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UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF CALIFORNIA
FRESNO DIVISION

THE DELTA SMELT CONSOLIDATED CASES	Case No. 1:09-cv-407 OWW **Declaration of Frederick V. Feyrer In Support of Federal Defendants' Motion for Stay Pending Appeal**

I, Frederick V. Feyrer, declare as follows:

1. I am currently employed as a Fish Biologist in the Bay Delta Office of the U.S. Bureau of Reclamation ("Reclamation") in Sacramento, California. Prior to working for Reclamation, I worked for the California Department of Water Resources in a capacity nearly identical to my present position. I have spent my professional career researching and advising management on fishes of the San Francisco Estuary. I have a BS in biology from the University of California, Davis and a MS in biology from Sacramento State University.

2. Over the last 10 years, I have authored or coauthored over 30 peer reviewed journal articles and edited a book on fishes in the San Francisco Estuary. At least a dozen of the peer reviewed journal articles I have contributed to have had some focus on delta smelt. I have authored two articles relied on extensively in the 2008 BiOp. The first primarily described the abiotic habitat of delta smelt and its long-term trends and was published in 2007 in the journal *Canadian Journal of Fisheries and Aquatic Sciences* (referenced as Feyrer et al. 2007 in the 2008 BiOp, *see* Administrative Record ("AR") at 18266-18277). The second primarily examined projections of potential future abiotic habitat conditions for delta smelt and was published in 2011 in the journal *Estuaries and Coasts* (referenced as Feyrer et al. 2008 in the 2008 BiOp, *see* AR at 18278-18306).

3. In addition to conducting original research, I also serve as a senior fish biologist for real-time and ongoing resource management and water operation issues for Reclamation's Bay Delta Office. In this capacity I serve on the Management Teams of the Interagency Ecological Program, the Pelagic Organism Decline Investigation, the Smelt Working Group, and have chaired the Interagency Ecological Program's Resident Fishes Workteam. In the past I have also participated on the Data Assessment and Water Operations Management Teams. Among numerous other technical working groups, I also participate on the U.S. Fish and Wildlife Service's Delta Native Fishes Recovery Team. Recently, I participated on a working group at the National Center for Ecological Analysis and Synthesis at the University of California, Santa Barbara, which focused on modeling factors contributing to the Pelagic Organism Decline. I also recently served on an expert panel of independent scientists advising

the California State Water Resources Control Board on flow criteria for the Sacramento-San Joaquin Delta. In addition to these activities, I have also served in a leadership role in professional societies, having been on the executive committees of the California-Nevada Chapter of the American Fisheries Society and the California Estuarine Research Society.

I. Delta smelt status

4. The delta smelt population is in a precarious state of decline (Figure 1). As background, delta smelt is a slender-bodied fish typically reaching 60–70 mm standard length (SL) with a maximum size of about 120 mm SL. The species is endemic to the upper San Francisco Estuary, primarily the Delta and Suisun Bay. Delta smelt is generally associated with the low salinity zone locally indexed by X2, which is the distance (in km) along the axis of the estuary from the Golden Gate to the 2 psu isohaline measured near the bottom of the water column (Jassby et al. 1995). Delta smelt feed primarily on planktonic copepods, cladocerans, and amphipods. Delta smelt is basically an annual species and spawns in freshwater in the Delta. Upstream migration of maturing adults generally occurs in the late fall or early winter with most spawning taking place from early April through mid-May (Bennett 2005). Larval delta smelt move downstream until they reach favorable rearing habitat in the low salinity zone. Some apparently remain in upstream reaches including the Cache Slough-Sacramento deepwater ship channel region and the central Delta region year-round. A very small percentage of delta smelt is believed to live 2 years and spawn in one or both years (Bennett 2005). Delta smelt was listed as a threatened species by both the federal and state governments in 1993. Its status was changed to state endangered in 2009. A similar change to federal endangered status was recently determined to be “warranted but precluded” (USFWS 2010).

5. Against a background of highly variable abundance, delta smelt have suffered a long-term abundance decline (USFWS 2008, Sommer et al. 2007; Thomson et al. 2010). The decline spans the post-1966 portion of the “post-reservoir period” described in Baxter et al. (2010) and was particularly marked in the “POD [Pelagic Organism Decline] period” (Baxter et al. 2010). Long term trend analyses confirm that a step decline in pelagic fish abundance marks

the transition to the POD period (Manly and Chotkowski 2006, Moyle and Bennett 2008, Mac Nally et al. 2010, Thomson et al. 2010, Moyle et al. 2010) and may signal a rapid ecological regime shift in the upper estuary (Moyle et al. 2010, Baxter et al. 2010). The dramatic decline of delta smelt over the last decade is readily apparent in the negative population growth rate of the species trending towards extinction (Figure 1).

