWA has the scientific approach been followed, although elements of the approach have been applied to the program from the beginning. Examples of the use of scientific data (especially monitoring data) or thought processes include:

- The need for an EWA arose from scientific data and analyses that led NOAA Fisheries, the US Fish and Wildlife Service, and the Department of Fish and Game to conclude that incidental take of listed fish species could jeopardize the continued existence of these species. To avoid jeopardy, the fish agencies specified incidental take limits on Delta operations of the Central Valley and State Water projects. Water project pumping was in turn affected by actions taken by the DWR and the USBR to avoid exceeding the take limits (normally by reducing pumping), thus affecting California's water supplies.
- The size of the EWA (amount of water to be acquired – i.e. the assets) was estimated using historical flow and fish salvage data from the state and federal export facilities, along with knowledge to the life histories of the target fish species. Genetic data were used to refine the life history pattern of winter Chinook, in particular the time of movement through the Delta and numbers taken at the federal and state pumping intakes.
- During its first four years, allocation of EWA water was based on monitoring data and analyses which led resource agency biologists to recommend actions to reduce Delta pumping to avoid exceeding take limits and thus reducing impacts to winter and spring Chinook, steelhead and delta smelt.
- Determining the benefits of EWA for target species requires scientific understanding of how the actions taken affected these species at specific life stages or at the population level, and some efforts have been made toward this determination.

These examples illustrate that scientific thought processes are pervasive throughout EWA. However, we suggest that for EWA to be called a science-based program requires more. The principal reason for this concern is that to date most of the information transfer within EWA, and most of the basis for decisions about how to use water, have been based on oral reports and presentations, or documents that have not received thorough peer review. There seems to be little time, opportunity, or pressure to get this information written up, peer reviewed, and published (note that are not necessarily advocating publication in the peer-reviewed academic literature, but some form of reviewed report series is essential as a basis for EWA).

The lack of peer review also applies to programs that contribute information used in the EWA's Tier 1 baseline, including the OCAP biological opinion. For example, the USFWS program to estimate survival of salmon smolts through the Delta has not been critically reviewed, nor has the sampling design for the DFG 20-mm survey or fall

midwater trawl study. Yet these and other agency programs are fundamental to the analyses that go into EWA.

We believe that the 3-year extension of EWA, and the high probability that EWA will continue beyond 3 years, offer both a requirement and an opportunity to develop a more rigorous scientific framework for EWA.

Can the EWA be Adaptive Management?

Several discussions at previous workshops have concerned the term "Adaptive Management." People are confused: EWA is certainly adaptive, and it is obviously management. However unfortunate the choice of terms, though, "Adaptive Management" refers to the scientific approach to management espoused by Holling (1978), Walters (1986, 1997, Walters and Holling 1990), and others, and described in some detail in the CALFED Ecosystem Restoration Program Strategic Plan. To help somewhat in keeping terms clearly defined, we use upper case to refer to this approach. AM emphasizes the value of information about the system, which in early stages of a program should be considered as valuable as the actions themselves, since the uncertainty about the efficacy of the actions is so high. In AM this learning is primarily about the ecosystem being managed, rather than the ways of managing it. Thus, although EWA has been called an "experiment", it is an experiment only in social science and management, not in natural science.

For EWA to be an Adaptive Management program would require:

- Explicit statements of hypotheses or alternative models to be tested
- Predictions of outcomes of actions (or possibly classes of actions)
- Formal comparison of realized outcomes to predictions
- Refinement of models to reflect new information, and revision of actions when warranted by examination of the new models.
- Periodic, formal evaluation of the models, their basis, and their continuing development.

Adaptive Management can be active (i.e., a manipulation designed to probe the system while achieving some management objective), or passive (i.e., manipulations for experimental purposes are infeasible, so the learning comes from monitoring and research using natural or other human perturbations to probe the system).

Active Adaptive Management experiments are being developed for Clear Creek, Yolo Bypass, and Dutch Slough under the ERP. To an extent, the entire ERP was intended as a passive AM experiment, although the required parts listed above are still mostly missing. The Vernalis Adaptive Management Program (VAMP), to which EWA has contributed water, has many of the elements of AM but the experimental design is suboptimal for actually answering the questions being asked.

There are several advantages to considering an AM design for EWA. First, it would honestly acknowledge the high degree of uncertainty about management actions. Second, it would require clear statement of alternative conceptual models, and the development of simulation models that would test the predictions of these concepts.

