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Testimony
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Committee on Resources
United States House of Representatives

Extinction is not a Sustainable Water Policy: The Bay-Delta Crisis and the Implications for California Water Management

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Introduction

Madam Chairman and members of the Subcommittee, my name is BJ Miller, and I am a consulting engineer working on behalf of the San Luis & Delta-Mendota Water Authority. I appreciate the opportunity to testify today regarding "*Extinction is not a Sustainable Water Policy: The Bay-Delta Crisis and the Implications for California Water Management.*"

For the past 26 years I have been a consulting engineer focusing on California water problems. Prior to becoming a consulting engineer I was a member of the California State Water Resources Control Board from 1978 to 1980. For many years I have taught a one-day course, "The Management of Water in California" for the UC Berkeley Engineering Extension and elsewhere on request. My primary focus has been on the Sacramento-San Joaquin Delta because of its importance for California water management.

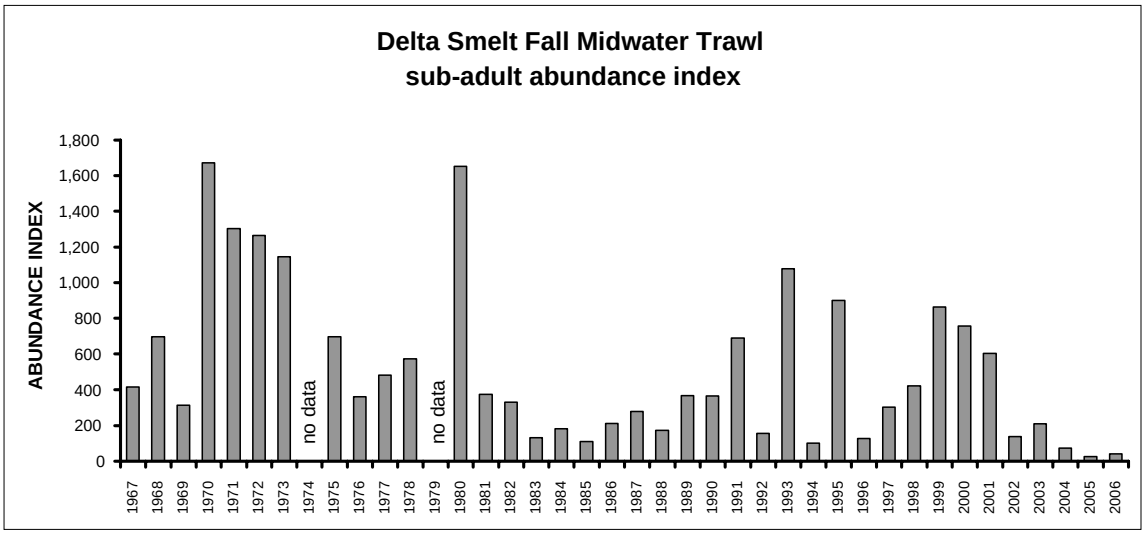
Since approximately 1992 I have worked primarily on issues related Delta fisheries because of the relationship between actions to protect Delta fisheries and operations of the State Water Project ("SWP") and Central Valley Project ("CVP") operations. With my colleague, Thomas Mongan, Ph.D., a licensed civil engineer with a doctorate in physics, and others, including Bryan Manly, Ph.D., one of the world's foremost statistical ecologists, I have conducted numerous analyses of factors affecting fish in the Delta. Most of our efforts have focused on delta smelt, the small, native fish listed as threatened under both the State and Federal endangered species acts.

Summary

To date, virtually the entire effort to recover the delta smelt has been focused on operations of the SWP and CVP. However, there are no valid statistical analyses showing that exports from the Sacramento-San Joaquin Delta or entrainment of delta smelt at the export pumps have important effects on abundance trends of delta smelt. Several analyses show a strong relationship between the decline in delta smelt abundance and significant declines in the densities of the zooplankton (small floating animals) delta smelt prey upon, especially in spring. Reliable analyses indicate routine management of Delta exports to minimize entrainment ("take") of delta smelt is a futile attempt to prevent extinction or achieve recovery. Certainly exports should be managed to prevent the rare, unusually high incidences of take. Beyond that, the key to saving the delta smelt is to find out what affects their food supply and, if possible, do something to address those limiting factors.

