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UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

THE DELTA SMELT CASES	CASE NO. 1:09-cv-407-OWW-DLB 1:09-cv-422-OWW-DLB 1:09-cv-631-OWW-DLB 1:09-cv-892-OWW-GSA PARTIALLY CONSOLIDATED WITH: 1:09-cv-480-OWW-GSA
SAN LUIS & DELTA-MENDOTA WATER AUTHORITY, et al. v. SALAZAR, et al. (Case No. 1:09-cv-407)	
STATE WATER CONTRACTORS v. SALAZAR, et al. (Case No. 1:09-cv-422)	**DECLARATION OF DR. BRYAN MANLY IN SUPPORT OF PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT**
COALITION FOR A SUSTAINABLE DELTA, et al. v. UNITED STATES FISH AND WILDLIFE SERVICE, et al. (Case No. 1:09-cv-480)	**DATE:** March 23, 2010 **TIME:** 8:30 a.m. **COURTROOM:** 3 Hon. Oliver W. Wanger
METROPOLITAN WATER DISTRICT v. UNITED STATES FISH & WILDLIFE SERVICE, et al. (Case No. 1:09-cv-631)	
STEWART & JASPER ORCHARDS, et al. v. UNITED STATES FISH AND WILDLIFE SERVICE, et al. Case No. 1:09-cv-892)	

I, Bryan F.J. Manly, declare as follows:

1. I am a consultant statistician working for Western EcoSystems Technology Inc., 2003 Central Avenue, Cheyenne, Wyoming. I have been employed by that company since 2000. Before that I was Professor of Statistics and the Director of the Center for Applications of Statistics and Mathematics at the University of Otago, in Dunedin, New Zealand. I have 40 years experience in the application of statistics in environmental and ecological areas. I hold a DSc degree from the City University in London, UK, am a Chartered Statistician of the Royal Statistical Society, and a Fellow of the Royal Society of New Zealand. A copy of my curriculum vitae is attached to this declaration as Exhibit A. I am the author of over 200 papers in refereed scientific journals, and seven books on applied statistics. A list of my publications is attached to this declaration as Exhibit B.

2. I have been involved in various statistical analyses of data from the Sacramento-San Joaquin Delta Estuary since 2003. In the last few years, this has included a number of analyses aimed at better understanding the apparent decline in the numbers of many pelagic fish species since about 2000. I have reviewed the December 15, 2008 biological opinion issued by the United States Fish and Wildlife Service ("Service" or "FWS") regarding the effects of the coordinated operations of the Central Valley Project ("CVP") and the State Water Project ("SWP") on the delta smelt (*Hypomesus transpacificus*) ("BiOp"). I have been asked to comment upon the statistical analysis in the BiOp. I have identified some important deficiencies in the effects analysis in the BiOp. In particular, the BiOp apparently attributes important long-term population level effects to CVP and SWP operations (also "water projects" or "projects"). I say "apparently" here because it is often not clear whether the BiOp is referring to a temporary short-term effect within a single year that has little influence on the future abundance of delta smelt, or instead an important long-term effect from one year to the next. The conclusions in the BiOp that project operations have population-level effects, i.e., effects from one year to the next, are not supported by use of the generally accepted statistical methods for assessing such effects.

3. In the BiOp, the Service identifies "three major seasonally-occurring categories of effects" of the water projects for specific focus: "entrainment of delta smelt, habitat

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restriction, and entrainment of *Pseudodiaptomus forbesi,* the primary prey of delta smelt during summer-fall." (AR 000218; BiOp at 203.) The effects analysis in the BiOp "assumes that the proposed CVP/SWP operations affect delta smelt throughout the year either directly through entrainment or indirectly through influences on its food supply and habitat suitability." (*Id.*) The BiOp further "assumes that any of these three major categories of effects described above will adversely affect delta smelt, either alone or in combination." (*Id.*) The explicit statement that adverse effects from project operations are "assumed" foreshadows the deficiencies I found in my review of the effects analysis in the BiOp. Specifically, rather than providing a scientific basis, the BiOp apparently assumes or surmises without supporting data and analyses that each of the three "major categories of effects" in a year significantly affects the population abundance of delta smelt in the following year.

