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UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

THE DELTA SMELT CASES, SAN LUIS & DELTA-MENDOTA WATER AUTHORITY, *et al.* v. SALAZAR, *et al.* (Case No. 1:09-cv-407)	1:09-cv-407 OWW GSA 1:09-cv-422 OWW GSA 1:09-cv-631 OWW GSA 1:09-cv-892 OWW GSA PARTIALLY CONSOLIDATED WITH: 1:09-cv-480 OWW GSA
STATE WATER CONTRACTORS v. SALAZAR, *et al.* (Case No. 1:09-cv-422)	**DECLARATION OF DR. RICHARD B. DERISO**
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. Ctrm: 3 Judge: Hon. Oliver W. Wanger
METROPOLITAN WATER DISTRICT v. UNITED STATES FISH AND 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, RICHARD B. DERISO, declare:

1. The facts and statements set forth in this declaration are true of my own knowledge and if called as a witness, I can testify competently thereto. Any opinions expressed in this declaration are based upon my knowledge, experience, training and education, as set forth in section I.

2. My declaration is set forth in the following manner:

I. INTRODUCTION

3. In July of this year, I prepared a preliminary declaration that set forth a general explanation of the statistical analysis contained in the 2008 Delta Smelt Biological Opinion ("BiOp") prepared by the United States Fish and Wildlife Service ("FWS"). In that declaration, I focused on three areas of analysis performed by FWS—(1) the relationship between Old and Middle River ("OMR") flows and salvage, (2) the effect of Fall X2 on population survival, and (3) the establishment of incidental take levels. In each of these areas, FWS employed statistics, data analysis, and/or statistical modeling—tools that require technical training to understand. The equations, the statistical, mathematical and fishery population dynamic principles, and the modeling exercises involved in the BiOp are highly complicated. Someone without the proper background and training would be unable to thoroughly review what FWS did in a meaningful way.

4. It is my understanding that the Court has authorized the submittal of this declaration so that I may address and explain in detail the issues I identified in my prior declaration. Since my prior declaration, I have been able to complete my review of the BiOp, as well as the relevant publications relied on by FWS and cited in the BiOp. This declaration sets

forth my comprehensive explanation of the statistical modeling and analysis that FWS performed, including its clear, fundamental errors, focusing again on OMR flows, Fall X2, and the incidental take levels. Below, and in the accompanying appendix, I explain what FWS purported to do, and the mistakes they made in reaching their conclusions. I have also provided the information and equations that I used in conducting my review in an appendix so that my statements and explanations can be critically reviewed by others.

II. BACKGROUND AND EXPERIENCE

5. I am the Chief Scientist of the Tuna-Billfish Program at the Inter-American Tropical Tuna Commission ("IATTC"), and I have held this position since 1989. *See* Summary Professional Vitae, attached hereto as Exhibit A. I supervise a scientific staff of approximately 20 scientists and our primary responsibilities are: (1) to collect statistics on the fisheries that operate in the eastern Pacific Ocean, such as tuna and tuna-like species, and (2) to conduct stock assessments annually on the principal tropical tuna species as well as periodically other species such as turtles, sharks, and billfish species. My work involves advising the Commission on the current status of the populations and making conservation recommendations that can permit stocks to be maintained at a level of abundance that will support maximum sustainable yields.

6. IATTC has a long history of successful management of the tuna stocks in the eastern Pacific Ocean. The largest fishery historically has been yellowfin tuna. Yellowfin tuna is currently at a level of abundance above that which would support maximum sustainable yield.

7. I have a Ph.D. in Biomathematics (Quantitative Ecology) from the University of Washington, a Master's of Science in Mathematics from the University of Florida, and a Bachelor's of Science in Industrial Engineering from Auburn University. I have been teaching courses in fish population dynamics, quantitative ecology, and related areas for over twenty years. I was an Associate Adjunct Professor at the Scripps Institution of Oceanography, University of California, San Diego, from 1990 to 2006 and an Affiliate Associate Professor of Fisheries at the University of Washington from 1987 to 2006. Among the graduate courses I have taught are "Theoretical Models of Exploited Animal Populations" at the University of Washington; "Decision Analysis for Exploited Populations" at the University of Washington; and

"Quantitative Theory of Populations and Communities" at Scripps Institution of Oceanography. I have additional professional experience through a current membership on the Scientific and Statistical Committee of the Western Pacific Regional Fisheries Management Council and a past membership on the Ocean Studies Board which governs the U.S. National Research Council, where I served as co-chairman of the Committee on Fish Stock Assessment Methods. I was also formerly a Population Dynamicist for the International Pacific Halibut Commission. I have been a consultant to several agencies and institutions, both public and private.

8. I have authored or co-authored over 50 peer reviewed publications and technical reports, including Deriso, R., Maunder, M., and Pearson, W, *Incorporating covariates into fisheries stock assessment models with application to Pacific herring*, Ecol. App. 18(5): 1270-1286 (2008); Deriso, R., Maunder, M., and Skalski, J., *Variance estimation in integrated assessment models and its importance for hypothesis testing*, Can. J. Fish. Aquat. Sci. 64: 187-197 (2007); and Quinn, T. and Deriso, R., *Quantitative Fish Dynamics*, Oxford University Press (1999). *See* List of Publications, attached hereto as Exhibit B.

9. I have been retained to evaluate the effects of entrainment on fish populations in many circumstances throughout the United States. I have consulted on the environmental review of once-through cooling systems of the Indian Point nuclear power plants on the Hudson and Delaware Rivers, focusing on impingement and entrainment of fish, with a particular emphasis on their impacts to population. For this analysis, I was retained by ESSA Technologies Ltd. through a contract with the New York State Department of Environmental Conservation. This analysis included modeling, and reviewing models of, the impacts of entrainment and impingement on fish populations. I am a member of the Estuary Enhancement Program Advisory Committee that reviews the mitigation measures for losses of fish through impingement and entrainment at the Salem Nuclear Power Plant on the Delaware River in New Jersey. I have evaluated both the mortality and related impacts of hydroelectric dam operations on Chinook salmon populations on the Columbia and Snake Rivers.

10. I am familiar with, understand, and am able to explain to the Court the concepts and techniques used in the 2008 Delta Smelt Biological Opinion to evaluate the impacts of the

Central Valley Project and the State Water Project operations on the delta smelt population. My testimony and opinions are offered in the context of explaining the standard practices and statistical methods that are used in fish population dynamics to evaluate impacts to fish populations, and the practices and statistical methods employed by the FWS in the BiOp.

III. GENERALLY ACCEPTED PRINCIPLES OF FISH POPULATION DYNAMICS THAT APPLY TO AN ANALYSIS OF IMPACTS TO FISH SPECIES

11. In the BiOp, FWS sought to evaluate the effects of the Central Valley Project and State Water Project on the threatened delta smelt. When looking at potential impacts of a project to fish species, the standard of practice is for qualified professionals to employ certain well-established principles of fish population dynamics.

A. Principle 1: Quantitative Analysis Should Be Conducted

12. The fundamental approach to assessing fish population dynamics is through quantitative statistical analysis (mathematical models) of population dynamics. "Quantitative analysis" involves the use of actual measured data and the testing of relationships between that data. The nature and degree of project impacts on a species must be determined using quantitative methods where quantitative data is available. Similarly, measures designed to benefit the species and avoid harm must be based on a quantitative approach. Only in this way can impacts and benefits be measured for proper evaluation of their effect on the species.

13. By contrast, a qualitative approach may be appropriate where no quantitative data or measurements are available. Qualitative analysis consists of a more subjective evaluation of the degrees of importance of particular factors and circumstances for which quantitative data and measurements are not appropriate or do not exist.

B. Principle 2: Impacts to the Total Population Should Be Evaluated

14. Population dynamics also involve a qualified scientist conducting an evaluation of project impacts to a threatened fish by focusing on impacts to the total population. Measuring effects on a single fish, or a limited group of fish, does not lead to reliable conclusions about population level effects. Such population level conclusions are essential when evaluating a project's impacts on the species as a whole and its ability to survive and recover.

15. Population level effects are properly evaluated using rates and proportions. This means that a given impact or variable cannot be taken as significant on its own without accounting for the *relative* impact on the total population. The population growth rate is an appropriate and reliable measure of population increases and decreases from year to year.

C. Principle 3: Models Should Be Reliable and Biologically Plausible

16. The standard of practice for a fish population dynamicist requires that any statistical models that are utilized must be reliable and biologically plausible. Such statistical models are based on mathematical formulas that assign numeric values to biotic and abiotic variables to explain the relationships among them. To be biologically plausible means that the mathematical formulas used must reflect the reality that the "variables" are reflective of the biology of the living organisms that are being assessed. For example, living organisms have a limited life span and limited reproductive capabilities that must be taken into account in any model used to evaluate their behavior and vulnerabilities. Thus, the models that are properly used are designed to attribute a quantitative value to those influential biological factors so that the model enables quantitative measurement of their interrelationships. Such models are designed to reflect biological realities and to evaluate the relationship between living stock and recruits.

D. Principle 4: Data Should Be Used Consistently

17. In performing a quantitative fish population analysis, generally accepted scientific standards require that the study be internally consistent in its use of data. Data that is rejected in one aspect of the analysis should not be relied upon elsewhere in the same study.

18. With these general principles in mind, I turn to the subject of this action, the 2008 Delta Smelt Biological Opinion for the Operations Criteria and Plan for the State Water Project and the Central Valley Project.

IV. THE BIOP'S EVALUATION OF PROJECT EFFECTS AND THE BIOP'S RPAS ARE BASED ON A "QUANTITATIVE" ANALYSIS

19. The core analyses and conclusions in the BiOp are contained in the sections entitled "Effects of the Proposed Action" (BiOp at 202-239 [Administrative Record ("AR") at 000217-000254]), "Reasonable and Prudent Alternative" ("RPA") (BiOp at 279-285, 324-81 [AR

at 000294-000300, 000339-000396]), and "Incidental Take Statement" ("ITS") (BiOp at 285-295 [AR at 000300-000310]). These sections define the effects of the water projects on the delta smelt and the restrictions which FWS imposed to avoid jeopardy.

20. In the section of the BiOp entitled "Effects Analysis Methods," FWS explains that the effects of the project pumps on entrainment (OMR flows and salvage, and incidental take levels) and the fall habitat suitability and its effect on population (Fall X2) "are quantitatively analyzed."