Third, it would provide for a formal feedback loop between actions through outcomes to information, allowing for refinement of models. These advantages would accrue even without an experimental manipulation which, at least in the case of salmon, may not be necessary given the high variability in the system during the migration periods.

Active AM might be considered specifically in the case of delta smelt. It seems likely, based on what we have been hearing at the workshops and the draft delta smelt white paper, that delta smelt are at least sometimes subjected to high mortality because of export pumping. At present we do not have a clear idea of which life stage is most important to protect, and therefore in what season this protection would be most effective. Thus, there may be an opportunity to vary the timing of EWA actions designed for delta smelt, in an effort to quantify the effects of these actions. This topic should probably be taken up at the next delta smelt workshop.

Science organization in the EWA

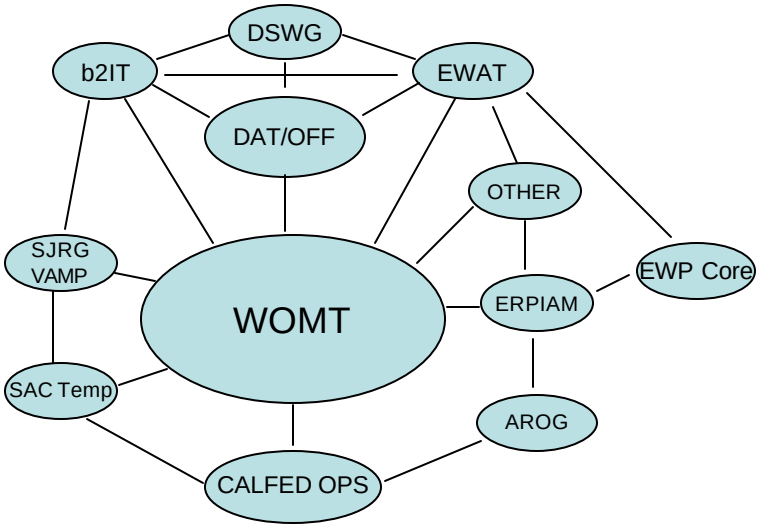
It is difficult to pinpoint the extent of scientific activities on behalf of EWA. As discussed below, much of the time spent by EWA agency personnel is not on science, but many other scientific activities such as monitoring also contribute to EWA.

To date there has been no dedicated science budget for the EWA. The table below gives an estimate of EWA staffing levels prepared by Jim White, plus our estimate of CBDA's effort including our time and that of CBDA staff.

Agency	**Approximate full-time staff**
DWR	5.75
DFG	1.5
USBR	3
USFWS	2
DOI Solicitor	0.5
NOAA	0.3
CBDA	1
TOTAL	14

These figures are only very rough approximations, though. It is difficult to separate the activities relating solely to EWA from other activities, and difficult to account for all of the staff time devoted to activities that contribute to EWA. The following diagram illustrates the complexity of organization of the scientific staff through the links among the various activities associated with operation of the EWA and related programs (Diagram courtesy of Roger Guinee, USFWS):

Increased coordination among environmental water programs/fish action decision process



The acronyms may need some explanation:

- DSWG – Delta smelt work group
- EWAT – EWA Technical Team
- ERPIAM – Ecosystem Restoration Program
- EWP core team – Environmental Water Program – part of the ERP
- AROG – American River Operations Group
- SAC Temp – we don't know this acronym
- SJRG VAMP – the San Joaquin River Group and the Vernalis Adaptive Management Plan
- b2IT - The CVPIA's b2 technical team
- DAT/OFF – Data assessment team and Operations and Fisheries Forum
- WOMT – Water Operations Management Team.

All of these groups engage in periodic, often frequent, meetings. Many of the EWA agency staff are on several of these groups. Therefore, scientists and engineers that are part of the EWA process spend much of their time in meetings and preparing for meetings. We are not arguing that the meetings are unnecessary, since we do not generally attend them. These meetings are the principal venue by which the essential functions of coordination and communication take place. Nevertheless, all of the meeting time leaves little time or mental capacity for analysis and writing. As was pointed out at the EWA workshop, instead of the present situation where many people wear more than one hat, we need more heads. The bottom line is that existing EWA staff time is very limited, and is generally not available for in-depth data analysis. .