Decline of the delta smelt

As you know, the abundance of delta smelt has declined sharply in recent years. The graph below shows the key measurement of smelt abundance, the Fall Midwater Trawl index. This index measures abundance of sub-adult delta smelt. I compared this index to the population index for spawning adults in winter, derived from the highly efficient Kodiak trawls that began in 2002. There is an excellent relationship, indicating the FMWT index is not only useful because of its length of record (since 1967), but also because it appears to be a good indicator of the following winter's spawning adult population.



The hearing today is largely because of this graph, so I would like to point out a couple of things about it. First, there has obviously been a decline in delta smelt abundance. It began in 1999 and was especially sharp after 2001. The 2005 index was the lowest of record. The 2006 index was higher, but still very low. Second, note the variation from year to year. Since 1996, the average change (up or down) in this index has been about 60%. So, if we want to figure out what happened to delta smelt, and possibly a few other pelagic fish whose abundance has declined, we should look for factors capable of causing a change of about 60% per year. We should also look for factors that changed at about the same time as delta smelt abundance did, that is, factors that changed for the good from 1996 to 1999, and for the bad thereafter.

It is possible that factors with subtle, long-term effects control delta smelt abundance in complicated ways. However, most (about 95%) delta smelt live for only one year. For a fish with a one-year life cycle, the most likely factors controlling abundance are those with important effects each year.

This is a data-rich estuary, so we have long-term data on many factors that might affect delta smelt. For example, we have long-term data on exports from the southern Delta, daily flows into and through the Delta, salvage of delta smelt at the export pumps, distribution and abundance of delta smelt throughout their one-year life, densities and location of delta smelt prey, and turbidity, salinity, and temperature of Delta water. We

also have data on the prey found in the guts of delta smelt. We have long-term data on the zooplankton (small floating animals) on which delta smelt feed, as well as on the phytoplankton (small, floating plants) consumed by zooplankton. That is not to say we have all the data we need, but as estuaries and fish problems go, we have lots of data.

Searching for export effects

Numerous analysts have worked for years to determine if there is a relationship between delta smelt abundance and operation of the SWP and CVP export facilities. I'll summarize the analyses most relevant to the delta smelt question.

- Dr. Bryan Manly (independent consultant) and Dr. Mike Chotkowski (Bureau of Reclamation) searched for river flow and export effects on delta smelt abundance. They found a statistically significant relationship between rates of exports and delta smelt abundance, but they concluded that this relationship could account for a very small percentage in the variation of smelt abundance. In other words, the effect was small and unimportant relative to the trend in delta smelt abundance. Dr. Manly summarized the relationship as follows: “I can sum up my conclusions from the analyses that I have done over the past few years by saying that so far it appears that river flows and exports cannot account for most of the downward trend in delta smelt numbers in recent years. Some other change to the system seems to have happened in about 1999 to cause the decline. What is therefore needed now is further work to better understand the system and to identify any important variables that are not currently being considered to account for the decline.” This finding is important for two reasons: First, an effect of exports was found. This indicates the analyses were capable of finding such effects. If no effect at all were found, one might wonder if the proper analysis had been carried out. We would expect *some* effect of exports. After all, delta smelt are entrained at the export pumps, and because of the fragile nature of this fish (unlike salmon and striped bass), few of those salvaged can be returned to the Delta. Second, the effects turn out to be unimportant relative to the changes in abundance of delta smelt. Manly characterizes the effects as one percent or so per year.
- Subsequently, I analyzed whether export effects were not found because exports only affect delta smelt abundance in some years but not in others. If this were the case, analyzing data from all years could obscure effects only occurring in some years. Delta smelt spend most of the year near the confluence of the Sacramento and San Joaquin Rivers, 30+ river miles from the export pumps. Smelt migrate upstream to spawn in winter. Sometimes a significant fraction of their population migrates toward the export pumps, and sometimes they do not. So, I searched for export effects only in years when delta smelt were closer to the export pumps. I (and Manly) found no such effects.
- Pelagic Organism Decline (POD) studies noted that salvage of delta smelt was high in the years of the decline. They assumed this coincidence (high salvage, low delta smelt abundance) indicated entrainment of delta smelt at the export pumps could be an important cause of declining delta smelt abundance. However, finally, POD analysts checked for statistically significant relationships between any