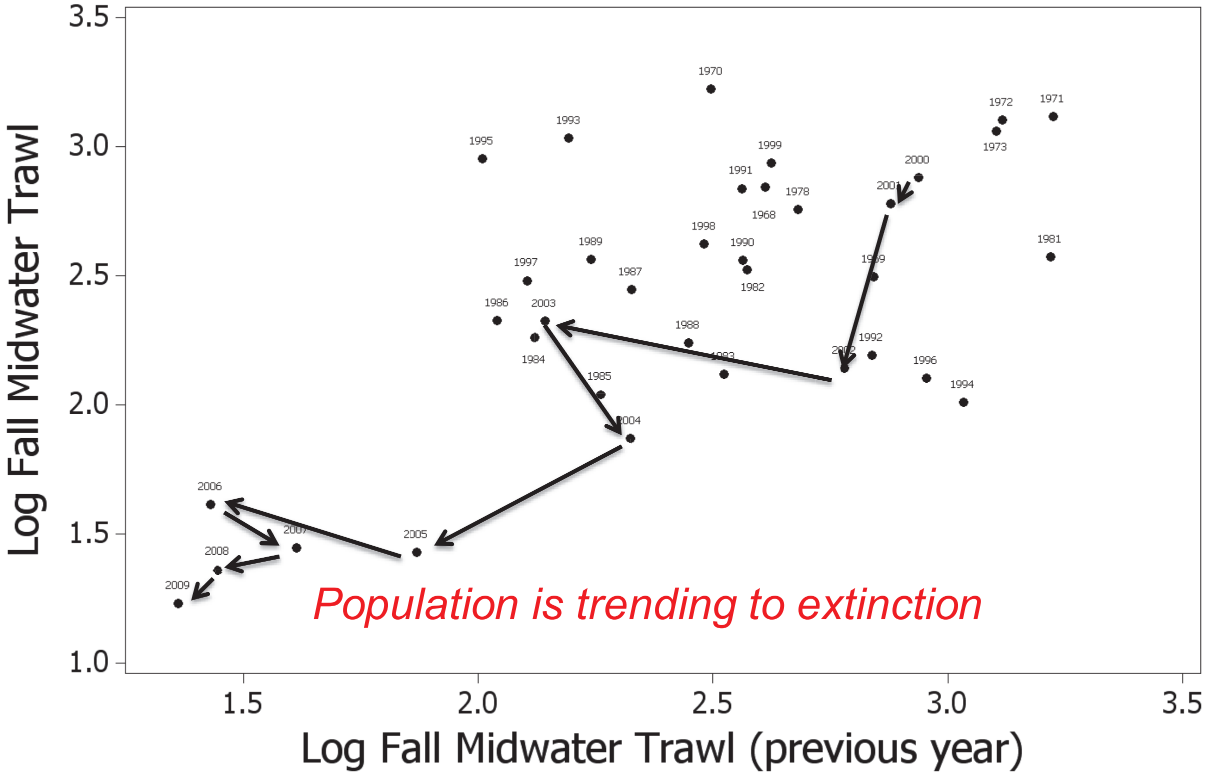


Figure 1. Delta smelt abundance index plotted against the abundance index for the prior year. Arrows follow the direction of consecutive years from 2000 through 2009 and demonstrate a pattern of population growth rate that is trending towards the origin, which could lead to the extinction of the species.

II. Delta smelt habitat and X2

6. Routine fisheries monitoring has been conducted in the San Francisco Estuary since the 1950s. As a result, there is a large amount of data available to assess the habitat requirements of fishes such as delta smelt. There have been numerous studies examining the

habitat of delta smelt, with papers published in peer reviewed scientific journals in the last four years having assessed the habitat requirements of delta smelt during the fall months. Feyrer et al. (2007; 2011) examined four decades worth of carefully collected scientific data on observations of delta smelt and concurrently measured water quality parameters. Applying a commonly-used statistical method for assessing the habitat associations of fishes and other organisms, Feyrer et al. (2007; 2011) found that delta smelt occupied a range of salinity and water clarity levels but that the probability of observing a delta smelt was greatest at low salinities, centering on about 2 psu, and at relatively high levels of turbidity. Recent work by Sommer et al. (2011) has complemented Feyrer et al. (2007; 2011) and demonstrated that the center of delta smelt distribution in the fall is positively related to X2, which is the tidally-averaged location of the 2 psu isohaline. The concept of X2 and its relation to the abundance or survival of numerous estuarine organisms was first established in a paper published in 1995 (Jassby et al. 1995); it has become an important metric used by scientists and resource managers to index flows and habitat conditions for estuarine species.

7. Feyrer et al. (2011) used the habitat data described above to develop an abiotic habitat index for delta smelt, which incorporated both the quantity and quality of habitat used by the species. In simple terms, the index can be thought of as representing the surface area of the estuary standardized for salinity and turbidity conditions that are favored by delta smelt. Feyrer et al. (2011) found that this annual index exhibited a negative stepped, or sigmoid (s-shaped) relationship with X2, as shown in Figure 2. The figure is a recreation of similar figures in the BiOp and in Feyrer et al. (2011).

