THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Metropolitan Water District of Southern California
Technical Review of
Proposed Summer Flow Action for Delta Smelt
(Final, August 2016)

This technical memorandum is in support of The Metropolitan Water District of Southern California's (Metropolitan's) August 2016 letter to the Collaborative Adaptive Management Team (CAMT). This technical memorandum describes the following:

- The limited scientific justification for the proposed new summer flow action;
- Discussion of the importance of treating the proposed actions as an experiment with testable hypothesis and a work plan to test the effects of the summer flow augmentation;
- The initial modeling results for the proposed reoperation of the Suisun Marsh Salinity Gates; and
- The initial modeling results for summer flows in the without State Water Project and Central Valley Project (SWP/CVP) condition.

It is Metropolitan's understanding that the Collaborative Science and Adaptive Management Program (CSAMP) will be reviewing the technical basis underlying the proposed summer flow action in August 2016. Metropolitan supports the CSAMP review and looks forward to participation in that process. This technical memorandum describes Metropolitan's view of the available data relevant to the issue of increased summer outflow for Delta Smelt. Metropolitan's analyses are preliminary, being based on our understanding of the not fully described conceptual models being promoted by the United States Fish and Wildlife Service (FWS) and California Department of Fish and Wildlife (DFW).

I. The expectation that the proposed summer flow action will benefit Delta Smelt is highly uncertain.

Metropolitan's understanding of the 2016 summer flow action is that the Department of the Interior (Interior) purchased between 80,000 and 100,000 acre-feet of water to be released July-September to satisfy FWS' goal of moving X2 to Collinsville (81km). Even though Sacramento River flows were above 7,100 cfs in July 2016, X2 was at 85km, and Interior abandoned the action for this year. As part of a larger future flow action in 2017 and 2018, it is Metropolitan's understanding that the FWS and DFW are seeking between 200,000 and 300,000 acre-feet in July through September with the same goal of putting X2 at Collinsville.

Both DFW and FWS have provided separate rational documents describing somewhat different hypotheses. DFW's rationale for the summer flow proposal suggests that growth and survival will be enhanced from augmented summer flows due to improved habitat conditions that could include improved temperatures, reduced harmful algal blooms, improved prey availability and quality, and reduced predation risks. FWS' rationale for the summer flow proposal suggests that improved year-to-year population growth improves under wet years more than dry years; and the increased flow would improve habitat conditions (as measured by salinity, turbidity, temperature, and prey) throughout Delta Smelt's occupied summer habitat, as well as move the low salinity zone to increase the overlap better habitat conditions as in Bever *et al* (2016).[1]

This technical memorandum explains that the existing peer reviewed scientific information does not support the FWS's and DFW's proposed summer flow actions because:

- The published literature shows that Delta Smelt abundance is unrelated to summer outflow and X2.
- The available evidence suggests that moving the low salinity zone westward has inherent risk as the majority of the low salinity zone would overlap the "bad" Suisun Bay habitat.
- The available data shows that lower Sacramento River habitat is roughly as good as Suisun Marsh habitat as defined by salinity, temperature, turbidity, and prey.
- The proposed increase in summer outflow would not result in a measureable improvement in the Delta Smelt's summer occupied habitat, because there is significant uncertainty that Delta Smelt will respond to subtle changes in water temperature, contaminant loading, turbidity, and food availability.
- To the extent that a flow/survival relationship exists, it may be due to factors contained in a wet year and increasing flow through reservoir releases will not artificially replicate those factors.

Metropolitan's analyses contained herein are preliminary, being based on our understanding of the FWS's and DFW's conceptual models.

A. Delta Smelt population abundance is unrelated to summer flow (X2).

The peer reviewed literature does not support hypothesized relationships between Delta Smelt abundance and outflow.

[1] Bever, A. J., MacWilliams, M.L., Herbold, B., Brown, L., Feyrer, F.V. 2016. Linking hydrodynamic complexity to Delta Smelt (*Hypomesus transpacificus*) distribution in the San Francisco Estuary, *San Francisco Estuary and Watershed Science*, 14(1).

1. The peer reviewed literature does not support hypothesized relationships between Delta Smelt abundance and outflow (X2)

Several scientists have investigated whether Delta Smelt have a flow-abundance relationship, related to changes in X2 or changes in the volume of low salinity habitat. They concluded that there is no statistically significant relationship. It is, therefore, unreasonable to assume that new summer flow or changes in X2 would have any impact on Delta Smelt abundance.

Historically, Delta Smelt have not been a species with a flow-abundance relationship. As Kimmerer *et al*. 2009 at p. 11[2] concluded, "… abundance of Delta Smelt did not vary with X2."[3] Kimmerer *et al.* 2013[4] also investigated the potential for Delta Smelt abundance to be increased by expanding the size of low salinity habitat, which could occur if X2 were moved downstream. The investigators looked at two time periods: March through July and September through December (20mm, STN, and MWT surveys). For the winter-spring and fall time periods, Kimmerer *et al*. determined that Delta Smelt abundance was unrelated to the volume of low salinity habitat, stating at p. 13:[5] "Given the difficulty in determining the controls on the Delta Smelt population, it is not surprising that such a simple descriptor of habitat is inadequate for this species," and, "Our findings generally imply that extent of suitable salinity by itself is not a major determinant of the response of abundance to flow for most of the estuarine species we examined."[6]

Nobriga *et al*. 2008[7] completed a similar investigation for the summer months (STN) and also concluded that changes in salinity (location of X2) had no relationship with Delta Smelt abundance. They investigated multiple water quality constituents in the summer and none of them appeared to explain Delta Smelt abundance.

