The Informational Proceeding to Develop Flow Criteria for the Delta Ecosystem

Noticed for March 22, 23, and 24, 2010

SUMMARY OF WRITTEN TESTIMONY

Submitted on Behalf of
The San Luis & Delta-Mendota Water Authority,
State Water Contractors,
Westlands Water District,
Santa Clara Valley Water District,
Kern County Water Agency, and
Metropolitan Water District of Southern California

The San Luis & Delta-Mendota Water Authority, State Water Contractors, Westlands Water District, Santa Clara Valley Water District, Kern County Water Agency, and Metropolitan Water District of Southern California, collectively referred to herein as the State and Federal Water Contractors, submit the following summary of their testimony for the State Water Resources Control Board's Informational Proceeding to Develop Flow Criteria for the Delta Ecosystem.

I. INTRODUCTION

A. Background

Since October 2006, a broad cross-section of stakeholders has been working to develop a plan to address the co-equal goals of restoring and protecting the State's water supply and providing for the consideration and management of species native to the Delta. Known as the Bay Delta Conservation Plan (BDCP), this effort is aimed at developing a level of protection for the Delta consistent with a Natural Communities Conservation Plan (NCCP) and its federal counterpart, a habitat conservation plan (HCP). In developing the BDCP, stakeholders are taking a more holistic approach to addressing the array of stressors that have been identified through numerous scientific investigations as adversely impacting the Delta's species and ecosystem. The BDCP is utilizing an assortment of experts from various scientific and technical disciplines to bring forth the best available science to address these stressors. While this work is far from complete, and is not singular in its view as to what factors contribute in comparative degree to the decline of the Delta ecosystem, the resultant opinions and management recommendations will be a significant break from the past unsuccessful flow-centric approaches that have propelled prior efforts to protect Delta-related species.

Importantly, the BDCP is considering flow in relation to the many stressors impacting the Delta ecosystem. For example, the BDCP will highlight the need to address through study and action the effects of ammonia/um concentrations, aquatic habitat losses, food web declines, predators, invasive species, pesticides, other pollutants, and several other stressors, all of which the scientists now recognize play a role in the decline of Delta-related species. While recognizing the importance of flows, the BDCP also realizes that it alone does not provide a complete or comprehensive solution at the root of the Delta's myriad of troubles. In striving to create solutions that treat the cause of the problems, as opposed to the symptoms, the BDCP intends to implement a number of actions that will directly address the origins of stressors impacting the Delta's species and ecosystems.

B. The Legislation

Sensing the prospects for the BDCP and a solution to the pernicious Delta problems, the Legislature sought to enlist the wisdom and experience of the State Water Resources Control Board (State Water Board) to inform the "…planning decisions for the Delta Plan and the Bay Delta Conservation Plan…" (See Senate Bill No. 1 of the 2009-2010 Seventh Extraordinary Session, Section 85086 of the California Water Code. Hereinafter, Sec. 85086.) Within the context of this planning effort, the Legislature provided the State Water Board nine (9) months to develop pursuant to its public trust obligations, flow criteria for the Delta ecosystem necessary to protect public trust resources. (*Id.*) Given the time allotted and the state of Delta related science, that task is daunting at best.

C. The Ecological Role of Flows

As noted above, the Legislature imposed on the State Water Board a difficult task to be completed within a challenging timeframe. This task, however, can become more manageable if the State Water Board focuses on identifying and capturing the state of the science related to the mechanisms that underlie the correlations that suggest that flow and protection of fishery resources are related. To date, determination of just what factors drive Delta ecological conditions, including the abundance of particular fish species, has proven to be very difficult. Part of the problem is that a great number of factors tend to occur in unison through the hydrological cycle, and not all those factors have a causal relationship to species abundance or other indices of environmental health. Regulatory standards that are based upon an incorrect assessment of which factors are central to causation could waste the State's precious water resources and impose unnecessary environmental and economic harm without generating commensurate benefits.

In the case of the Delta, various measures of flow are frequently presented as having a causal relationship with the abundance of various native and non native fish. For example, the log of Delta outflow in the spring (expressed in terms of spring X2) has been noted to correlate with abundance indices for several species of fish. However, the existence of correlations, by themselves, cannot properly be used to assume that simply forcing a particular level of outflow will result in any improvement in fish abundance. It must first be determined whether flow per se causes changes in fish abundance or whether high spring flows are simply correlated to other factors that are the true causal factors.

In this Summary of the Written Testimony, the State and Federal Water Contractors first provide examples of situations where the question of whether a flow correlation captures the true causal factor is complex and could lead to an erroneous management/regulatory action unless steps are taken to go beyond the correlation and search of the causal mechanisms. Then, the State and Federal Water Contractors describe a process which will allow one to distinguish between the spurious correlation and those where there is a direct correlation between cause and effect.

Example 1: Sacramento Splittail: The habitat needs of splittail presents a perfect example of an X2 correlation that did not identify the true causal factor. Splittail abundance is statistically correlated with spring X2. However, simply moving X2 downstream is unlikely to generate any significant benefits for splittail. Instead, splittail need inundation of flood plain habitat. Flood plain habitat is generally only inundated as a result of large pulses of inflow associated with large storms -- pulses much higher than the water management system can provide. Possible modifications to the flood control system (for example, set-back levees) to restore floodplains that can be inundated more frequently during flood flows of lower magnitude might provide a benefit. But requiring greater Delta outflow will not likely help splittail and could even harm them by creating more empty space in upstream reservoirs leading to more capture of the needed flood flows.

