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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) STATE WATER CONTRACTORS v. SALAZAR, et al. (Case No. 1:09-cv-422) COALITION FOR A SUSTAINABLE DELTA, et al. v. UNITED STATES FISH AND WILDLIFE SERVICE, et al. (Case No. 1:09-cv-480) 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)	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 **DECLARATION OF DR. RAY HILBORN IN SUPPORT OF PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT** **DATE:** March 23, 2010 **TIME:** 8:30 a.m. **COURTROOM:** 3 Hon. Oliver W. Wanger

I, Ray W. Hilborn, declare as follows:

1. I am a professor of Aquatic & Fishery Sciences at the University of Washington in Seattle, Washington. My curriculum vitae is attached to this declaration as Exhibit A. I have spent my professional career teaching, researching, and advising in the scientific fields of fish biology and ecology and fish population dynamics and management. Since 1993, I have been an Independent Science Advisor to the Commission for the Conservation of Southern Bluefin Tuna. I have supervised millions of dollars in research projects investigating fish populations and their management. I have authored or co-authored over 200 peer-reviewed journal articles and book chapters involving fisheries population analysis, modeling, and management, also listed in Exhibit A. I currently serve on the editorial boards of seven professional scientific journals. I have been awarded the "Award of Excellence" by the American Fisheries Society and the "Outstanding Achievement Award" by the American Institute of Fisheries Research Biologists. Each of these awards is the highest honor the society provides for professional contribution.

2. As a result of my education, training, research, and experience, I have developed an in-depth and extensive experience evaluating biotic and abiotic factors affecting populations of fish species. This includes experience using and developing generally accepted statistical and other conceptual and applied modeling methodologies to identify the factors affecting fish population abundance and determining the significance or relative importance of distinct factors in causing fish population increases or decreases.

3. I have reviewed the December 15, 2008 Biological Opinion on the effects of the Coordinated Operations of the Central Valley Project and State Water Project on the delta smelt (*Hypomesus transpacificus*) ("BiOp"). The BiOp states a conclusion that the proposed operations of the Central Valley Project ("CVP") and the State Water Project ("SWP") would likely jeopardize the continued existence of the delta smelt, and would likely adversely modify its critical habitat. I have also reviewed several scientific articles that appear to form the foundation of many of the BiOp's main conclusions regarding the effects of these water project operations on the delta smelt. These include Feyrer et al. (2008), Feyrer et al. (2007), Grimaldo et al. 2(007), Kimmerer (2008), Krimmer and Nobriga (2008), Manley and Chotkowski (2006), Nobriga et al.

(2008) and Sommer et al. (2007). I have also reviewed data related to the delta smelt including abundance indices, (the fall midwater trawl, summer tow net), and data related to environmental conditions in the Delta, such as flows in Old and Middle Rivers, X2, salinity, zooplankton availability and temperature.

A. Summary of Opinion

4. The BiOp fails to use the best available and generally accepted scientific methods to determine whether the operations of the CVP and SWP are having a population level effect on the delta smelt. Specifically, the BiOp fails to use available quantitative population dynamics models that track a population through its life histories. These quantitative models are the best available and most reliable method to assess whether an action will have population level effects upon a fish species that is subject to multiple factors that affect survival rates over its various life stages. These methods are commonly employed in the field of fisheries science to determine the impacts on a population of factors such as harvest, diversions for power plants, or as in this case, water project operations. Indeed, a number of other biological opinions have employed such models to assess impacts on other species.

