When All You Have Is a Hammer: Scientific Uncertainty and Bay-Delta Policy, 1995 to Present

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One of the most difficult and long-standing environmental problems in the country has been the continuing decline of the ecosystem of the San Francisco Bay/Sacramento-San Joaquin Estuary (the Bay-Delta Estuary). Not only is the Bay-Delta Estuary the largest estuary on the West Coast of the Americas, it is the linchpin of California's extensive system to move water from areas in Northern California to the San Francisco Bay Area, the San Joaquin Valley, and Southern California. Two-thirds of California's people and a large proportion of California agriculture depend on water that moves through the Bay-Delta Estuary.

This article examines the way in which the California State Water Resources Control Board (the SWRCB) had dealt with questions relating to scientific uncertainty in making policy for the protection of the Bay-Delta Estuary for the past two decades. Faced with an extensive drought from 1987 to 1992, the SWRCB in 1995 established water quality objectives (California's term for water quality standards) that would have substantially increased the minimum flows from the Delta into San Francisco Bay, including those required from the San Joaquin River. During the subsequent hearing that addressed which water agencies would be required to provide water to meet the new water quality objectives, the SWRCB agreed to a proposal to engage in a long-term experiment in the face of competing perspectives on how to restore the San Joaquin River component of the Bay-Delta Estuary. In formally adopting this proposal in 2001, the SWRCB adopted something of a hybrid approach to uncertainty. On the one hand, the SWRCB mandated certain flows at certain times of the year, regardless of what was otherwise occurring in the Bay-Delta Estuary. On the other hand, the SWRCB also mandated certain water agencies to release short-duration/large quantity "pulse flows" and required the operators of the federal Central Valley Project (the CVP) and the State Water Project (SWP) to protect fish on a "real-time" basis and curtail project operations to avoid entrainment. Hence, the SWRCB adopted a regulatory regime that generally called for fixed standards but allowed a portion of the regulated community to experiment in a controlled manner that limited the adverse effects on the fishery.

In updating the 1995 Water Quality Control Plan (WQCP) in 2006, the SWRCB embraced the concept of experimental studies more fully, calling for scientific studies that would address areas of uncertainty and controversy. In the years since the 2001 decision, fish populations had fallen dramatically, and these efforts to understand the changed dynamics of the Bay-Delta Estuary were a response to that declining population. Unfortunately, few of those studies were undertaken as contemplated by the 2006 plan. In essence, the SWRCB called for studies to address uncertainty but was unable to compel those studies and/or found itself overtaken by the activities of other actors (most notably the Delta Vision Commission and Delta Stewardship Council's science boards). Uncertainty gave way to paralysis.

Most recently, the SWRCB has commenced a process of workshops to gather the most current science regarding the continuing decline of many species that reside in or migrate through the Bay-Delta Estuary. Based on comments of SWRCB members and staff, the impetus of this process is to identify actions that the SWRCB can take in order to foster the recovery of species in the Bay-Delta Estuary. The SWRCB is mindful of the significant scientific uncertainty (and controversy) related to every aspect of the Estuary and is explicitly seeking proposals for how it may adaptively manage in the face of that uncertainty. Although the SWRCB has not yet reached a final conclusion, it appears that the SWRCB is now looking not only to create a regulatory regime that allows for controlled scientific experiments, but instead is seeking a regulatory regime that actively uses scientific experiments to drive innovation while meeting its obligations to protect all beneficial uses of water. Resolving that tension will be at the heart of the current proceedings.

This article will discuss, in turn, the three ways that the SWRCB has chosen (or not chosen) to address uncertainty: (1) a hybrid approach with large-scale experimentation, (2) seeking to resolve uncertainty only through studies (with little follow-through to ensure that the studies were, in fact, completed), and (3) creating a regulatory regime that uses experiments to drive innovation. After discussing each of these three ways in which the SWRCB has (or has not) dealt with scientific uncertainty, this article will conclude with the author's recommendations for how the SWRCB can create a regulatory regime that protects all beneficial uses, uses scientific uncertainty to drive innovation and more effective water use, and is nimble and yet stable enough to react to new information without making the current system unmanageable.

