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SAN LUIS & DELTA-MENDOTA WATER AUTHORITY; WESTLANDS WATER DISTRICT

UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

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| THE DELTA SMELT CASES | CASE NO. 1:09-cv-407-OWW-DLB<br>1:09-cv-422-OWW-DLB<br>1:09-cv-631-OWW-DLB<br>1:09-cv-892-OWW-GSA<br>PARTIALLY CONSOLIDATED WITH:<br>1:09-cv-480-OWW-GSA<br><br>**DECLARATION OF DR. RAY HILBORN** |
| 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) | |

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 publications and reports involving fisheries population analysis, modeling, and management, also listed in Exhibit A. I currently serve on the editorial boards of several professional scientific journals.

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"). 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.

4. Some of the main conclusions set forth in the BiOp are based on evaluations of biological and physical data using qualitative and quantitative methods of analyses including numerous statistical and other mathematical models. Similarly, the articles on which the BiOp prominently relies also employed statistical and other mathematical or conceptual analyses to reach their conclusions. I would not expect a person without extensive training and experience in the fields of biological or statistical sciences to understand these methods. I would also not expect such a person to be able to detect, appreciate, or identify potential errors in assumptions,

selection of datasets, or choice of statistical or mathematical models.

5. After reviewing the BiOp and several of the key scientific articles it relies upon, I have several serious concerns regarding the mathematical or conceptual models used to analyze the available data. I also have serious concerns regarding the scientific justification and defensibility of several conclusions reached in the BiOp. I explain these concerns below.

**A. The BiOp Never Estimates The Extent Of Any Impact From Project Operations On Delta Smelt Population Size Or Survival**

6. My overarching criticism of the BiOp is that it provides no quantitative basis for evaluating the risk to the delta smelt population posed by the operations of the Central Valley Project and State Water Project ("water projects"), which I understand to be the chief question and issue intended to be addressed in the BiOp. There are well accepted methods within the discipline of fisheries science for assessing the effect of a particular adverse factor upon the likelihood of survival of a fish species. I find the failure of the BiOp to employ such methods to be inexplicable, and outside the realm of generally accepted scientific standards.

7. For instance, the BiOp devotes considerable attention to the fact that water project pumping operations are known to entrain adult and juvenile delta smelt. However, the BiOp does not analyze or estimate this entrainment effect on delta smelt population size in the following year. The BiOp nowhere attempts to support these assumptions with any quantitative analysis or estimate of the magnitude of these mortality factors, among others, at the population level.

8. Without any analysis or description of the extent, if any, of the effect of project operations on the viability or size of the delta smelt population, it is impossible to gauge the significance of the effect of project operations on the delta smelt population's size or viability. Likewise, without such an analysis, it is impossible to evaluate the effect of any change in water project operations on delta smelt population size or viability.

9. One such standard method used in fisheries science that could have been applied here is a spawner-recruit model in which the index of delta smelt abundance in the Fall Midwater Trawl ("FMWT") in one year would be used to predict the FMWT in the next year, and statistical analyses would be done to see if factors such as project operations, or variables such as X2, OMR

flow, or occurrence or density of food items had a statistically or biologically significant impact on FMWT the next year. Using such a model and analyses, the quantitative impact of proposed actions on the delta smelt's population or viability could be evaluated.

10. Another standard method, which I believe the scientific community would consider the preferred approach to investigate whether, and to what extent, if any, water project operations are affecting delta smelt population size and viability, would be to use a stage by stage life history model. Such a stage by stage life history model would examine the impact of different factors on the survival and growth of delta smelt from one life history stage to the next life history stage to develop an overall picture of what particular factors at what stages are driving delta smelt population dynamics. These kinds of models are commonly employed in Endangered Species Act recovery plans for salmonids on the Columbia River that I have reviewed. These models also form the basis of almost all marine fisheries management in the United States. The same methods can, and I believe should, be applied to assess the delta smelt population.