> The effects analyses range from qualitative descriptions and conceptual models of project effects to quantitative analyses. The effects of Banks and Jones pumping on adult delta smelt entrainment, larval-juvenile delta smelt entrainment, and fall habitat suitability and its predicted effect on the summer townet survey abundance index are quantitatively analyzed. The remainder of proposed action elements and effects are not analyzed quantitatively because data are not available to do so or it is the opinion of the FWS that they have minor effects on delta smelt.

BiOp at 208-209 (AR at 000223-000224). This representation is consistent with my review of the BiOp—FWS conducted a quantitative statistical analysis in order to (1) evaluate project effects on the smelt population and (2) develop RPAs designed to mitigate and avoid any such effects to the extent necessary to avoid jeopardy to the species and adverse modification of its critical habitat. As I would expect of most any scientific exercise, FWS relied on and used data when it was available, unless FWS concluded that the issue was too "minor."

21. Because the BiOp concludes that the projects jeopardize the species and adversely modify its critical habitat, it includes RPAs that restrict project operations in an attempt to avoid jeopardy and adverse modification. The RPAs address categories of effects to which FWS applied quantitative analyses: adult entrainment and larval/juvenile entrainment as related to OMR flows, and fall habitat. These are outlined in more detail below.

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22. **Actions 1 and 2 (Winter OMR Flows)**.[1] Actions 1 and 2 are designed to avoid jeopardy to adults from entrainment. These Actions restrict Old and Middle River ("OMR") flows to reduce adult salvage in the winter. Action 1 is triggered first and lasts for 14 days, followed immediately by Action 2, which is triggered if certain criteria are present and lasts until spawning begins or a certain water temperature is reached. Both of these Actions prescribe a similar range of OMR flows, but at different times of the year. The quantitative analysis presented in Attachment B to support the prescribed OMR flow levels in Actions 1 and 2 is set forth in the BiOp at 345-349 and is represented in two graphs labeled Figure B-13 and Figure B-14, which appear to share the same data. *See* BiOp at 348, 350 (AR at 000363, 000365). Figure B-13 depicts the BiOp's analysis of the relationship between winter OMR flows and adult salvage, concluding that as flows become more negative, salvage increases. Based on this relationship, Actions 1 and 2 set less negative flow levels to reduce salvage.

23. **Action 3 (Spring OMR Flows)**. Action 3 is designed to avoid jeopardy to larvae and juveniles from entrainment. This Action restricts OMR flows to reduce larval/juvenile salvage in the spring. FWS did not apply statistical modeling to evaluate whether or not reductions in OMR flows or X2 would reduce impacts to juveniles, because there is no actual data on larval and juvenile salvage for fish smaller than 20 millimeters. Instead, FWS relied on the assumption that larval and juvenile movement can be predicted using a particle tracking model. A particle tracking model is a theoretical simulation of the flow of neutrally buoyant particles through a water system, where particles are used as surrogates for actual fish. Similar to Actions 1 and 2, Action 3 sets less negative flow levels to reduce salvage.

24. **Action 4 (Fall X2)**. Action 4 is designed to protect fall habitat for adults. This Action prescribes Delta outflows to push X2 more seaward during the fall. The BiOp relies primarily on the quantitative analysis represented by the summary statistics for the stock-recruit

[1] The RPAs are divided into four "Components," which are supported by supplemental information in Attachment B to the BiOp. Attachment B breaks down the RPA Components into five "Actions," such that Component 1 is represented by Actions 1 and 2, Component 2 is supported by Action 3, Component 3 is supported by Action 4, and Component 4 is supported by Action 5. Because most of the technical analysis is contained in Attachment B, and for ease of reference, I will refer to the RPAs in terms of the Actions rather than the Components.

model set forth in Figure E-22 to establish that the location of Fall X2 has a significant effect on delta smelt abundance. *See* BiOp at 268 (AR at 000283). Based on this purported relationship, Action 4 sets Delta outflow levels to control the location of X2.

25. **Incidental Take Statement**. The BiOp also includes an Incidental Take Statement, which prescribes the acceptable level of take of larval/juvenile and adult delta smelt using quantitative methods. For each of larvae/juveniles and adults, FWS took the average salvage rate from certain prior years which it deemed to be representative of future conditions under the RPAs. The average salvage rate from the prior representative years was set as the maximum take level under the RPAs. *See* BiOp at 385-390 (AR at 000400-000405).

26. To summarize, FWS used quantitative methods to evaluate the effects of water project operations (OMR flows) on the species, on its fall habitat (as represented by Fall X2), and to establish incidental take levels. I will next explain the clear, fundamental errors I have identified in that quantitative analysis.

V. THE QUANTITATIVE ANALYSIS BY FWS DOES NOT FOLLOW STANDARD FISH POPULATION ASSESSMENT METHODS

A. Actions 1 & 2 (Winter OMR Flows): Use of Raw Salvage Numbers Instead of the Salvage Rate

27. Actions 1 and 2 prescribe OMR flow levels based on the BiOp's calculation of the relationship between OMR flows and adult salvage. This relationship is depicted in Figure B-13 and compares OMR flow levels to raw salvage numbers. The salvage numbers used are the total number of fish counted at the salvage facilities.

28. Raw salvage numbers do not represent the proportion of the total population that is lost to salvage, which is the salvage rate. For example, a raw salvage total of 100 adults has vastly different significance depending on whether the total population is 200 (salvage rate of 50 percent) or 10,000 (salvage rate of 1 percent). Thus, Figure B-13 does not show what effect OMR flows have on the total delta smelt population.

29. Use of raw salvage numbers, rather than the salvage rate, could be appropriate if the total delta smelt population was known and a model that incorporates every life stage of the

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species (a life-cycle model)[2] was being used. Salvage of delta smelt is a source of loss of individuals—it is analogous to using catch as a mortality loss to the population. If the total delta smelt population was known, then the salvage numbers themselves could be incorporated directly into a life-cycle model and would make it possible to determine the population effects of salvage. A simple version of such a model is explained in Hilborn, R. & Walters, C., *Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty*, Chapman & Hall (1992) at 298:

> The changes in a population's biomass from one time to the next can be simply written as
>
> next biomass = last biomass + recruitment + growth – catch – natural mortality.

Salvage would take the role of catch in a similar life-cycle model for delta smelt.

30. Here, however, the total population of delta smelt is unknown, although there have been recent attempts to provide such estimates. Because actual abundance is not known, raw salvage numbers cannot be used to show population level effects.

31. In the absence of actual adult abundance numbers, adult abundance is estimated by the Fall Midwater Trawl Survey ("FMWT"), which collects samples around the Delta. An index of the FMWT is used to track the relative increase or decrease in adult abundance from year to year. The survey counts the number of smelt captured in a net of known dimensions and multiplies it by the volume of water actually sampled. That number is then applied to the entire estimated volume of water where the smelt is believed to reside. From this data, an index is derived.

32. The FMWT index is scientifically reasonable and widely relied upon by scientists studying the delta smelt, though not without its technical flaws. It is a numerical scale used to compare variables derived from a series of observed facts with one another or with some reference number to reveal relative changes as a function of time. Because actual abundance is not known, raw salvage numbers cannot be used to show population level effects.

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[2] A life-cycle model is a well-accepted and reliable method of evaluating population dynamics from generation to generation (adults to adults), rather than focusing solely on one age group or the change from adults to juveniles.

33. For adult delta smelt, the scientifically accepted and reliable method is to use the cumulative salvage index to evaluate whether a relationship exists between OMR flows and adult salvage. The cumulative salvage index is equal to the raw number salvaged divided by the prior year FMWT index. *See* BiOp at 338 (AR at 000353). In this way, the cumulative salvage index represents an index of the proportion of abundance that is lost to salvage each year. In the absence of abundance figures, the prior year FMWT index stands as a usable denominator for a ratio that would reveal any population level effects from entrainment.

B. Actions 1, 2 & 3 (Winter and Spring OMR Flows): Failure to Evaluate the Smelt's Population Growth Over Time

34. The BiOp's failure to evaluate population level effects using the correct variable (salvage rate) is consistent with its more general failure to use the well-accepted, reliable statistical models typically used to evaluate population level effects. The BiOp did not employ life-cycle modeling**,** which, among other things, is used to estimate a population's growth.

35. Life-cycle modeling is a well-accepted and reliable method of evaluating population dynamics from generation to generation (adults to adults). It typically consists of the simple models known as biomass dynamic models and stock production models, or the more complex models such as age-structured models. *See* Quinn & Deriso (1999) at ch. 2, 6-8; Hilborn & Walters (1992) at 297.

36. In fisheries science, often the total number of fish in a population is unknown. It is standard practice that, given the data available, population level effects can be determined using surrogate methods such as the population growth rate and the salvage rate.

37. Similar to Actions 1 and 2, the BiOp omits any analysis of the effect of spring OMR flows (Action 3) on the delta smelt population growth rate. A standard life-cycle model could be applied to determine whether spring OMR flows, which would potentially affect larvae and juveniles, are affecting the change in total population from year to year. This kind of quantitative analysis would make it possible to reliably calculate population level effects for delta smelt.

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C. Action 4 (Fall X2): Use of a Linear Additive Model Instead of a Multiplicative Model

38. FWS's quantitative Fall X2 analysis for Action 4 of the BiOp is based on a stock-recruitment model. A stock-recruitment model is a model used to evaluate population level effects that quantitatively characterizes the relationship between the parental "stock" and the progeny it produces ("recruits"). In the BiOp, the parental stock is measured through the FMWT and the progeny is measured at the juvenile life stage through the Summer Townet Survey ("TNS").

39. There are many different stock-recruitment models. In selecting a model, one necessary criterion is that the model must be biologically plausible. This means that the mathematical formulas reflect biological reality and limitations, as described above.

40. FWS employed a linear additive stock-recruitment model when evaluating Action 4. A linear additive model adds several factors together to achieve a sum, without use of logarithms. A simple example is A + B = C. This type of model is not appropriate for stock and recruitment relationships, for two main reasons.

41. First, adding and subtracting factors can generate a positive sum, even if one of the factors is zero. This seems mathematically accurate, but it does not work in a situation where the factors are living organisms with certain non-mathematical properties. For instance, in an equation where various factors are added to adult abundance to determine the effect on their juvenile offspring, one can achieve a positive sum (number of juveniles) even if the factor representing the number of adults is zero. In terms of biological reality, zero adults cannot produce offspring. Thus, simply adding the factors does not reflect the manner in which populations grow.