Example 2: X2 as a Determinant of Habitat Volume. Delta outflow clearly influences the location of the salinity field in the estuary and thus influences where species sensitive to salinity can live. Some people have speculated that by aligning particular portions of the salinity field with particular parts of the estuary, the volume of habitat available to species can be increased and thus to abundance. There is, however, no positive evidence for this theory. Kimmerer analyzed the volume of potential habitat as a function of flow measured by the location of X2 for a number of species: bay shrimp, starry flounder, pacific herring, northern anchovy, American shad, longfin smelt, delta smelt and striped bass (Kimmerer et al. 2009). Kimmerer found that the theory that X2 defines habitat volume was inconsistent with the abundance data for all of these species except striped bass and American Shad (both of which are introduced species). Kimmerer acknowledges that consistency between volume of habitat as defined by X2 and the abundance of striped bass and American shad means that volume cannot be ruled out as a driver of abundance, but does not provide positive evidence that volume determines abundance. Most scientists now believe that the abundance of adult striped bass is closely tied to ocean conditions rather than X2. Moreover, David Fullerton (personal communication) has found that the American Shad/X2 relationship may simply represent a preference by individual American shad to spawn during wet years rather than in dry years. In fact, high Delta outflow is not only associated with higher American shad Fall Mid-Water Trawl (FMWT) during the same year, but reduced FMWT for the next several years.

Moreover, even if aligning X2 with habitat locations were valid, another approach would be to create additional habitat farther upstream in order to maintain high volumes of habitat even at higher values of X2. For example, habitat under consideration in the BDCP on the upper end of Sherman Island would create substantial volumes of new habitat well upstream of the confluence. Similarly, new habitat in Cache Slough may only be available to Delta smelt as a result of not high, but low Delta outflow.

Figure 1 shows the ratio of average Delta smelt catch in Cache Slough/Non Cache Slough FMWT Stations versus Delta outflow in the same month for September through February. The years plotted cover 1970 – 2004. The plot makes it clear that Delta smelt densities in Cache Slough are rarely significant until Delta outflow drops below about 8,000 cfs. Given the fact that smelt distribution is influenced by salinity and salinity is influenced by outflow, this result suggests that Cache Slough habitat will be most valuable only if flows are low enough to allow smelt to move upstream into it. Thus, providing high flows for improved smelt habitat in Suisun Bay could result in degraded habitat for the species in Cache Slough, which at present is one of the key breeding areas for the species.

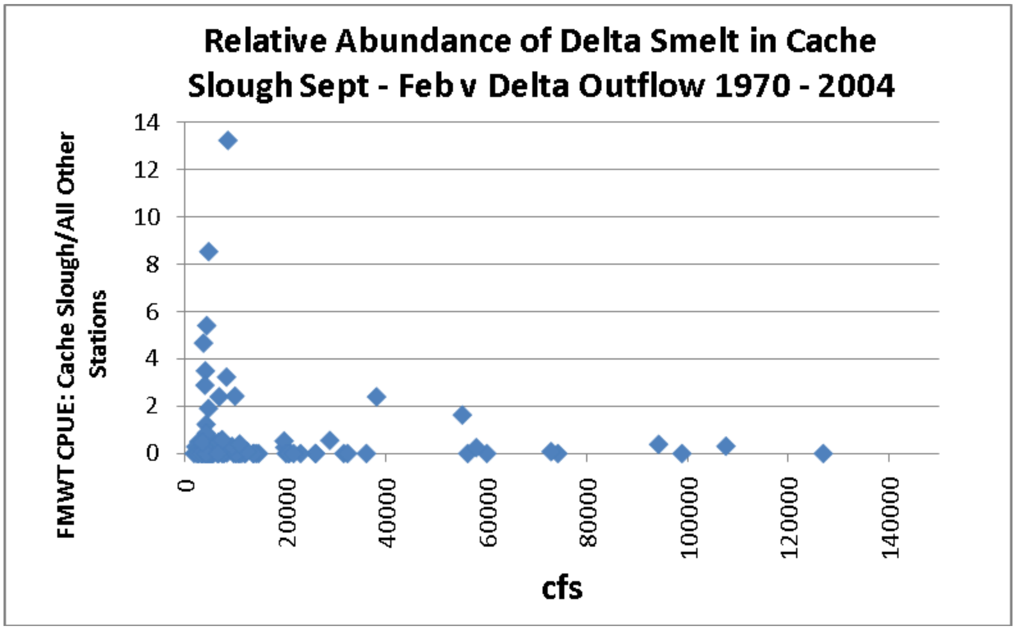

FIGURE 1. Relative abundance of delta smelt in Cache Slough and Delta outflows 1970-2004. The period analyzed is from September-February.