measure of salvage and the subsequent FMWT. They found no statistically significant effect. I conclude from this that high salvage and low delta smelt abundance were coincidences, rather than indication of a cause and effect relationship. This conclusion is reinforced by the importance of food limitation to delta smelt abundance, described below.

- Drs. Wim Kimmerer (SF State University), Pete Smith (USGS), Mongan and I all independently estimated the percent of the total population of delta smelt entrained each year at the export pumps. All of us estimated percentages in the range of 30-40% in one year. However, no one has been able to find statistically significant relationships between annual estimates of percent entrainment and subsequent FMWT index or annual changes in the index. These analyses suggest two conclusions: First, the estimates may not be correct. There are uncertainties inherent in each of them. Second, because they might be correct, it would be prudent to assume high entrainment events, although unusual, can occur and should be prevented.
- Several representatives from environmental organizations and state and federal resource agencies have presented analyses purporting to show a relationship between exports and the subsequent FMWT abundance index. All of these correlations are spurious for the same reason: They do not consider the important effect of "regime changes" affecting delta smelt abundance. These correlations result from stretching the analysis over all years, both before and after the delta smelt decline that occurred in 1981. Such analyses violate a fundamental assumption in regression analysis. The fundamental assumption necessary to draw reliable conclusions from regression analyses is that the models considered include all of the important variables in the system, with no important hidden variables. If there is a change in the system at some point in time due to unknown causes, the effects of known variables can be analyzed either by fitting separate models before and after the change, or by including terms for changes in the mean level of the response variable and changes in regression coefficients. Clear change points can be detected from patterns in regression residuals. Failure to allow for change points can lead to spurious conclusions about the effects of variables. In other words, if delta smelt abundance underwent a step decline in 1981, for reasons having little or nothing to do with exports, and if this step change is not accounted for in the regression analysis, any factor that tended to be high (or low) before the step change and low (or high) after the step change may show a correlation with delta smelt abundance, even if this factor had little or nothing to do with abundance of delta smelt. Exports were generally low before 1981 and generally higher after 1981. Hence, the spurious correlations.
- Dr. Bill Bennett (UCD) proposed a "Big Mama" theory hypothesizing that high exports before mid-April entrain early hatching delta smelt larvae that, if not entrained, would grow into larger spawners the next winter. Larger female delta smelt produce more and better eggs. This theory has been popular among those who believe exports must have important effects on delta smelt abundance. However, the theory has two problems. First, long-term data on delta smelt size in December show a step decrease in size that has no relationship with the recent

decline in delta smelt abundance. It occurred around 1990; the smelt decline began in 1999, when the December size was level. Second, the theory does not account for the demonstrated importance of food limitation in determining the size of spawning delta smelt. Put another way, there are two ways to become a Big Mama: hatch early and grow for a longer time or eat well after you hatch. Well-fed delta smelt at the delta smelt culture facility grow so fast that they spawn in October rather than waiting until March. So, besides the evidence of food limitation discussed below, we know from actual data on delta smelt that food is important to spawning size.

- Dr. Ted Sommer, and associates (Department of Water Resources), in a study conducted for the Pelagic Organism Decline effort, looked for declines in residence time of water in the Delta during the period of the recent decline in delta smelt abundance. Residence time could be affected by exports. They did not find evidence of a major shift in residence time. In fact, they observed that residence times may have increased slightly in the San Joaquin River.