42. Second, a linear additive model treats factors as having a fixed effect on the population, rather than a proportional effect. That is, by adding a factor, it will always increase or decrease the sum by the same absolute amount. While mathematically accurate, this does not work when the factors being added are habitat components that have a changing proportional effect on the sum (population abundance), not a fixed effect. When the total population is

smaller, a smaller number of individuals exist that can potentially be affected by a given factor. This is accounted for by using proportions and rates.

43. In contrast, multiplicative stock-recruitment models produce biologically accurate results and they are appropriate for fish population dynamics. Simply put, a multiplicative model reads as A x B = C. Two multiplicative models available to FWS are the Beverton-Holt and Ricker models. These models are typically used because they are well-accepted by the scientific peer community and are reliable.[3]

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[3] *See, e.g.*, Jorgensen, S. & Fath, B. (eds.), *Encyclopedia of Ecology*, Academic Press (2008); Knowler, D., Estimation of a Stock-Recruitment Relationship for Black Sea Anchovy (Engraulis encrasicolus) Under the Influence of Nutrient Enrichment and the Invasive Comb-Jelly, Mnemiopsis leidyi, 84:3 Fisheries Research 275-281 (May 2007); Owen-Smith, N., Introduction to Modeling Wildlife and Resource Conservation, Blackwell Publ’g (2007); Brauer, F. & Castillo-Chavez, C., Mathematical Models in Biology and Epidemiology, Springer-Verlag New York, Inc. (2006); Kritzer, J. & Sale, P. (eds.), Marine Metapopulations, Elsevier Academic Press (2006); Mangel, M., The Theoretical Biologist's Toolbox: Quantitative Methods for Ecology and Evolutionary Biology, Cambridge Univ. Press (2006); Ferrier, R., et al. (eds.), Evolutionary Conservation Biology, Cambridge Studies in Adaptive Dynamics, Cambridge Univ. Press (2004); Hoff, M., Biotic and Abiotic Factors Related to Rainbow Smelt Recruitment in the Wisconsin Waters of Lake Superior, 1978-1997, 30 Journal of Great Lakes Research, Supp. 1 Exploring Superior, 414-422 (2004); Walters, C. & Martell, S., Fisheries Ecology and Management, Princeton Univ. Press (2004); Hart, P. & Reynolds, R. (eds.), Handbook of Fish Biology and Fisheries, 1 Fish Biology, Blackwell Publ’g (2002); Haddon, M., Modeling and Quantitative Methods in Fisheries, Chapman & Hall (2001); Jennings, S., et al., Marine Fisheries Ecology, Blackwell Publ’g (2001); Lorda, E. et al., Application of a Population Dynamics Model to the Probabilistic Assessment of Cooling Water Intake Effects of Millstone Nuclear Power Station (Waterford, CT) on a Nearby Winter Flounder Spawning Stock, 3 Envtl. Science & Policy, Supp. 1, 471-482 (Sept. 2000); McCallum, H., Population Parameters: Estimation for Ecological Models, Blackwell Publ’g (2000); Guenette, S. & Pitcher, T., An Age-Structured Model Showing the Benefits of Marine Reserves in Controlling Overexploitation, 39:3 Fisheries Research 295-303 (Jan. 1999); Quinn & Deriso (1999); Ricklefs, R. & Miller, G., Ecology, 4th ed., W.H. Freeman (1999); Hilborn & Walters (1992); Rothschild, B., Dynamics of Marine Fish Populations, Harvard Univ. Press (1986); Walters, C., Adaptive Management of Renewable Resources, MacMillan Publ’g Co. (1986); Mangel, M., Decision and Control in Uncertain Resource Systems, Academic Press (1985); Pauly, D., Fish Population Dynamics in Tropical Waters: A Manual for Use With Programmable Calculators, 8 ICLARM Studies & Reviews (1984); Fournier, D. & Archibald, C., A General Theory for Analyzing Catch at Age Data, 39 Canadian Journal of Fisheries & Aquatic Sciences 1195-1207 (1982); Pitcher, T. & Hart, P., Fisheries Ecology, Kluwer Academic Publ’g (1982); Walters, C. & Ludwig, D., Effects of Measurement Errors on the Assessment of Stock-Recruitment Relationships, 38 Canadian Journal of Fisheries & Aquatic Sciences 704-710 (1981); Clark, C., Mathematical Bioeconomics: The Optimal Management of Renewable Resources, Wiley (1976); Ricker, W., Handbook of Computation for Biological Statistics of Fish Populations, Bulletin 119 of the Canada Fisheries Res. Bd. (1958), issued again as Ricker, W., Computation and Interpretation of Biological Statistics of Fish Populations, Bulletin 191 of the Canada Fisheries Res. Bd. (1975); Weatherley, A., Growth and Ecology of Fish Populations, Academic Press (1972); Beverton, R. & Holt, S., On the Dynamics of Exploited Fish Populations, 14 Fishery Investigations Series II, Ministry of Agriculture, Fisheries & Food (1957).

44. For measuring population level effects, multiplicative or rate-based models such as Ricker and Beverton-Holt should be used to achieve scientifically accepted, reliable results. Additive models should not, because they generate inaccurate and unreliable results. These are the two most widely-used models in actual practice because they were designed to be biologically accurate and reflect the relationship between stock and recruits. A feature of a multiplicative model is that when there are zero adults on one side of the equation, there are zero young on the other side; i.e., zero adults yields zero offspring. This follows because any number multiplied by zero will always equal zero. As stated in Ricker (1975) at 281, the model is designed "so that when there is no adult stock there is no reproduction . . . ." The same result can be expected using other types of multiplicative models.

D. ITS: Use of Rejected Data Points Instead of Representative Data Points

45. The BiOp sets the adult incidental take limit based on the average salvage rate from the years 2006, 2007, and 2008, which FWS determined to be representative of future conditions under the RPAs. BiOp at 385-86 (AR at 000400-000401). According to the list of salvage levels contained in the ITS, salvage in 2007 was extremely low compared to other years and to 2006 and 2008 in particular. *See* BiOp at 386 (AR at 000401) (Table C-1). In another section of the BiOp, FWS itself had considered the salvage level in 2007 as unusable for purposes of analyzing salvage and OMR flows due to that year's low average water turbidity, a presence/absence indicator. *See* BiOp at 348 (AR at 000363) (Figure B-13, Note). Thus, FWS recognized that the unusual conditions in 2007 made it an unrepresentative year that would skew its analysis of salvage impacts. Use of an unrepresentative data point that was rejected elsewhere in the same study runs counter to basic principles of quantitative fish assessment. FWS does not attempt to justify why the data point would be used in one instance and not another, so one possible explanation is that it is simply a material error in the analysis.

46. To calculate the incidental take limit for larvae and juveniles, FWS largely followed the same methodology that it used for adults. BiOp at 389 (AR at 000404). The take limit is set based on the average monthly juvenile salvage index from four years – 2005, 2006,

2007, and 2008. According to data listed in the BiOp, the salvage in 2006 was extremely low compared to other years. *See* BiOp at 392 (AR at 000407) (Table C-4). I examined this year carefully and discovered through my review of OMR flow data obtained from a Freedom of Information Act ("FOIA") request to FWS[4], that in 2006, average OMR flow was strongly positive in April through June. When analyzing the effects of OMR flows on salvage in the Effects Analysis section of the BiOp, FWS explained that positive OMR flow yields zero or very low salvage. BiOp at 163 (AR at 000178). Thus, FWS's use of 2006 as a "representative" year for larval/juvenile salvage is internally inconsistent with its explanation elsewhere that positive OMR flow (which is what occurred in spring 2006) yields little or no salvage. The year 2006 was therefore not representative and should have been omitted, as it was elsewhere by FWS for other purposes.

VI. THE BIOP'S APPLICATION OF STATISTICAL MODELS AND INPUT VARIABLES IS INCONSISTENT WITH STANDARD PRINCIPLES OF FISHERIES POPULATION DYNAMICS

47. To decipher the models and methods that FWS used, I reviewed and interpreted the limited graphs and tables provided in the BiOp, along with similar information and studies in the administrative record.

48. I compared FWS's models against the standard models employed by the scientific community, and particularly those models that are commonly used in fish population modeling. My review and comparison revealed that the BiOp does not use the well-accepted models in more

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[4] My review of the BiOp and the administrative record revealed that FWS had not provided all of the underlying data that FWS relied on in performing its work on the BiOp. In my experience, a full scientific analysis is not possible without making the underlying data available so that the work may be checked and evaluated by others. This omission hinders the ability to conduct a standard peer review of the FWS analysis without estimating data point values from the graphs or searching for data in other sections. FWS's failure to include the data underlying its basic analyses and determinations is an inexplicable defect given the conclusions FWS reaches. After I identified the missing categories of data, the Metropolitan Water District of Southern California requested that data through a FOIA request. On October 29, 2009, more than ten weeks after the request was made, FWS provided a disc containing portions of the data underlying the BiOp. Included on that disc were daily OMR flow data. I used those data to calculate several average OMR flows, including monthly average flows, as noted in this declaration.

than one place, but rather relies on models that are not biologically sound and lead to erroneous results.

49. I evaluated the same data presented in the BiOp and input it into the standard models to determine whether the end result would be different. The results are fundamentally different from the results reached in the BiOp.

