IEP Delta Smelt Review - Science Advisory Group Report

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Introduction

On April 13/14, the IEP Science Advisory Group (SAG) met with IEP staff to review the current IEP effort monitoring and studying delta smelt. The purpose of this meeting was to examine current sampling programs and strategies with regard to their utility and value towards understanding what factors influence the health, i.e. the abundance, of delta smelt populations, and hence towards managing water project operations in the Delta that affect delta smelt.

Findings

The following summarize the key findings that the SAG believes deserve the most attention by IEP.

1. Delta smelt review epitomizes what IEP can and should accomplish

As demonstrated in the various materials, presentations and posters presented to the SAG in the course of this review, application of the monitoring and special projects data to critical scientific analysis such as the decline in delta smelt extends the full potential of the IEP program, beyond status and trends and management thresholds. Most of the data are very useful for various analyses and model inputs, particularly given the long-term duration of some of the critical datasets, such as the townet catches. Since the emergence of concern for delta smelt in the mid-1980's, samples from IEP monitoring have also provided invaluable material for both IEP and other analyses. The broad involvement within and beyond IEP also demonstrates the collaborative and open nature of the program, particularly when it comes to data and sample access.

2. The power of collaboration

The SAG wishes to further emphasize that the delta smelt review illustrates the power of close collaboration of scientists within and outside IEP. The SAG has repeatedly called for greater conversion of IEP data to information available to

management and the external scientific community. It is clear from this review that advances have been made in that regard, although not necessarily following the path(s) IEP and the SAG historically discussed. The competent data collection and excellent job of making data available in a timely manner are great strengths of IEP. Analysis of the data by the DAT team clearly provides a direct pathway to day-to-day management; but it does not provide a historical record or a full analysis of the data. The assignment of IEP scientists like Matt Nobriga to analysis of specific questions is a very encouraging development. The increasing prominence of analyses by the individuals from the stakeholder and academic community is, at present, the most productive avenue for such analyses. But support for such work must be available. With regard to Delta smelt, analyses by Drs. Bennett, Kimmerer and Miller, for example, have creatively exploited many aspects of IEP data. Centering such analyses around the modeling efforts will further promote this work. These are somewhat implicit collaborations, supported largely by CALFED. This is an excellent example of how the CALFED-IEP partnership can be profitable. Every effort should be made to continue to facilitate and expand these fruitful types of institutional/individual collaborations (implicit and explicit) –see recommendations.

3. Existing monitoring program needs to be continued, but with some critical re-evaluation

The SAG absolutely appreciates the value of the long-term dataset that the IEP monitoring program sustains and the continuity it provides for understanding the dynamics of delta smelt and other pelagic organisms. The remarkable dedication of the staff to efficiently and accurately conduct the surveys is admirable. That they generate and disseminate (through a very effective website) the data extremely rapidly is even more commendable.

However, the SAG is concerned about the diffuse and extensive number of stations and sampling programs from the standpoint of extracting the most critical information most effectively. There is an appearance of unwillingness to methodically examine what stations provide the most value, not only for delta smelt but for most pelagic organisms, their prey and environmental variables. Rigorous statistical analysis of the data gathered across all of these programs could assess the level of redundancy and

value of both the stations and the sampling designs (see Recommendations).

This is NOT intended in any way to reduce the monitoring effort, but to reallocate the incredible effort to maximize the value of the data and samples. This would free up the monitoring program to incorporate new techniques, conduct new or more complete analyses of archived samples, and be more flexible in the spatial and temporal structure of sampling designs with the current techniques. Accordingly, the SAG also believes that the monitoring needs to be more adaptive when particular issues can be addressed by extension or modification of the routine design to accommodate new questions (e.g., diel behavior) or variable situations (e.g., expanded or contracted habitat). We applaud that IEP has already employed some flexibility to explore methodological variations that compare sampling gear, design and protocols, but suggest incorporating this approach as a more explicit, adaptive component rather than its present ad hoc occurrence.