On the positive side, other science programs play important roles in support of the EWA and CALFED ecosystem programs in general. Key examples of the other programs are:

- The $14M/year Interagency Ecological Program, comprising the same agencies involved in EWA, provides information used in EWA decision-making and in assessing water project impacts. Studies include:
    - Salmon trawl catches at Sacramento, Chipps Island, internal Delta beach seine sites and a trawl site on the San Joaquin River.
    - Experiments and analyses to examine factors affecting juvenile salmon survival through the Delta.
    - Genetic analyses of salmon in the watershed and the estuary to distinguish the races.
    - The 20 mm survey to determine the distribution of the early life stages of delta smelt and other fishes.
    - The summer townet and fall midwater trawl surveys to index delta smelt abundance at later life stages.
- DWR and USBR fund collection, identification, and counting of the fish salvaged at the state and federal fish protection facilities in the Delta.
- With CALFED funding, USFWS operates the screw traps just below the Red Bluff Diversion Dam that provide information on timing of winter Chinook emigration and the estimated annual numbers of juvenile winter Chinook leaving the spawning area – the Juvenile Production Index.
- DFG and the USFWS conduct the winter Chinook carcass surveys which provide the foundation for calculating the Juvenile Production Estimate – the basis for take levels in the Delta.
- DFG with various funding operates rotary screw traps on Mill, Deer and Butte creeks and on the Sacramento River at the Glenn-Colusa Irrigation District and Knights Landing. Data from these sampling stations provide information used in the salmon decision tree.

The Science Program is in the best position to organize scientific activities around EWA. However, there are several impediments to actually carrying out this responsibility. Principal among them are:

- The Science Program has no authority to direct any agency group to conduct any line of work. This is probably a good thing: the Science Program is responsible for organizing reviews of EWA and other agency-led activities, and the agencies have other agendas than science. Nevertheless, this implies a need for negotiation between the Science Program and agency heads to get some kinds of work done.
- The Science Program is constrained to conduct most of its activities through the PSP or other solicitations. In its current configuration it cannot undertake research or analysis itself, but must rely on outside entities. Because of the need to use the PSP, and the even-handed peer-review process that all proposals must

go through, there is never a guarantee that the questions that need to be addressed actually will be. The Science Program cannot cherry-pick the necessary projects from the list of applications, because to do so would circumvent the peer-review process.

- Contracting takes too long. Sometimes questions need to be answered in the short term, based on efforts measured in days to months. This does not match with the contracting process. For example, proposals for the 2001 ERP solicitation were not funded until late in 2003.

Contracts are limited in time to 3 years. This makes it difficult for the Science Program to support monitoring in more than a stopgap mode, a mode that we would like to see disappear.

Scientific advances related to EWA

Although the agency personnel most actively involved in EWA cannot, as discussed above, spend much time on scientific activities, several important advances have been made through the EWA process. Much of this progress has been achieved through the efforts enumerated above. Although these efforts were not designed and funded to support EWA, they provide essential input to the EWA process. What is perhaps not so widely recognized is the degree to which EWA has served as a catalyst to convert some of the data developed by these programs into knowledge useful both to EWA and other programs.

Significant advances in knowledge at least partially catalyzed by EWA include:

- Revision of the JPE and realization of the tight relationship with JPI. Although the changes in calculation of the JPE would have probably occurred without the EWA, we think the EWA was a major factor in making the changes early in the trial.
- Salmon life cycle modeling. Perhaps partly in response to the EWA there has been a renewed interest in modeling winter Chinook. Steve Cramer has assembled much of the available information on winter Chinook and has distributed a useful conceptual life cycle model, as well as a working spreadsheet model. We are working on a winter Chinook model as well and expect to publish it in the spring of 2005.
- The effects of pumping on delta smelt. The EWA, mainly with its shoulders on VAMP, caused CALFED and agency biologists, BJ Miller, and Bill Bennett to take a closer look at delta smelt abundance in the south Delta and how their seasonal distribution may affect entrainment and population impacts. That and Bennett's work on converting indices to abundance estimates may help us move from speculation to mechanistic models of how delta smelt are affected by export pumping and therefore how EWA can best protect smelt.

The future for science in the EWA

We now turn to the role of science in the future of EWA. This role hinges on one assumption and on the answers to two questions:

Assumption: EWA will continue for the next 3 years more or less as it has, and then roll over into a long-term program. If this is true, then it is necessary to plan for science in the long-term program. If it is not true, then science can continue more or less as it has until the program ends.