4. In this declaration, I address the bases in the BiOp for its conclusions regarding water project effects on delta smelt population abundance through entrainment of delta smelt and entrainment of an important food species, *Pseudodiaptomus forbesi*. I have been informed that other witnesses will address the third identified category of "major" effects, an effect on delta smelt habitat as measured by X2.

5. In summary, the failure of the BiOp to apply basic statistical methods to analyze its hypothesis that project operations have population level impacts on the delta smelt through entrainment of delta smelt in the winter and spring, and entrainment of *Pseudodiaptomus forbesi* in the months from July through September, is contrary to generally accepted scientific standards and methods. The Service could reasonably have applied various methods to analyze the available data to test these theories. However, the BiOp's method, which was to draw conclusions regarding these two effects of project operations without applying any of the recognized and commonly accepted methods to analyze the available data, is unreasonable and unscientific.

A. The Service's Conclusion That Entrainment Affects Subsequent Year Abundance Of Delta Smelt Even "Sporadically" Is Not Supported By Generally Accepted Scientific Standards And Methods

6. The BiOp acknowledges that "currently published analyses of long-term

associations between delta smelt salvage and subsequent abundance do not support the hypothesis that entrainment is driving population dynamics year in and year out (Bennett 2005; Manly and Chotkowski 2006; Kimmerer 2008)." (AR 000225; BiOp at 210.) As stated, the available statistical investigations do not show a statistically significant, important relationship between the level of entrainment in one year and abundance in the following year, including the 2006 study I authored with Chotkowski.

7. In the same paragraph, however, the BiOp makes the following statement: "[t]he population-level effects of delta smelt entrainment vary; delta smelt entrainment can best be characterized as a sporadically significant influence on population dynamics." (AR 000225; BiOp at 210.) This statement is unclear and confusing. As the BiOp acknowledges, the available studies have not found evidence of important long-term population level effects from entrainment, contradicting the BiOp's statement that the population level effects may "vary," if this means long-term effects, i.e., effects from one year to the next. The BiOp goes on to observe that "Kimmerer (2008) estimated that annual entrainment of the delta smelt population (adults and their progeny combined) ranged from approximately 10 percent to 60 percent per year from 2002-2006." (AR 000225; BiOp at 210.) If the Service meant only that the abundance at a point in time during a single year may vary depending upon entrainment, then Kimmerer's estimates support that statement. But if, as appears more likely, the Service was relying upon Kimmerer's estimates to support a conclusion that entrainment sometimes causes abundance to vary significantly later in the same year or in following years, then the statement in the BiOp has no scientific basis.

8. First, it is important to understand that Kimmerer's article, *Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento – San Joaquin Delta* (2008) ("Kimmerer (2008)") (AR 018854-018880) estimated percentage losses of delta smelt within single year classes of delta smelt, but Kimmerer did not conclude that such losses reduce delta smelt population abundance from one year to the next. To the contrary, Kimmerer concluded that effects of such entrainment are negligible in comparison to the effects of other factors. He noted that in the summer to fall period (after entrainment by the

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project pumps has ceased), there has been up to a 50-fold variation in survival of delta smelt, apparently depending upon the availability of the zooplankton on which delta smelt feed. (AR 018878; Kimmerer (2008) at p. 25.) He explained that conditions affecting survival in the summer-fall period (after the entrainment of delta smelt at the export pumps) appear to "dominate variability in abundance of delta smelt in fall." (*Id.*) Kimmerer also found that "despite substantial variability in export flow in years since 1982, no effect of export flow on subsequent midwater trawl abundance is evident." (*Id.*) Therefore, even assuming Kimmerer's estimates of the percentages lost to entrainment are correct, data and analysis in Kimmerer (2008) do not support the Service's conclusion in the BiOp that entrainment has a substantial effect on delta smelt abundance later in the same year or in following years. Kimmerer concluded his article with his policy views regarding management of exports, including a suggestion that exports should be managed to limit entrainment "even though export effects are relatively small." (*Id.*) But Kimmerer was clear that the data, and the methods he used to evaluate the data, do not show that entrainment in the winter and spring (including when measured by exports) has a meaningful effect on subsequent fall abundance as measured by the Fall midwater trawl index. Kimmerer (2008) therefore does not support the Service's theory in the BiOp that entrainment has a "sporadically significant" effect on delta smelt abundance from one year to the next.