Kimmerer *et al*. 2013 also concluded that changing the volume of the LSZ did not benefit phytoplankton primary production, stating at p. 11:

---

[2] Kimmerer, W.J. and Gross, E.S. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume. *Estuaries and Coasts*. Online DOI 10,1007/s12237-008-9124-x.
[3] Kimmerer *et al*. considered a wider range of months in their 2009 paper as compared to Jassby *et al.* 1995.
[4] Kimmer, W.J., MacWilliams, M.L., Gross, E.S. 2013. Variation of fish habitat and extent of the low-salinity zone with freshwater flow in the San Francisco Estuary. *San Francisco Estuary and Watershed Science*, 11(4). http://escholarship.org/uc/item/3pz7x1x8.
[5] The study evaluated Longfin Smelt, Delta Smelt, Northern Anchovy, Threadfin Shad, American Shad, and Striped Bass.
[6] Feyrer *et al.* 2011 did not find a relationship between abundance and salinity or outflow. Manly *et al*. 2015 evaluated Feyrer *et al.* and showed that salinity alone was not a good descriptor of Delta Smelt habitat and other factors, including geography, also had explanatory power that was indistinguishable from the power of salinity.
[7] Nobriga, M. L. Sommers, T.R., Feyrer, F., and Fleming, K. 2008. Long-term trends in summertime habitat suitability for Delta Smelt (*Hypomesus transpacificus*). 2008. *San Francisco Estuary and Watershed*, 6(1). http:scholarship.org/uc/item/5xd3q8tx.

> Phytoplankton primary production and specific growth rate in the LSZ did not change appreciably as flow decreased and X2 moved into central Suisun Bay through spring-summer of 2006-2007 (Kimmerer *et al.* 2002). Thus, the change in shape of the LSZ with its movement does not appear to result in substantial changes in phytoplankton production.

Therefore, increased flow and resulting change in shape of LSZ would also not be expected to enhance primary productivity in the occupied areas of Delta Smelt summer habitat.

2. Preliminary results from Newman's life cycle model (Lite) weakly support summer flow action with a high level of uncertainty.

Polansky *et al.*[8] have also investigated potential relationships between Delta Smelt survival and summer outflow (or X2). In an unpublished study, Polansky *et al.* used the Newman life cycle model (lite) to evaluate potential relationships between the fraction of Delta Smelt surviving in July-August and outflow (X2) in the same period. See Figures 1 and 2, below.

Figure 1

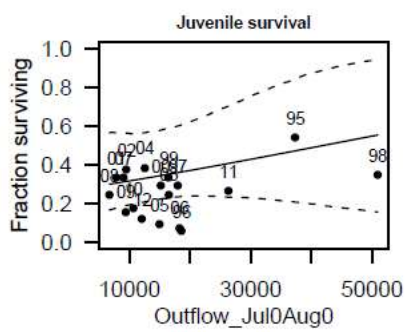
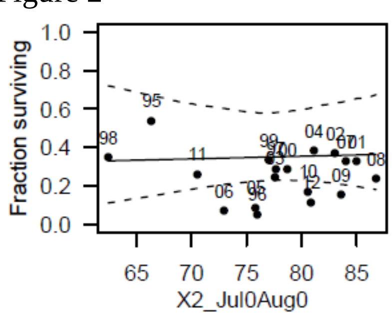


Figure 2



---

8 Polansky et al., *unpub*.

In Figure 1, the flows range from 10,000cfs to 50,000 cfs. The majority of points between 10,000-20,000 are clustered in a "cloud" and show no relationship between survival and flow, while points above 20,000 (i.e., 1995) appear to drive the "relationship." High summer flows at or above 20,000 cfs (July-August) cannot be provided by the SWP/CVP in dry and critically dry summers without draining reservoirs and significantly impacting salmon through depletion of cold water pool and other wildlife species that rely on refuge water supplies. The high summer outflow (i.e., above 20,000 cfs) years are the result of wet hydrology and not reservoir releases. Regardless, the range of uncertainty shown in Figure 1 at these high outflows is very wide, suggesting that Delta Smelt survival is just as likely to decrease as it is to increase at these higher summer outflows.

In Figure 2, the results show that moving X2 downstream in July/August would have no effect on Delta Smelt survival. Delta Smelt survival appears to be about the same regardless of whether X2 is at 85 km or at 65 km.

3. The results of the FWS' analyses are highly uncertain.

The FWS's introduction appears to reject correlation analysis in favor of life cycle models. (FWS at p.1.) Metropolitan agrees that life cycle models (or models that consider prior life stage) are very useful tools. The FWS's analysis should have identified the published Delta Smelt life cycle models and multivariate models that do consider prior life stage, which include Thomson *et al.* 2010,[9] MacNally *et al.* 2010,[10] Rose *et al.* 2013,[11] Maunder and Deriso 2011,[12] and Miller *et al.* 2012.[13] Coincidentally, none of these papers identified Delta outflow as important to Delta Smelt abundance.

At pp. 1-2, the FWS introduction proceeds to cite a list of papers and then concludes that there is a substantial body of work on Delta Smelt. It is unclear if these are the papers that the FWS intends to reject, which would not be appropriate, as some of the cited work includes models that

[9] Thomson, J., Kimmerer, W., Brown, L., Newman, K., MacNally, R., Bennett, W., Feyrer, F., Fleishman, E. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. *Ecological Applications*, 20(5), p. 1431-1448.

[10] MaNally, R., Thomson, J., Kimmerer, W., Feyrer, F., Newman, K., Sih, A., Bennett, W., Brown, L., Fleishman, E., Culberson, S., Castillo, G. 2010. Analysis of pelagic decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). *Ecological Applications*, 20(5), pp. 1417-1430.