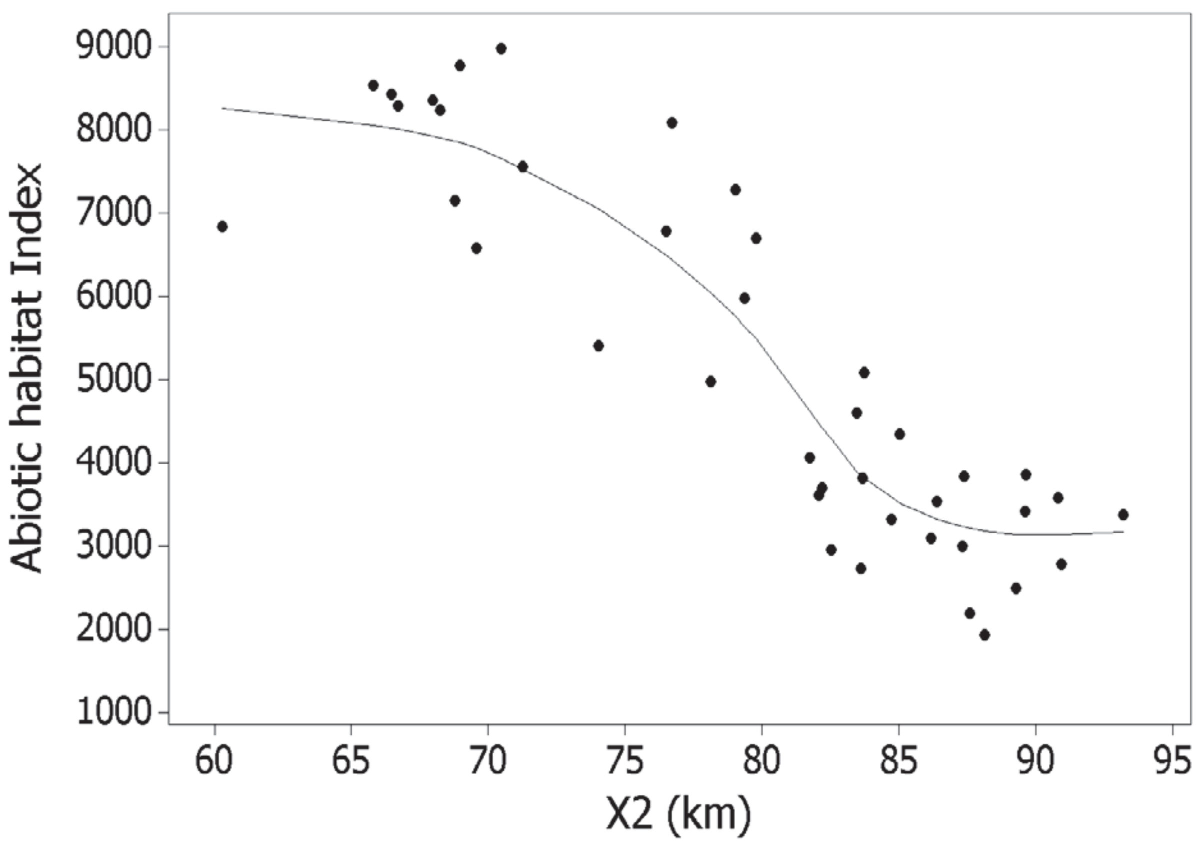


Figure 2. Delta smelt abiotic habitat index plotted against X2. The curve is a LOESS smooth

8. As can be readily observed in Figure 2, the largest degree of change (steepest portion of the curve) in the habitat index occurs at X2 values approximately between 85km and 70km, with less change beyond those values. Across this 15-km range of X2, habitat suitability increases approximately 2-fold. The nature of this s-shaped relationship between the habitat index and X2 is caused by the geography of the estuary. The 15-km range in X2 where the habitat index changes dramatically corresponds to a geographic area that includes the confluence of the Sacramento and San Joaquin rivers, which is located at approximately 80km. As can be seen in Figure 3 (this figure is taken directly from Feyrer et al. 2011) and Figure 2, as X2 is located further downstream of the confluence there is an increasing larger area of suitable habitat because the low salinity zone encompasses the expansive Suisun and Grizzly Bays, which results in a dramatic increase in the habitat index. In contrast, when X2 is located increasingly further upstream of the confluence, habitat is restricted to the smaller river channels. Note that in Figure

3 increasingly dark shading represents increasingly good habitat quality. Thus, as is described above and is illustrated in Figures 2 and 3, X2 reflects (a) where delta smelt habitat is located, (b) how much delta smelt habitat exists, and (c) the suitability of habitat for delta smelt.