9. Second, if the Service did not want to rely upon Kimmerer's analysis and wished to test for itself whether the high percentages of entrainment within a year estimated by Kimmerer (2008) in some years have "sporadically" reduced abundance by a significant proportion the following year, it could have used a number of methods for testing this hypothesis based on an analysis of the available data. These methods range in complexity from simple evaluations, comparisons, and interpretations of the raw data to much more sophisticated regression and other statistical analyses of the data. The BiOp, however, fails to apply any of these available methods. The Service's failure to apply any such methods in the BiOp, and instead simply asserting an effect without supporting data and analysis, is not in accordance with generally accepted scientific standards and methods.

10. I have authored a textbook called *Statistics for Environmental Science and*

Management, 2nd Edition, Manly, B.F.J. (2009). This book discusses the use of statistical methods in a wide variety of situations with ecological and environmental data, including examples involving fish and wildlife. In Chapter One, I describe a number of examples where the appropriate use of statistical methods has been crucial, and I emphasize that in addressing biological issues such as those raised in the BiOp, the proper use of statistical analyses is an essential part of the scientific process.

11. Textbooks by other authors regarding the use of statistics in the environmental sciences reach the same conclusions (e.g., the classical book *Sampling Design and Statistical Methods for Environmental Biologists* by R.H. Green, 1979).

12. In sum, it is well accepted in the scientific community that it is appropriate and necessary practice to use statistical methods to evaluate available data. Under generally accepted scientific standards, the Service could and should have used one or more of the available statistical methods to determine whether the data supports a conclusion that entrainment at the export pumps as calculated by Kimmerer, "sporadically" has a significant effect on subsequent population abundance. The BiOp reports no use of any of the accepted methods (or any methods at all) to support the effect of entrainment on abundance that is assumed in the BiOp. The Service's failure to do any such analysis is contrary to generally accepted scientific standards and methods.

13. In order to assess whether this failure was material, I applied some straightforward methods that the Service could have used without using significant time or requiring advanced expertise in statistical methods. The most basic approach would be to simply compare the percentage of the population entrained (as calculated by Kimmerer (2008)) in the winter and spring with the percentage change in the Fall midwater trawl index the subsequent fall. If entrainment is important to abundance, then as entrainment increases, abundance should decline. Conversely, if entrainment decreases, then abundance should increase. Using Table 1 and Figure 1 below, I perform and discuss such analysis of the data.

Table 1

Year	Annual Proportional Entrainment of Adults & Juveniles	Subsequent FMWT Index	Percent Change In FMWT Index From Previous Index
1995	18	899	781
1996	5	127	-86
1997	17	303	139
1998	1	420	39
1999	10	864	106
2000	19	756	-13
2001	24	603	-20
2002	38	139	-77
2003	36	210	51
2004	36	74	-65
2005	12	27	-64
2006	3	41	52

14. Table 1 provides proportional entrainment data based on Kimmerer 2008, and smelt abundance as indexed by the Fall midwater trawl ("FMWT") for the period 1995 to 2006. Table 1 was produced using several easily verifiable sources of data that I reference below where appropriate.

15. The first column of Table 1 simply labels the years 1995 through 2006, which are the years for which Kimmerer provided estimates of entrainment. The second column provides estimates of the annual proportion of the delta smelt population entrained by the CVP and SWP export pumps in the years 1995-2006 based on Kimmerer. For this table, I have combined his estimates of the percentage of adults entrained with his estimate of larvae and juveniles entrained. Each generation, entrainment can occur from approximately December to June of the next year, and includes both adults and juveniles and larvae. Thus, the proportional entrainment estimate for the year 1995, 18 percent, is an estimate of the proportion of the delta smelt population that was entrained from approximately December 1994 to June 1995.

16. The data in the third column of Table 1 lists the Fall midwater trawl index ("FMWT Index") of annual delta smelt abundance. These data were obtained from, and are readily verifiable at, the California Department of Fish and Game ("DFG") website: http://www.dfg.ca.gov/delta/data/fmwt/charts.asp. The FMWT Index is developed from trawl

surveys conducted by DFG in the fall of each year, generally from September through December.