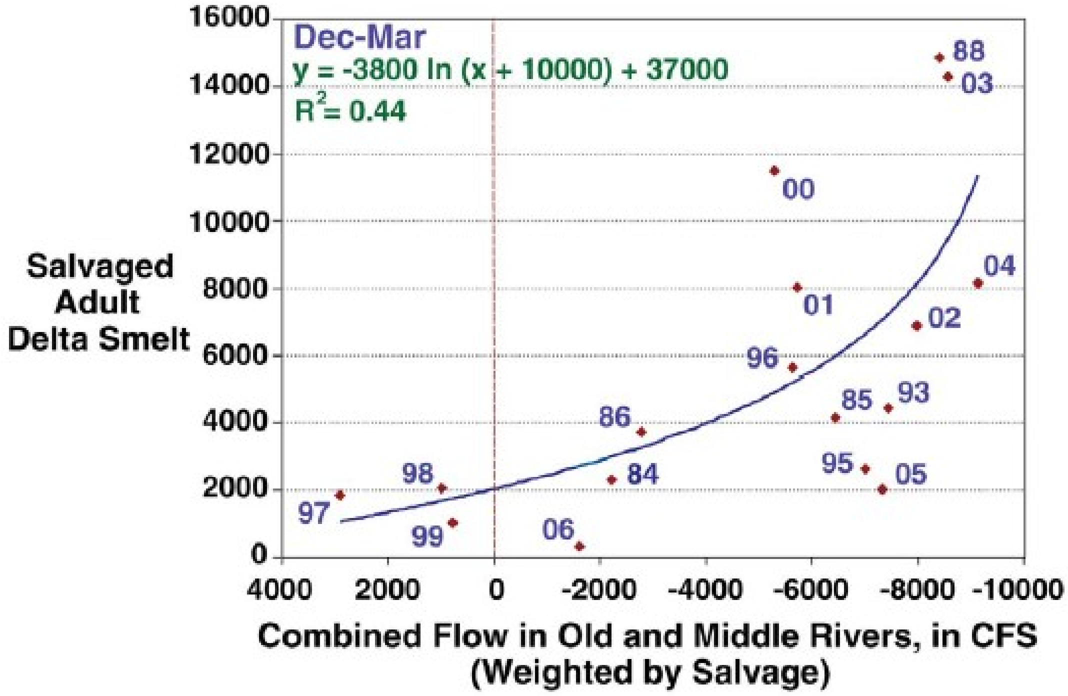
50. Based on the material I reviewed, the fundamental errors I have identified call into question the jeopardy and adverse modification conclusions in the BiOp and reveal that FWS had no reliable scientific basis for imposing the RPAs adopted.

A. FWS's Analysis of the Relationship Between Old and Middle River Flows and Adult Salvage Is Flawed

51. The BiOp's analysis of the effects of the projects on adult delta smelt and its conclusion that winter flow restrictions are necessary are based on a statistical model of the alleged relationship between OMR flows and adult salvage. The modeling and analysis are contained in the Effects of the Proposed Action section of the BiOp, pages 202-279 (AR at 000217-000294), and RPA Actions 1 and 2 in Attachment B to the BiOp, pages 329-356 (AR at 000344-000371). Actions 1 and 2 rely on Figure B-13 on page 348 (AR at 000363) and on various studies, including Kimmerer, W., *Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta* (AR at 018854), and the work of Pete Smith, which is cited by Kimmerer.

(1) Improper Use of Total Adult Salvage Numbers Instead of Cumulative Salvage Index

52. FWS uses total adult salvage numbers to demonstrate an alleged relationship between OMR flows and adult salvage. *See* BiOp at 163-65; 347-50 (AR at 000178-000180; 000362-000365). The alleged relationship is derived from the graph in Figure B-13 which compares the number of adults salvaged each year to the corresponding OMR flow rate for that year. BiOp at 164, 348 (AR at 000179; 000363).



Note: Data shown are for the period 1984-2007, excluding years 1987, 1989-92, 1994, and 2007 that had low (<12ntu) average water turbidity during Jan-Feb at Clifton Court Forebay.

Figure B-13. OMR-Salvage relationship for adult delta smelt. (source, P. Smith). Data from this figure were the raw data used in the piecewise polynomial regression analysis.

53. FWS relied on this graph to conclude that OMR flows correlate to total salvage numbers—suggesting that as negative OMR flows increase, more adults are salvaged.

54. This conclusion by FWS is scientifically flawed because raw salvage numbers do not have a directly proportional effect on population and do not take into account the overall size of the population as determined by representative survey data. Nonetheless, FWS relied on Figure B-13 and Figure B-14 (which appear to share the same data) to set OMR flow levels in RPA Actions 1 and 2. In other words, FWS set OMR flow levels in Actions 1 and 2 without determining population level effects.

55. The scientifically appropriate approach would have been for FWS to use the cumulative salvage index to evaluate whether a relationship exists between OMR flows and adult salvage. FWS had already developed that index for other purposes. *See* BiOp at 386 (AR at 000401) (using the cumulative salvage index in another context, to calculate the incidental take). The cumulative salvage index represents an index of the salvage rate, taking into account data on the size of the population. This has long been recognized as appropriate for analysis of delta

smelt by those scientists actively studying the smelt. *See, e.g.*, Bennett, W., *Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California*, San Francisco Estuary & Watershed Science, Cal. Bay-Delta Auth. Science Program & John Muir Inst. of the Env't (2005) at 37 ("As first step [sic], assessing the potential impacts of the water project operations on delta smelt requires estimating the proportion lost relative to population abundance."). The cumulative salvage index is proportional to the fraction of adult fish that are lost due to water diversion.

56. The concept of dividing fish loss by abundance is well-accepted and reliable and is applied in other, similar applications, such as part of the procedure for estimating the impact of entrainment and impingement of fishes by water withdrawals of once-through cooling systems for nuclear power plants on the Hudson River.

> This approach is based on conditional mortality rates, or the fraction of an initial population that would be killed by some agent during the year if no other sources of mortality operated. Conditional entrainment mortality rates are used as estimates of the direct impact of power plants on individual year classes . . . . (2) Conditional mortality rates can be entered directly into life-cycle models for assessing potential long-term impacts on fish populations.

Barnthouse, L., et al. (eds.), *Science, Law, and Hudson River Power Plants: a Case Study in Environmental Impact Assessment*, Am. Fisheries Soc'y Monograph 4, Am. Fisheries Soc'y (1988) at 122.

57. Another example is biological reference points ("BRP") which can be used as targets for optimal fishing: "A BRP can be expressed as a fishing mortality rate (F) and/or as a level of stock biomass (B)." Comm. on Fish Stock Assessment Methods, Nat'l Research Council, *Improving Fish Stock Assessment Methods*, Nat'l Academy Press (1998) at 45. The fishing mortality rate (F) depends mathematically on the ratio of catch divided by biomass and it is similar to a cumulative salvage index in that both represent a ratio of losses to abundance.

58. Since total population data does not exist, the cumulative salvage index uses a survey index which gives a relative increase or decrease in annual survey numbers to monitor population levels. Use of the cumulative salvage index to evaluate the effects of OMR flows is

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scientifically accepted, reliable, and superior to using the raw salvage numbers themselves (as used in Figure B-13), for the following reasons:

59. The total number of adults salvaged does not indicate population level effects. *See* BiOp at 338 (AR at 000353) ("the total number salvaged at the facilities does not necessarily indicate a negative impact upon the overall delta smelt population"). Stated differently, to make sense of total adult salvage numbers, total adult abundance must be taken into account. For example, a salvage of 100 adults has vastly different significance depending on whether the total population is 200 or 50,000.

60. In contrast, the cumulative salvage index is an index of the *proportion* of adults salvaged from the total population, using the FMWT to relate salvage to population levels. The cumulative salvage index is equal to the number salvaged divided by the prior year FMWT index. *See* BiOp at 338 (AR at 000353).

61. Use of the cumulative salvage index, rather than total salvage numbers, was recommended by the Peer Review. *See Independent Peer Review of USFWS's Draft Effects Analysis for the Operations Criteria and Plan's Biological Opinion, 2008* at 6 (AR at 008818) ("The Panel suggests that the use of predicted salvage of adult smelt should be normalized for population size. . . . Expressing salvage as a normalized index may help remove some of the confounding of the temporal trends during the baseline period.").

(2) Use of the Cumulative Salvage Index Shows That There Is No Statistically Significant Relationship Between OMR Flows and Adult Salvage for Flows Less Negative Than -6100 Cubic Feet per Second at the Very Least

62. To assess FWS's methods, I plotted a graph of the relationship between the cumulative salvage index (salvage rate) and the OMR flows for each year that was analyzed in the BiOp. In developing this graph, I used the cumulative salvage index data provided in the BiOp. *See, e.g.*, BiOp at 386 (AR at 000401). Because Figure B-13 uses salvage weighted OMR flows, which are not listed anywhere in the BiOp, I visually estimated a magnified version of the OMR flow curve in Figure B-13 and interpolated the data points for each year.

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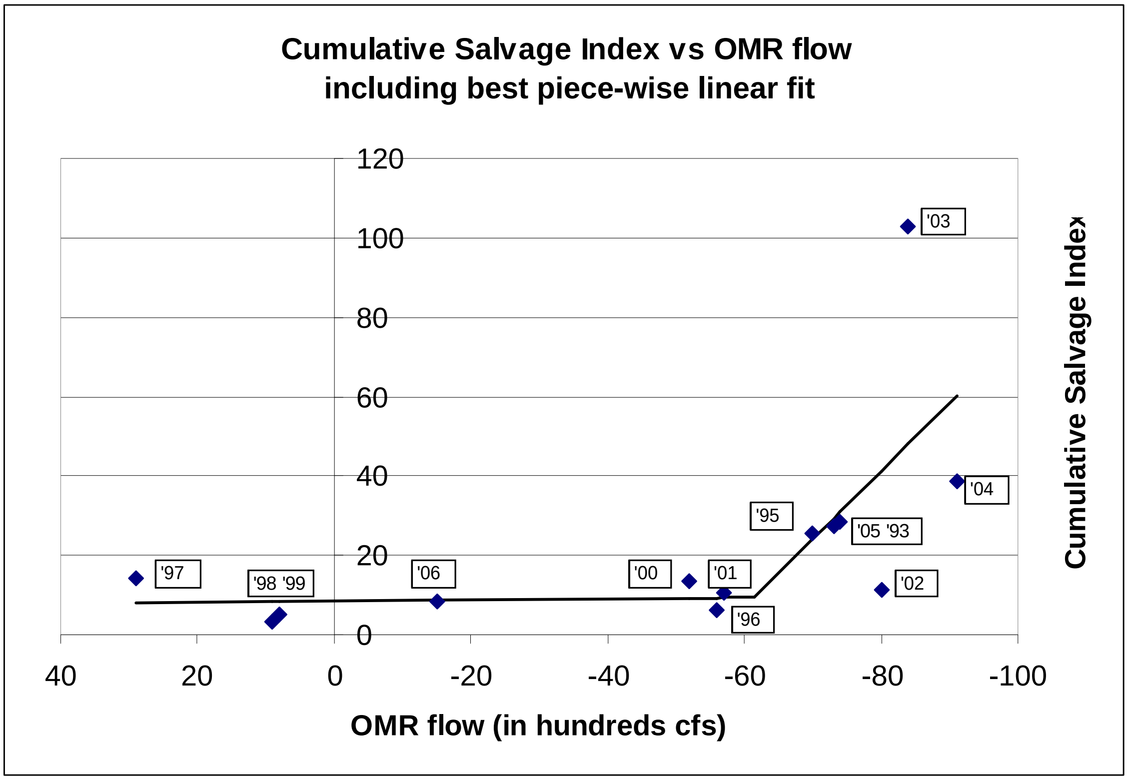

The Cumulative Salvage Index (Table B-2 & C-1) and corresponding Dec-Mar salvage weighted OMR (Figure B-13); note the salvage weighted OMR flows were visually estimated from Figure B-13. Years span 1993-2006 but exclude 1994 because that was also excluded in Figure B-13. A piece-wise linear model (the line on the figure) is also shown whose coefficients were obtained by the statistical procedure of maximum likelihood estimation.