5. There are ample available data relating to the delta smelt and the environmental conditions believed to affect its survival to apply quantitative population dynamics models to the issue addressed by the BiOp. The BiOp, however, fails to apply such models to determine what effects operations of the CVP and SWP are having upon the delta smelt population. The approach in the BiOp instead focuses on particular actions which cause mortality to individual fish during a particular life stage, without adequately putting such mortality in the context of its overall life cycle in any rigorous or quantitative way. For example, the BiOp devotes considerable discussion and emphasis to entrainment of delta smelt at the CVP and SWP export pumps, but it does not use the available quantitative population dynamics models to analyze the available data and determine whether such entrainment produces population level effects on the delta smelt, *i.e.*, whether it materially alters the number of delta smelt that survive to spawn as adults. The BiOp's approach is an unreliable method of assessing whether the action is having an effect on the population overall. Focusing on a particular source of mortality in a particular life stage without

analyzing all the available data in the context of a comprehensive model is not the most reliable method for assessing effects upon fish species such as the delta smelt. This is so, for example, because other intervening factors during a later life stage can be far more important to the number of delta smelt that survive to spawn than the total entrainment at the CVP and SWP export pumps in the winter and spring. Indeed, Kimmerer's analysis indicates that conditions in the summer and fall, probably related to food limitations, have a dominating effect on subsequent delta smelt abundance. (Kimmerer 2008.) A carefully prepared model would account for such effects in determining what factors are important to abundance. While there can be reasonable debate about what model to use, what factors to include, and what assumptions to make, the failure to use any quantitative population dynamics model at all is unreasonable, and not in accord with generally accepted scientific standards. In failing to use a quantitative population dynamics model such as a stock recruitment or life stage model to analyze what factors are important to the population abundance of delta smelt, the Service failed to use the best available and most reliable method to determine whether the operations of the CVP and SWP are significantly affecting the delta smelt population.

6. I explain the bases for my opinion below. First, I provide an explanation of the stock assessment models and how they have evolved to become widely accepted in the scientific community as the best available method for assessing how various factors will affect a fish population. I include examples of how these methods are applied, including in support of other biological opinions. Second, I assess the appropriateness of such models for use with the delta smelt. As I explain, there is ample available data regarding the delta smelt and the conditions relating to delta smelt survival and abundance to usefully apply these methods. Third and finally, I discuss how use of these methods would redress the fundamental shortcoming in the BiOp, its failure to relate in any meaningful way the various adverse factors it identifies to population level effects upon the delta smelt. Unless and until the Service applies these methods to assess the effects of CVP and SWP operations on the delta smelt, its conclusions will not be based upon the best and most reliable scientific methods available, and will not be in accord with generally accepted scientific standards and methods.

B. The Use Of Quantitative Population Dynamics Models Is The Most Reliable And The Generally Accepted Scientific Method To Assess Whether A Particular Factor Is Having Population Level Effects

7. Understanding the impacts of water project operations on fish populations is a problem in applied population dynamics. Analyzing the issue addressed in the BiOp, what impact project operations will have on the delta smelt, requires understanding the expected impacts of alternative actions involving project operations, and alternative scenarios about the future of non-controllable factors such as climate, on the abundance of the delta smelt. Delta smelt lives its life in a complex ecosystem where predators, food supply, habitat and other environmental factors interact. Complex ecosystems are characterized by non-linear relationships where a small change in one component may result in a large change in another, or conversely where a large change in one component may result in little if any change in another. With respect to a biological opinion, we are interested in the population level impacts of human actions, but these are rarely simple. Project operations, for example, may directly affect individual delta smelt, but so does their range of predators, prey and competitors. The methods of applied population dynamics use the available data to evaluate the expected consequences of alternative management actions or environmental changes, and to distinguish when a small change will result in a large consequence, or where a large change will result in a small consequence. For example, there is an extensive literature examining the consequences to fish populations of the impacts of power plant mortality on juvenile fish. We now know that many species exhibit non-linear survival so that even if 50% of the eggs and larvae of a species were killed by a power plant there would be little impact on the adult population. (Myers et al. 2002).

8. Among some field biologists there is a strong aversion to quantitative population dynamics modeling, and for people who spend their careers in the field handling fish, models may be considered unrelated to the real world. It is true that models are no substitute for data, and a model analysis is no better than the data that go into it. But what field biologists often fail to recognize is the difference between individual effects and population level effects. One can see that an individual fish has been killed on the screen of a power plant – that is a very real observation. However this does not mean that the long term population will be one fish smaller.