Example 3: Flows That Dilute Pollution. Another flow related correlation may result from the dilution of various forms of pollution. That is, higher flows reduce the concentration of various pollutants such as pesticides and nutrients. To the extent that pollutant concentrations, for example, suppress the food web, statistical correlations of abundance versus flow will show that higher flow is better for fish. But the real causal problem would not be flow, but rather pollution. The appropriate management response would not be to increase flows in an attempt to dilute pollution, but to manage the pollution at the source. Indeed, the pollution explanation of the X2 relationship to fish abundance can help explain why the spring X2 relationships have shifted downward in recent years. As loads of nutrients from the Sacramento Regional Water Treatment Plant have grown, concentrations of ammonium have grown in the Sacramento River. Flow still dilutes these concentrations, but they are now higher for the same flows. Thus, the same Delta outflow (or X2) is associated with lower abundance of food and fish. Figure 2 shows average annual ammonium concentrations in the Suisun Bay to Confluence Region from 1980 to 2005. The influence of hydrology is evident. Ammonium concentrations dropped below the trend line during the early 1980s, rose above the trend during the drought in the late 1980s, dropped below the trend in the wet late 1990s, and rose above the trend in the dry early 2000s. But beyond hydrology, the upward trend in concentrations is evident. Ammonium inhibition of diatom growth is likely very powerful above ammonium concentrations of about .05 mg/l. Baseline ammonium concentrations are now at twice that level on an annual average.

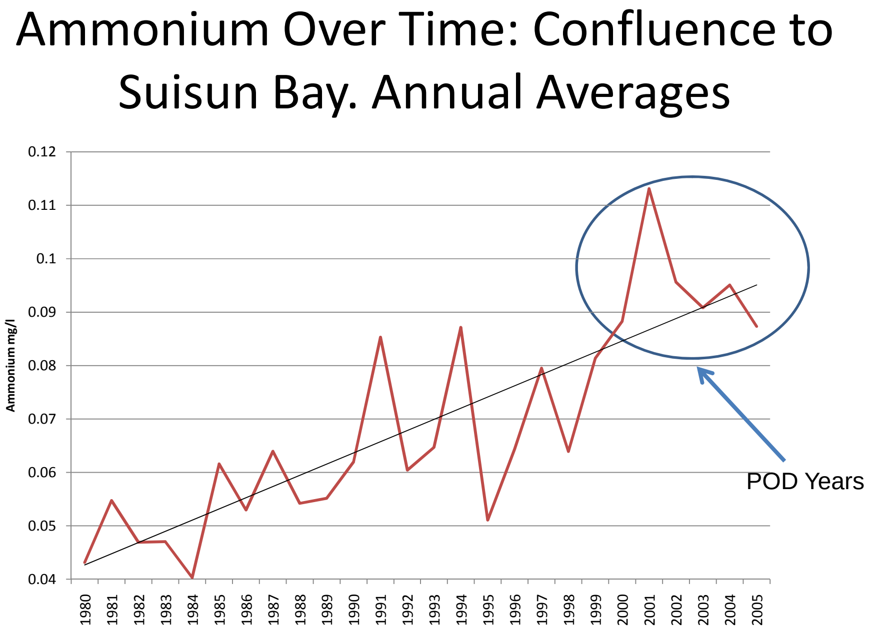

FIGURE 2. Ammonium concentrations from the confluence to Suisuin Bay. Concentrations were averaged on an annual basis. Data from Bay-Delta Tributaries Project http://www.bdat.ca.gov.

Figures 3 and 4 show correlations between abundance of fish and X2 that could, in fact, represent the dilution of pollution by flow. Figure 3 shows the relationship between log (longfin FMWT) and X2 during January and June. The period of record is divided into two sets of data with the split occurring between 1989 and 1990. The reduced response in longfin abundance to X2 is evident in the later period. For some reason the same flow no longer provides the same level of benefits. One possible explanation for the shift in the response is shown in Figure 4, which is log (longfin FMWT) versus ammonium concentration during the winter and spring. Not only is the correlation as good or better than the correlation with flow (X2), but the correlation did not shift after 1989. The fact that longfin remain correlated to ammonium with the same slope and intercept through the entire period is a signal that ammonium is more likely to be a true causal factor while the outflow correlation simply reflects dilution of a constantly growing load of pollution.

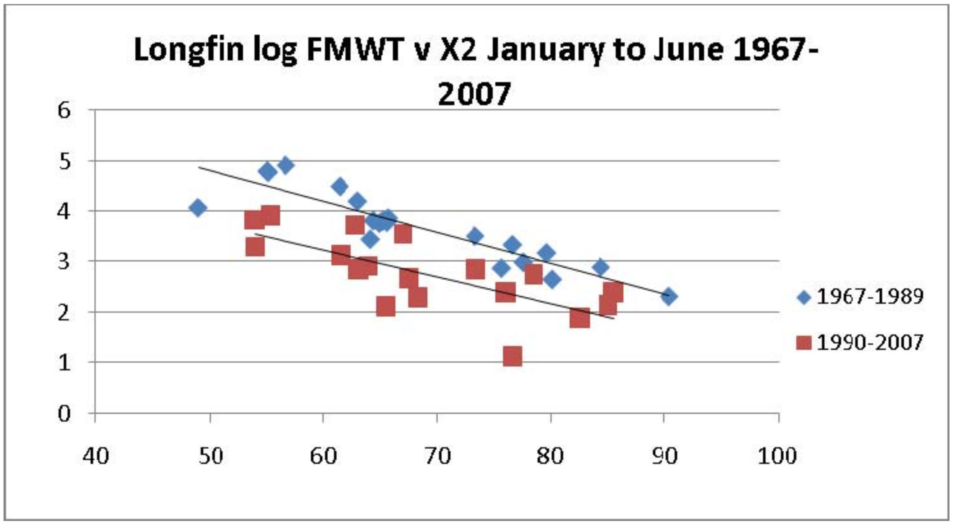

FIGURE 3. Longfin smelt abundance, as measured by the FMWT, and spring X2.