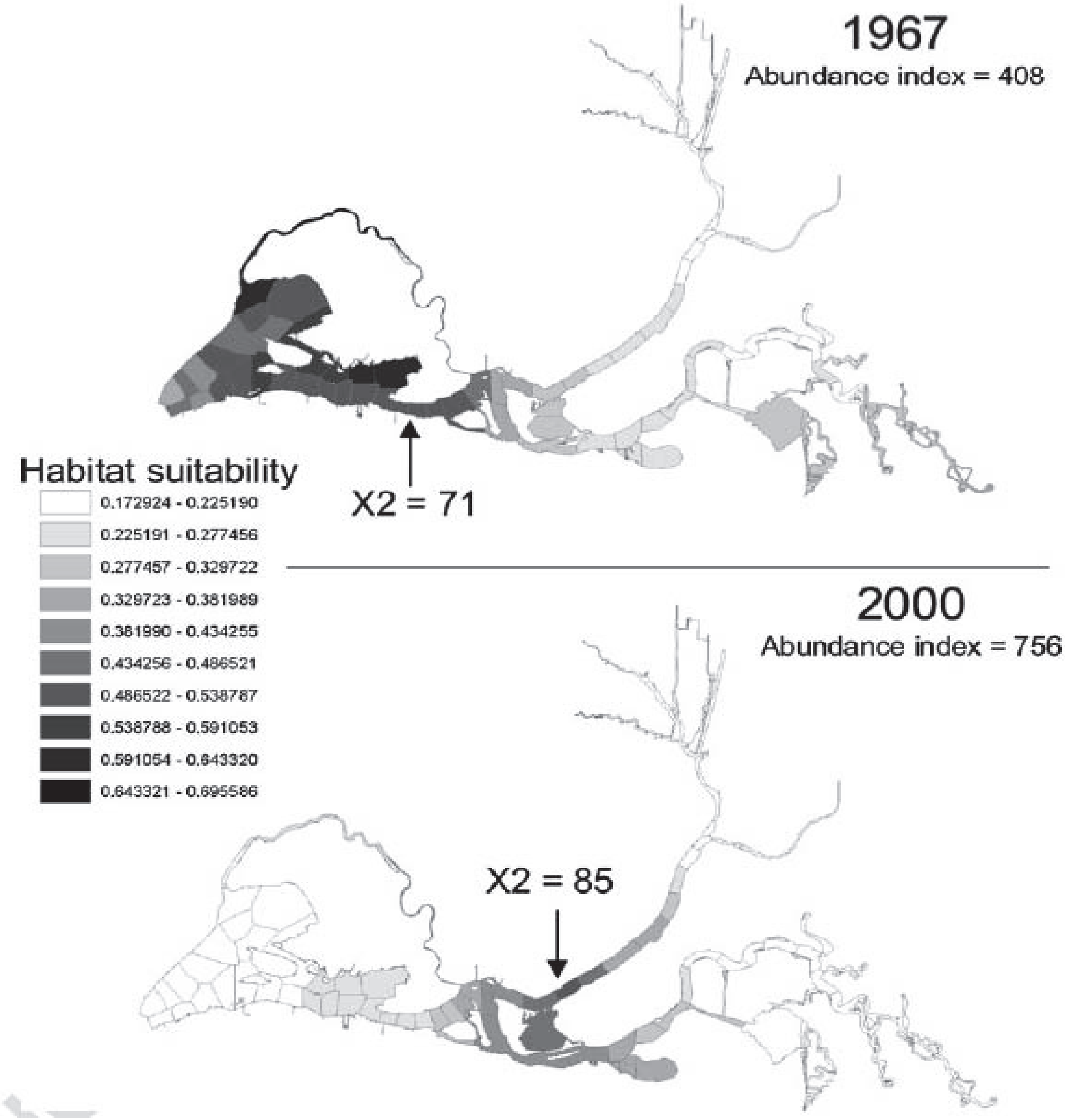


Figure 3. Spatial distribution of delta smelt habitat suitability for years in which X2 was either below (1967) or above (2000) the confluence of the Sacramento and San Joaquin Rivers. Abundance index is from the fall midwater trawl survey.

9. There is a variable but demonstrable link between X2 and delta smelt abundance. The same two key papers I have authored (Feyrer et al. 2007; 2011) demonstrate lines of evidence of an association between delta smelt abundance and summer and fall habitat conditions. First, Feyrer et al. (2007) demonstrated that incorporating abiotic habitat covariates into a basic stock-recruit model linking the abundance of sub adult delta smelt (fall midwater trawl abundance index) to juvenile production (summer townet abundance index) improved the fit of the model. Models that included the abiotic habitat variables accounted for approximately 20% more of the variance in the data set than those without the abiotic habitat variables (r-squared values improved from 0.39 to 0.59, meaning that the model went from explaining approximately 40% of the variability in juvenile delta smelt production to approximately 60% of the variability in juvenile delta smelt production).

10. Second, Feyrer et al. (2011) demonstrated a relationship between the abiotic habitat index and the delta smelt abundance index. Against a background of high overall variability in abundance index values, the boundary values that envelope the floor (lowest values) and especially the ceiling (highest values) in this relationship define regions of the graph in which combinations of the habitat index and the abundance index have not been observed.

11. Flows from the Delta entering the estuary control the location of X2. Seasonally, these flows are highest in the spring and lowest in the fall. Although the seasons differ in the overall magnitude of flow, historically there has been a correspondence in the flows between the seasons. Presently, water project operations have an extremely high degree of control over flows during the fall such that X2 is largely determined by water project operations before winter storms begin during the onset of winter. Since 1967, average fall X2 has moved upstream and become constant regardless of flows during the spring (Figure 4; in the figure spring flows are indexed according to the official water year type classification).