63. The graph of salvage rate versus OMR flow shows that salvage rate remains flat as OMR flows increase until OMR flows reach -6100 to -7000 cubic feet per second ("cfs"). At -7000 cfs, salvage rate begins to increase as negative OMR flows increase. The graph demonstrates that OMR flows do not correlate to the salvage rate at flows less negative than -6100 cfs at the very least. I have determined that, based on the data available and using the appropriate reliable analytic method, there is no scientific basis for FWS's imposition of OMR flow restrictions at flows less negative than -6100 cfs (and potentially -7000 cfs). For additional technical detail, see Appendix 1 at Point 1.

64. As shown in the x-axis label on Figure B-13 (see ¶ 52 above), FWS used "Combined Flow in Old and Middle Rivers, in CFS (Weighted by Salvage)" to evaluate the relationship between OMR flows and salvage. "Weighted by Salvage" is not defined in the

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BiOp; however, a logical definition is that the salvage weighted average OMR flow is an average over several time periods, such as weeks, and the influence that a given week's OMR flow has on the overall average is set proportional to the salvage in that week.

65. FWS's October 29, 2009 FOIA response included daily OMR flow data (as opposed to the weighted average flows used in Figure B-13). I constructed December through March average OMR estimates based on the daily OMR flows provided by FWS. I modeled the relationship between the straight average OMR flows and the cumulative salvage index and confirmed that the results are consistent with those reached using the Figure B-13 weighted average flows. Using the straight average, the flows were not significant until a much more negative flow level (approximately -7943 cfs). The results are shown in Appendix 1 at Point 1.

B. The BiOp Fails to Evaluate Population Level Effects Using the Population Growth Rate – Interpreting the Data in This Way Shows That Salvage and OMR Flows Do Not Have a Statistically Significant Effect on the Population Growth Rate

66. Given the data in FWS's possession, and given its goal of evaluating the projects' effect on the total population, the appropriate analysis is to use that data to evaluate the effect on the population from year to year. This includes interpretation of the data to determine the effect of salvage (or more generally, population removals) on the population growth rate by application of a life-cycle model, as is standard practice in fisheries stock assessment. This approach is confirmed by the authors of widely read and accepted texts, which discuss the reliable methods of undertaking these analyses. *See, e.g.*, Quinn & Deriso (1999) at ch. 2; Hilborn & Walters (1992) at ch. 8. The population growth rate represents the relative increase or decrease in adults from one year to the next, which is a full life-cycle approach. Owen-Smith (2007) at 28. This approach is critical for evaluating the species' potential for recovery in that it measures the population's ability to rebound from year to year. *See, e.g.*, Bennett (2005) at 41 ("Population modeling may be the best way to evaluate the potential impacts of water export operations relative to other sources of mortality.").

67. Interpreting the data to evaluate the effect of salvage on the population growth rate is necessary because the survival of the species at one life stage cannot necessarily be the basis

for population level conclusions. To evaluate the effects of salvage, one must look beyond a single phase of life (i.e., FMWT only) or even adults to juveniles (i.e., FMWT to TNS). A complete analysis requires an evaluation of trends from one year's FMWT to the next year's FMWT because mortality in one life stage may be offset by mortality in another life stage or it may be affected by density dependence (described below in ¶ 68). As noted by Bennett (2005) at 44, when discussing simulation results of a hypothetical population model for delta smelt, "These results show how export mortality could be easily offset or masked by very small changes in mortality at other life stages." A generation-to-generation analysis eliminates or reduces the risk that population level conclusions will be drawn based on mortality effects in one life stage or the apparent change in mortality effects due to offsets in another life stage.

68. Delta smelt appear to exhibit reduced population growth when population abundance is high due to density dependence. Density dependence can occur through many mechanisms, as described by Ricker (1975) at 280: "Although cannibalism of young by adults is possible in many species, it is likely that the effect of parental stock density upon recruitment is usually exerted *via* the density of the eggs or larvae they produce, survival of the latter being affected by density-dependent competition for food or space, compensatory predation, etc." Thus, density dependent effects must be taken into account when evaluating the population growth rate. Density dependence terms are present in all major stock production, biomass dynamic, and stock-recruitment models, including the Ricker model. *See* Quinn & Deriso (1999) at chs. 2, 3.

69. Standard practice dictates that population level conclusions should not be based solely on raw salvage numbers. Rather, a fish population dynamicist should evaluate population level effects using the cumulative salvage index (salvage rate), and also evaluate the effect of the cumulative salvage index on the population growth rate, just as is typically done with harvest rates. As noted by Bennett (2005) at 37, "In several respects, losses to the water export facilities are analogous to harvest in a fishery, with the main exception that 'harvest' in this case includes all life stages (except eggs)." Harvest rates are routinely evaluated for their population level effects, and their consequence to population growth levels over time, in fisheries stock

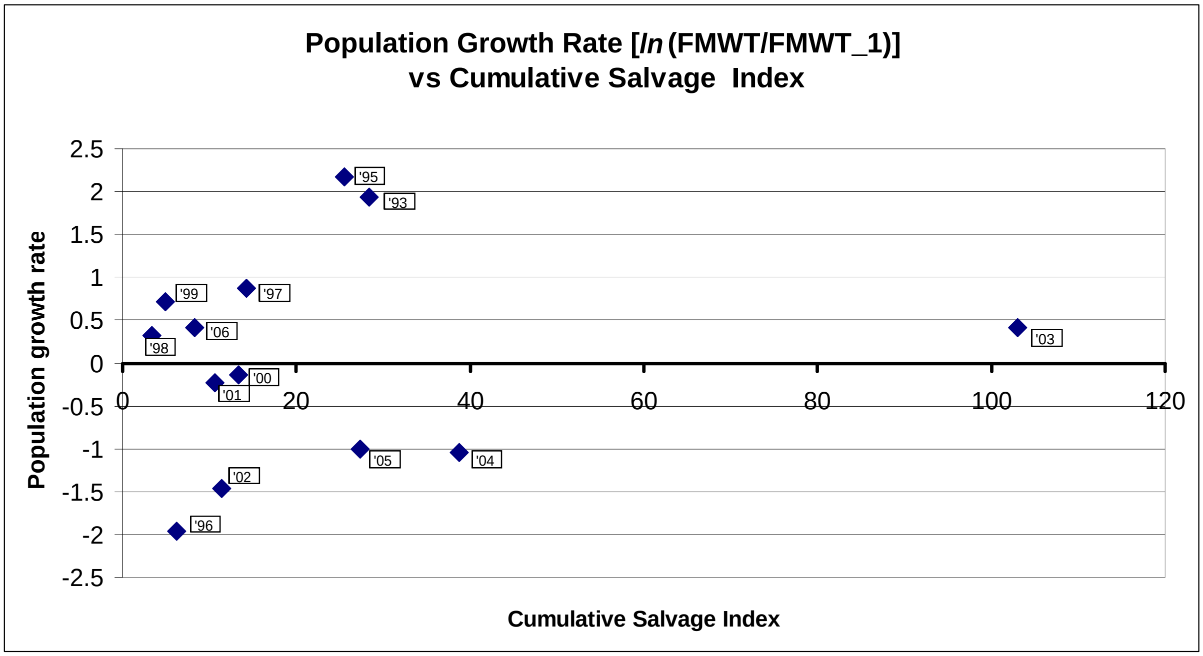
evaluations. *See, e.g.*, Quinn & Deriso (1999) at ch. 2; Hilborn & Walters (1992) at ch. 8. Only by looking at population level effects can it be determined whether salvage is impacting the delta smelt population and its ability to recover in a statistically significant way.

70. Through my review of the modeling and analysis in the BiOp, I determined that FWS did not apply a life-cycle approach in the BiOp. FWS did not attempt to evaluate the effect of the projects on the population growth rate. The BiOp completely omits any analysis or conclusions about project effects on the overall life cycle of the delta smelt and its ability to recover from year to year. However, the data to perform such an analysis is all available, and evaluating population growth rate effects is an elementary exercise. When I looked at the data for such effects, I readily recognized that there is no statistically significant relationship between salvage and the population growth rate.

(1) Adults – Salvage

71. Applying standard principles to calculate population level effects, and using the correct variable to determine those effects (the salvage rate), I modeled the relationship between the cumulative salvage index and the population growth rate. The life-cycle model used for this analysis is a standard Ricker stock-recruitment model in which consecutive year FMWT estimates take the role of stock and recruitment, respectively. I used the cumulative salvage index data taken from the BiOp itself. *See* BiOp at 386 (AR at 000401).

72. The output of this standard model shows that there is no statistically significant relationship between salvage and the population growth rate. This demonstration is based upon using 0.05 as the significance level—the standard benchmark in applied statistics for determining a significance level. *See, e.g.*, Sigler, S., *Fisher and the 5% Level*, 21:4 Chance, Springer New York (Dec. 2008). Statistical significance is found when the p-value is less than 0.05. The p-value is the probability that the result obtained in a statistical test is due to chance rather than a true relationship between variables. In the analysis that I performed, the p-value was 0.76, which is greater than the benchmark and thus not statistically significant. *See* Appendix 1 at Point 2 for additional technical detail. The population growth rate and cumulative salvage index are depicted in the graph below as a visual aid.