11. My concern is that instead, the BiOp does not use any of the available methods for assessing population-level effects. The BiOp does not use either a spawner-recruit model or a stage by stage life history model, or any other method that seeks to quantitatively estimate or determine whether water project operations, or any other biotic or abiotic factor affects delta smelt population dynamics, abundance, or viability. While in some places the BiOp attempts to use a crude life history model, it does so using deficient methods that would not be used by the general scientific community without serious and express reservation. For instance, the BiOp relies upon an unpublished paper by Feyrer et al. 2008, which builds a two stage life history model that relates the fall delta smelt abundance index to the summer delta smelt abundance 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. Secondly, even if the methods in Feyrer et al. 2008 were valid, the BiOp still made no attempt to use these model results to estimate the quantitative impact of

proposed water project operations.

12. 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. 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 importance of the issues in the BiOp, it is inexplicable why FWS did not perform such an analysis for delta smelt.

13. As I mentioned, a spawner-recruit model or a stage by stage life history model would have been the appropriate and generally accepted method for the BiOp to estimate quantitative effects of water project operations on delta smelt population size. Such models are commonly used by the United States Fish and Wildlife Service ("FWS"), and I see no reason why such models could not have been used here. In fact, given the quantitative data available to FWS, it is inexplicable why FWS did not employ such a methodology to answer what I understand is the chief issue in the BiOp, which is to what extent do proposed water project operations affect the survival and recovery of the delta smelt. I consider this a major failing of the BiOp and not in accordance with generally accepted scientific standards.

**B. Deaths Of Individual Delta Smelt Do Not Equate To Population-Level Impacts On Survival Or Recovery**

14. A characteristic of most fish life histories and population dynamics is the interaction of various biotic or abiotic factors to produce population bottlenecks at different parts of a species' life history. A consequence of such bottlenecks is that the population may be limited in some places and some times by the availability of resources such as food, appropriate temperature or salinities, or protection from predators, etc.

15. Much of the BiOp is devoted to discussing how changes in the Sacramento-San Joaquin Delta were and are caused by a range of factors. These include habitat destruction, invasions and establishment of exotic plant and animal species, dykes, reservoirs, and flow modification. As the BiOp indicates, these factors may have altered the delta smelt's habitat and


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effectively made some of the bottlenecks tighter.

16. When bottlenecks exist in certain places and times, it means that there is a non-linear relationship between the number of eggs, larvae or juveniles produced, and how many individuals of the species survive to reproduce and contribute to the next generation. The result is that entrainment or impingement mortality of eggs, larvae or juveniles does not necessarily result in a proportional loss of adult population size. Thus, it would be improper to assume that the loss of individual eggs, larvae, or juveniles of a fish species has a population-level effect on the next generation unless the various other mortality factors and the potential population bottlenecks are understood and evaluated.

17. A key use of life history models is to identify these population bottlenecks, the extent to which management actions can modify the size of the bottlenecks, and the relationship between entrainment and impingement mortality of certain life stages and overall population level impacts, if any. If it is believed that there are now numerous bottlenecks in the life history of delta smelt caused by factors other than water project operations – associated with for instance the overall decline of pelagic organisms in the Delta – then reduction in the number of eggs, larvae and juvenile delta smelt by water project pumping operations may have little impact on subsequent spawning populations.

**C. The BiOp's Conclusions Regarding Effects Of Water Project Operations On Delta Smelt Habitat Is Unsupported And Refuted By Common Ecological Principles**

18. Another serious deficiency in the BiOp is that it concludes that water project operations reduce the extent or nature of Delta habitat in such a way that the capacity of this habitat to support delta smelt is reduced. The BiOp further concludes that this reduction in habitat carrying capacity is suppressing the delta smelt's population size, or preventing it from increasing to higher levels. However, this concept is not well supported in the BiOp and, as I explain below, runs counter to ecological theory.

19. According to my calculations, the population abundance of delta smelt as indicated by the FMWT in 2006-2008 was 2.5% of the values of the FMWT index during 1971-1973, and only 4.6% of the value it was during 1993-1995. This indicates that delta smelt abundance and



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densities today are much lower than in the past.