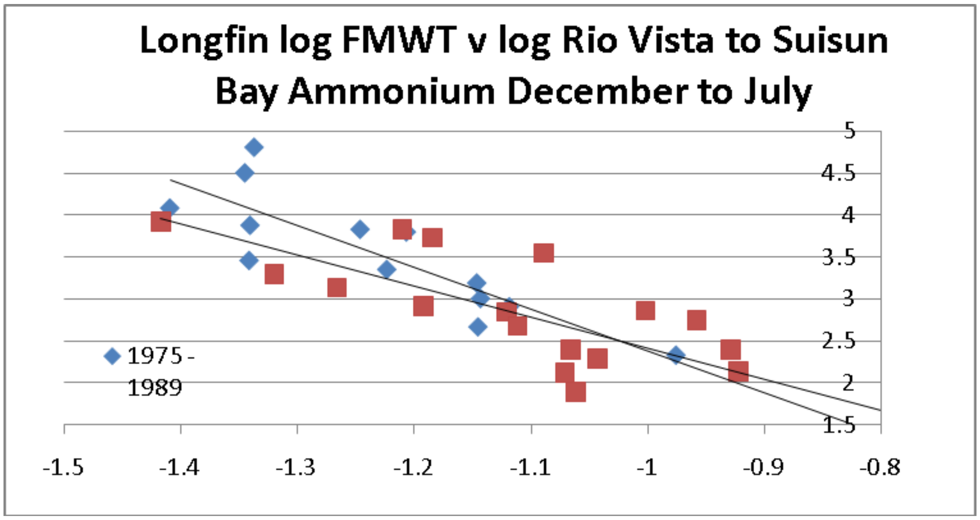

FIGURE 4. Longfin smelt abundance, as measured by the FMWT, and Suisun Bay ammonium concentrations. The period analyzed is December-July. Ammonium data is from the Environmental Monitoring Program.

Example 4: Flow as a Transport Mechanism. One benefit of flow is as a "transport" mechanism for young fish and other organisms. For larval fish with little swimming ability, higher flows can mean higher rates of transport. To the extent that insufficient flows might prevent a larval fish from reaching a downstream feeding area prior to the time its yolk sac is depleted, lack of flow can be a causal factor. However, in other circumstances the ultimate problem may not be transport velocity, but high rates of mortality associated with predation in the Delta channels. The relative importance of rapid transport would be reduced if mortality caused by invasive predators could be reduced. Reductions may be possible through modified fishing regulations, modification of channel geometry (to avoid holes where predators lurk), elimination of structures in the Delta channels (from which predators can ambush their prey), habitat restoration to provide more hiding areas for young fish, and local predator removal programs.

Example 5: Turbidity. One reason that predation may be a greater problem today than it used to be is reduced turbidity in the estuary. The greater the distance at which predators can see prey, the less energy they need to expend to feed and the greater the potential abundance of predators. Moreover, turbidity, suspended sediment, and flow are correlated with each other. Much of the suspended sediment and turbidity entering the Delta does so during large storm events (Figure 5). However, regulatory requirements for greater releases from upstream reservoirs on the Sacramento River and its tributaries are not likely to generate more turbidity or suspended sediment. The flow levels required to move sediment bed load are above those that could be generated by the water management system. Moreover, the source of much of the sediment in the Sacramento River is the large number of unregulated creeks (such as Deer, Mill, and Cottonwood Creeks) that emit enormous volumes of suspended sediment during large rainfall events. Also, some speculate that sediment left over from the Gold Rush is finally clearing the system now. Others suggest that invasive plants (e.g., *Egeria densa*) are causing turbidity to settle out of the water column more quickly. In any case, simple requirements for more flow on the Sacramento River will not generate more turbidity. Nonetheless, because sediment levels are related to higher flows, a correlation may be found but that correlation would not form the basis for a useful management action.