[11] Rose, K., Kimmerer, W., Edwards, K., Bennett, W. 2013. Individual-based modeling of delta smelt population dynamics in the upper San Francisco Estuary: II. Alternative baselines and good versus bad years. Transactions of the American Fisheries Society, 142:5. 1260-1272

[12] Maunder, M. and Deriso, R. 2011. A state-space multistage life cycle model to evaluate population impacts in the presence of density dependence illustrated with application to delta smelt (Hyposmesus transpacifics). *Can. J. Fish. Aquat*. Sci. 68: 1285-1306.

[13] Miller, W. Manly, B., Murphy, D., Fullerton, D., Ramey, R. 2012. An investigation of factors affecting the decline of delta smelt (*Hypomesus transpacificus*) in the Sacramento- San Joaquin Estuary. *Reviews in Fisheries Science*, 20:1, 1-19.

consider prior life stage.

If the FWS intends to reject all correlation analyses that do not consider prior life stage, it would be rejecting (from the cited list) the following: Jassby *et al.* 1995,[14] Kimmerer 2002,[15] Kimmerer et al. 2009.[16] None of these papers identified a relationship between Delta Smelt FMWT abundance and X2.[17] However, all of these papers did find a relationship between Longfin Smelt FMWT abundance and X2. So if the FWS no longer finds simple correlation analysis as the best available science, does that mean that the FWS is not going to rely on these papers on regulatory issues related to Longfin Smelt? Metropolitan does not believe the FWS can justify relying on the conclusions in these papers as they relate to Longfin Smelt but not Delta Smelt.

The FWS biologists have provided a preliminary analysis of the potential effect of additional summer flows on Delta Smelt population growth, as shown in Figures 3 and 4.[18] Based on these figures, the FWS states at p. 2 that:

> We find that increasing outflows through the San Francisco Bay-Delta increases the likelihood of Delta Smelt, as fish that lives only one year, surviving to propagate the species. The results of both tests provided very strong statistical support of the null hypothesis.

Metropolitan strongly disagrees with this statement. The analyses presented in Figures 3 and 4 are highly uncertain. For example, it appears that FWS adopted a linear model on what appears to be binomial data, which makes it difficult to determine how to interpret Figure 4. It also appears that FWS interprets month as a factor while the underlying analysis actually uses a continuous variable. Metropolitan would like to recreate the FWS' analysis to make sure we understand the approach, but the FWS has not provided the data. It appears that the FWS aggregated the data and cleaned it in ways that cannot be determined based on the available information. Even without that information, however, the figures do not strongly support the FWS's summer action.

---

[14] Jassby, A.D., Kimmerer, W., Monismith, S.G., Armor, C., Cloern, J.E., Powell, T.M., Schubel, J.R., Vendlinski, T.J. 1995. Isohaline position as a habitat indicator for estuarine populations. *Ecological Applications,* 5(1), p. 272-289.

[15] Kimmerer, W. 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages. *Mar. Prog. Ser*., Vol. 243, p. 39-55.

[16] Kimmerer, W., Gross, E.S., MacWilliams, M.L. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? *Estuaries and Coasts,* 32:375-389.

[17] The list of literature provided in the FWS' analysis document is incomplete, making the purpose of the list unclear. A couple of the citations, like Bennett 2005, do not include a statistical analysis, being rather a description of a conceptual model. There are also notable citations missing from the list.

[18] FWS unpub., *Why flow is a necessary element of Delta Smelt habitat*.

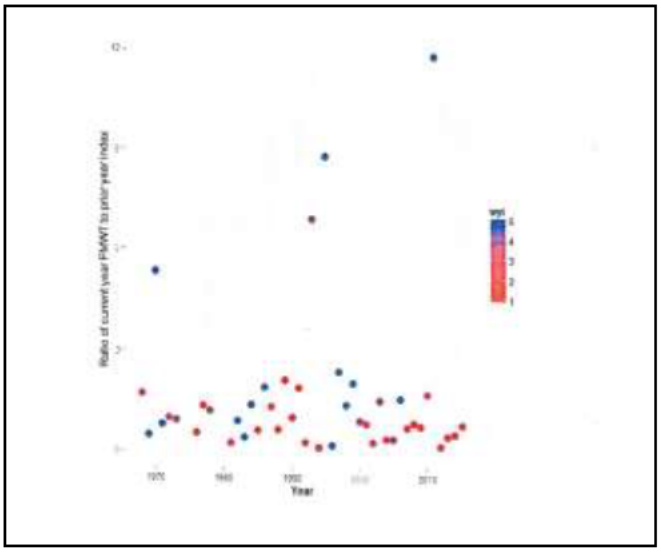


Figure 3. Ratio of current year FMWT to prior year index from 1970 to after 2010.

Figure 3, which plots Delta Smelt population abundance (as measured by the FMWT) against water year type, shows that Delta Smelt abundance has a widely variable response to flow. There is no statistically significant relationship between flow (as represented by water year type) and Delta Smelt abundance. Figure 3 is weak evidence.