Knowledge of individual effects and either field observation or small scale experimentation does not take us to population level effects. This population level effect requires understanding the complex interactions between survival, growth and reproduction at the population level.

9. The field of applied population dynamics has been particularly well developed in the study of fish populations because of the worldwide demand for scientific evaluation of the impacts of alternative fisheries harvesting plans. Most fisheries agencies around the world now regulate fisheries harvest through a combination of restrictions on catches, fishing effort, fishing gears, and times and areas where fishing is allowed. These agencies must use the data available from these populations to determine the consequences of alternative regulations, and in particular to determine the allowable harvests. The data available typically include surveys of fish abundance, length and or age distributions of the population of interest, and any known removals through direct harvesting or other anthropogenic cause. The determination of allowable harvests is often called "fisheries stock assessment" and the two primary textbooks in the field were published in the 1990s and represented a summary of a field that had been developing over most of the 20th century. These two textbooks are Hilborn and Walters (1992) and Quinn and Deriso (1999). There are now in excess of 300 published assessments of fish stocks around the world using these methods, and most of them are now summarized in a data base that was described in Worm et al. (2009). The central tool in fishes stock assessment are computer models of the life history of the fish, where the impact of different factors on growth, survival and reproduction are evaluated in a statistical framework that allows analysis of the relative importance of competing impacts on the abundance of the population.

10. Quantitative population dynamics models are also commonly applied to the problems of populations at low abundance and in particular to endangered species. Life-history models and statistical methods are used to evaluate the impact of alternative human actions and environmental effects to evaluate population level impacts on populations.

11. Quantitative population dynamics models fall into several classes including: (1) stock-recruitment models that describe the change in population abundance from on generation to the next with no tracking of life history stages in between; (2) life-stage models that track the

abundance and often size of individuals from one life history stage (eggs, larvae, young of year etc.) to another (age-structured models are one type of stage structured models); and (3) size structured models that track the number of individuals in different size class, irrespective of their age. In general the kind of model chosen depends on the data available. When the only data available are the number of individuals from one generation to the next (as is common in Pacific salmon), then spawner recruit models are often used, but when data on intermediate life history stages are available the life-stage models are commonly employed. As I discuss below, there are extensive data available for the delta smelt. Accordingly, a life cycle model that follows the population through the series of life stages monitored by surveys could be, and should have been, employed for delta smelt.

12. The use of quantitative population dynamics models has become standard procedure in biological opinions prepared by the U.S. Fish and Wildlife Service and that National Marine Fisheries Service. A Google search on the key words "population viability analysis" (a common term for the use of such models) and "biological opinion" produced 1,940 hits. These models have been used extensively in the ESA process. The USFWS has used them for a range of species that includes at least the short-tailed albatross, the pronghorn antelope, the marbled murrelet, the fat threeridge mussel, the California gnatcatcher, the Florida panther, the Stellar's eider, the golden-cheeked warbler, the black capped vireo, and the polar bear. NMFS has used quantitative population models in biological opinions for several species of turtle, North Atlantic right-whales, beluga whales, Stellar's sea lions, and a wide range of salmon stocks. In evaluating the impacts of human action on ESA listed species the use of these models is the accepted scientific standard.

13. In some instances, there are not sufficient data on a species to use these methods. Insufficient data normally means that the species abundance and the potential factors that impact it have not been collected over sufficient time or range of conditions to be statistically informative. For instance, in evaluating the critical habitat for plant species from the island of Molokai, Hawaii, the Fish and Wildlife Service said "The lack of detailed scientific data on the life history of these plant species makes it impossible for us to develop a robust quantitative