17. The third column of Table 1 provides the FMWT Index for the year listed in the first column. For instance, the FMWT Index value of "899" that appears in the third column in the row labeled year 1995 represents the FMWT Index determined from sampling during September through December of the year 1995.

18. The fourth column shows the annual percentage change in the FMWT Index compared to the FMWT Index for the prior year. Thus, for example, in 1999 the FMWT Index increased by 106% as compared to the FMWT Index in 1998.

19. Table 1 provides a straightforward and simple way to evaluate whether entrainment of delta smelt may be having population-level effects. This method is to examine the percent changes in the FMWT Index from year to year against the magnitude of the intervening annual proportional entrainment that occurred between the two FMWT Indices, as calculated by Kimmerer. If there is a substantial relationship between percentage entrainment and subsequent abundance, changes in entrainment levels should result in corresponding changes in abundance. Table 1 shows that they do not.

20. Table 1 reports that during 1995, 18 percent of the smelt population was entrained (Second Column). Table 1 also reports that the subsequent FMWT Index for 1995 was 899. The fifth column in the row for 1995 reports that this represented a 781 percent increase in the FMWT Index from 1994 (which was 102, which is not shown in Table 1).

21. In the next year, 1996, Table 1 reports that 5 percent of the smelt population was entrained (Second Column), and the subsequent FMWT Index was 127. This represented a decrease in the FMWT Index of 86 percent. Thus, while proportional entrainment fell from 18 percent to 5 percent, abundance declined by 86 percent.

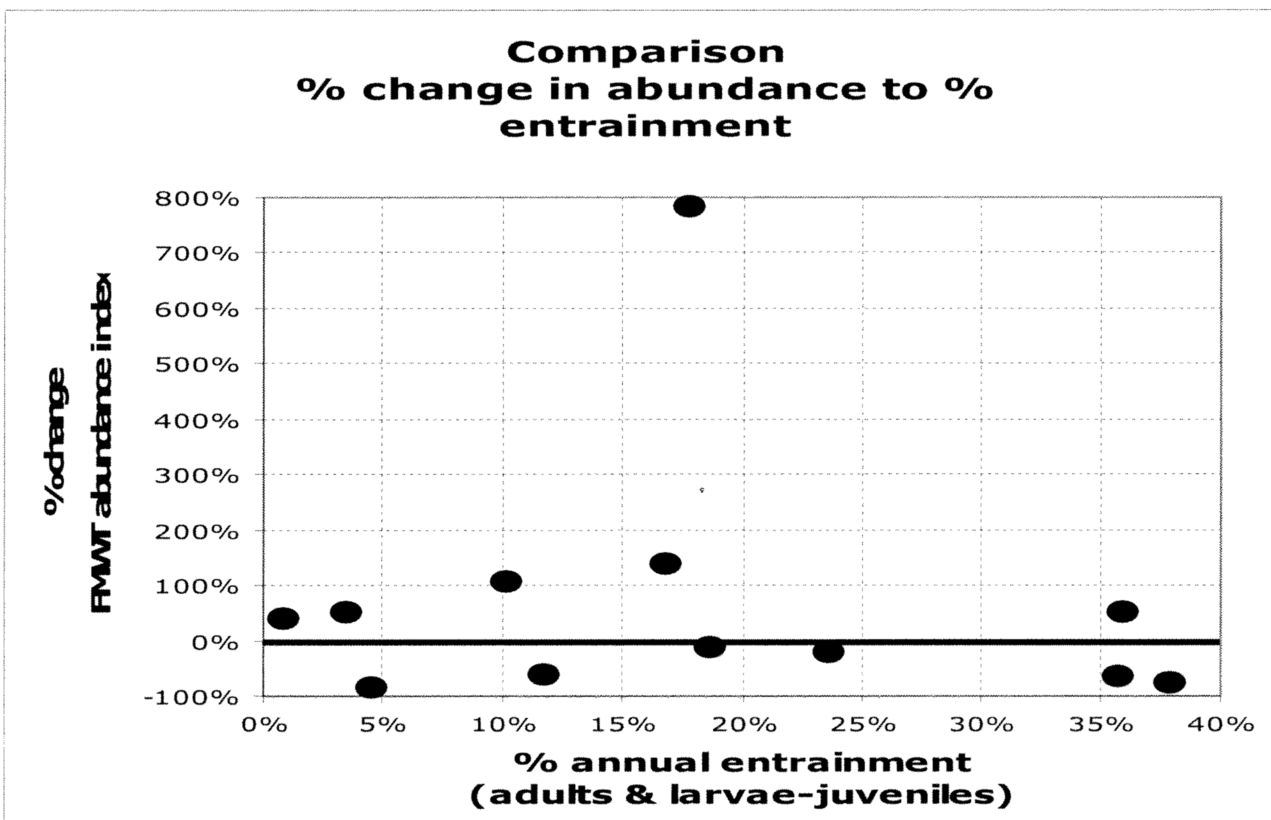
22. By analyzing only these two years, it can be observed that although proportional entrainment was three times higher in 1995 than in 1996, the subsequent FMWT Index increased from 1994 to 1995. In contrast, in 1996 when proportional entrainment was three times lower than in 1995, the FMWT Index actually decreased substantially, by 86 percent. Such an observation would not be expected if annual proportional entrainment has a significant adverse