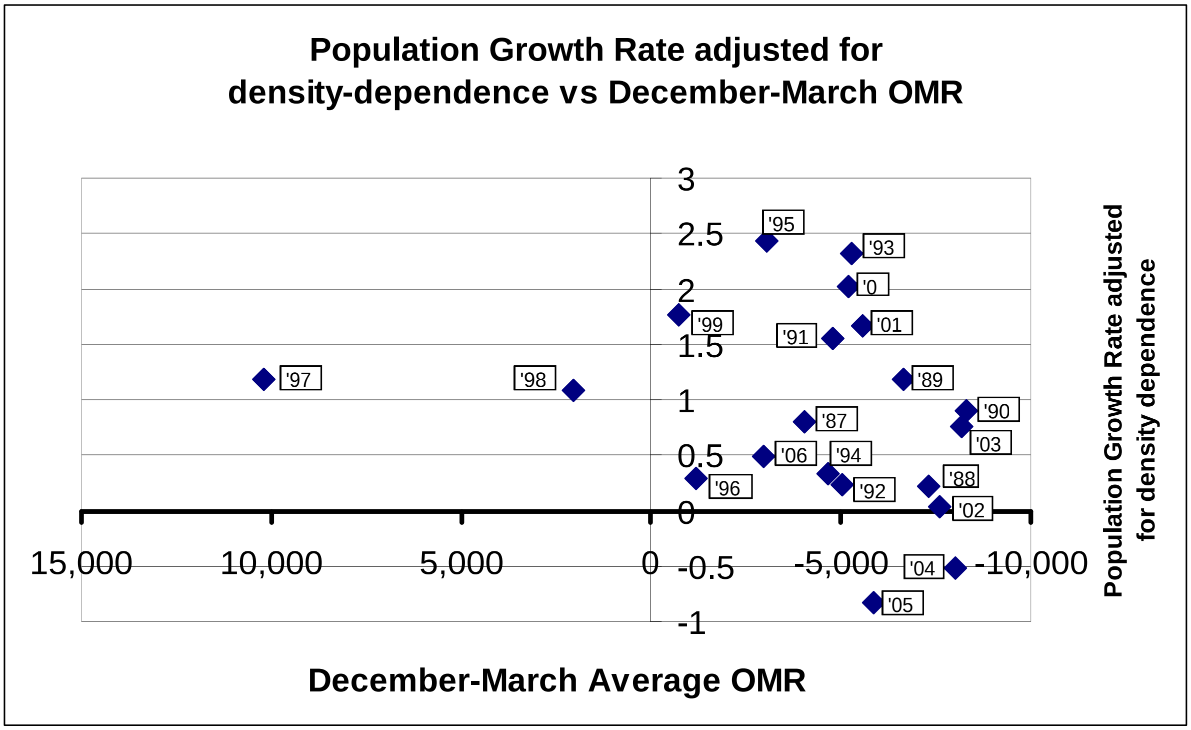


73. If the cumulative salvage index had a strong negative effect on population growth, the above graph would have been expected to show a pronounced negative slope. Instead, the graph shows no trend in population growth rate as the salvage rate increases. If the population has a growth rate of zero, then the population is neither increasing nor declining. A positive growth rate means the population is increasing on an annual basis, and a negative growth rate means the population is declining on an annual basis. Here, the population growth rate did not trend in a negative direction as the cumulative salvage index increased, so there is no statistical basis to conclude that cumulative salvage has a negative population level effect within the range of cumulative salvage index levels historically observed.

(2) Adults – OMR Flows

74. I conducted a second analysis to evaluate the relationship between December-March average OMR flows and the population growth rate. I calculated the average flows using the daily OMR flow data from the October 29, 2009 FOIA request. Using a standard Ricker stock-recruitment model and the standard 0.05 significance level, I found that the relationship between March-December OMR flows and the population growth rate is not statistically significant. The p-value is 0.321, which is above the significance level of 0.05. The modeling

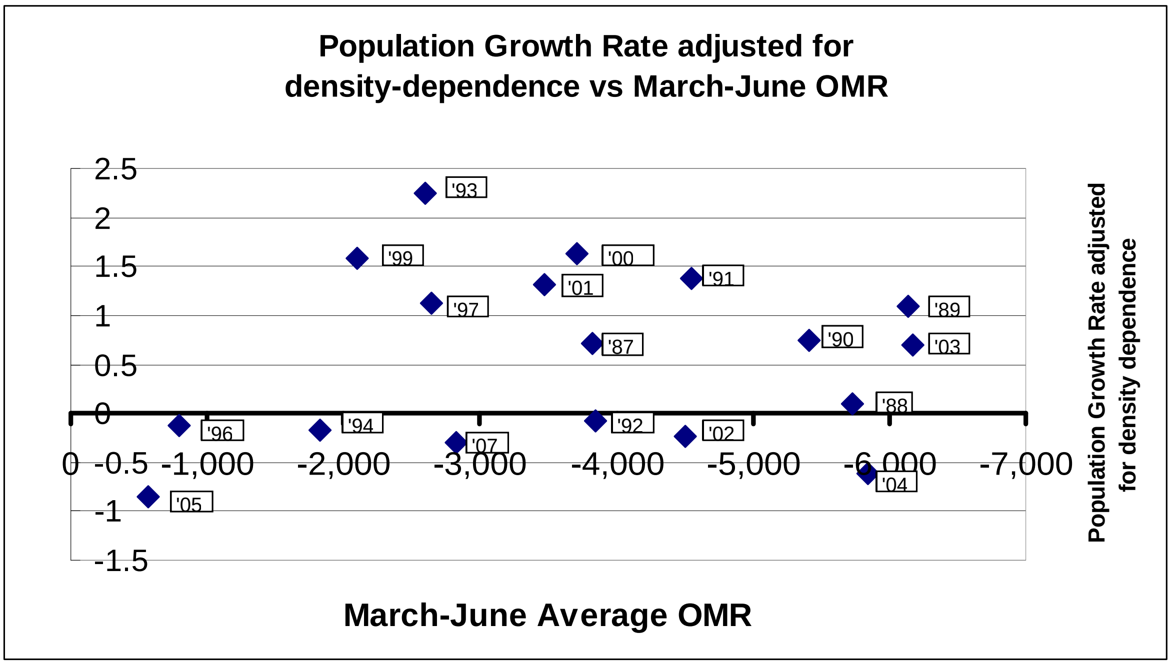
results are shown below as a visual aid. Thus, here too, there is no statistical basis to conclude that the OMR flows cause a negative population level effect within the range of December-March average OMR flows historically observed. For additional technical detail, see Appendix 1 at Point 3.



(3) Juveniles

75. The BiOp includes entrainment estimates for larval-juvenile delta smelt based on the work of Kimmerer (2008), who in turn bases those estimates on a method in which the assumption is made that entrainment is proportional to the southward OMR flow. I tested whether or not average southward OMR flow during the larval/juvenile salvage months of March through June could explain a statistically significant amount of the variation in population growth. I used the Ricker model again as a life-cycle model. March-June average OMR flow for years during the time span 1987 through 2007 in which the average flow was negative (that excluded years 1995, 1998, and 2006) was entered as a candidate explanatory variable and regression analysis was used to test whether or not the candidate variable was statistically significant. A starting year of 1987 was used because that is the starting year used in the BiOp, as data from that year forward "represents current delta smelt population dynamics." *See* BiOp at

236 (AR at 000251). Results show that March-June average OMR does not have a statistically significant impact on smelt population growth rate (the p-value is 0.703, which is above the significance level of 0.05). For additional technical detail, see Appendix 1 at Point 4. Even if entrainment of larval/juvenile smelt is related to spring OMR flow, that entrainment does not have a statistically significant impact on population growth. The result can be seen visually in the graph below which shows that variation in population growth rate (adjusted for density dependence) is not explained by the average March-June OMR flow.



76. March-June OMR does not negatively impact population growth, as can be seen visually in the graph above, where even at the most negative observed average OMR flows, the population growth rate was positive (irrespective of whether a density dependent adjustment is made). For additional technical detail, see Appendix 1 at Point 4. This result implies that there is no scientific justification for proposed RPA Action 3.

C. The Model Used in FWS's Analysis to Compare the Effect of Fall X2 on Population Survival Is Biologically Implausible and Potentially Misleading – It Is Simply Inappropriate for Fish Population Dynamics Modeling

77. FWS used statistical modeling to demonstrate an alleged relationship between Fall X2 and delta smelt abundance. The modeling and analysis are contained in the Effects of the

Proposed Action section of the BiOp, pages 233-238 and 265-274 (AR at 000248-000253 and 000280-000289), and in RPA Action 4 in Attachment B to the BiOp, pages 369-376 (AR at 000384-000391). FWS relied on various studies, particularly the work of Feyrer et al. in a 2007 article, *Multidecadal Trends for Three Declining Fish Species: Habitat Patterns and Mechanisms in the San Francisco Estuary, California, USA* (AR at 018266) and a draft 2008 manuscript, *Modeling the Effects of Water Management Actions on Suitable Habitat and Abundance of a Critically Imperiled Estuarine Fish (Delta Smelt* Hypomesus transpacificus) (AR at 018278); a 2005 article by Bennett, *Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California* (AR at 017004); a 2008 report by Baxter et al., *Pelagic Organism Decline Progress Report: 2007 Synthesis of Results* (AR at 016922); and a 2008 article by Nobriga et al., *Long-Term Trends in Summertime Habitat Suitability for Delta Smelt,* Hypomesus transpacificus (AR at 019940).

(1) FWS Used a Linear Additive Model

78. FWS used a linear additive model to demonstrate an alleged relationship between Fall X2 and delta smelt abundance. The model finds that juvenile abundance, as measured by the TNS, is equal to the sum of a constant number plus the previous year's FMWT index (times a constant number), less X2 (times a constant number). *See* BiOp at 268 (AR at 000283) (Figure E-22). Essentially, this calculation finds that A = B + C - D.

79. FWS followed the linear additive model developed by Feyrer et al. (2007), which claims that Fall X2 has a population level effect. This model runs counter to well-accepted, basic modeling principles for this type of calculation. When analyzing the effect of Fall X2, FWS also cites to a 2005 article by Bennett. *See* BiOp at 236 (AR at 000251). However, Bennett applies a well-established stock-recruit model, namely, the Beverton-Holt model, and an alternative linear multiplicative model. *See* Bennett (2005) at 28-29.

80. The linear additive model produces the result that zero adults in one year could still yield some young in the following year, a result that is biologically implausible. Using the simple translation A (juveniles measured in TNS) = B (constant) + C (adults measured in FMWT) – D (Fall X2), one can see that, if C were set at zero (no adult spawners), B – D could still

produce a positive number for A (juveniles). This model thus has the biologically impossible property of generating juveniles from zero adults.

81. A linear additive model also treats the environmental factor X2 as an additive factor, which has the implausible property of reducing the absolute numbers of juveniles by the same quantity for a given value of X2 irrespective of the total population. For example, if X2 is set at a certain value such that when X2 is added, 1,000 juveniles are lost, that model would produce the result that 1,000 juveniles are always lost irrespective of the total number of juveniles present or the total number of juveniles that actually respond to X2.