Such a consolidation would also allow the program to explore the use of new and emerging technologies that could complement, replace or extend existing monitoring. Acoustic, sonar, automated plankton counting, biological sensors and other technologies could possibly be used to address special issues (e.g., diel behavior, spawning) that are presently intractable given the limitations of the existing techniques.

Finally, a critical reassessment of the program could also allow redirected investment to meet some of the critical data gaps identified in the review. The most notable of these gaps were: (1) the need for meteorological data from strategic points in the Bay-Delta, to support the hydrodynamic modeling; (2) population genetics information, which could utilize both archived and new collections; (3) individual fish histopathology and other physiological condition analyses; and, (4) spawning sites and egg abundance data which could provide critical information on egg-larvae survival for individual-based and matrix modeling.

4. Use of data in management actions

The SAG is impressed with the ways in which IEP is seeking to incorporate their data explicitly into management actions. The value of these data and associated analyses and modeling is immeasurable when it provides unequivocal and quick feedback about the resource response. However, we feel that IEP and the water managers aren't maximizing

the potential to directly incorporate feedback into revised actions in an adaptive management context. The example that seemed most obvious was to use opportunities for directed studies to assess pumping entrainment, rather than rely on salvage at the pumps as the proxy measurement. IEP and managers should evaluate whether, within regulatory pumping constraints, they have the opportunity to take a more experimental approach rather than opportunistic/operational mode to explicitly document entrainment.

5. It's more of a POD than just a delta smelt issue

It was apparent to the SAG that, although this was technically a delta smelt review, the evidence assembled and analyzed had implications for the broader pelagic organism decline (POD) in the Bay-Delta that went far beyond just the IEP and CALFED. Suggestions of cohort failure, density dependence, carrying capacity limitations, and other constraints (contaminants?) on delta smelt survival and vitality imply system-wide failure to sustain a viable pelagic community and food web. In conjunction with the existing POD initiative, IEP could play a significant role to initiate a broader, more comprehensive assessment of IEP, CALFED, other agency and academic data about this level of systematic degradation in Bay-Delta ecosystems.

Recommendations

Based on these findings, the SAG makes the following recommendations:

1. Improve Strategic Monitoring

The IEP monitoring programs are extensive in scope and diverse in targets. The value of monitoring data sets generally increases greatly with time, and the utility of the multidecadal IEP data is no exception. The program has now expanded to include key monitoring efforts on several life stages of the Delta Smelt. There are two important opportunities for synthesis of the IEP data that would be greatly beneficial. The first is a strategic analysis of existing sampling designs to assess whether similar or better insight could be gained from alternative designs with less redundancy. The second (discussed below) is a synthetic analysis of the different components of IEP to more effectively integrate their findings into a comprehensive assessment of delta smelt demographics and threats to their persistence.

Monitoring Assessment:

We believe that IEP has done a very good job assessing the design of their monitoring programs up front, before they are implemented. These analyses consider sampling design and statistical power effectively given the limited knowledge that exists prior to sampling. As is true of most long term monitoring efforts, however, the IEP has not done sufficient assessments of their sampling design in light of the knowledge gained from decades of sampling the system. Given that there are a number of issues that are not being adequately studied because of lack of sufficient funding, the timing is ripe for an assessment of the monitoring efforts to evaluate whether they can be made more efficient and cost effective. For example, are there sites that can be dropped from sampling because they provide redundant information? Is sampling effort being allocated most efficiently between the number of replicate samples per site and the number of sites? Should more effort be focused on analyzing archived samples before more samples are collected? We believe that a rigorous statistical assessment of such issues, especially one that incorporates geostatistical spatial analyses, holds great promise for modified sampling designs that provide equal or even greater insight with a smaller investment of resources in data collection and sample processing. Given that there are several issues that warrant additional sampling effort (e.g., larval and egg sampling, adaptive management assessments), but are constrained by resources, the strategic monitoring assessment should be a high priority.