effect on subsequent population size of delta smelt.

23. A review of the remaining years in Table 1 presents no evidence of a direct relationship between entrainment levels and subsequent abundance. The FMWT Index increased in half of the years (i.e., 1995, 1997, 1998, 1999, 2003, 2006), and the FMWT Index decreased in the other half (i.e., 1996, 2000, 2001, 2002, 2004, 2005). I can not discern any pattern in the increases and decreases in the FMWT Index and the proportional entrainment estimates for each year. For instance, in 2003 annual proportional entrainment was 36 percent and the subsequent FMWT Index increased by 51 percent. Conversely, the year 2004 had the same proportional entrainment, but the subsequent FMWT Index decreased by 65 percent.

24. In sum, an examination of the data in Table 1 shows that the FMWT Index of abundance increases and decreases in a manner apparently unrelated to whether the annual proportional entrainment was low or high. Below, I present the same data contained in Table 1, but I include it as a figure that graphically illustrates the same point.

Figure 1



25. Each black dot in Figure 1 represents a year. The horizontal x-axis indicates the annual proportional entrainment estimated for that year (i.e., Table 1 Second Column). The vertical y-axis indicates the percent change between the previous FMWT Index and the subsequent FMWT index for the same year (i.e., Table 1 Fourth Column). The solid black line running horizontally across the figure represents no change in FMWT Index from one year to the next (i.e., 0%).

26. As can be observed, the data points in Figure 1 can be divided into three general groups based on level of entrainment. First, there are three data points when estimated annual proportional entrainment was below 5 percent. Of these three, two experienced increases in the subsequent FMWT and one experienced a decrease. Next, there are six data points (i.e., years) where annual proportional entrainment ranged between 5 and 25 percent. In this range three such entrainment events were followed by an increase in the FMWT Index and three were followed by a decrease. Finally, three years had estimated annual proportional entrainment greater than 35 percent. In this group two years were followed by decreased FMWT Indices and one year was followed by an increase in the FMWT Index.

27. Similar to Table 1, Figure 1 reveals no discernable pattern in the increases and decreases in FMWT Index, and certainly does not appear to show any relationship between proportional entrainment and subsequent FMWT Index. Again, half the years led to an increase in the FMWT Index and the other half led to decreases. While there are only 12 data points, the increases and decreases in the FMWT Index are essentially evenly spread throughout the range of proportional entrainment values. In fact, some of the years with the largest increases in the FMWT Index occurred in the middle range of observations when annual proportional entrainment exceeded 15 percent.

28. Based on this initial, relatively simple assessment of the raw data as shown in Table 1 and Figure 1, I do not conclude that the annual proportional entrainment of smelt has a significant, predictive relationship to the subsequent population size of delta smelt as measured by the FMWT Index. However, while this preliminary assessment is the logical first step in any such investigation, it should not be the final step of a rigorous scientific and statistical analysis.