Question 1: Is the long-term EWA supposed to contribute to recovery of listed species? This may seem obvious from the ROD, but it is not obvious from at least the early efforts to assess EWA. Increasingly people are asking, and trying to answer, questions about the magnitude of that contribution. Nevertheless, the long-term EWA might not have recovery as its goal, but rather water supply reliability. Although this reliability would be based on a false premise (that EWA provides protection to listed species without evidence of a contribution to recovery), it is possible that the long-term EWA will have reliability as its foundation.

If the answer to this first question is "no", the long-term EWA does not need much of a scientific basis or effort. The efforts to interpret, refine, and revise the scientific content of EWA could be reduced to a periodic review and revision.

Q*uestion 2: If the long-term EWA is supposed to contribute to recovery, is it to be based on science?* This may also seem a bit naïve. However, if we apply the full definition of "science" to this question, as discussed above, the answer for the initial experiment is clearly "no". We discuss above the various pieces of the scientific approach that are used in EWA, but none of it applies the entire cycle from theory through publication, and most of it has been peer-reviewed, if at all, only on the basis of oral presentations. Thus, if CBDA is going to claim that the long-term EWA is based on science, the need is clear to begin making that the case.

For the rest of this discussion we assume that the answer to both questions is "yes": the long-term EWA will be a science-based program whose purpose is to contribute to recovery.

<u>Organizational issues for conducting science</u>

We are not social scientists, but both of us have been involved in the organization of science for a long time. There are several institutional aspects of science surrounding EWA that will need to be resolved to bring the scientific discourse up to the level implied by the previous section.

We believe that the ultimate responsibility for science in the EWA and other CALFED programs lies with the CBDA Science Program and the Lead Scientist. Since the IEP is now technically part of the Science Program, the IEP falls within the purview of the Lead Scientist. The Science Program should take the lead to work with CALFED, agency, academic and stakeholder scientists and managers to develop a list of information needs and lay out a program to meet those needs. In addition to EWA, we need to track the performance of ERP projects and their progress toward meeting MSCS requirements. Furthermore, under the "one blueprint" concept, performance of CVPIA and Four-pumps

activities funded under the CALFED umbrella should also be evaluated by the Science Program.

To accomplish these evaluations will require a program of monitoring and research, including modeling and analysis of monitoring data. Based on past history, IEP is very good at monitoring, but at present does relatively little analysis or research. The Science Program excels at stimulating, funding, and promoting research. Therefore a strong partnership should provide the means to achieve the evaluation needed.

An example of the need for a defined science program has arisen in year five of the EWA. Funding for DFG's fish sampling on Deer, Mill and Butte creeks and on the Sacramento River at Glenn-Colusa Irrigation District and Knights Landing dried up this fall. Data from these stations are needed for the EWA's salmon decision tree, and the stations also provide information useful for understanding Chinook salmon life histories, in particular the complex spring Chinook life history. DWR came up with stopgap funds to keep the some of the programs going. If these stations are needed for the EWA and other CALFED programs, they require a strong agency commitment and firm funding.

To fulfill this rather daunting need for program-wide monitoring and research , we will need the help of the ERP Science Board, the Independent Science Board, the IEP coordinators, as well as agency and stakeholder scientists and managers. We think this has be done if we are to have any chance of sorting out the biological benefits of EWA actions and those of CALFED program in general.

The science needs for a long-term EWA differ somewhat from those of the short-term program. To some extent this provides leeway in terms of the time needed to coordinate and get programs in place, and to develop necessary knowledge. However, this leeway can easily be squandered, and efforts should begin now if it appears that our assumptions above are to be met.

<u>The scientific questions</u>

Assembling lists of scientific questions relevant to management can be a sterile exercise. Nevertheless, for EWA it is pretty clear what issues most need to be addressed. More importantly, based on presentations at the recent workshop and other information we can begin to provide at least partial answers to some questions now, helping us to sharpen our focus on those questions for which we lack answers. The questions below are probably key in terms of evaluating and improving the efficacy of EWA.

- *What classes of actions appear to be most/least effective?* We remain consistent with past Science Program practice in not attempting to second-guess the real-time decisions of the agencies. However, the suite of tools available for real-time decisions is most definitely open to scientific scrutiny. Although we have some ideas about the relative effectiveness of various actions, answering this question will require considerable effort at analyzing the available data on alternative classes of actions. For example, one such class is using EWA water to protect spawning habitat in the American River from reductions in river stage when mandatory minimum flows decrease. What is the scientific basis for this class of actions, what species does it protect, how strong is the protective effect, and how well do we know?