Technological Advances

The challenges of studying delta smelt and other estuarine species in the bay delta are logistically daunting. Most life stages are small, patchily distributed, and mobile. Although IEP has done an excellent job developing sampling programs to address some of these challenges, we believe there are opportunities for incorporating more technological solutions. We know that IEP has explored and rejected the use of acoustic and optical sampling technologies that are being used in marine settings to solve similar problems. The technology underlying these sampling approaches is evolving rapidly, however, especially with the national focus on ocean observing systems. IEP needs to stay abreast of these new advancements, and where possible encourage their use in the bay as a testbed. We believe there would be real merit in convening a group of innovators in these new methodologies (e.g., Jules Jaffe at Scripps Institute of Oceanography,

others?) to address the sampling challenges of IEP.

2. Improve utilization of existing data

The IEP has a tremendous wealth of data and their general accessibility provides the opportunity for additional analyses providing insight into system-wide patterns. One potentially fruitful area is an explicit evaluation of spatial patterns in the density of different life stages, the distribution and extent of presumed nursery habitat, and growth or health of the collected fishes. A spatial framework would allow the assessment of source and sink locations, potential distribution of spawning locations, vulnerability of various population components to pumping operations, temporal expansion and contraction of available habitat, etc. A concerted effort should be made to process archived fish samples to measure population genetic structure, growth, age composition (occurrence of 2-year-olds), fish health (liver condition, muscle lipids, etc), diet. etc. It is important to examine these data as potential correlates of interannual variability in fish abundance, but they are also extremely valuable within years to examine spatial variability in contribution to the year's delta smelt production. Spatial patterns in stable isotope patterns or otolith microchemistry will also be useful in evaluating contributions to adult population.

Other vital information is also potentially available with focused data mining of existing datasets. As an example, the apparent shift in size composition of the delta smelt population should be critically evaluated over as many years as possible. Multivariate analyses that examine interactions among multiple environmental factors in relation to abundance/distribution of different life history stages provide another valuable opportunity.

A concerted effort to link hydrological models to hindcasting and forecasting is needed, with an attempt to move beyond particle tracking. For example, information on spawning locations based on the presence of ripe females should be linked to eventual entrainment at the pumps.

Special studies can fill critical gaps in needed information on basic biology of delta smelt. Approaches examining underlying mechanisms for observed patterns in growth, mortality, spatial distribution, etc. are especially important. For example, the 'characteristics of survivors' approach used by Bennett to examine processes affecting

survival in different years is valuable. Integration with ongoing lab studies of behavior and physiology of cultured smelts would be valuable in understanding potential interactive effects of different environmental factors. The ongoing modeling efforts by Bennett and Kimmerer will also provide major syntheses of available data and will directly examine potential mechanisms influencing growth, movement, and survival.

As always, publication in the peer-reviewed literature should be strongly encouraged and appropriate time and support for writing should be made available. Collaboration with outside researchers can provide a mechanism for ensuring production of manuscripts and follow through for the publication process.

3. Take better advantage of adaptive management potential to quantify entrainment losses

The SAG recommends that the IEP make better use of the adaptive management potential of the fact that some elements of water project operations, notably EWA actions, are based on predictions of effects of increased or curtailed pumping on the spatial distributions of delta smelt. These predictions, albeit made assuming that delta smelt behave like passive (non-swimming) particles are amenable to testing through enhanced sampling effort in the region around the pumps. We recognize that the sampling problem for delta smelt is severe. For example, 1 fish found during the 20 mm townet survey at the station immediately north of Clifton Court translates into a level of significant concern at the pumps. However, given the fact that manipulations of water project operations due to ESA concerns for delta smelt have major implications for water resources management in California, it seems that the potential value of knowing the effects of these kinds of directed actions would be quite valuable. It seems possible that increased sampling effort in the likely domain of influence of the pumps (which could be defined by modeling either with the PTM or with more sophisticated models like the RMA 2D model used for evaluating levee breaches) could help with the signal to noise problem.