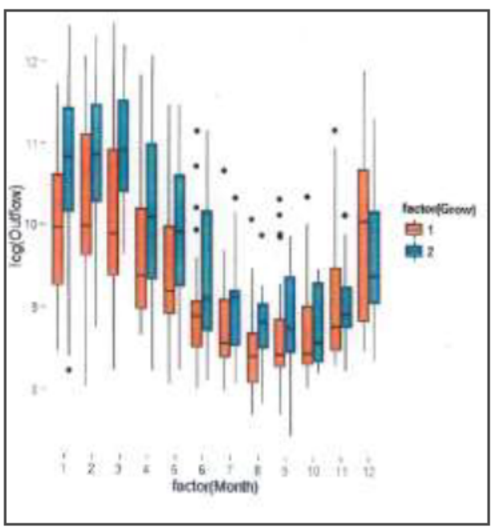


Figure 4. Median and range of log outflow by month for years with an increase in abundance from one year to the next in blue and a decrease in abundance in red based on the FMWT.

Figure 4 shows the median and range of monthly outflows on a log scale for years with increased, compared to years with decreased, Delta Smelt abundance relative to the prior year's index. However, there is enormous variability in the outflows, even greater than what is shown in the figure due to the log scale; and in almost all months the outflow ranges for positive and negative population growth overlap, indicating that population growth could both increase and decrease over the same range of outflows.

In addition, the analysis underlying Figure 4 removes significant detail from the survey results, including the relative change in population growth. The FWS method aggregates many years of data into a single flow range and consolidates survival data into a single increase/decrease variable. In Figures 5-8, the flow-survival ratio data is disaggregated by month (June – September). When the data is disaggregated, it is clear that the relationship with flow is weak and potentially confounded by the aggregation methodology.

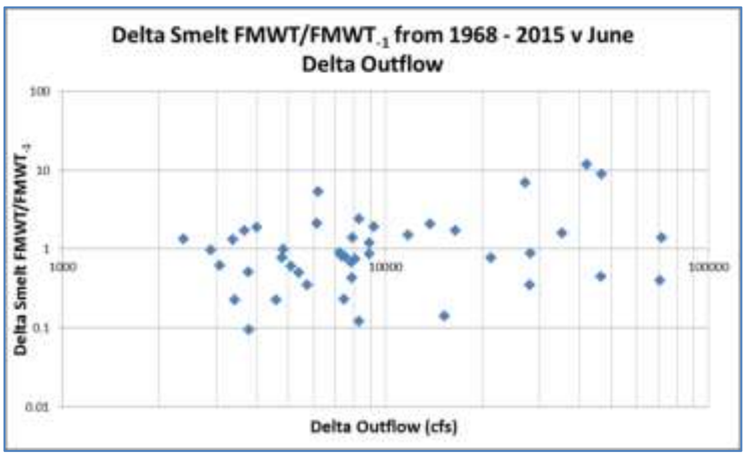


Figure 5. Ratio of Delta Smelt FMWT/FMWT (1968-2015) to June outflow.

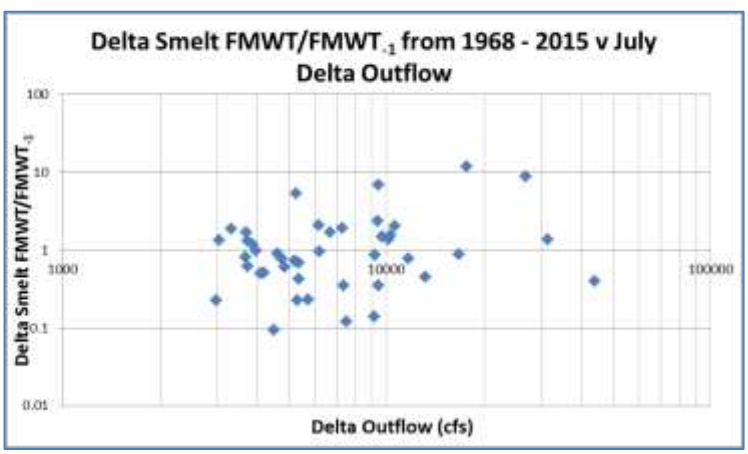


Figure 6. Ratio of Delta Smelt FMWT/FMWT (1968-2015) to July outflow.

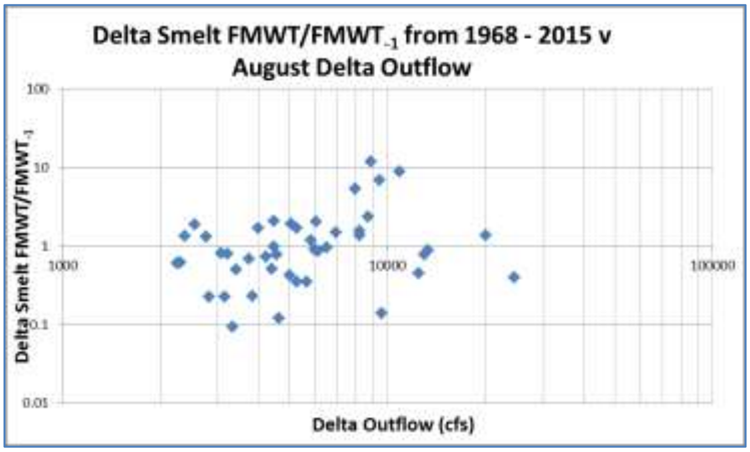


Figure 7. Ratio of Delta Smelt FMWT/FMWT (1968-2015) to August outflow.