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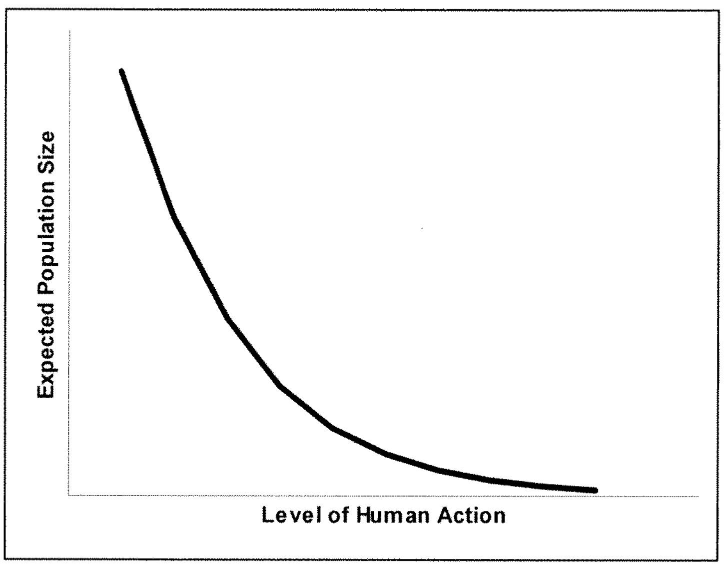
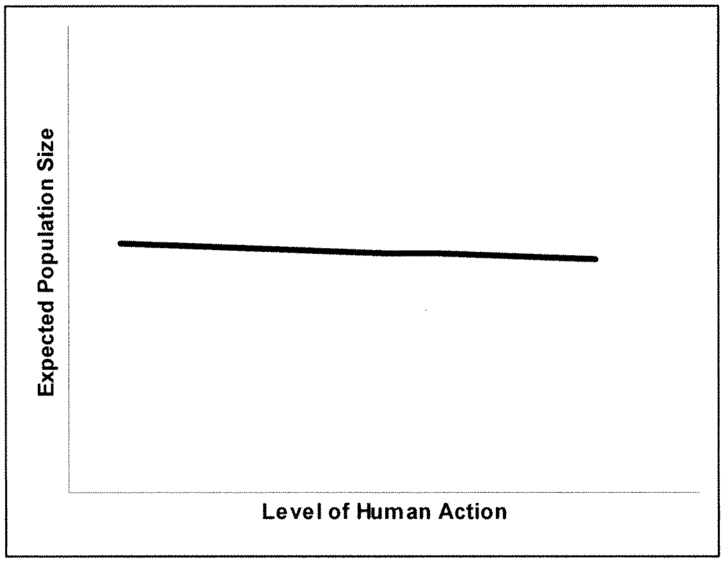
model (e.g., population viability analysis (NRC 1995)) to identify the optimal number, size, and location of critical habitat units to achieve recovery (Beissinger and Westphal 1998; Burgman et al. 2001; Ginzburg et al. 1990; Karieva and Wennergren 1995; Menges 1990; Murphy et al. 1990; Taylor 1995)." Federal Register / Vol. 68, No. 127 / Wednesday, July 2, 2003 / Rules and Regulations. But where, as for delta smelt, there are sufficient data, quantitative population dynamics models are the tool of choice, and should have been applied in the BiOp.

14. In a variety of circumstances, resource managers must evaluate how some human activity will affect the population of a species of interest. They will evaluate a range of alternative management actions, and ask how the stock of interest is affected by each possible action. One form of analysis is to compare the average abundance, expected chance of rebuilding or probability of extinction for different proposed management actions. The results of models can also be presented graphically;



In this figure, the X axis is the intensity of human action; for example level of harvest or intensity of water withdrawals. The Y axis is a measure of the expected consequences on the population size. A graph relating the intensity of the action to expected population levels is a typical output from a quantitative population dynamics model. If a model produced an output such as the one in the example above, then it would be very clear that the population level would be very sensitive to the level of human impact.



If, however the output of the model looked like the graph above, then it would be clear that restricting the human action would have little impact on population size. Quantitative population dynamics models are a vital tool to help resource managers understand which graph better represents the effects of a human action on a particular species, and hence inform decisions about management actions.

15. Quantitative population dynamics models are grounded in what is known about the biology of a species, and the processes that may plausibly affect its abundance. For example, it is well established that over the life history of a fish there are many places that competition takes place, and this competition may be intense. This can take the form of competition for food, protection from predators, or good refuges in times of environmental stress. The result of intense competition is that significant mortality at one life history stage, such as eggs or larvae, will mean that human actions that kill fish at one stage can have little impact on the total population size later in the life history. Population models use historical data to estimate the population level effect of this competition. This is a real and important part of the life history of fishes, and not a statistical abstraction.