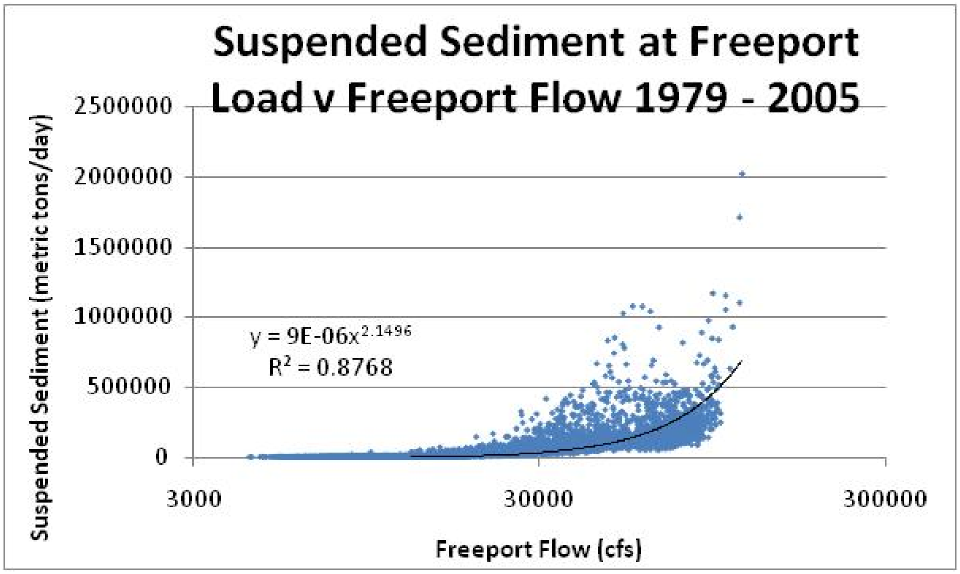

FIGURE 5. Suspended sediment load at Freeport and Sacramento River flow at Freeport. Data is from USGS and DAYFLOW. Note that very little suspended sediment enters the Bay-Delta system until Sacramento River flows are well above 30,000 cfs. The X axis is on a logarithmic scale.

In each of the examples just discussed, for various reasons, accepting a correlation of flow and fish population as a simple case of cause and effect would lead to an erroneous management or regulatory action. The multiple layers of causation in the Delta, as the Written Testimony submitted by the State and Federal Water Contractors and the science papers in the Appendix of Supporting Citations show, create a highly complex ecosystem which, in turn, compels an approach to setting flow objectives that pays close attention to that complexity and uses methodologies well adapted to discovering which group of factors that are occurring in unison is, in fact causing the observed response within the fishery community.

The State and Federal Water Contractors now turn to the approach they believe the State Water Board should follow to reach conclusions that are supported by the best available science.

D. A Method for Identifying Causes of Fish Abundance Declines

During one early effort, striped bass was viewed as the appropriate indicator species of ecosystem health; what was thought necessary to support the bass population was also believed to protect the overall ecosystem. Next came the so-called entrapment zone theory, which hypothesized that the location at which tidal and river flows were in balance (the "null zone") created the best habitat for the various fish species. The location of the 2000 ppt isohaline, or X2, as a way of measuring Delta outflow, captured the science community in the 1990s and persists today. Most recently, the rates and direction of flows in Old and Middle Rivers and their correlations to entrainment in the SWP and CVP pumps have dominated the regulatory focus. None of these approaches has succeeded in recovering fish populations, strongly suggesting that a different method of analysis is needed.

Given the complexity of the Delta science issues as summarized above and the resultant failure of past flow-centric management approaches to "fixing" the Delta, this section asks the question, which types of statistical analyses are appropriate to determine management actions when multiple stressors are suspected of causing fish declines? It then offers a method for analyzing multiple factors to identify those factors most important to abundance of fish.

Despite the recent working hypothesis that declines were caused by multiple factors (*see e.g.*, Baxter et al. 2008), some analyses have continued to focus on only one factor or a few factors, river flow being the most popular. These might be termed "first generation" analyses. Examples would be the analyses linking spring Delta outflow (as measured by X2) to abundance of several species of fish (Kimmerer 2002), the VAMP experiment searching for effects of river flow, exports, and a barrier at the head of Old River, and more recently, Feyrer et al. (2007) linking delta smelt abundance to fall X2.

There are two serious problems with such analyses. First, by focusing on a single factor or narrow set of factors, it is possible, if not likely, that one would overlook the most important factor. Feyrer et al. (2007) analysis is a good example. There, Feyrer et al. studied a narrow set of factors (water temperature, specific conductivity, and secchi depth). When only one other factor, spring prey density, is included as an independent variable, the relationship with fall X2 identified by Feyrer et al. becomes insignificant and a better correlation is found with spring prey density, as shown in Table 1. Note that addition of any of three measures of spring food availability to the correlation renders previous fall X2 highly statistically insignificant.

R^2	Ln previous FMWT	previous fall X2	Ln minimum Eurytemora + Pseudodiatpomus density in Apr-June	Ln average total calanoid copepod density April-June	Ln average Eurytemora density in late April
0.50	**0.0004**	**0.63**	**0.04**		
0.48	**0.00008**	**0.71**		**0.09**	
0.62	**0.0002**	**0.18**			**0.0005**

TABLE 1. Level of statistical significance of various factors in correlations with the Summer Townet Index of juvenile abundance of delta smelt.

The second problem is that even if the candidate single factor or few factors are found to have statistically significant relationships with abundance and are therefore deemed important, it does not necessarily follow that control of those factors is appropriate. The relationship of abundance of Sacramento splittail to spring X2 as described in the previous section of this introduction is a good example. Ignoring the mechanism underlying this correlation might have resulted in decisions to curtail spring exports on behalf of splittail, which would have had no beneficial effect on inflow and, therefore, on splittail abundance.