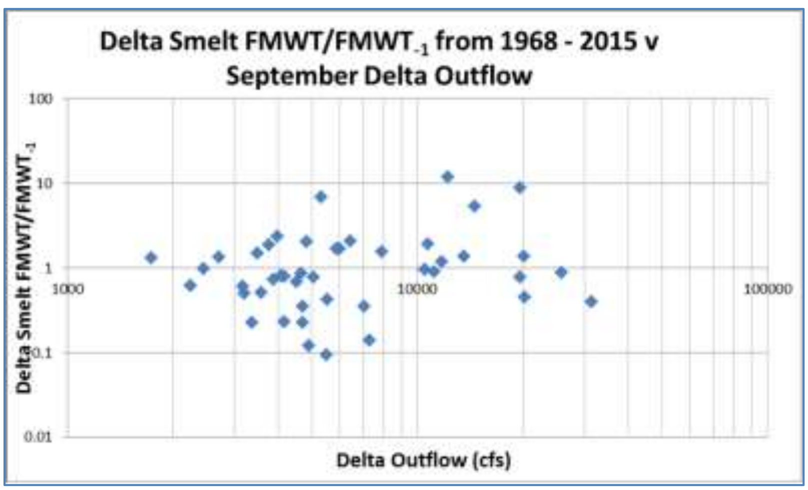


Figure 8. Ratio of Delta Smelt FMWT/FMWT (1968-2015) to September outflow.

Our review suggests that the FWS' preliminary analysis does not support the use of summer outflow to increase Delta Smelt population growth.

4. The results of DFW's analysis are highly uncertain.

The DFW also provided an analysis of the proposed summer flow action. (DFW, unpub.)[19] Metropolitan appreciates DFW's inclusion of the conceptual model from the MAST report; and while only providing a high level description, it does provide some context for the proposed summer action. Metropolitan also appreciates the DFW's initial thoughts regarding factors that should be included in a monitoring program. However, Metropolitan disagrees with DFW's analysis and interpretation of the data.

In DFW's Figure 4, it analyzes the ratio of FMWT/STN and outflow by month July-September for the years 2002-2014. DFW admits this observed relationship does not exist for years prior to 2002 and we do not believe that DFW has sufficiently justified ignoring all data prior to 2002. We also do not believe these figures support the idea that new outflow can be added in summer to recreate a wet water year. The relationship shown in Figure 4 ignores the significant correlations with prior month's flows on subsequent flow and conflates potentially significant effects prior to the summer months on Delta Smelt survival. Wet years may create favorable conditions for Delta Smelt in a wide variety of ways, including higher sediment and organic loading, higher turbidity, and lower air temperatures. Wet years are also associated with higher summer flows. DFW has not established causality between artificial flows originating from reservoir releases in the summer/fall and increased Delta Smelt survival. DFW would have to establish a mechanism directly related to flow, regardless of source.

Metropolitan is not convinced there is a summer flow-survival relationship, however. DFW's observed relationship degrades when different ratios are considered, particularly those involving the SKT and 20 mm rather than the STN. As observed on p. 1 of the FWS' analysis, the SKT and 20 mm are considered by the FWS to represent the best available scientific evidence. When different ratios are considered, including those including the SKT and 20 mm, the observed relationship degrades. See Figures 9-17.[20]

[19] DFW, unpub., CDFW rationale for summer Delta flow augmentation for improving Delta Smelt survival.

[20] DFW provided an analysis for each month however the results are the same if the relationship is evaluated for the range of months July-September. In an attempt to maintain a manageable number of figures, we have considered the ratios using the range of months July-September.

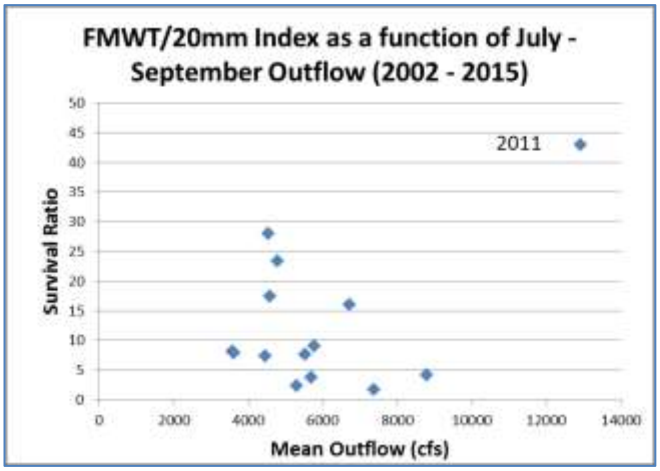


Figure 9. FMWT/20mm index as a function of July-September outflow (2002-2015)

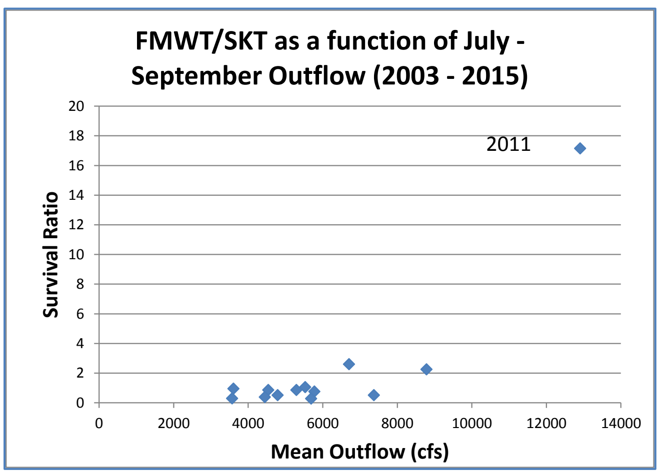


Figure 10. FMWT/SKT as a function of July-September outflow (2003-2015)