The Vernalis Adaptive Management Program and Decision 1641

The 1995 WQCP was notable in that it was the result of a compromise by a large number of parties both to establish specific water quality objectives and to investigate the advantages

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and disadvantages of certain operational measures. The program of implementation—which was the heart of the plan—began by indicating that the SWRCB would use its water right authority to allocate responsibility for meeting the additional flows called for in the WQCP while allocating that responsibility in the interim to the CVP and SWP. Of more interest, the program of implementation also identified a number of areas for future investigation, such as losses at unscreened diversion, losses due to sportfishing, losses due to introduced (i.e., non-native) species predation, and alternative ways to convey water through the Delta. Nonetheless, the only effort by the SWRCB to actually authorize an experiment was a proposal for "pulse flows" that would have the effect of moving juvenile fish and eggs into areas that were considered more hospitable and less subject to predation. Thus, the 1995 WQCP understood that experiments and adaptive management of a complex ecosystem could be important, but largely focused on more traditional regulatory tools, such as specific water quality objectives and general studies or evaluations of proposed actions.

The VAMP is a long-term, large-scale scientific experiment to test the proposition that increased flows will improve the San Joaquin River fishery.

After adopting the 1995 WQCP, the SWRCB then turned to the promised water right hearing that would allocate the obligations to provide water sufficient for the increased flows needed to meet water quality objectives. Water users on the San Joaquin River were opposed to the water quality objectives governing San Joaquin River flows and contended that those flows exceeded the flows needed to support a robust ecosystem. Put in terms of the federal Endangered Species Act (although the matter was framed in terms of California law), these water users believed that the water quality objectives were not based on the "best available science." These water users then had a novel idea: because the dispute was, in the end, a dispute about science, why not test the hypothesis underlying the new water quality objectives? Thus was born the Vernalis Adaptive Management Program (VAMP).

The VAMP is a long-term (twelve years), large-scale scientific experiment to test the proposition that increased flows will improve the San Joaquin River fishery. The experimental design called for different levels of thirty-one-day pulse flows during the spring salmon outmigration period, in years with different hydrology, in order to determine the nature of the relationship between flows and population abundance. At the same time as flows in the mainstem San Joaquin River are increased, CVP and SWP exports from the Bay-Delta Estuary are decreased in order to reduce the likelihood that outmigrating salmon will be diverted from the San Joaquin River. In addition, in some years, there has been a physical barrier that provides additional protection against salmon straying out of the mainstem of the San Joaquin River.

A recent peer-review of the VAMP experiment concluded:

> Panel members are in agreement that simply meeting certain flow objectives at Vernalis is unlikely to achieve consistent rates of smolt survival through the Delta over time. The complexities of Delta hydraulics in a strongly tidal environment, and high and likely highly variable impacts of predation, appear to affect survival rates more than the river flow, by itself, and greatly complicate the assessment of effects of flow on survival rates of smolts. And overlaying these complexities is an apparent strong trend toward reduced survival rates at all flows over the past ten years in the Delta. Nevertheless, the evidence supports a conclusion that increased flows generally have a positive effect on survival and that it is desirable, to the extent feasible, to reduce or eliminate downstream passage through the Old River channel. The panel understands, of course, that flow, exports, and the placement of barriers in the Delta are the variables affecting survival that are most easily managed.

Delta Science Program, 2010 Review of the VAMP, May 13, 2010.

More recently, a review of the 2011 VAMP found that there was far too little survival of fish, inconsistent results within the year and across years, and other technical problems that made it difficult to devise management solutions.

These evaluations of the VAMP begin to point to both the strengths and the weaknesses of this particular effort to address scientific uncertainty. On the positive side, VAMP directly addresses one of the major scientific issues plaguing the Bay-Delta Estuary and does so in a way that has reduced conflict in the system. On the negative side, the scale of the VAMP experiment and the many variables that affect salmon smolt survival have made it difficult to draw useful conclusions about the hypothesized relationship between flows and salmon survival. Moreover, the general declining population trend aggravates the difficulty of drawing conclusions. Last, but not least, VAMP illustrates the enduring power of preconceptions. The VAMP experiment was designed to test the proposition that flows drive salmon population abundance. Yet, while finding that predation had a greater effect than flows, the expert panel still recommended increased flows. The panel's apologetic conclusion (stating that flows and other elements of the VAMP "are the variables affecting survival that are most easily managed") shows that one key factor in addressing uncertainty is the need to openly engage with experimental data rather than using those data to ratify previous conclusions.