In the same way, the SAG recommends that the model which will soon be constructed by Kimmerer et al with CBDA/Calfed support[1] might be used to evaluate seasonal trends in the spatial distribution of delta smelt and how those distributions

[1] The SAG chair, Monismith, is one of the PIs on this modelling effort.

respond to hydrology (among other things). This modeling effort may also point to improved spatial layout of the sampling effort.

4. Engage in NCEAS synthesis activity

As insight into the life cycle and demographics of delta smelt has increased, the diversity of issues potentially affecting their dynamics has also grown. It is clear that declines in delta smelt are not a simple response to a single factor. Nonetheless, scientific progress will be slow and effective management actions will be unclear if we simply conclude that a suite of factors all potentially threaten delta smelt and other species in the bay. Some threats are more critical than others, and threats can interact to produce outcomes that are unpredictable by considering them separately. There is a pressing need to do a comprehensive synthesis of the findings that have emerged from the many component IEP studies. This synthesis is unlikely to emerge from the cumulative findings of a number of somewhat independent studies. The pending whole life-cycle modeling efforts and coordinated transport models are a step in the right direction toward this synthesis, but we believe much more is possible with a synthetic effort that is led by scientists associated with IEP, but that draws on outside expertise.

The model for this synthesis effort is the working group approach developed at the National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara. The challenge of multiple interacting threats is an issue that likely faces every recovery plan for listed species regardless of the habitat involved. IEP needs to look at these other efforts for successful models of integration. Bringing together a working group of scientists that draws on experts from a diversity of fields, particularly those who have successfully met similar challenges in other systems, would be extremely valuable. Although such a synthesis effort could be convened by IEP, there are real merits (i.e., funding, data management support, history of success on hundreds of other synthesis efforts) to taking advantage of the opportunity for proposing a working group on this topic at NCEAS. One intriguing possibility would be to do a comparative working group focused on comparing issues in the Bay Delta with those in Florida Bay. The SAG would be happy to work with IEP to coordinate an effective NCEAS proposal for this effort.

5. Develop consensus on a coherent working conceptual model.

Knowledge of delta smelt and the pelagic organism decline has grown extremely

rapidly in the last few years following the collaborative formula described above. Every effort should be made to continue the growth of such knowledge. However, the presentation of what is known or not known, especially in the IEP presentations, does not reflect the state of knowledge. Viewing lists of "stressors" that could be important leave the impression of no progress and/or that theories are competing rather than complementing each other. In fact, a number of factors appear to be acting on Delta smelt, perhaps differently in the context of different years. Figure 1 gives an example of a "gauntlet" type conceptual model. The factors in the life cycle "gauntlet" listed on the right can be of different significance in different years, as supported by some existing evidence. Delta smelt must confront each step in the gauntlet as they progress through their life cycle. New studies should be presented in the context of a model like this. A presentation like this also shows that there are things that might be done ("knobs") to influence Delta smelt populations and thus lead to the development of testable hypotheses that can form the basis of adaptive management.

Final remarks

1. Outcome of the Review:

If the SAG is be effective and to sustain its role as an advisory group to IEP, the outcomes from its review must be made widely available, and the response of IEP leadership to the advice should be obvious. In the past, (and based upon the level of leadership involvement in the Delta smelt review), it is unclear how seriously IEP leadership will take the SAG review. To that effect the SAG has two specific recommendations:

- The SAG will provide a written review, as always. A detailed point-by-point response from IEP leadership is essential.
- Both the SAG review and the IEP response should be on the IEP website. The IEP is courageous in undertaking this review and it should take credit for that. But IEP needs to demonstrate transparency in displaying and accepting both positive and constructively critical comments. Improved credibility will be the outcome of improved transparency with regard to these reviews.