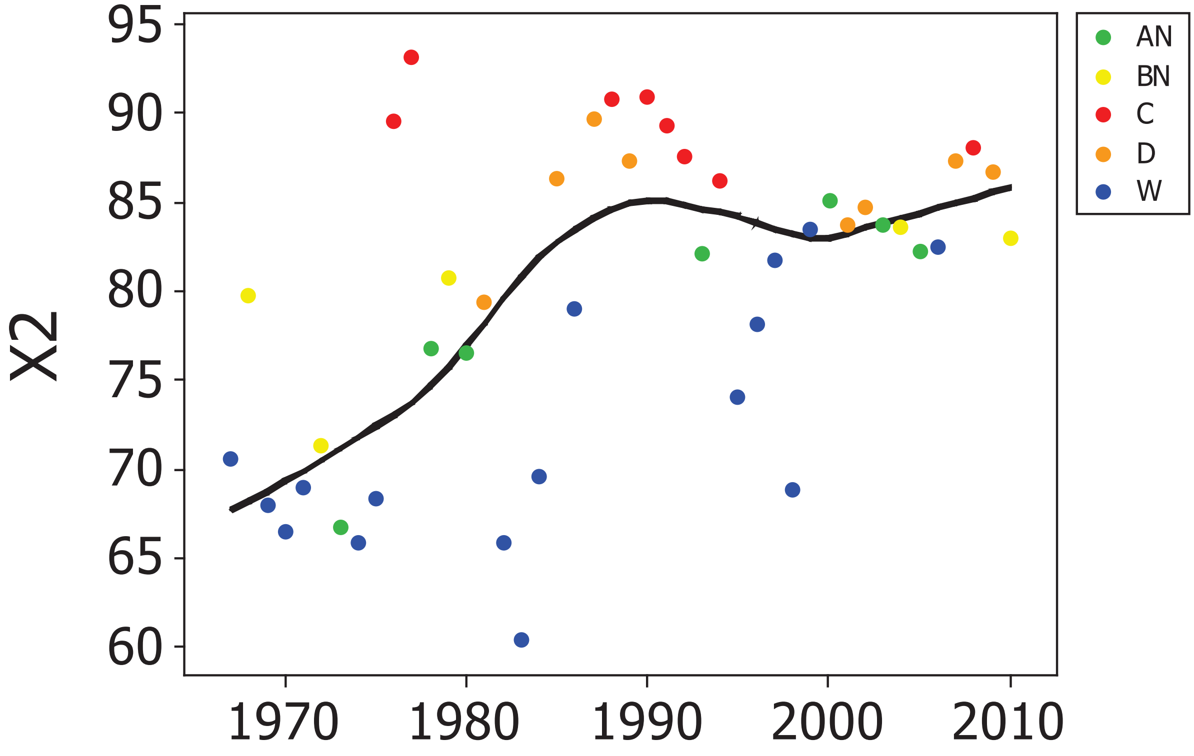


Figure 4. Time series of average fall X2 (km, September – December) since 1967. Symbols: water year type of the preceding spring for the Sacramento valley (W: wet, AN: above normal, BN: below normal, D: Dry, C: critically dry). A LOESS smooth is fitted to the data.

Since 1967, the upstream shift in X2 has resulted in a decline in the average delta smelt abiotic habitat index, with the effect most pronounced in wet or above normal years (Figure 5; Feyrer et al. (2011) calculates a 78% decline from 1967 to 2008).