As the splittail example illustrates, it is not always appropriate to control a factor that has an important, statistically significant relationship with abundance. Rather, an understanding of the mechanisms behind the relationship is also necessary. Suppose the real cause of abundance declines is discharge of a pollutant. Flow might have an important, statistically significant relationship with abundance because the higher the flow, the more dilution of pollutant load, the lower the pollutant concentration, and the less the effect on abundance. If pollution were the actual mechanism, there would be a legal mandate to control the pollutant discharge. Increasing flow would amount to controlling pollution by dilution and would not receive serious consideration.

The realization that fish abundance can be affected by multiple factors has spawned what might be termed “second generation” statistical analyses. The first of these for delta smelt was the Manly multivariate analysis (Manly 2009). Since then, several other such analyses have been completed or are in progress (Mac Nally 2010, Thompson 2010, Hamilton 2010). Such analyses may give rise to a problem related to those described above. The problem results from the combined effect of multicollinearity (the statistical phenomenon in which two or more predictor variables in a multiple regression model are highly correlated) and differential measurement error (MDM). Zidek et al. have shown that if candidate factors are related to each other, the factor with lower measurement error can displace more important factors that have higher measurement error (Zidek 1996).

As an example, consider an analysis of multiple factors, each with a plausible mechanism of effect on abundance of delta smelt. Flow would typically be chosen as one of those factors. In the San Francisco Bay-Delta estuary, flow is measured with considerably less error (see references for Dayflow) than some other candidate factors, such as, for example, prey densities (see Monthly Zooplankton Survey and 20 mm Survey) or ammonium concentrations (see references for Environmental Monitoring Program and USGS Water Quality Monitoring). According to Zidek et. al. and numerous other authors, even if prey density or ammonia concentration were, in fact, the most important factors affecting abundance, because of MDM, a statistical analysis might indicate that flow was the important factor and prey density or ammonia concentrations were unimportant.

The probability of such a misleading result increases as the difference in measurement errors increases, and more importantly, the analyst would not know if the result was misleading or not.

So there would appear to be a dilemma: It seems clear that single (or very few) factor analyses are inappropriate if multiple factors are suspected of causing the effect. Almost no confidence can be placed in results of such analyses as the basis for management actions. We can find ample proof of the futility of this approach in the fact that single or few factor-based management decisions (spring X2, VAMP, export:inflow ratio, Old and Middle River flow) have been coincident with significant declines in fish abundance. On the other hand, consideration of multiple factors is necessary but confounded by MDM errors.

A “third generation” analysis seems appropriate. It arises from the need to satisfy three goals. The first two goals are to include all relevant factors and to reduce the possibility of occurrence of MDM errors by reducing the number of factors analyzed. Analysts might cull through candidate factors, eliminating as many as possible to reduce the chances of an MDM error. This approach has obvious shortcomings; what if a key factor is eliminated?

The third goal is to focus the “third generation” statistical analysis not on identifying the most important factors in a statistical sense, but rather, on elucidating relationships among factors and, of course, among factors and fish abundance. Implicit in identifying candidate factors is the notion that factors act in a hierarchical manner, with one factor linked to another through a series of intermediate linkages. An example of a hierarchical causal hypothesis follows: ammonia load and river flow affect ammonium concentration, which affects phytoplankton densities, which affect zooplankton densities, which affect delta smelt abundance. If this were an important hierarchy, it would be useful to understand it. If it were understood, more effective management decisions might follow. If the statistical analysis is carried out by throwing all candidate factors into the statistical blender, so to speak, the MDM error is likely to result in identification of river flow as the important factor and, therefore, controlling river flow would follow as the appropriate management action. On the other hand, if the statistical analysis served to elucidate the hierarchy, even if the statistical relationships were not as satisfying, it is likely that an entirely different management decision would follow.

There is an approach that accomplishes all of the goals. That approach is simple in principal and is not new. It is called “path analysis” or “structural equation modeling.” (see references for path analysis and structural equation modeling) and has recent application in fisheries management (Wells 2008). It consists of arranging candidate factors, that is, all factors with a plausible mechanism of effect, according to the hierarchy through which they act. At the top of the hierarchy would be factors that act directly on fish to affect abundance, such things as predation, entrainment, and food availability. We could call these “first level” factors. Conveniently, there are not many first level factors. All other factors, then, act through those first level factors in a hierarchical manner, giving rise to second, third, etc. level factors.

The statistical analysis is directed at the hierarchy, so, first there would be an analysis to identify important first level factors. A simple multiple regression analysis would suffice, although more complex methods are sometimes appropriate. Because there are relatively few first level factors, at least compared to the total number of candidate factors, there is much less chance that an MDM error will confound the results. Once important first level factors were identified, each of these would be the subject of a separate analysis, directed at identifying the second level factors most important to each of the important first level factors, and so forth, down the hierarchy. Rather than one, complicated, statistical or modeling analysis, a series of relatively simple analyses would be required, each with a limited number of factors and, therefore, each with a reduced chance of the MDM problem. Another advantage of this approach is that it facilitates intervention by biologists and other experts to apply specialized expertise or common sense.