- *How much can EWA contribute to the recovery of salmon?* The answer to this partially depends on the previous question, since different actions will have different results. Focusing on the reduction of export flows in the Delta, which have been the principal use of EWA water, we can at least begin an evaluation of this. For winter-run salmon all indications so far are that EWA actions provide an increase in survival of less than 1%, and possibly much less. Spring-run salmon, because of their varied life history, are more difficult both to protect and evaluate. Although not numerous, yearlings may contribute more to the spring-run population than earlier life stages since mortality generally decreases as fish grow, so EWA actions targeted at spring-run yearlings might be effective if the appropriate timing can be determined. We need to know more about the movements, genetic identities, and variability of spring-run Chinook. We need to know more about the use of the Delta by all races of Chinook salmon for rearing, and some progress is being made. EWA benefits to steelhead have not been defined and the steelhead biological data base needs to be expanded in all areas of the system.
- How much can EWA contribute to the recovery of delta smelt? A preliminary answer to this question may be forthcoming in the next few years as new data, analyses, and models become available. Delta smelt appear the most likely to be affected by export pumping of all fish species by virtue of their location. One of the original concepts behind EWA was to reduce export pumping at times when real-time monitoring revealed that delta smelt and other fish were vulnerable. This concept has not been borne out because the sampling effort in time and space is too low. However, progress is being made toward a better understanding of delta smelt biology that may show what physical conditions (e.g., temperature) result in high or low entrainment rates.
- What other species might benefit measurably from EWA actions? We include "measurably" here to indicate that we are not interested in vague statements of possible benefits, but in benefits that can be quantified in some way. At present we do not believe such benefits are likely, since EWA has been applied very specifically.

We exclude from this list any mention of ecosystem-level benefits. For several reasons we do not believe such benefits are worth listing as positive outcomes of EWA. First, the amount of water involved is actually rather small compared to the amounts of water flowing in the major rivers and major diversions. Second, EWA actions are targeted at specific times, and there is no reason to expect ecosystem benefits at those times in particular. Third, ecosystem-level benefits are by definition diffuse, and therefore difficult or (more likely) impossible to measure. This issue can be reopened if any specific ecosystem benefit is identified in the future, but for the moment we do not believe this is worth pursuing, and it should be dropped.

What do we need to do?

As Larry Brown pointed out in his workshop presentation and in his report on the first four years of the EWA, the annual technical workshops and the annual technical review panel meetings have had the major benefit of keeping science in the spotlight. The

workshops should continue and be open to interested public and stakeholders. The frequency of review panel meetings might be reduced from annually to every 2 or 3 years, if this could be done without taking the pressure off the scientists. This pressure, necessary to maintain focus and get work products out, could be maintained through the workshops. The principal advantages of reducing the frequency of panel reviews would be that it would reduce wear and tear on panel members, and reduce time spent in preparing reports and presentations. Some panel members could be involved in workshops, as has happened in the past, thereby maintaining continuity.

In the short term we recommend two specific actions to improve the science associated with examining EWA and other CALFED actions in the Delta. These actions are important and should be started immediately.

Institute a series of technical workshops between the annual open workshops. The term "workshop" has been diluted to include conferences, and most of our recent EWA workshops have not involved any work on the part of the participants beyond preparing talks. In this case "workshop" would mean that attendance would be limited to those participants with extensive background in the area to be discussed, with a maximum of 20 attendees. Since it is impossible (and generally undesirable) to exclude anybody, we would allow for a non-participating audience with one or two limited time periods for audience comment.

We propose that the first technical workshop be held in the spring of 2005 to focus on survival of juvenile salmon though the Delta. Although workshop details are to be developed, some of the workshop attributes would probably be.

- The EWA science advisors would take the lead.
- We would solicit a limited number of presentations from scientists working on the issues associated with Delta survival, and invite scientists with backgrounds that may help in the discussion (for example, a hydrodynamics person, a geneticist and a biometrician/statistician).
- There would adequate time (at least half of the time) for discussion during this1-day workshop.
- Materials for the review would be prepared and sent to participants in advance.
- A written product from the workshop would describe conclusions, recommendations, and next steps. This would include a statement of alternative perspectives and opinions.