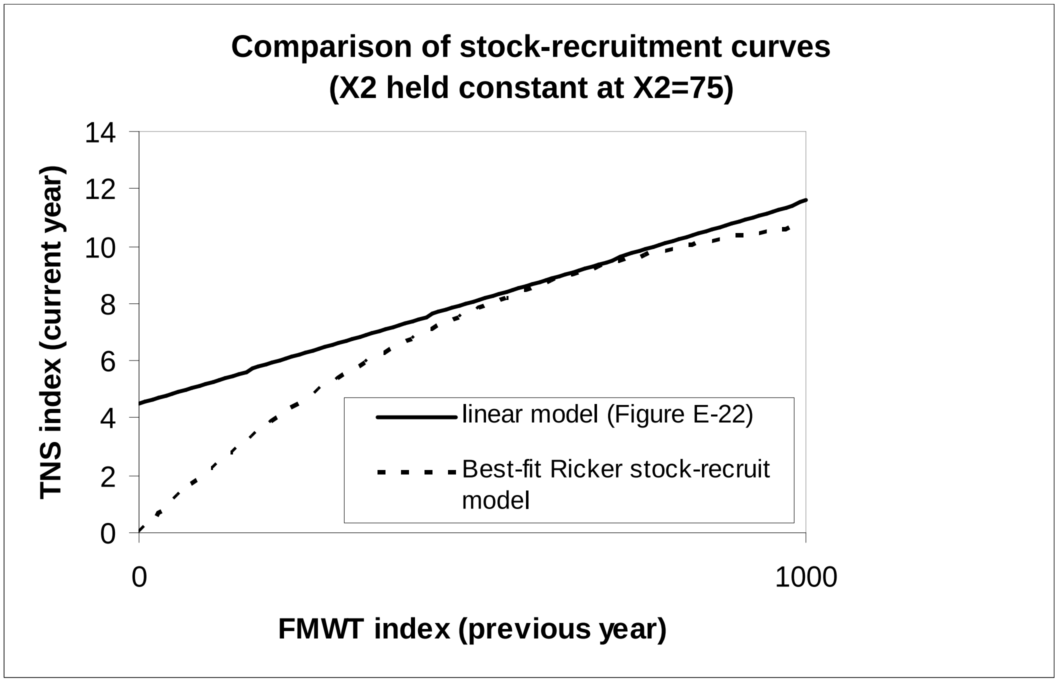
82. For reasons such as these, a linear additive model is inappropriate for stock-recruitment modeling, because the results are biologically impossible.

(2) FWS Should Have Used a Multiplicative Stock-Recruit Model

83. FWS inappropriately used a linear additive model to conduct the analysis that FWS performed with respect to the effect of Fall X2 on population survival. It is well established by those scientists qualified to conduct the type of analysis undertaken by FWS that a multiplicative stock-recruitment should be used. A multiplicative stock-recruit model better reflects actual biological realities when modeling fish populations because it describes survival of a year-class of fish. An example is the Leslie Matrix population model (equation 7.2 in Quinn & Deriso (1999) at 269). Survival processes are inherently multiplicative because the fraction of individuals that survive to a given age is given by the product of daily survivals through each day since the day of birth (*see, e.g.*, cumulative survival in Quinn & Deriso (1999) at 292). A commonly used, well known multiplicative stock-recruit model is the Ricker model. A qualified scientist in this field would be familiar with this model and would have no difficulty using it to perform the analysis that FWS did.

84. Any reliable, scientifically accepted stock-recruit model, such as the Ricker model or the Beverton-Holt model, is not a linear additive model. Such multiplicative stock-recruit models produce the biologically appropriate result that zero adults yields zero young. Thus, regardless of the presence of other factors, if there are zero adult spawners, there will be zero juveniles the following year. A graphical depiction of the difference between a multiplicative

model, such as the Ricker model, and a linear additive model is helpful to illustrate how a multiplicative model better reflects biological reality.



85. A multiplicative model, as opposed to an additive model, yields the sensible result that varying an environmental factor such as X2 will elicit a proportional response in population abundance. This is appropriate for a factor that affects survival because survival is, by definition, a fraction (what proportion of the population survives). In contrast, the linear additive model produces an absolute response irrespective of the size of the population. Multiplicative models are appropriate when describing the survival of a given cohort of fish. Additive terms may be appropriate components in certain types of cohort models when tracking the absolute abundance of a cohort over time—i.e., in situations that involve calculating the total raw population numbers over time, an exercise that has not been done for the delta smelt. *See* Quinn & Deriso (1999) at 323.

86. The BiOp itself questions the use of a linear additive model to evaluate the effect of Fall X2, stating that "some type of transformation of the data would help to define a better fitting model," but declines to correct the situation (such as through the use of a multiplicative model). BiOp at 236 (AR at 000251).

87. The Peer Review also criticized the linear additive model, finding that "[t]he [Effects Analysis] points out that the residuals from this analysis are not normally distributed and that some transformation might be required. We suspect that a few of the data points may have high influence on the outcome. These results together suggest that the model may be inappropriate for the data being used." *Independent Peer Review of USFWS's Draft Effects Analysis for the Operations Criteria and Plan's Biological Opinion, 2008* at 7 (AR at 008819).

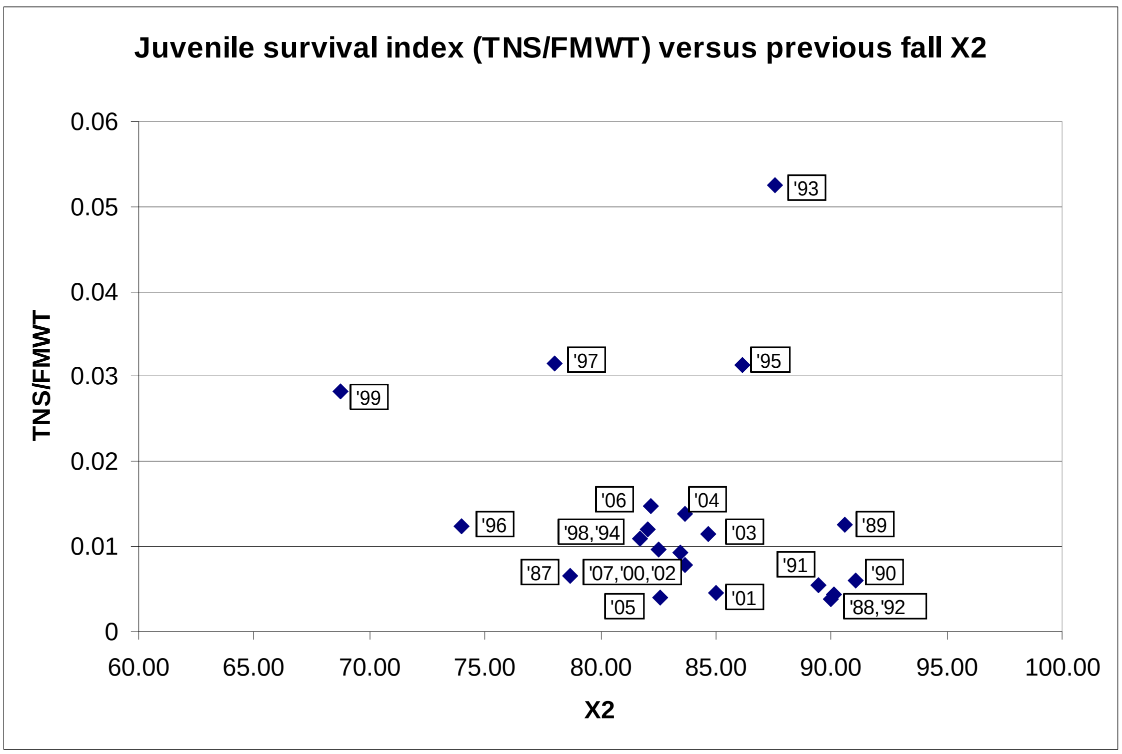
88. During my review of FWS's analysis, I plotted a stock-recruit curve of the relationship between FMWT (previous year) and TNS (current year) using the standard Ricker stock-recruitment model that was obtained by fitting the model to data. See details in Appendix 1 at Point 5. A visual comparison of the linear additive model that FWS used in the BiOp against the Ricker model is shown above. As shown on the comparison, when FMWT is set at zero in the linear model that FWS used, TNS is above zero. In contrast, when FMWT is set at zero in the standard Ricker model, TNS is also zero.

89. In order to evaluate whether there is a relationship between Fall X2 and abundance, I used the publicly available FMWT and TNS data and publicly available Fall X2 data in a standard Ricker stock-recruit model.[5] After employing the Ricker stock-recruit model, I was able to determine that there is no statistically significant relationship between Fall X2, stock abundance, and recruit abundance. The p-value for Fall X2 is 0.059, which is greater than the benchmark significance level of 0.05. See Appendix 1 at Point 5 for additional technical detail. The contrary conclusion that FWS reached is due to its improper use of a biologically implausible linear additive model.

90. I determined that the density dependent term in the Ricker model was not statistically significant. As a result, I used a reduced survival model that omitted the density

[5] FMWT data is available at: http://www.delta.dfg.ca.gov/data/mwt/charts.asp. The BiOp cites to http://www.delta.dfg.ca.gov as a source for FMWT data at page 143 (AR at 000158). TNS data is available at: http://www.delta.dfg.ca.gov/data/projects/?ProjectID=TOWNET. The BiOp cites to this website as a source for TNS data at page 300 (AR at 000315). Fall X2 data is available at: http://www.iep.ca.gov/dayflow/output/index. The BiOp relied on CALSIM modeling to calculate X2 values, and cites to http://www.iep.ca.gov/dayflow for "historical hydrologic data provided in the DAYFLOW database" which was used in the CALSIM modeling. *See* BiOp at 204, 235 (AR at 000219, 000250).

dependent term. The result shows that Fall X2 term is not statistically significant, since the p-value of 0.094 is greater than the 0.05 significance level. The graph below is included as a visual aid to show that there is no relationship between an index of juvenile survival ("TNS/FMWT_1") and Fall X2. If there had been a strong negative effect of Fall X2 on juvenile survival, the graph would have been expected to show a pronounced negative slope. Instead, the graph shows no trend in juvenile survival as X2 increases. For additional technical detail, *see* Appendix 1 at Point 5.