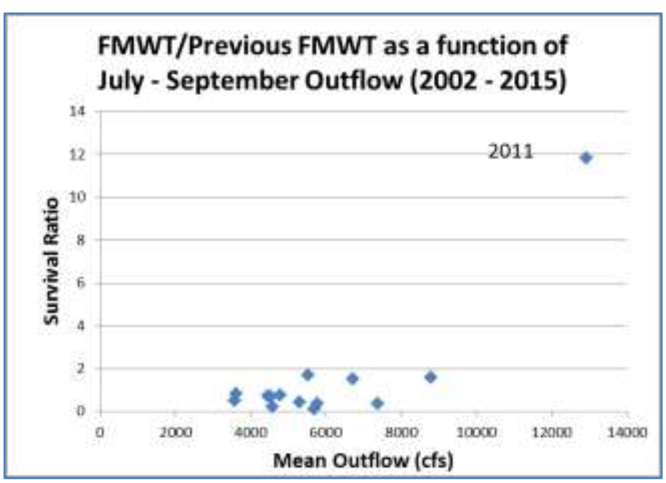


Figure 11. FMWT/Previous FMWT as a function of July-September outflow (2002-2015)

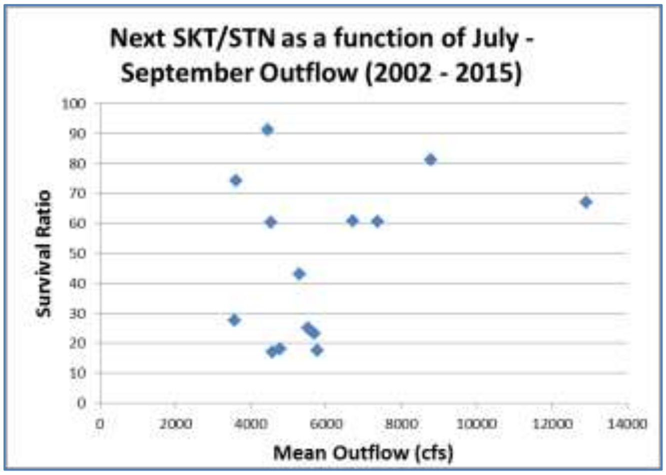


Figure 12. Next SKT/STN as a function of July-September outflow (2002-2015)

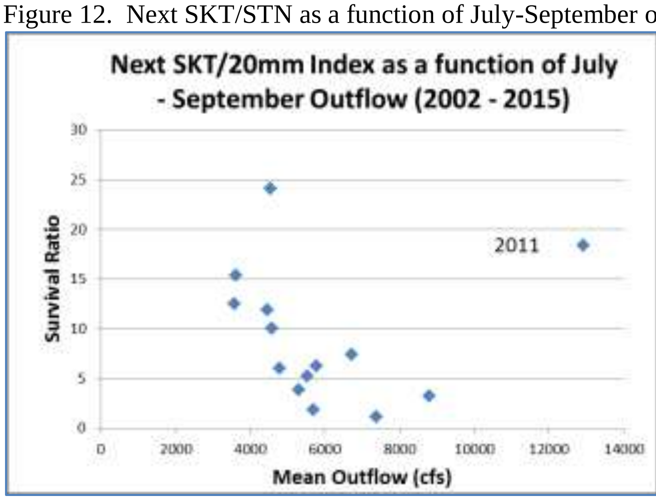


Figure 13. Next SKT/20 mm Index as a function of July-September outflow (2002-2015)

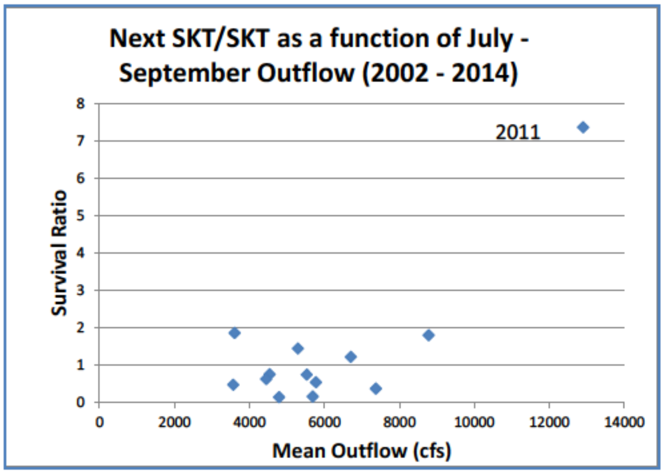


Figure 14. Next SKT/SKT as a function of July-September outflow (2002-2014)

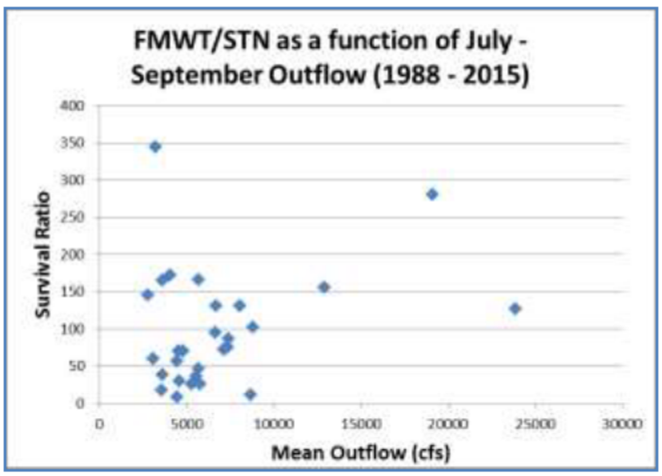


Figure 15. FMWT/STN as a function of July-September outflow (1998-2015)