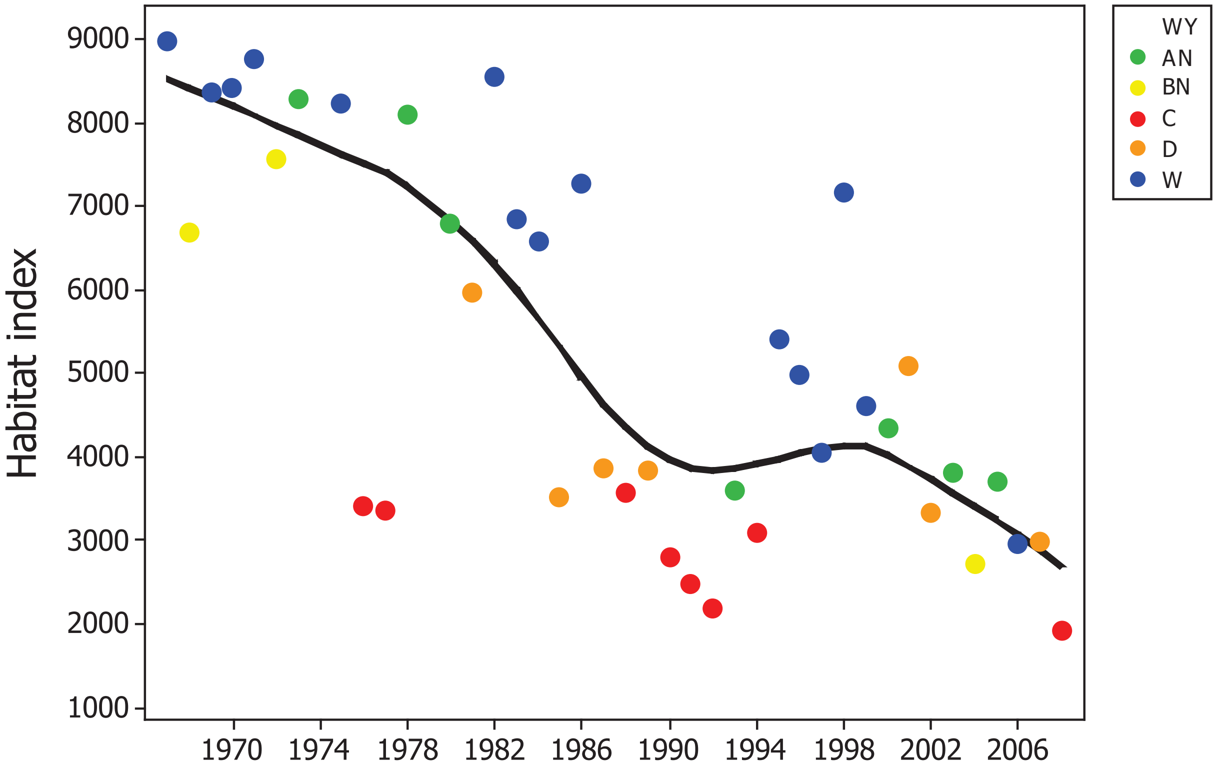


Figure 5. Delta smelt habitat index time series. A LOESS smooth is fitted to the data.

This decline in delta smelt habitat has coincided with the long-term decline in delta smelt abundance (Feyrer et al. 2010). Operations modeling to evaluate the effects of project operations indicated that reduced and homogeneous fall outflow conditions will persist into the future (USBR 2008). Feyrer et al. (2011) concluded that the effects of future project operations in combination with climate change are likely to lead to further declines in delta smelt habitat in all water year types.

III. The District Court's August 31, 2011 Findings of Fact

A. Setting X2 at 79 or 80 km

12. My testimony in this matter is not consistent with a finding that positioning X2 at 79 or 80 km would provide sufficient habitat quality and quantity for delta smelt during the fall

relative to positioning X2 at 74 km. *See* 7-28-11 Tr. at 122:9-16, 125–126, 213; Findings of Fact and Conclusions of Law ("FOF") (Doc. 1007) (Aug. 31, 2011) at 30, 75, 139-140.

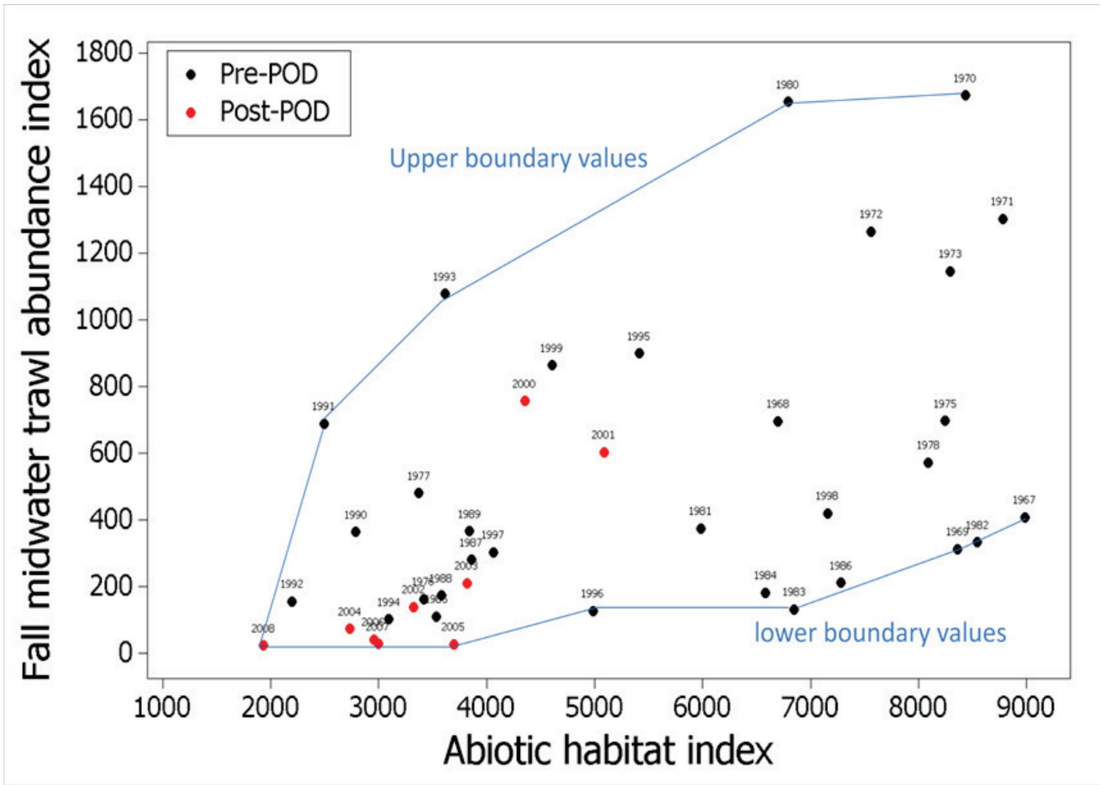
13. When X2 is located at 74km, the majority of the low salinity zone covers the expansive Suisun, Grizzly, and Honker Bays. *See* U.S. Bureau of Reclamation, Revised Adaptive Management Plan at 6 (Fig. 12) (Doc. 1002-2). As X2 moves upstream (X2 values get larger) so does the low salinity zone. Once X2 reaches the confluence of the Sacramento and San Joaquin Rivers, located at approximately 79 or 80 km, the low salinity zone is pushed upstream into the river channels and only marginally covers Honker Bay, the most upstream of the three bays. There is always some variability and so some delta smelt can be found in the downstream bays during most instances, even when X2 is located upstream. However, because the center of the population tracks X2, the population will center on this area when it is overlaid by X2.