(3) Use of a Scientifically Appropriate Multiplicative Model Shows That Fall X2 Has No Statistically Significant Effect on the Population Growth Rate

91. In my review of the BiOp, I determined that FWS did not evaluate the effect of Fall X2 on the population growth rate. Use of the population growth rate would enable FWS to evaluate effects on the full life-cycle of the delta smelt.

92. Instead of carrying forward the linear additive model, as did FWS, the proper scientific method is to model the relationship between Fall X2 and the population growth rate

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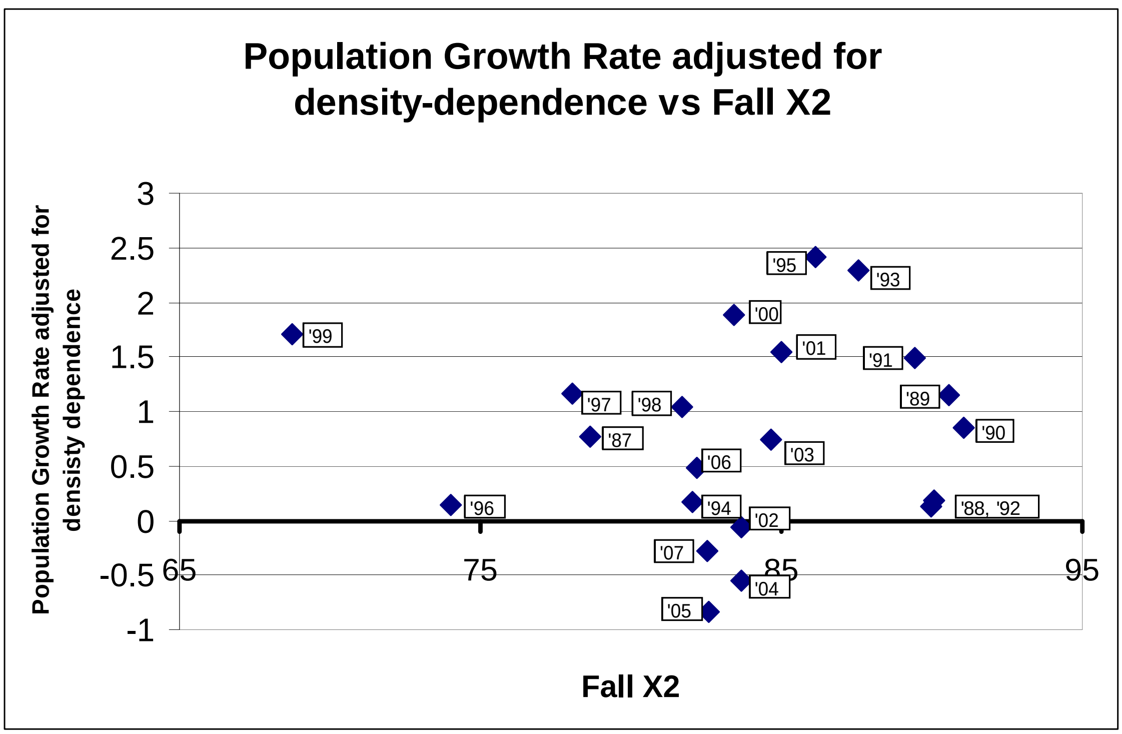
using a multiplicative model. As explained above, a multiplicative model is the scientific standard for fish population dynamics.

93. I used a Ricker model, which is a multiplicative model, to calculate the population growth rate and to evaluate the relationship between Fall X2 and the population growth rate with the regression method described in Appendix 1 at Point 6. I adjusted for density dependence in the modeling. In this application, I determined that the density dependent term in the Ricker model was statistically significant. Thus, the population growth rate had to be adjusted to account for these effects so that the potential effect of Fall X2 could be isolated. For additional technical detail, see Appendix 1 at Point 6. This relationship, adjusted for density dependence, is depicted below.



94. My application of a multiplicative Ricker life-cycle model demonstrates that Fall X2 does not have a statistically significant effect on the population growth rate. As Fall X2 increases, the population growth rate varies randomly. Taken together with the modeling I performed above (comparing Fall X2 to abundance, see ¶ 89) and statistical analysis of the regression estimates, this means that Fall X2 does not have a statistically significant effect on population abundance in a given water year (adults to juveniles), or on the full life-cycle of the

delta smelt (adults to adults). Since FWS's imposition of Fall X2 restrictions in RPA Action 4 is based upon its erroneous use of the wrong model—which, in turn, has led to the incorrect result that Fall X2 has population effects on the delta smelt—it is scientifically unjustified.

D. FWS's Incidental Take Analysis Is Improperly Influenced by Unrepresentative Data Points That Even FWS Rejected for Other Purposes

(1) FWS's Adult Incidental Take Analysis Is Improperly Influenced by an Unrepresentative Data Point

95. FWS's adult incidental take analysis can be found in Attachment C to the BiOp, pages 382-396 (AR at 000397-000411). In developing the incidental take limit for adult entrainment, FWS relied on a series of statistical analyses and calculations in the BiOp and in Kimmerer (2008).

96. The incidental take limit is set at 7.25 times the prior year's FMWT index of adult abundance. BiOp at 386 (AR at 000401). The 7.25 figure represents the average salvage rate from only three years—2006, 2007, and 2008. *See* BiOp at 385-86 (AR at 000400-000401). The BiOp uses the average salvage rate for these three years as a predictor of take levels during each year that the RPAs will be in effect. Although salvage data is analyzed dating back to 1993, the BiOp claims that "these years [2006 through 2008] within the historic dataset best approximate expected salvage under the RPA Component 1," which restricts OMR flows. *Id.*

97. The BiOp lists the annual salvage numbers and salvage rates for the years 1993-2008, and shows that the salvage in 1994 and 2007 were extremely low compared to the other years and to 2006 and 2008 in particular. *See* BiOp at 386 (AR at 000401) (Table C-1). The cumulative salvage index is just 0.88 for 2007, compared to 8.3 for 2006 and 12.6 for 2008. *Id.*

98. In my review, I searched for additional information regarding the conditions that might have contributed to these salvage levels. In another section of the BiOp, I discovered that FWS had considered the salvage level in 2007 as ***unusable*** for purposes of analyzing salvage and OMR flows due to that year's low average water turbidity. *See* BiOp at 348 (AR at 000363) (Figure B-13, Note). The low turbidity explains why salvage in 2007 was extremely low, as turbidity is a strong indicator of presence or absence of delta smelt near the project facilities.

Lower turbidity means fewer fish will be present and, accordingly, fewer fish are capable of being entrained. Thus, FWS recognized that the unusual conditions in 2007 made it an unrepresentative year that would skew its analysis. For FWS to then go ahead and use that salvage level in the incidental take equation is scientifically unjustified.

99. Without the year 2007 factored into the equation, the take coefficient increases from 7.25 to 10.45, which lies within the range of historical estimates based on the figure shown in ¶ 62 above for flows less negative than -7000 cfs. This figure represents the average of the salvage indices in 2006 and 2008, and would significantly increase the permissible take level. FWS's calculation should be corrected to remove the outlier year of 2007.

(2) FWS's Larval/Juvenile Incidental Take Analysis Is Improperly Influenced by an Unrepresentative Data Point

100. FWS's larval/juvenile incidental take analysis can be found in Attachment C to the BiOp, pages 382-396 (AR at 000397-000411). To calculate the incidental take limit for larval/juvenile entrainment, FWS largely followed the same methodology that it used for adults. BiOp at 389 (AR at 000404).

101. The incidental take limit is set at 1.5 times the Concern Level for larvae and juveniles. The Concern Level is equivalent to the average monthly juvenile salvage index from 2005-2008 times the current water year FMWT of adult abundance. BiOp at 390 (AR at 000405). Combining these two formulae, the incidental take limit can be calculated by multiplying 1.5 times the average monthly juvenile salvage index times the FMWT. Only four years are considered – 2005, 2006, 2007, and 2008.

102. The BiOp lists the annual salvage numbers and salvage rates for the years 1995-2008, and shows that the salvage in 2006 was extremely low compared to all other years, with the exception of 1995 and 1998 (see discussion below). *See* BiOp at 392 (AR at 000407) (Table C-4). The juvenile salvage index is just 0.4, compared to 23.4 for 2005, 65.1 for 2007, and 60.9 for 2008. *Id.*

103. In my review of the BiOp, I searched for additional information that might explain the conditions that were present in these years and how they contributed to salvage levels. I was

provided with daily OMR flow data through a FOIA request to FWS. I discovered that in 2006, average OMR flow was strongly positive for the months April through June, the first three (of four) months during which the monthly juvenile salvage index is calculated. OMR flow was negative in July 2006, but typically, very few fish are salvaged in July. *See, e.g.,* BiOp at 391 (AR at 000406) (Figure C-3) (showing that cumulative salvage reaches a plateau in July).

104. When analyzing the effects of OMR flows on salvage in the Effects Analysis section of the BiOp, FWS explained that "net OMR flow generally works very well as a binary switch: negative OMR flow is associated with some degree of entrainment, while positive OMR flow is usually associated with no, or very low, entrainment." BiOp at 163 (AR at 000178). The juvenile salvage index is reported in the BiOp for the years 1995-2008. BiOp at 392 (AR at 000407). During that time, there were three years when salvage was nearly zero – 1995, 1998, and 2006. These are the only three years when OMR flow was positive. *See* BiOp at 254 (AR at 000269) (Figure E-8). Thus, FWS's statement that positive OMR flow yields zero or very low salvage is supported by historical measurements of juvenile salvage and OMR flow. It also undermines FWS's decision to include one of those years – 2006 – in the incidental take equation.

105. Without the year 2006 factored into the equation, the average juvenile salvage index increases, which necessarily increases the Concern Level (monthly juvenile salvage index times FMWT) and the incidental take level (1.5 times Concern Level). The incidental take level increases by approximately 32-33 percent in May, June, and July, and decreases by approximately 14 percent in April (when salvage is low). Overall, in the months with the highest salvage, removal of the unrepresentative year 2006 significantly increases the take level. FWS's calculation should be corrected to remove the year 2006, which had positive OMR flow.

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I declare under penalty of perjury under the laws of the State of California and the United States that the foregoing is true and correct and that this declaration was executed on November 13, 2009 at St. Thomas, U.S. Virgin Islands.

RICHARD B. DERISO, Ph.D.

Appendix