In the following paragraphs I explain more sophisticated methods of analysis commonly used and generally accepted by the scientific research community that could and should have been used to evaluate such data and to test the hypothesis in the BiOp that entrainment of delta smelt as estimated by Kimmerer has population level effects.

29. Using the same years reported in Kimmerer's article, 1995 through 2006, and assuming his estimates of loss to entrainment are correct, I related the logarithm of the Summer Townet Survey abundance index to the logarithm of the previous Fall Midwater Trawl index. The fitted equation accounted for 68% of the variation in the logarithm of the Summer Townet index, indicating that there is a close relationship between the summer delta smelt abundance and the abundance in the previous fall. I then tried adding the logarithm of Kimmerer's estimated survival rates from entrainment into the equation with the idea that if entrainment has important effects, then the summer abundance should be lower than expected in the years when the entrainment survival rate is low. There was no significant effect of the logarithm of survival when this was added to the equation, and the predicted Summer Townet abundances are almost exactly the same with Kimmerer's entrainment survival estimates either in or out of the equation, as shown in Figure 2 below. Hence, I could find no evidence from this analysis that the entrainment of adults in one generation or juveniles in the next generation affects the number of delta smelt in the next or any following generation in any important way.

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Figure 2

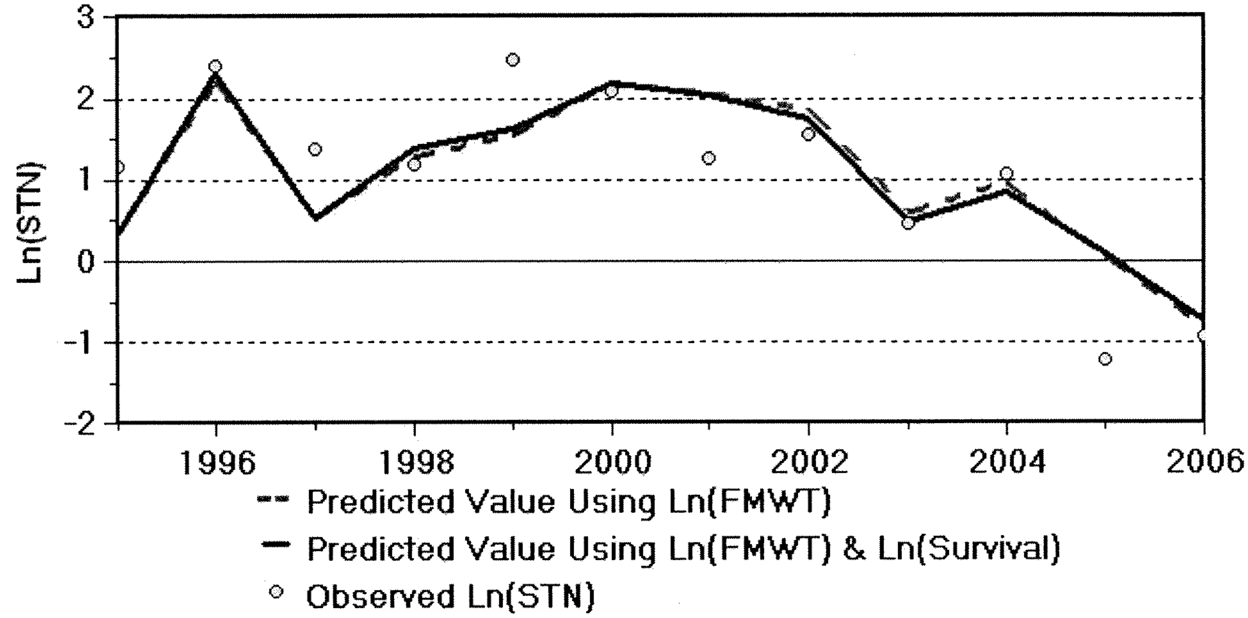

Figure 2. Values of the logarithm of the summer townet abundance index predicted based on the logarithm of the previous fall midwater trawl abundance index, predicted based on the logarithm of the previous fall midwater trawl and the logarithm of the estimated survival rate from entrainment, and the observed logarithm of the summer townet index. The predicted values are almost the same with or without the use of the estimated entrainment survival rate.