Assist the Delta program with statistical expertise. There is unanimous agreement that statistical help is needed, but in four years of asking nothing has happened. Part of the reason is different perceptions of what is needed, and by what mechanism. We believe that a statistically-capable ecologist would fit the needs of the program better than a person with a purely statistical background. For several reasons, a contract position may be preferable to a staff position to fill this need. We propose the following actions

- Enlist the temporary help of Steve Obrebski of the Tiburon Center to work with the salmon survival study (initial steps have been taken).
- Explore the possibility of hiring the necessary expertise through the Pacific States Marine Fisheries Commission. Doing this will require:
    - A mechanism to provide funds. DWR has an existing contract with the PSMFC for data technicians that could be amended. If CALFED funds are to be used, they would have to be transferred to DWR. The best alternative would be to have the funds made available through the IEP.
    - Agreement on a job description.
    - Suitable candidates can be identified. The PSMFC has hired this type of person before.
    - A qualified candidate can be selected by an interagency panel and he or she accepts the position. The position should be for two years and the person would be located in Stockton or Sacramento at the agency's discretion.

Science for the long-term EWA

A science plan should be developed for the long-term EWA. This plan should start from a description of over-arching questions such as those discussed above, which should lead into a description of the information needs and the research or monitoring necessary to fill those needs. Some efforts have been undertaken but this needs to be more focused on the long-term EWA, and it should be agreed to by the major scientific players in EWA (i.e., agency heads and the Science Program).

A long-term science program would do the following:

- Integrate science into EWA – meaning that EWA would apply a scientific approach to its activities.
- Integrate science for the longterm EWA into the overall CALFED program providing information on the ERP, the Delta Improvement Package and the Multi Species Conservation Strategy. One of the first areas of examination would be the direct and indirect effects of project pumping on several sensitive fish species. This focus is necessary because understanding these effects is critical for the EWA and other CALFED efforts to modify Delta export patterns and quantities.
- Develop a plan and funding for research needed to address questions critical to EWA
- Develop a plan and funding for monitoring essential for EWA, and ensure there is a long-term commitment to this monitoring
- Establish minimum standards for statistical reporting, either through training, peer review, or by hiring statistical help
- Start publishing the basis for EWA actions. This must be timely – it need not be in a scientific journal, but should be reviewed internally (among the agencies, Advisors, and CBDA staff), then anonymously reviewed by people reasonably

familiar with the key issues. There may be a reason to establish a technical report series in conjunction with SFEWS to allow for publication (and review) of material used in management and restoration but not of broad enough scientific interest to warrant publication in SFEWS.

In addition to the science plan, we believe there are several criteria for the scientific aspects of a long-term EWA:

- Scientific efforts should focus on population-level effects. Without this focus there is little reason to put a lot of effort into science. We do recognize that understanding population effects will require us to understand the effects at individual life stages such as Chinook salmon smolts.
- Analyses should focus on alternative strategies; for example, would it be better to protect fish in the Delta or upstream? The Science Program should establish a framework for comparing actions, with a common currency and using some sort of population model as an organizing tool.
- Develop priorities with a 5- to 10-year horizon
- Continue developing conceptual and simulation models
- Develop a method for examining alternative futures, using population models and other analytical tools to explore outcomes. This has been done to good effect for water supply, using the gaming process, but the biological side of that was limited to take. It should be possible at some point to compare quantitatively the likely outcomes of alternative programs.

Consider placing EWA in an Adaptive Management framework. AM should be applied when uncertainty is high, smaller-scale studies cannot provide results applicable to the larger scale, and for active AM, opportunities exist to manipulate the system in a way that is expected to produce measurable results. The first two criteria apply, but we are not sure about the third. This should be explored through simple simulations using models developed for delta smelt.

Conclusions

We believe that to date the EWA program has been remarkably successful in bringing about coordination and cooperation, and in catalyzing a number of important scientific advances. However, if there is to be a long-term EWA and it is to be a science-based program with an emphasis on ultimate benefits to populations of fish rather than individuals, then the Science Program should begin preparations for that program now. If that is going to happen, we are ready to help.

References cited

Bisbal, G. A. 2002. The best available science for the management of anadromous salmonids in the Columbia River basin. Canadian Journal of Fisheries and Aquatic Sciences **59**:1952-1959.

Holling, C. S., editor. 1978. Adaptive environmental assessment and management. Wiley, New York.

Walters, C. J. 1986. Adaptive management of renewable resources. MacMillan, New York.

Walters, C. J. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology **1**.

Walters, C. J., and C. S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology **71**:2060-2068.