Note that some of the statistical relationships may not be satisfying, in part because of large measurement errors for some factors. In some cases, relationships might be deduced rather than illuminated by statistical analysis. In spite of these shortcomings, the result of such an approach is much more insight into what is really affecting fish abundance and what management actions have the best chance of success.

While the description of this approach and the science that sets out the process can be very dense and difficult for the layperson to follow, the concepts behind it are important and represent the latest scientific thinking when dealing with multiple hypotheses as to what variable that may be affecting the basic needs of a healthy fishery. We believe the past failures in solving Delta fishery issues are likely examples of inappropriate management decisions based on false understandings of what is driving the system.

To illustrate this approach, Figure 6 shows how this hierarchal approach would be applied to Delta smelt. As a narrative example of the approach, one can look at the first tier needs of Delta smelt as including an acceptable range of water temperatures necessary for their support. Since the data is clear that ambient air temperatures, as contrasted to water flows, control Delta water temperatures, the SWRCB could quickly determine that flow criteria are not needed to address this basic smelt need. A more complex example might revolve around the basic first tier need for adequate food. The inquiry here would seek to determine if and how flow changes would increase food production, or if other overriding factors, such as an imbalance in the essential nutrients at the base of the food chain, is the causal factor, which would either eliminate any benefit from changing flow patterns or, if corrected, remove the need for flow changes. The exercise would assemble all the second-tier hypotheses related to Delta food production and analyze them to determine which appear to control or dominate the amount and types of phyto- and zoo-plankton that are produced in the estuary that are necessary to support higher trophic levels.

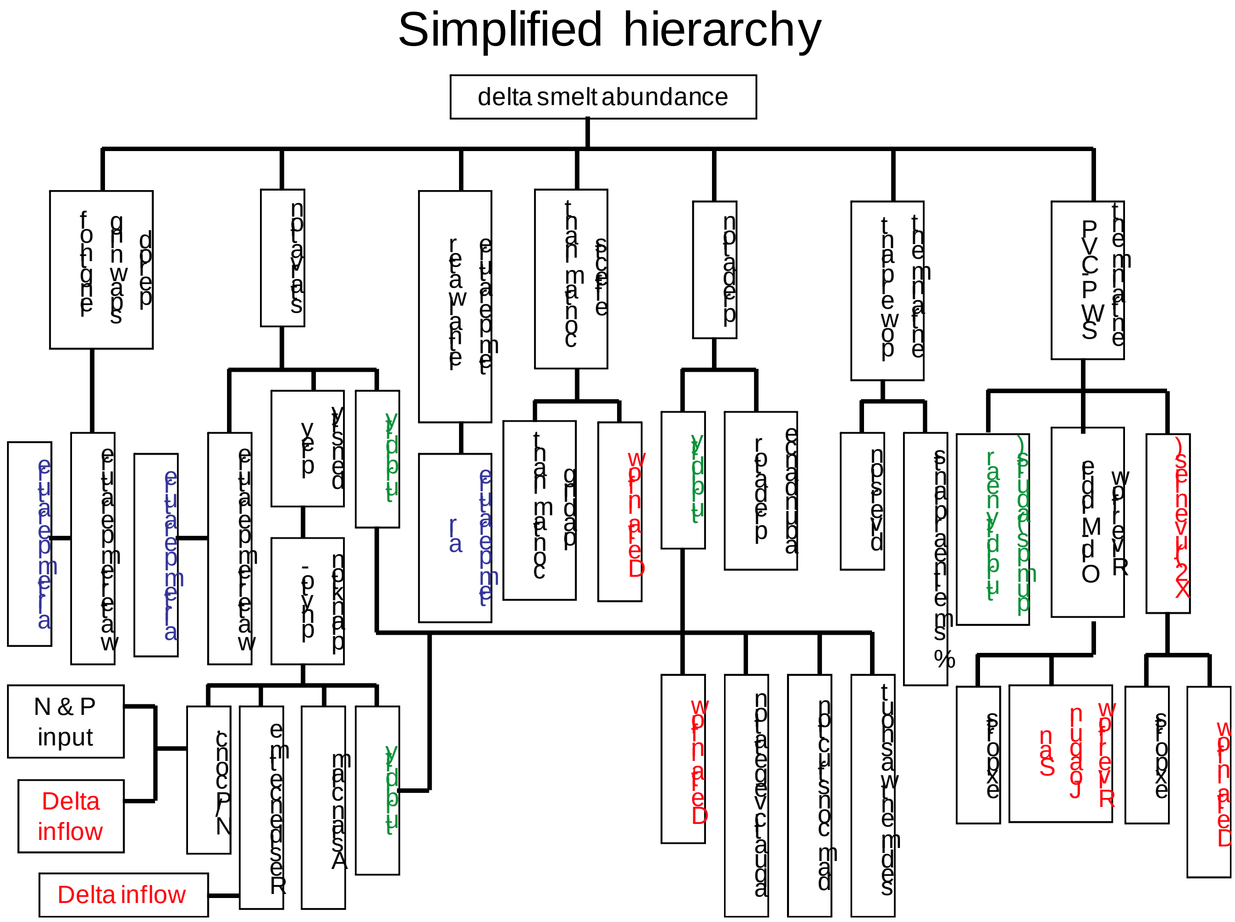

FIGURE 6. A hierarchical approach to evaluating effects on delta smelt abundance.