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16. In theory, population level effects can be studied experimentally. One could have multiple populations and subject some to different levels of mortality or habitat change. This kind of experimentation is often done in the laboratory, experimental ponds or even in small lakes, and is the backbone of the experimental approach to many fields. But for the important real-world questions posed under the ESA, this kind of experimentation is impossible. There is only one short-tailed albatross population; there is only one delta smelt population. We cannot perform replicated experiments on these populations. There is simply no alternative to using the statistics and quantitative population dynamics models. These methods synthesize all of the available information in a framework that provides the best explanation for the data and allows scientists to provide decision makers with the best available evaluation of the consequences of alternative management decisions.

17. Analysis of impacts of human action on delta smelt in the BiOp is very poorly developed in comparison to other issues. For example, in the field of fisheries management, state and federal agencies routinely use population dynamics models to evaluate the consequences of alternative fisheries management actions, particularly level of harvest. NMFS has conducted assessments on over 110 fish stocks and in almost every case a spawner recruit or life stage model is the core element in the analysis.

18. One very high profile, early example of the use of models in evaluating consequences of entrainment on fish populations involved the licensing of power plants on the Hudson River. The chief issue concerned the impact of power plant mortality on eggs and larvae on several fish species, most prominently striped bass. The key biological question was the intensity of competition early in the life history that would mitigate the impact of egg and larval mortality. Spawner recruit and life history models were developed and applied to address these issues. The early history of the use of these population models to evaluate the impacts of water projects is best documented in Barnthouse et al. (1984), which describes the history of scientific research on fisheries impacts of Hudson River power plants. In the 1970s it was clear that operation of Hudson River power plants was killing juvenile fish by both entrainment and impingement. What was less clear was the population level impacts of such mortality. "The

Hudson River controversy was a unique test of the ability of biologists to use their science to aid public decision-makers in achieving an equitable solution to an important environmental problem." (Barnthouse et al. 1984). Over the decades since, alternative population dynamics models of the impacts of the power plants were proposed, and the core scientific issues were expressed in the form of these alternative models. By the 1990s, full life-history models were extensively employed and debated. These models tracked the population through the individual stages of the first year of life, and were fit to the data on eggs, larvae, juveniles and young-of-the-year.

19. The approach was subsequently duplicated for the licensing of several Hudson River power plants, the Salem Plant on the Delaware River (Myers et al. 2002), and the Brayton Point plant in Massachusetts. Dey et al. (2000) describe how the process has evolved towards formal risk-based approaches, and how population models are a central part of the quantitative evaluation of impacts on fish populations from entrainment.

20. Perhaps the best example for what should be done in the Sacramento-San Joaquin Delta is illustrated by the methods employed on the Columbia River. Several ESU's of salmon are listed as endangered on the Columbia and Snake rivers, and quantitative population dynamics models have been the core tool in the biological opinions for evaluating extinction risk and recovery plans. As in the case of the power plants, the Columbia River analysis focused intensively on the alternative population dynamics models, and indeed started an independent peer-reviewed process to evaluate these models.

21. "In 1995, the National Marine Fisheries Service (NMFS), after three years of comparing these models and subjecting them to external peer review, issued a Biological Opinion on the FCRPS (a document that summarizes the status of listed stocks and prescribes hydropower system operations to avoid extinction), in which they concluded that the emphasis should shift to identifying and evaluating the models' assumptions (NMFS 1995:124, Rec. 17). This recommendation was augmented by a 1994 court ruling (IDFG vs. NMFS, D.Or 1994) that determined that NMFS must consult with State and Tribal biologists. The new, collaborative process that was formed in response to the NMFS and court recommendations became known as

the Plan for Analyzing and Testing Hypotheses (PATH). At its formation, PATH was intended to help reduce uncertainties in NMFS's future hydrosystem decisions." (Marmorek and Peters 2002)

22. In a paper in Science (Kareiva et al. 2000), several NOAA biologists present a life stage model to evaluate extinction risk and recovery plans and the use of these models has become a central part of the biological opinion.