The Pelagic Organism Decline and the 2006 Water Quality Control Plan

In the aftermath of Decision 1641 in 2001, there was a general feeling that the SWRCB had taken a major step forward toward a regime in which all of the beneficial uses of water within the Bay-Delta Estuary would be supported. Reality, however, quickly intruded. From 2001 to 2007, the Bay-Delta Estuary suffered from what has become known as the Pelagic Organism Decline (POD). Many aquatic species that reside in the Bay-Delta Estuary and its mix of saline and freshwater (pelagic species) suffered tremendous population declines in a relatively short period of time. Not surprisingly, these declines caught the attention of the SWRCB.

In 2006, the SWRCB conducted its triennial review of the WQCP and chose in part to focus that effort on enhancing understanding of the POD and beginning to find ways to address the POD. While awaiting the results of (yet another) expert panel, the SWRCB did not really expand its efforts to deal with uncertainty beyond the tools that it had used in the 1995 WQCP and the VAMP. In other words, the 2006 WQCP recognized that there was substantial uncertainty in the system, due to the POD, to climate change and to other factors but did not modify the way that it approached the 2006 WQCP in order to provide flexibility to address that uncertainty.

To its credit, the 2006 WQCP did identify a number of studies/evaluations that could have been crucial to addressing areas of scientific uncertainty. In particular, the WQCP endorsed the continuation of the VAMP as a way to "provide critical data about flow needs on the San Joaquin River during the Spring pulse flow period." Other areas of uncertainty to be addressed were the effects of introduced species, and the effects of pulse flows on juvenile fish. These study subjects (with the exception of VAMP) were very similar to the subjects identified in the 1995 WQCP. In other words, the 2006 WQCP identified the same types of uncertainty and avenues to address that uncertainty as the 1995 WQCP.

In the face of the SWRCB's seeming inability to address the POD, other actors came to the fore. Most notably, in late 2006, Governor Schwarzenegger created the Delta Vision Task Force as a "blue-ribbon" panel to address the problems in the Delta. Then, after the Task Force completed its report in 2008, the California Legislature considered problems in the Delta and, in 2009, enacted a comprehensive water package that featured substantial reforms in the Delta. Of most note was the effort in the Delta Reform Act to recognize that the Delta was changing and that "adaptive management" would now be the order of the day. Of course, as legislation, the Delta Reform Act did not itself implement adaptive management. However, the very fact that the Legislature found it necessary to mandate such an approach illustrates the SWRCB's inability to move forward effectively in light of uncertainty and the POD.

Updating the 2006 Water Quality Control Plan—Scientific Workshops and Uncertainty

In September 2012, the SWRCB began its latest effort to address problems in the Bay-Delta Estuary by holding a series of technical workshops to better understand scientific and technical developments since 2006. Those workshops have explicitly identified the question of uncertainty as a major subject for discussion. Conversations with the members of the SWRCB have made it clear to the author that the question of how to address uncertainty in a technically sound way that further California's policy of co-equal goals (water supply reliability and ecosystem restoration) is fundamental to the current effort to update the 2006 WQCP.

As one might expect, the approaches toward uncertainty advocated by the various parties presenting information to the workshops vary considerably. For instance, American Rivers opined that "scientific certainty . . . is not a realistically achievable standard of evidence. . . . There are simply too many confounding variables." Because the problem is so complex, American Rivers simply advocated that the "precautionary principle [should be] . . . the proper standard." The California Department of Fish & Game (DFG) advocated a different approach. DFG proposed a "Plan, Do, and Evaluate and Respond" adaptive management process wherein one effort leads into the next. Yet, DFG acknowledges that adaptive management "has been far less successful than one would expect." DFG attributes this failure to a lack of understanding of why adaptive management is needed, a lack of leadership and a lack of funding. Moreover, for adaptive management to be successful, there needs to be an information gap on management questions, prospects for filling that gap in a timely manner, and the chance to modify operations/actions based on the new information. DFG concludes: "while adaptive management is necessary, it is not easy, quick, or inexpensive to implement and will require a significant investment in planning and development on the part of the State Water Board and interested stakeholders." This is hardly a ringing endorsement for the adaptive management concept, which is intended, after all, to stem the POD.