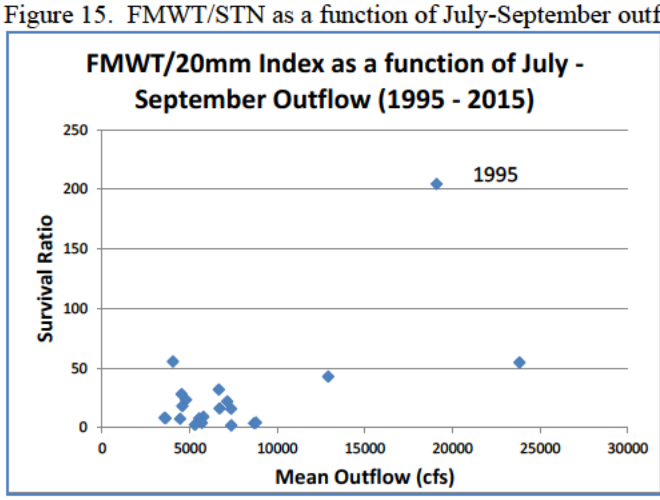


Figure 16. FMWT/20 mm Index as a function of July-September outflow (1995-2015)

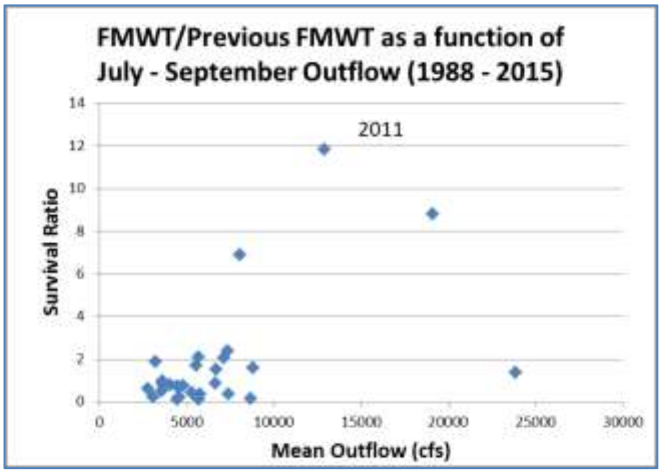


Figure 17. FMWT/Previous FMWT as a function of July-September Outflow (1998-2015)

Since DFW's observed relationship disappears when different surveys and different data ranges are considered, Metropolitan believes that DFW's observed relationship in DFW Figure 4 is spurious, particularly without an established biological mechanism to explain the relationship.

DFW's Figure 3 is the analytical approach that FWS cautioned against in its analysis at p. 1. Most scientists are relying more heavily upon survival ratios and stock recruitment ratios rather than simple plots of abundance versus environmental variables. This approach is associated with an inherent risk of correlation by random chance. Moreover, the assumed relationships in Figures 3 and 4 are somewhat incompatible, as Figure 3 assumes that overall abundance is related to only summer flow, while Figure 4 purports to show that flow impacts survival from spring (or some other reference point) to fall. It seems implausible that both could be true.

If we ignore the likelihood that this relationship in DFW Figure 3 is spurious, we still have no reason to believe that the relationship is causal. At best, the correlation may suggest that Delta Smelt abundance increases in some wet years. Using the same approach as in DFW Figure 3, we can create correlations with a number of factors influenced by wet hydrology. See e.g., Figures 18-19. Any one of these or other wet year variables could be responsible for any relationship that exists. It is highly improbable that summer reservoir releases could recreate the causal factors that might link some wet years to improved abundance.

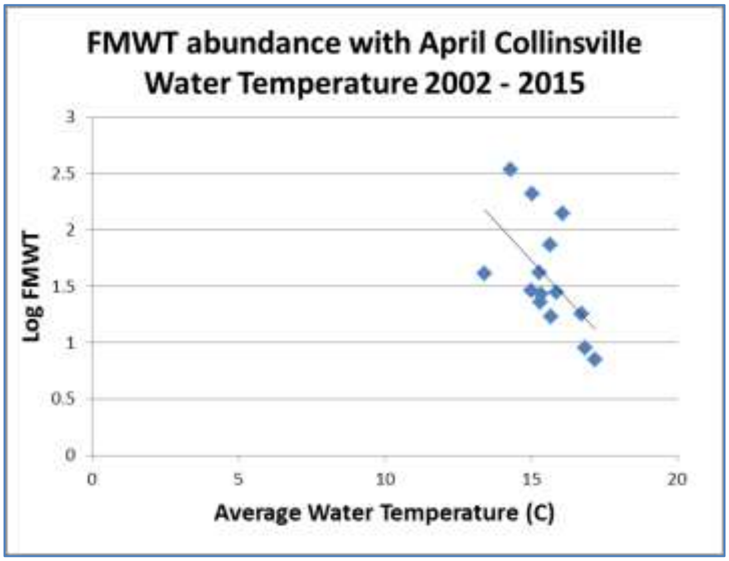


Figure 18. FMWT abundance with April Collinsville water temperature (2002-2015)

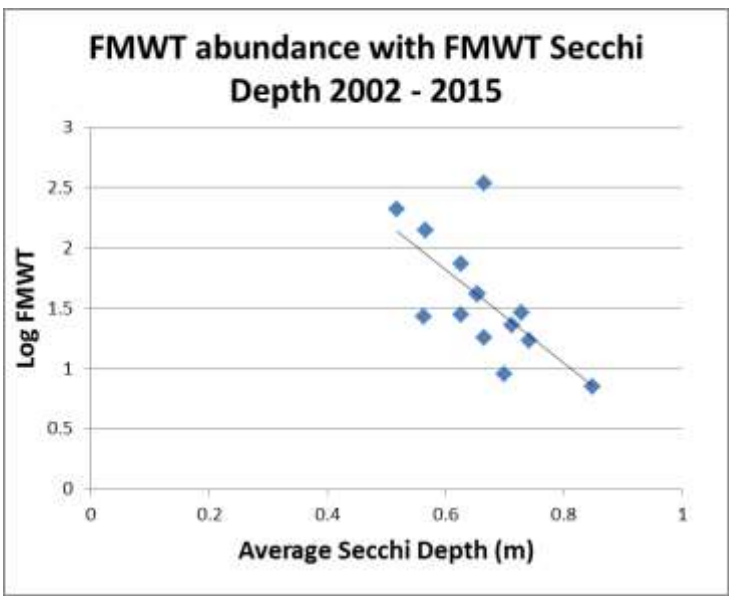


Figure 19. FMWT abundance with FMWT secchi depth (2002-2015)