23. These models often link the physical models, such as are used in the delta smelt biological opinion, with the population dynamics models. For instance "The Hydro Workgroup included several sub groups covering a new juvenile fish passage model, potential hydro actions, and forecasting. The hydro workgroup described and evaluated several alternative scenarios for operating the hydro system to optimize survival benefits for all the listed species." .... "The Passage Model Workgroup collaborated on the Comprehensive Passage (COMPASS) model, which is used to compare the effects of alternative hydropower operations on juvenile fish survival and migration timing through the FCRPS, with adult return rates. This workgroup helped to define relationships that characterize survival and migration through the successive reservoirs and dams of the FCRPS, dam passage survival and passage route selection, and post-Bonneville survival. COMPASS materials and alternative views were submitted to the Independent Scientific Advisory Board multiple times for review." From: Executive Summary of the FCRPS 2008 Biological Opinion.

24. There is recognition that population dynamics models should become a central part of analysis on the Sacramento River. The National Marine Fisheries Service, in its biological opinions for Sacramento River salmon, has employed life-history analysis, but not used full life cycle models intensively. An independent evaluation of the NMFS work on Sacramento River chinook commissioned by NMFS recommended moving to life cycle models as an important part of their analysis.

> Biological Opinion has benefited from a consideration of a life cycle approach, whereby a population's growth rate (or fitness) is a result of events (impacts) at different life stages and transition rates between stages. However, the approach could be more comprehensively applied throughout the BO. It is introduced early in the BO, but becomes somewhat hidden when assessment of the risk of proposed actions is examined. Given that particular actions

> may have sublethal effects that cross life stages, a life cycle framework provides an effective means of capturing these. It also provides an explicit means of moving from individual effects towards population effects (i.e. population vital rates and growth).

Fleming (2009).

Further

> Development of population models (e.g. population viability analysis, life table analysis) from the sequential life stage analyses would refine the assessment of population responses. Moreover, it would allow for an analysis of sensitivity or elasticity and insight into those life stages and impacts that particularly affect the population growth rate.

Fleming (2009).

25. Within the realm of conservation science quantitative population models are often called "Population Viability Analysis" or PVA. Wikipedia defines PVA as "Population viability analysis (PVA) is a species-specific method of risk assessment frequently used in conservation biology. It is traditionally defined as the process that determines the probability that a population will go extinct within a given number of years. More recently, PVA has been described as a marriage of ecology and statistics that brings together species characteristics and environmental variability to forecast population health and extinction risk. PVA is also used to compare proposed management options and assess existing recovery efforts. PVA is frequently used in endangered species management to develop a plan of action, rank the pros and cons of different management scenarios, and assess the potential impacts of habitat loss."

26. Within the scientific literature there is wide-spread recognition of the importance of this type of modelling. "Population viability analysis (PVA) has become a cornerstone of conservation science. It is both a process and a tool that has been used to analyze data and project population trends, and to make policy decisions." Beissinger (2002). By the end of the 1990s, use of population dynamics models was well accepted as an essential part of conservation science. Use of these models is taught in universities around the world, and is the subject of numerous textbooks.

27. In summary, the use of quantitative population dynamics models to assess the effects of entrainment on fish populations is not new. It began decades ago in the licensing

process for the Hudson River power plants. It has been a central part of the ESA process on the Columbia River since the early 1990s. It has been employed in dozens of biological opinions in the last 20 years. It is now widely accepted in the scientific community as the best available method for assessing the impacts of an activity or factor on fish population levels. Thus it is particularly remarkable that population dynamics models have been largely ignored in the BiOp.