20. At such low levels of abundance and density, ecological theory suggests that the habitat capacity, or availability of suitable habitat for delta smelt, would not be a limiting factor on delta smelt population size. In the same way, ecological theory suggests that habitat availability should have no impact on recovery of the delta smelt to population levels enjoyed prior to the recent pelagic organism decline. Ecological theory suggests that reductions in habitat capacity will limit the ultimate size the delta smelt population can rebuild to, but not its ability to rebuild from the current very low numbers to higher numbers.

21. The BiOp does not address this general ecological principle or attempt to explain why it does not apply in this case to the delta smelt. It appears that without any justification, the BiOp simply assumes or embraces some hypothesis that habitat capacity is currently limited, but it provides no data to support this assumption.

22. Furthermore, even if one assumes that water project operations have reduced the habitat carrying capacity, and then uses X2 or OMR as indicators of the habitat carrying capacity, then it is quite inconsistent to believe that the obviously high carrying capacity seen in the period 1993-1995 as indicated by the FMWT index, has been reduced by 90% or more due to changes in X2 or OMR. To support its claims, the BiOp should have been much more explicit about what factors affect the capacity of the habitat to support and produce delta smelt, as opposed to what factors reduce survival of delta smelt.

**D. The BiOp's Conclusions Regarding The Relationship Between Salvage Losses And OMR Flows Rely On Circular Logic**

23. The BiOp provides estimates of salvage losses of delta smelt at the water project pumps based largely on a scientific article written by Wim Kimmerer in 2008 entitled "*Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta*." On page 212 (AR 000227), the BiOp claims that there is a significant relationship between these estimates of salvage losses and OMR flows. However, the BiOp's estimates of salvage losses are derived from Kimmerer's 2008 article, which uses OMR flow as an input variable in the equations its contains to estimate salvage. Thus, there is total

circularity in the BiOp's conclusions that these estimates of salvage are significantly related to OMR flow. Such a result and relationship between OMR and estimated salvage is to be expected because OMR was used to estimate salvage by Kimmerer 2008 and by the BiOp. Thus, the BiOp is making a misuse of the Kimmerer 2008 article.

24. This circularity is a significant methodological flaw, however, the BiOp fails to identify or explain this circularity in any way. Instead, it uses its ill-founded conclusion regarding the relationship between OMR flows and estimated salvage to suggest modification and control of OMR flows to reduce salvage. A competent statistician or researcher would have identified this methodological flaw, and would not have based conclusions or recommendations on it without explaining or in some way accounting for this circularity.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. Executed this 9th day of October, 2009, at Seattle WA.

Ray W. Hilborn

RAY W. HILBORN

# EXHIBIT A

# CURRICULUM VITAE

## Ray William Hilborn

### Date of Birth

December 31, 1947

### Education

B.A. (Biology) Grinnell College, Grinnell, Iowa (1969)

Ph.D. Department of Zoology, University of British Columbia (1974)

### Employment History

| | |
|---|---|
| 1987-present | Professor, School of Aquatic and Fishery Sciences, University of Washington. |
| 1985-1987 | Senior Fisheries Scientist, Tuna and Billfish Program, South Pacific Commission, Noumea, New Caledonia |
| 1980-1985 | Adjunct Associate Professor, Institute of Animal Resource Ecology, University of British Columbia. |
| 1975-1980 | Policy Analyst, Departments of Environment and Fisheries, Government of Canada. Concurrently Honorary Lecturer, Institute of Animal Resource Ecology, University of British Columbia. |
| 1974-1975 | Research Scholar. International Institute for Applied Systems Analysis, Laxenburg, Austria. |

### Major Professional Activities

| | |
|---|---|
| 2006 – present | Member Board of Reviewing Editors, Science Magazine |
| 2002 - present | Associate Editor, Canadian Journal of Fisheries and Aquatic Sciences |
| 2003 – present | Member Editorial Board, New Zealand Journal of Marine and Freshwater Research |
| 1999-present | Member Editorial Board, Fish and Fisheries. |
| 1993-present | Member Editorial Board, Reviews in Fish Biology and Fisheries |
| 2007-present | Member Senior Advisory Council, Natural Resource Modeling. |
| 2008-present | Member Editorial Board, The Open Fish Science Journal |
| 1993-2007 | Member Editorial Board, Natural Resource Modeling. |
| 1999-present | Independent Science Advisor, Commission for Conservation of Southern Bluefin Tuna |