Implications for managing exports

Taken together, these analyses indicate the following principles for managing exports with regard to delta smelt:

1. No rigorous scientific analysis indicates entrainment of delta smelt at the export pumps caused the recent decline in delta smelt abundance. Moreover, there is no scientific analysis that demonstrates that controlling exports will contribute to the prevention of extinction or achievement of recovery of the species. Therefore, routine management of exports or river flows to minimize entrainment (or take) of delta smelt as a means of preventing extinction or achieving recovery is futile.
2. Because analyses indicate that unusually high entrainment events have occurred in the past, exports and other water project operations should be managed to prevent such occurrences in the future. This should be done by real-time monitoring of the distribution of sub-adult, spawning adult, and larval-juvenile delta smelt, coupled with judicious use of mathematical Particle Tracking Models and close monitoring of river flows and turbidity related to entrainment.

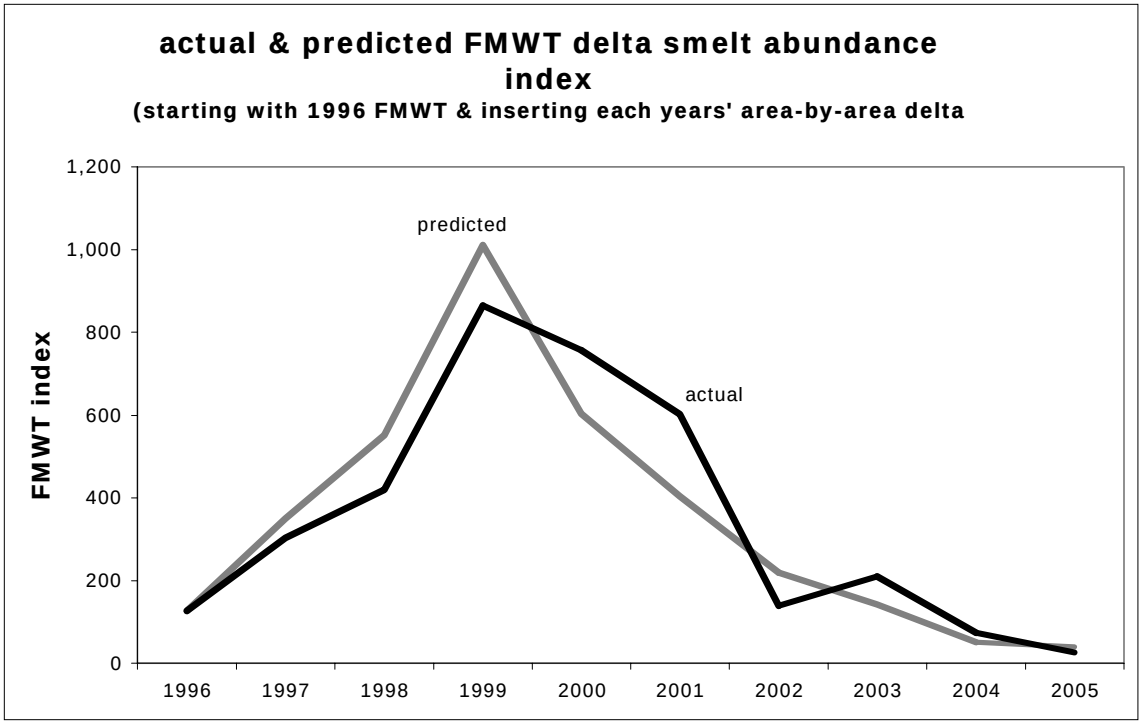
The importance of food

If exports or entrainment did not cause the decline in delta smelt abundance, what did? I summarize below recent analyses related to this question.

- Dr. Bill Bennett “autopsied” 100+ delta smelt and found most of them were food limited in the summer.
- Mongan and I, keying on Bennett’s finding, analyzed the co-occurrence of delta smelt and their primary prey (the two alien zooplankton, *Eurytemora affinis* and *Pseudodiaptomus forbesi*) in July. We found a good correlation for the period 1981-2006 between, on the one hand, July co-occurrence of delta smelt and density of the two zooplankton and, on the other hand, the subsequent FMWT abundance index. This was the first correlation with an obvious explanation (delta

smelt must feed to survive) ever found between any factors and the subsequent FMWT.