Conclusion—Managing in an Uncertain World

This review of the SWRCB's efforts to develop a successful adaptive management program for the Bay-Delta Estuary over the past two decades could be depressing. When faced with one of the most significant environmental challenges in the country, the SWRCB has just not been able to find a way to address serious scientific uncertainty in a sustained fashion. In the spirit of the glass being half full, it seems as if the SWRCB's past efforts could serve as a good foundation for future adaptive management. Here are the lessons to be learned.

The VAMP experience has shown that large-scale, long-term experiments are difficult to assess.

Experiments need to be small. The VAMP experience has shown that large-scale, long-term experiments are difficult to assess. There are a very large number of potential variables and those variables differ substantially from year to year. Thus, it is very difficult (though not impossible) to develop good comparisons that isolate key variables and so yield results that have the requisite scientific rigor.

Experiments need to be quick. Again, the experience of the VAMP and some of the more recent experimental work by state and federal regulatory agencies has shown that some results show up immediately and some require a period of several years (e.g., the return period of three years for a juvenile salmon to return to spawn). However, periods of a decade or more (as is the case with VAMP) are difficult to evaluate because so many variables (e.g., POD, drought, new invasion species) can intervene. That doesn't mean that such long-term experiments aren't valuable (e.g., it may take several return periods to show whether a particular measure intended to promote salmon is really working), but it does mean that there needd to be careful evaluation methods used in such experiments.

Monitoring is critical. Up until recent years, fisheries biologists evaluated the results of experiments like the VAMP by doing coded wire tag (CWT) studies, where tagged fish are released into the wild and then recovered. More recently, biologists have been using acoustic tracking to achieve the same result. Unfortunately, the acoustic transmitters used do not allow a biologist easily to distinguish between a fish that is alive and a fish that has been eaten and whose acoustic transmitter is now in the stomach of a predator. Fisheries biologists are now working on ways to identify fish that have been eaten, but this problem illustrates the need for intensive monitoring—and monitoring that can be trusted to provide accurate data—of the results of experiments. It also counsels for an awareness of what can go wrong in a complex ecosystem.

Climate change must be differentiated. One of the key challenges for future adaptive management efforts will be to differentiate the effects of the program being studied from the effects of climate change. Not only do we not yet know that pace of climate change (which seems to be faster than anticipated), but we cannot as of yet in advance differentiate the effects of climate change from natural variations in the weather. Separating out these effects is key to being able to manage an ecosystem that is under the very real prospect of climate change.

Hypotheses must be tested. It seems elementary, but still relatively few adaptive management programs explicitly use the structure of developing a hypothesis and then testing the hypothesis under conditions where the experiment can yield results that might directly lead to the revision of the hypothesis.

Paralysis must be avoided. In the end, adaptive management is about having a willingness to take calculated risks with the understanding that some of these experiments will not work. Contrary to the views of many agencies, an experiment that doesn't work is more valuable than one that does, as long as the agency uses the failure to understand more about the processes that caused the failure. Too often, the prospect of failure leads an agency to not act, rather than to act with knowledge of what might go wrong and a plan to limit those effects.

It is to be hoped that the SWRCB will take these and other lessons to heart as it attempts to craft a new WQCP. The SWRCB should be willing to authorize limited experiments that have the potential to help us understand the ecology of the Bay-Delta Estuary or to field test new ways to support the many species that live in or migrate through the Estuary. If the SWRCB fails to encourage this type of innovation, the likely result is that some other regulatory effort will take the place of the WQCP as the cornerstone for protection of the Bay-Delta Estuary and, more importantly, that we will be unable to protect the many beneficial uses (the environment, agriculture and municipal/industrial uses) that depend on water from the Bay-Delta Estuary.