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| 2002 – 2003 | Chair, National Academy of Sciences/National Research Council Committee on Cooperative Research in the National Marine Fisheries Service |
| 2002 - 2004 | Member Scientific Advisory Board for Presidents Commission on Ocean Policy |
| 1999-2001 | Member Ocean Studies Board, National Research Council |
| 1996-2000 | Member International Committee for recovery of the vaquita (*Phocoena sinus*) |
| 1997-1998 | Member National Academy of Sciences Panel on status of New England groundfish stocks. |
| 1996-1997 | Member National Academy of Sciences Panel on Fisheries Stock Assessment Methods |

## Honors and Awards

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| 2009 | American Institute of Fisheries Research Biologists Outstanding Achievement Award |
| 2006 | Volvo Environmental Prize (shared with Carl Walters and Daniel Pauly) |
| 2005 | Elected Fellow of Royal Society of Canada |
| 2005 | Recipient of American Fisheries Society 2005 National Award of Excellence |
| 2005 | Recipient of Western Division, American Fisheries Society, Award of Excellence |
| 2001-2008 | Richard C. and Lois M. Worthington Professor of Fisheries Management |
| 1997 | College of Ocean and Fisheries Sciences Distinguished Research Award |
| 1988-1991 | H. Mason Keeler Professor of Recreational Fisheries Management. |
| 1985 | Stevenson Memorial Lecture, Canadian Conference for Fisheries Research. |
| 1976 | Wildlife Society award for best paper in fisheries science. (Adaptive management of renewable resources with C. Walters). |
| 1972-1974 | National Research Council Canada. Graduate Fellowship. |

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## Major Research Funding

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| 2008-2011 | Funding from Moore Foundation for salmon research. $3.6 million over 3 years. |
| 1999-present | Funding from Bristol Bay Salmon Processors for salmon research in Bristol Bay, Alaska. Average $200k per year. |
| 2005-2007 | NOAA funding for development of SHIRAZ model to evaluate habitat impacts on salmon $200k |
| 2005-2007 | Funding from Pew Institute for Ocean Sciences for research on dynamics of small populations. $250k over 2 years. |
| 2005-2008 | Funding from Moore Foundation for salmon research. $2.3 million over 3 years. |
| 2002-2006 | NOAA funding for graduate student support in marine fish population dynamics $255,000 |
| 2004-2009 | NSF funding for "Biocomplexity and fisheries sustainability" $2.0 Million. I am the lead P.I. |
| 2004-2006 | SeaGrant funding for spatial dynamics of geoducks in Puget Sound. With David Armstrong. $150k over 3 years. |
| 2003-2007 | NSF Biocomplexity funding Award 0308440 for study of spatial structure in fish recruitment. Dave Siegel U.C. Santa Barbara lead P.I. my portion $315,607 |
| 1996-present | New Zealand Seafood Industry Council funding of stock assessment in New Zealand Fisheries $67,000-$125,000 per year. |
| 2003-2006 | NOAA/SeaGrant funding for graduate fellowship for Eric Ward in fisheries stock assessment. $37k per year for 3 years. |
| 2002 | NMFS funding for post-doc on salmon habitat modelling. $50k |
| 2002-2003 | Alaska Department of Fish and Game funding for grad student support on prediction of salmon run timing. $30k |
| 2002-2004 | NMFS Stock Assessment Improvement Program funding for grad student support. $70k per year |
| 2002-2005 | NSF LTREB funding for Alaska Salmon studies. $35k per year. Jointly with Tom Quinn and Daniel Schindler. |
| 2001-2003 | NSF funding for field station infrastructure, $200k for new laboratory and classroom at Porcupine Island Alaska field station. Tom Quinn lead P.I. |