E. Summary and Conclusions

The conclusions reached after following the process outlined above and after considering the science analysis that follows can be broken into two broad categories. First, the best available science does not support establishing Delta flow criteria without first considering and attempting to understand, for the fish species at issue, whether, how, and why the criteria will address in a positive manner an identified stressor that is impairing the improvement of the year-to-year species population. The flow-centric approaches of the past have failed and will, if continued, fail in the future. Second, any flow criteria that emanate from these proceedings should be narrative in character and should set out or otherwise describe the error bands that reflect the uncertain state of the available science. Pretending that the available science points clearly in only one direction will not make it so and will render the final product useless for providing guidance for future actions.[1] More specifically, the science leads to the following conclusions:

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[1] To the extent the State Water Board attempts to establish numeric criteria, the criteria must reflect likely different flow needs in different months or seasons of the year, different flow needs in different water-year types, scientific uncertainties, potential ranges needed to ensure the ability to balance the limited water resources for competing public trust resource needs, and potential range needed to ensure the ability to balance the limited water resources between for public trust resource needs and the needs of other beneficial uses.

1. Flow is only one of the drivers of ecosystem health in the Bay-Delta aquatic system. We must gain an understanding of all the other first tier drivers and the lower tier conditions and natural processes that effect each of them if we expect management actions to provide benefits. Only with a multi-variate approach can one hope to discover and understand the fundamental causal factors that are impacting populations.

2. Delta flows mask the affects of other stressors such as pollution or predation by non-native species.

3. Spring X2, as theorized in the mid-1990s, no longer acts as a good predictor of fish abundance and continues to suffer from a lack of understanding of the mechanisms that create what ever correlations remain. For Delta smelt X2 does not correlate at all.

4. Fall X2 is at best a hypothesis. There is no accepted statistical analysis that supports it and the best science indicates that food limitation rather than flow is the causal factors for the Delta smelt decline.

5. Habitat cannot be measured by X2. Habitat is much broader in scope, encompassing many different physical, chemical, and biological aspects. The hypothesis that recent declines in pelagic species resulted from declines in the amount of desirable habitat is not reasonable considering the relative changes in abundance of these fish and in volume or area of desirable habitat.

6. Significant declines have occurred in density of most of the desirable zooplankton that pelagic fish prey upon.

7. There are important statistically effects of prey density on abundance of delta and longfin smelt in the last decade or so, effects that explain the sharp decline in abundance of these fish.

8. Changes in prey density are not related to flow in most cases, and the few relationship that do exist can be explained by flow diluting ammonium discharges that have important effects on the food web.

9. Turbidity has declined markedly over the last four decades, especially in the San Joaquin River part of the Delta, and is now at levels that impair larval feeding success for delta smelt and discourage migration of adults to that area.,

10. Ammonium discharges are significantly affecting the base of the food web and are likely responsible for the shifts in phytoplankton species that are detrimental to many native fish species.

11. Toxics, while not yet consistently at acute levels, nevertheless are at levels that likely cause chronic effects over extended periods.

12. The native fish long ago adapted to the tidal nature of their habitat, with twice daily shifts in flow direction in the channels and the adults are able to hold position in the water column. Thus, until Old and Middle River flows exceed at least -6,100 cfs, they do not cause a higher proportion of adult smelt to be entrained at the export pumps

13. To the extent entrainment occurs, the available science cannot discern any important effect on the entrained species at a population level. This is likely because other stressors, such a food limitation, predation, water temperature increases, and turbidity changes are controlling population levels.

Turning to the form of the product that will be delivered to the legislature and to the BDCP and the Delta Commission, it is essential that the State Water Board focus on the legislative intent and the utility of its final product to its target audience. Its purpose is for "…informing planning decisions for the Delta Plan and the Bay Delta Conservation Plan…". Therefore, it is essential that the State Water Board's effort be well informed on the full scope of factors being considered by the new Delta Stewardship Council and BDCP Steering Committee as they develop the plans to meet the co-equal goals. If the work of the State Water Board is to be of use to the BDCP process and the development of the overarching "Delta Plan" (Blue Ribbon Task Force 2008), whatever criteria are developed must provide guidance beyond August 31, 2010.

The State Water Board can use this proceeding as an opportunity to establish largely narrative criteria that will guide future analyses of the ecosystem and that allows flow and non-flow hypotheses to be evaluated and management decisions to be made using the best data. History and the current state of the science clearly demonstrate numeric flow criteria cannot be properly established until flow is studied in a proper context that analyzes the ecological services it provides, and it is determined that flow is the proper mechanism to provide those services.

In sum, given scientific uncertainties, the ultimate need to balance the limited water resources between competing public trust resources, and the ultimate need to balance the limited water resources between public trust resource needs and the needs of other beneficial uses, the State Water Board cannot, at this time, reach any final quantitative conclusions on flow needs. The establishment of a framework built largely around narrative criteria will provide great value and guidance to the Delta Plan and BDCP processes, particularly since those processes are considering long-term planning within the highly altered 21st century Bay-Delta system, which will continue to change.

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