- Dr. Anke Mueller-Solger, Department of Water Resources, noted that after 1996, the FMWT index depends solely on July delta smelt abundance. That is, the co-occurrence with prey was not necessary in recent years. She concluded from this and other analyses that food limitation was not the problem. However, this conclusion rests on the questionable assumption that delta smelt feed equally well on yet another recently introduced alien zooplankton, *Limnoithona tetraspina*, as they do on their established favored prey, *Eurytemora* and *Pseudodiaptomu*s. Without this assumption, there is a clear drop in prey densities. *Limnoithona* now occur at extraordinarily high densities in July in delta smelt habitat. However, *Limnoithona* were not found in the guts of delta smelt examined in 2005, when Limnoithona levels were merely high, but were found in 2006 when they were extraordinarily high. Individual *Limnoithona* are much smaller than both *Eurytemora* and *Pseudodiaptomus*, so more energy is required by delta smelt to capture *Limnoithona*. It is possible that, rather than being a good source of food for delta smelt, *Limnoithona* are starvation rations that may interfere with survival by being so numerous and requiring so much more energy to capture.
- We attempted to find out what determined delta smelt abundance in July. We discovered an even better correlation between late-April co-occurrence of delta smelt and their primary springtime prey, *Eurytemora*, and the subsequent FMWT abundance index for 1997-2005. This is the period when July abundance determines the FMWT index. As mentioned above, the FMWT index is closely related to subsequent winter spawning abundance. Using the relationship developed for 1997-2005, we can predict the FMWT abundance index from the previous year's index and the co-occurrence of delta smelt and *Eurytemora* in late April. Predicted and actual FMWT index values are shown below. The predicted line uses only one estimate of delta smelt abundance, the FMWT index of 1996. From that index and annual late-April densities of *Eurytemora* and distribution of delta smelt (not their abundance), the next nine years of FMWT indices can be predicted. Exports and entrainment of delta smelt at the export pumps is not a factor in this prediction. It is solely determined by *Eurytemora* densities in areas where delta smelt are in late April. I conclude from these analyses that the problem with delta smelt is a significant drop in the densities of their prey, initially in the summer and, in recent years, in the spring. Why this drop occurred is a mystery. If it were caused by exports, exports would show up as an important factor affecting delta smelt abundance, but the data do not support that possibility. Something else must be affecting the zooplankton that delta smelt prey on. If we could identify those factors and do something about them, we might be able to save the delta smelt. No reliable, statistically significant analyses suggest we can save delta smelt or cause their recovery by managing exports or entrainment.



Conclusion

One might reasonably ask how it is possible that so much emphasis is put on exports as the cause of the delta smelt abundance decline if there are no reliable analyses supporting this belief and several analyses indicating that food is the problem. An answer can be found in the report of outside experts, the Review Panel for the Pelagic Organism Decline Program. These panelists are listed below.

> Mark D. Bertness, Brown University
> Stephen M. Bollens, Washington State University Vancouver
> James H. Cowan, Louisiana State University
> Ronald T. Knelb, University of Georgia Marine Institute
> Parker MacCready, University of Washington
> Russell A. Moll, California Sea Grant College Program
> Paul E. Smith, Scripps Institution of Oceanography
> Andrew R. Solow, Woods Hole Oceanographic Institution
> Robert B. Spies, Applied Marine Sciences

Their first conclusion concerning “weaknesses” of the Pelagic Organism Decline Program in their December 2005 report is as follows:

> “The program relies too heavily on local perspectives and resources for problem analysis, research and solutions. This can give rise to a culture of common assumptions that impedes alternative possibilities.”

I agree with this conclusion. The belief that exports have important effects on delta smelt and other fish has been a fundamental tenet of Delta water project management for years. It has proven to be an unfounded belief for striped bass and salmon, and many analyses of the wealth of data in this estuary indicate it is also unfounded for delta smelt. Nevertheless, as evidenced by the title of this hearing, it remains a powerful paradigm, contrary to the science, and to the detriment of delta smelt.