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| 2002-2005 | NOAA/SeaGrant funding for graduate fellowship for Melissa Haltuch in fisheries stock assessment. $37k per year for 3 years. |
| 2001-2003 | Institute of Marine Research, Iceland funding for research on Icelandic cod and age structured models $16k per year. |
| 2001-2004 | NOAA/SeaGrant funding for graduate fellowship for Ian Stewart in fisheries stock assessment. $37k per year for 3 years. |
| 2000-2001 | NOAA funding for study of salmon run timing. $70k. |
| 2000 | NMFS funding for Research Faculty position in groundfish assessment. $120k |
| 1999-present | Funding from Bristol Bay Salmon Processors for salmon research in Bristol Bay, Alaska. Average $200k per year. |
| 1998-2009 | NOAA funding for salmon research at Chignik Lakes, Alaska $30k per year. |
| 1998-2002 | Funding of PNCRS research on salmon survival (Sea Grant and NOAA joint funding) Multi PI program, my portion $35,000 per year. |
| 1998-present | Chignik Regional Aquaculture Association funding for salmon research at Chignik Lakes, Alaska. $45k-$10k per year. |
| 1998-2003 | Alaska Department of Fish and Game funding for operation of Pt. Moller test fishery. $30k per year. |
| 1996-1997 | National Marine Fisheries Service funding for analysis of interaction between habitat, ocean conditions and harvest in chinook salmon. $49,000 |
| 1997-1998 | Washington Sea Grant: modeling the interaction between habitat, harvest, ocean conditions and hatcheries. $32,000 |
| 1995 | Gift of $100,000 as part of Consent Decree between Reynolds Aluminum and Washington Public Interest Research Group for research on Columbia River Chinook Salmon. |
| 1990-1996 | New Zealand Fishing Industry Board. with Prof. Ellen Pikitch "Analysis of New Zealand TAC setting policies." $100,000-$150,000 per year. |
| 1993-1995 | Washington Sea Grant. "Hatcheries: what works and what doesn't." $100,800 |
| 1993-1994 | National Marine Fisheries Service funding for Bayesian risk analysis of Snake River Fall Chinook. $35,000 |
| 1989-1993 | Bonneville Power Administration. "Analysis of historical patterns of survival among Columbia River salmonids". $450,000. |
| 1991-1993 | Washington Sea Grant. "Salmon management using coded-wire-tags." $96,000 |
| 1990 | International Pacific Halibut Commission. "Analysis of IPHC transboundary tagging experiments, part II." $54,105. With J.R. Skalski. |

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| 1990 | Provosts fund for Interdisciplinary research. "In search of sustainable development." $15,000. With Kai Lee and Gardner Brown. |
| 1988 | International Pacific Halibut Commission. "Analysis of IPHC transboundary tagging experiments". $40,315. With J.R. Skalski. |
| 1988 | Bonneville Power Administration. "Flow requirements for the Hanford reach, relative to the number of chinook salmon spawners". $23,357. With D. E. Rogers. |
| 1988 | Northwest Indian Fisheries Commission. Statistical procedures for comparing results of coded wire tag releases. $10,000. |
| 1989-1991 | Washington Sea Grant. Managing Adaptively: early experience in Western North America. $144,000. With Kai N. Lee and Janice E. Carpenter. |
| 1987-1990 | Vice Provost for Computing University of Washington. $177,731 for microcomputer teaching lab for Colleges of Forest Resources and College of Fisheries and Ocean Sciences. Proposal written by Dr. Gordon Swartzman and myself. |
| 1975-1985 | National Sciences and Engineering Research Council of Canada operating grants in Population Biology ($6000-$12,000 per year). |
| 1980-1985 | Department of Fisheries and Oceans. Contract support for Cooperative Fisheries Research Unit ($60,000-$110,000 per year). With C.J. Walters. |
| 1985-1987 | 3 year Strategic Grant from National Sciences and Engineering Research Council ($90,000 per year) for "Adaptive management of fisheries resources." With C.J. Walters and D. Ludwig. |
| 1978 | B.C. Science Council. ($24,000). Behavior of B.C. purse seine fleet. |
| 1978 | Canadian National Sportsman's Fund ($12,000). A study of B.C. salmon purse seine vessels. |