2.Limits to Hydrodynamic Models

A significant aspect of the discussion focused on using models to understand how

entrainment at the pumps might affect delta smelt populations. In particular, from the presentations given, it seems to be assumed by the IEP that the role of hydrodynamics can be considered to be known accurately through the use of the one-dimensional hydrodynamic model DSM2 and its associated particle tracking model. In reality, given that flows in the delta are three dimensional, it must be recognized that inferences based purely on DSM2 output should viewed only as viable hypotheses. We note that in the POD review, it was recommended that the IEP move to three-dimensional modeling to address critical issues of hydrodynamic effects on fish populations. However, no matter how nice the software tools may be, modeling alone is not enough. We think that it in addition to current modeling efforts it would be productive for IEP to develop a plan (that must be peer reviewed in advance) for new interdisciplinary (and probably expensive) field work along the lines of the Entrapment Zone studies done in the 90's.

More importantly, several of us were struck by the fact that none of the IEP scientists/engineers involved in hydrodynamics research participated in the delta smelt review. It is our sense that if hydrodynamics is thought to play a major role in delta smelt population dynamics, the involvement of scientists like those of the USGS California District hydrodynamics group must be a critical component of the IEP effort.

3. Revised recovery plan.

It is clear that the existing criteria for recovery are not adequate. The fact that Delta smelt were nearly listed as recovered immediately before the population collapsed is direct evidence that different criteria for recovery need to be developed. The SAG recommends the USFWS begin the process of refining the recovery plan based upon the developing knowledge of this fish (much of which was unknown when the last plan was developed). Development of a coherent conceptual model might be the first step in such process. In addition, the SAG recommends that independent experts on Delta smelt be consulted and participate in development of the plan.

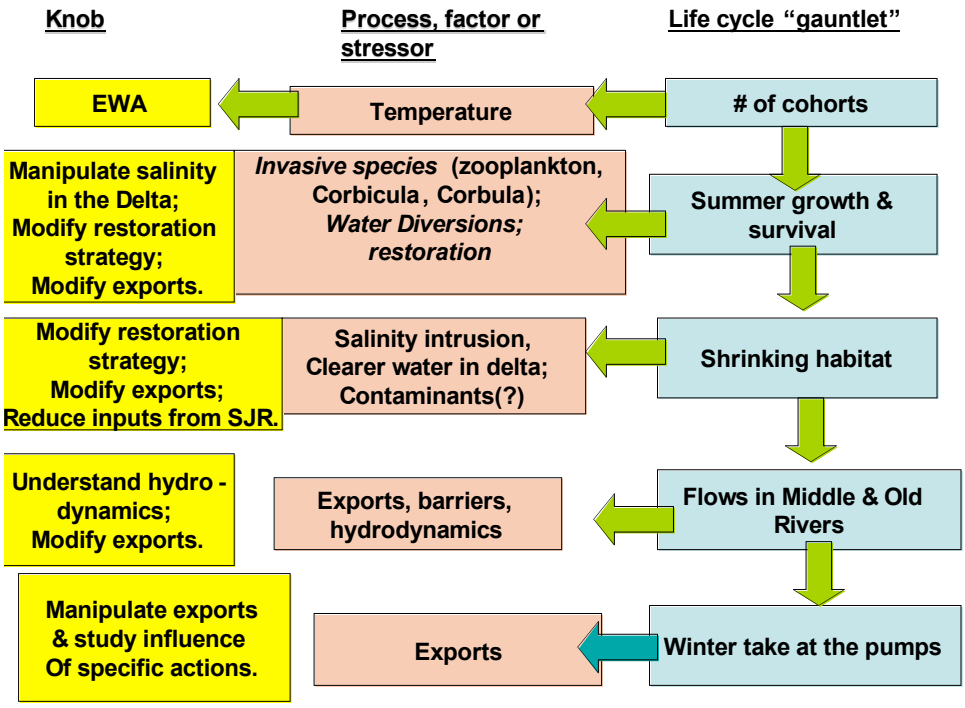

Figure 1: Sample conceptual model