30. There are a number of potential explanations why the sometimes the high rates of entrainment calculated by Dr. Kimmerer would not show up in reduced proportional abundance in the fall. One possibility is that Dr. Kimmerer's estimates of entrainment losses are too high. He acknowledges that there is significant uncertainty in the estimates, and that his extrapolation from salvage to total entrainment could result in an estimates as much as 3 times too high for adult proportional entrainment. (Kimmerer 2008 at p. 20.) Thus, the statistical analysis may show no effect on subsequent abundance because the percentage of the population entrained was actually much lower than he calculated. Another possibility, as is stated by Dr. Kimmerer, is that other factors such as limited food availability overwhelm any effect from entrainment. In his 2008 article, Dr. Kimmerer reported a 50–fold (5000%) variability in survival from summer to fall as compared to a possible 10% effect of entrainment, assuming Kimmerer's estimates are not too high.

31. In sum, as the BiOp acknowledges, the available studies do not show that

entrainment has any meaningful effect upon abundance from one year to the next. The BiOp's apparent reliance upon Kimmerer 2008 to support a hypothesis that entrainment "sporadically" affects long term abundance is misplaced, at least in terms of long-term population effects. I do not know whether the Service employed readily available statistical methods to test its hypothesis that such effects do occur. The BiOp reports no such tests. My statistical analyses show no evidence of "sporadic" effects that are lasting. The assertion that entrainment of delta smelt has a sporadically significant affect on long term abundance, without any supporting analysis of the data, is contrary generally accepted scientific standards and methods.

B. The Service's Conclusion That Entrainment Of *Pseudodiaptomus* In The Summer Is Limiting Abundance Is Not Supported By Generally Accepted Scientific Standards And Methods

32. The other "major category" of effect attributed to project operations is the entrainment of the *Pseudodiaptomus forbesi*. The BiOp theorizes that summer exports are removing the *Pseudodiaptomus* from the south Delta during the summer, and that such zooplankton would otherwise drift downstream to the western Delta, where delta smelt reside during the summer. The BiOp says this "might" be depriving the delta smelt of an important food source. (AR 000243; BiOp at 228). As with the conclusion in the BiOp that entrainment has a sporadically significant effect on fall abundance, the BiOp does not report any effort to test this theory with available statistical methods. Again, this failure is contrary to generally accepted scientific standards and methods.

33. The peer review of the draft effects section of the BiOp recommended that the Service reanalyze the supposed relationship between summer export volumes and *Pseudodiaptomus* densities, considering various factors. If the Service did so, the BiOp does not report the results of the reanalysis. The peer review states that "If a revised analysis does not show a substantial (not necessarily statistically significant) pattern, the analysis should be mentioned but the results dropped as a quantitative metric from the EA." (AR 008821.)

34. Based on analyses done by others, the Service's failure to use available methods to test its hypothesis was material. A November 19, 2008 comment letter (AR 006367-006392) describes a regression analysis that included factors that the peer review recommended

be considered. This analysis concludes concerning the effects analysis in the BiOp that

> . . . with respect to *Pseudodiaptomus forbesi*, the major flaw is [that] *Pseudodiaptomus* densities in Suisun Bay are not correlated with exports or densities in the Delta. The Service fails to account for the fact that *Pseudodiaptomus* densities in Suisun Bay are highly correlated with densities in Suisun Marsh. This indicates that subsidization is occurring from nearby Suisun Marsh and is not affected by entrainment of delta *Pseudodiaptomus* by export pumping.

(AR 006369.)

35. Hence, the only statistical analysis of the available data that I am aware of does not support the Service's conclusion that entrainment of food in the summer is limiting the abundance of delta smelt.

D. Conclusion

36. In sum, the BiOp is deficient in its failure to use available and generally accepted methods to test its hypotheses regarding the effects of entrainment of delta smelt and the entrainment of its food supply. The Service's failure to use these methods is contrary to generally accepted scientific standards and methods.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. Executed this 13th day of November, 2009, at Sacramento, California.

B F J Manly

BRYAN F.J. MANLY