14. The center of distribution of delta smelt is the area of greatest concentration. The analysis in Sommer et al. (2011) calculates the center of distribution through a process of weighting the locations of delta smelt observations by their abundance. Therefore, in fact, the center of distribution in this case does represent the center of the concentration of the fish.

15. If X2 is set at 79 or 80 km, most of the delta smelt population will not align with the shallow, biologically productive, turbid waters of Suisun Bay, Grizzly Bay, and Honker Bay. Thus, positioning X2 at 79 or 80 km would provide far less habitat of sufficient quality and quantity than it would positioned at 74 km.

B. Upper Limit of Smelt Abundance and Abiotic Habitat Loss

16. The Court also found that the habitat index, described above, was "devalue[d]" due to Plaintiffs' witnesses' criticisms of the following plot of the habitat index against the Fall Midwater Trawl ("FMWT") Index.



Delta smelt abiotic habitat index plotted against the Fall midwater trawl abundance index for the same year. Blue lines connecting the high and low boundary values were hand-drawn. Pre-POD period is 1967-1999. Post-POD period is 2000-2008. Figure is adapted from Feyrer et al. (2011).

17. In particular, the Court gave credence to Plaintiffs' witnesses' assertions that because both axes of the plot included data from the fall midwater trawl and therefore any correlation derived from the plot is "meaningless." This criticism of the plot is not valid, because the plot is useful in demonstrating the long-term association of delta smelt habitat and delta smelt abundance. Although the variables are constructed with different data (one is abundance data and the other is water quality data) there is some built in correlation because they both stem from the same fall midwater trawl data set. However, it is the very nature of the correlation that is the point of interest in the plot. Regardless, any criticisms of this plot do not impact the reliability of the habitat index itself, as the habitat index is just one of the input variables given in this plot, and does not depend on any conclusions drawn from this plot.

C. Purported Uncertainty in Feyrer *et al.* (2007), (2008), and (2011)

18. The Court found "that it was 'scientifically improper' for Mr. Feyrer to chain the results of multiple modeling efforts together without accounting statistically for the error introduced at each step." FOF at 34. However, the statistical output for each analysis, plus several figures and tables are provided to explicitly demonstrate the statistical uncertainty associated with every analysis in the two papers. *See* Hearing Exhibits 7, 586; AR 18272. Moreover, the work was peer reviewed and published in two of the leading fisheries and estuarine science journals in the world.

D. Analysis of Turbidity in Habitat Index

19. The Court found that I "acknowledged that the analysis in Feyrer (2011) does not provide a basis for calculating the proportion of the variation in the delta smelt abundance index attributable to salinity as a stand-alone variable." FOF at 36 (quoting 7-29-11 Tr. at 74:16-75:2). However, in the cited transcript pages, Plaintiffs' counsel asked not about the entire study, but only whether, "[b]ased on *Figure 2-C* in your paper, can you determine what proportion of the variation in the fall midwater trawl abundance index is attributable to salinity and salinity alone?" to which I answered, "not based on the figure." 7-29-11 Tr. at 74:11-75:2 (emphasis added); *see also id.* (asking same question with respect to Figure 5 in the Feyrer, *et al.* (2011) study; same answer).

20. In fact, the Feyrer, *et al*. (2007 and 2011) studies did isolate salinity from turbidity during the Generalized Additive Modeling ("GAM") runs which describe the habitat associations of delta smelt. *See* Hearing Exhibit 7 at 4; Hearing Exhibit 586 at 6 (AR 18271). The GAM concluded that salinity accounts for most of the variability in delta smelt catch, rather than turbidity. *See id.*.

21. Moreover, in the large shallow bays downstream of the confluence, such as Suisun Bay, the water is more turbid than upstream because of wind re-suspension of sediment. In this way, the positioning of X2 does affect turbidity.

E. Use of "Core Stations" In Habitat Index

22. The Court perceived an inconsistency in my testimony that: (1) the habitat index included Cache Slough, the Liberty Island area, and part of the Sacramento Deep Water Ship Channel; and (2) that I used only data from the "core" fish sampling stations downstream of these areas to develop the habitat index. FOF at 39.