C. There Is Ample Available Data To Apply Quantitative Population Dynamics Models To Assess Whether CVP and SWP Operations Are Having Population Level Effects Upon The Delta Smelt

28. There is a rich body of data for delta smelt abundance, distribution and size at different life history stages, and considerable data on the environmental conditions. There are several different surveys that measure the abundance and in many cases the size of delta smelt at different stages in their life history. This is a much richer data set than is available for most species for which quantitative population dynamics modeling has been performed. It is certainly standard practice in fisheries science to combine much of these data in a single analysis to create a decision tool for evaluation of management and policy alternatives. The role of science in most resource management is to inform decision makers of the trade-offs between alternative management actions. Given the available data, and the importance of the issues addressed in the BiOp, it is inexplicable why FWS did not perform such an analysis for delta smelt.

D. A Quantitative Population Dynamic Model Would Address The Fundamental Shortcoming In The BiOp, Its Failure To Relate Factors To Population Level Effects

29. There is some use of population dynamics models presented in the BiOp. This occupies 2 paragraphs of page 236 and was described in Feyrer et al. (2008). The model used, however, does not conform to the generally accepted scientific standards and the best available methods. My understanding is that Dr. Deriso will address the deficiencies of the model approach used in the BiOp in detail. I briefly address it here only to distinguish it from the methods I describe above that the BiOp should have employed.

30. The most serious deficiency is that the model presented in the BiOp uses only a portion of the life history, from the fall midwater trawl to the summer tow net. This is the portion of the life history where the Feyrer et al. found an impact of X2. The BiOp does not use the

portion of the model that tracks changes from the summer tow net survey to the fall midwater trawl, a portion of the model that ameliorates impacts of X2. The BiOp does not use the model to evaluate the expected difference in the population size as a result of alternative project operations. The analysis does not calculate population over time, but assumes the population is always at one level and simply calculates the difference in the summer index under a range of alternative scenarios for X2. The calculations do not complete the life history from summer to fall, and the analyses does not carry forward the predictions from one year to the next. This approach is totally inconsistent with the accepted practice in population dynamics. It makes no allowance for density dependence or any form of competition, which the Feyrer et al. paper itself found to be quite biologically and statistically significant. The model analysis presented in the BiOp provides no guidance on the expected difference in population size as a result of project operations. It thus fails to provide what should be the core use of a population dynamics model.

31. The portion of the Feyrer et al. model used in the BiOp has serious deficiencies. Their model builds a two stage life history model that relates the fall midwater trawl index to the summer tow net index, with X2 as a factor influencing survival, and then the summer index to the fall index with X2 or other factors as possible explanatory variables for year to year differences in abundance. The authors of this report quite inexplicably used simple linear regression for the first life history stage, rather than the widely accepted and commonly used spawner recruit models found in every elementary fishery textbook.

32. At a minimum, a model for delta smelt should track population size through the life history from fall midwater trawl to the summer tow net, and from summer tow net to fall midwater trawl. The model should allow for density dependence as well as environmental conditions at each life history stage. Environmental variables in addition to X2 and OMR should be explored. Given the availability of size data, the model could also explore the impact of environmental factors on the growth of delta smelt, and the impact of size on survival. The model should be used to evaluate the expected impacts of different water project operations on the risk of extinction, and expected short and long term trends in population abundance.

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Conclusion

33. Quantitative population dynamics models have been used to evaluate consequences of alternative proposals for action over 2 decades, on a wide range of species and human impacts. These models are now accepted as the best available method to determine the impact of alternative actions upon fish species, and it standard and generally accepted scientific practice to apply these methods. There are more than sufficient data available for delta smelt to use quantitative population dynamics models to evaluate the consequences of alternative operations of the CVP and the SWP on the delta smelt. The failure of the BiOp to use these methods to assess the effects of CVP and SWP operations on the delta smelt is not consistent with the best available methods, or with generally accepted scientific standards and practices. This failure makes a difference. By failing to put the effects of project operations within the life cycle context that an appropriate population dynamics model would provide, the analysis in the BiOp presents an artificial and incomplete assessment of the effects of project operations. The analysis in the BiOp does not assess whether project operations are actually having an effect on the delta smelt population.

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

Ray W Hilborn

RAY W. HILBORN

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