23. However, as I testified, the habitat index is based on water quality measurements, not fish catch data. *See* 7-29-11 Tr. at 13:5-10. Although the "core" fish sampling stations are downstream of Cache Slough, the Liberty Island area, and part of the Sacramento Deep Water Ship Channel, water quality measurements at the "core" stations are well within the tidal excursions of those three areas, as the water there is fully mixed. *See* 7-28-11 Tr. at 124:18-22. Thus, water quality measures taken at the "core" sampling stations are accurate measurements of water quality in Cache Slough, the Liberty Island area, and part of the Sacramento Deep Water Ship Channel. *Id.*. There is no inconsistency in my testimony.

F. Potential Extinction Scenarios Predicted In Feyrer et al. (2008) Life Cycle Model

24. The Court perceived an inconsistency between my testimony that "that the negative abundance values [in the Feyrer *et al.* (2008) life cycle model] *might possibly* represent an extinction scenario rather than a flaw in the model," FOF at 44 (citing 7-29-11 Tr. at 88:6-25) (emphasis added), and a quotation in the Feyrer *et al.* (2008) paper that the negative abundance results were "largely" (but not exclusively) an artifact of the particular modeling construct used. *Id.*

25. However, in my testimony, I acknowledged that the negative abundance results were subject to different interpretations:

> Q. And why do you think the model generated those negative values? A. There could be a lot of reasons. There could be some noise in the data. And I mean, you can interpret it very – a couple of different ways. And we did such in the discussion there. *One interpretation is* that could be an indication of -- you could use that as an indicator of extinction probability for delta smelt *or you could use it as addressing some uncertainties in the data.*

7/29/11 Tr. at 88:14-22 (emphasis added). This is wholly consistent with the paper itself, which makes a nearly identical acknowledgement:

> *one could make an argument that the frequency of times that such an event occurred was a prediction of the probability of extinction....* However, the probability of negative abundances was *largely* a function of uncertainty in the parameter values as increasing the initial number of adult fish in the fall, even to 1,000, did not noticeably affect the probabilities.

AR 018289 (emphasis added); *see also* FOF at 44 (copying same quotation).

26. Since my testimony acknowledges the competing interpretations of these negative abundance model runs, as does the paper, there is no inconsistency.

G. Delta Smelt Life Cycle Modeling Efforts

The Court discussed three delta smelt life-cycle models that have been developed since the BiOp was completed: Maunder & Deriso (2011), Mac Nally et al. (2010) ("Mac Nally (2010)"), and Thomson et al. (2010) ("Thomson (2010)"), and concluded that they "undermine[] and contradict[]" the Feyrer papers. FOF ¶ 99. Respectfully, the Court is mistaken. I was a co-author on the Mac Nally 2010 and Thomson 2010 modeling efforts. *See* FOF ¶¶ 75-99. Neither these models, nor the Maunder & Deriso 2011 model, undermine or contradict any of the Feyrer papers. To the contrary, the life cycle models are entirely consistent with the Feyrer papers, and the Feyrer papers are the most relevant to the propriety of Action 4.

Specifically, the Court correctly observed that the three life cycle modeling efforts (Thomson, Mac Nally and Deriso) all came to the same conclusion, namely that the location of Fall X2 has no statistically significant effect on subsequent delta smelt abundance. However, based on this observation, the Court proceeds to conclude that "[t]he one clear conclusion that can be drawn from this dispute is that the Feyrer papers are neither definitive nor dispositive, and do not provide the level of confidence on which such unprecedented action should be based. They provide some evidence for the Fall X2 Action that is undermined and contradicted by the three most recent life cycle modeling efforts." *Id.* at ¶ 99. That conclusion is erroneous. The flaw in the Court's analysis is that the three modeling efforts should not be expected to demonstrate an effect between Fall X2 and subsequent smelt abundance because the models looked at the effect of X2 over the entire history of the data set for every single year in the record. That is not what Action 4 seeks to address, nor is it what the Feyrer papers looked at.

29. The Feyrer 2007 paper, which was completed prior to the three life cycle models, reached the same conclusion that the life cycle models did (*i.e.*, no long-term, year-after-year effect of the location of X2 on delta smelt abundance). However, Feyrer 2007 <u>did</u> find an effect between the location of X2 and smelt abundance after 1987. Moreover, Action 4 is triggered only in two out of five different year types (wet and above normal). None of the three modeling efforts looked at the effect of the location of X2 on smelt abundance using these parameters. *See* Defs.' Proposed Findings at ¶ 161 (Doc. No 1004). Feyrer 2008 is the only modeling effort that models the effects of implementing Action 4. Thus, it is not correct to state that the life cycle models undermine or contradict any of the Feyrer papers.

I declare under penalty of perjury under laws of the United States of America that the foregoing is true and correct to the best of my knowledge. Executed this 7th day of September, 2011, in Seattle, Washington.

FREDERICK V. FEYRER

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