B. It is unlikely that a change in summer outflow (X2) would redistribute Delta Smelt downstream; but even if it did, Delta Smelt would move into the bad Suisun Bay habitat, potentially harming the species.

The FWS and DFW proposal is at least partly based on the idea that by moving X2 to the confluence, Delta Smelt will redistribute themselves downstream to Suisun Marsh, or at least have access to habitat that overlaps improved habitat conditions as detailed in Bever *et al.* (2016).[21]

By finding environmental factors that explain species presence/absence, it should be possible to identify the environmental factors that, if changed, would affect the distribution of the species. The idea that Delta Smelt distribute themselves in relation to X2 was examined by Manly *et al*. 2015,[22] which tested the definition of Delta Smelt abiotic habitat originally described in Feyrer *et al.* 2011.[23] Feyrer *et al*. tested the extent that multiple abiotic factors, specifically salinity, turbidity, and temperature, could explain the distribution or presence/absence of Delta Smelt. Manly *et al.* 2015 reanalyzed Feyrer *et al.'s* statistical approach, corrected errors, and recalculated the explanatory power of salinity and turbidity, as well as physical location (region). Their results show that it is unclear whether salinity or geography is more important in determining Delta Smelt distribution.

Nobriga *et al*. 2008[24] did find that Delta Smelt presence in Suisun Marsh varied with salinity, with higher catch in the STN when Suisun Marsh was fresher. As Nobriga *et al.* also noted, however, these findings are consistent with relationships that exist in spring and early-summer, where catch in Suisun Marsh is also higher when the Marsh is fresher. Nobriga *et al.'s* results may just mean that the Delta Smelt that hatched in the Marsh in higher spring outflow years stayed in the Marsh throughout the summer. Their results do not necessarily show that Delta Smelt can be drawn to the Marsh by manipulating flow (salinity).

Even if manipulating the location of X2 could be used to successfully redistribute Delta Smelt downstream, this could harm Delta Smelt survival and fecundity, because Delta Smelt would be at least as likely to go into Suisun Bay, which is less desirable habitat than where the Delta Smelt would otherwise reside in the lower Sacramento River. Figures 20-22 show that when summer Delta Smelt catch is higher in Suisun Marsh, it is also higher in Suisun Bay (eastern stations). In

[21] Bever, A. J., MacWilliams, M.L., Herbold, B., Brown, L., Feyrer, F.V. 2016. Linking hydrodynamic complexity to Delta Smelt (*Hypomesus transpacificus*) distribution in the San Francisco Estuary, *San Francisco Estuary and Watershed Science*, 14(1).

[22] Manly, B.F.J. Fullerton, D., Hendrix, A.N. and Burnham, K.P. 2015. Comments on Feyrer et al's "modeling the effects of future outflow on the abiotic habitat of an imperiled estuarine fish. *Estuaries and Coasts*, 37(6). DOI 10.1007/s12237-014-9905-3.

[23] Feyrer, F., Newman, K., Nobriga, M. 2011. Modeling the effects of future outflow on the abiotic habitat of an imperiled estuarine fish. *Estuaries and Coasts*. DOI 10.1007/s12237-010-9343-9.

[24] Nobriga, M.L., Sommer, T.R., Feyrer, F., Fleming, K. 2008. Long-term trends in summertime habitat suitability for Delta Smelt (Hypomesus transpacificus), *San Francisco Estuary and Watershed Science*. 6:1.

Figures 20-22, the red lines indicate catch in Suisun Bay and the blue lines indicate catch in Suisun Marsh. The differences between the red and blue lines represent the relative difference in catch between the two regions. Figures 20-22 do not account for the difference in the volume of water sampled in Suisun Bay as compared to Suisun Marsh, so the number of Delta Smelt in Suisun Bay, and the relative difference between the two regions, is likely even larger than the figures suggest.

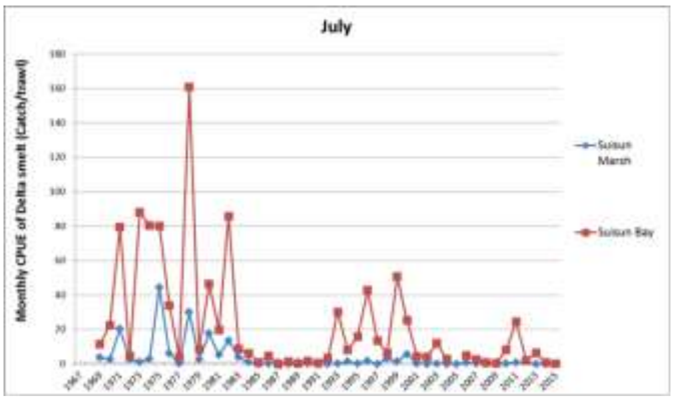


Figure 20. Monthly CPUE of Delta Smelt catch in Suisun Bay and Marsh, July, 1967-2015.

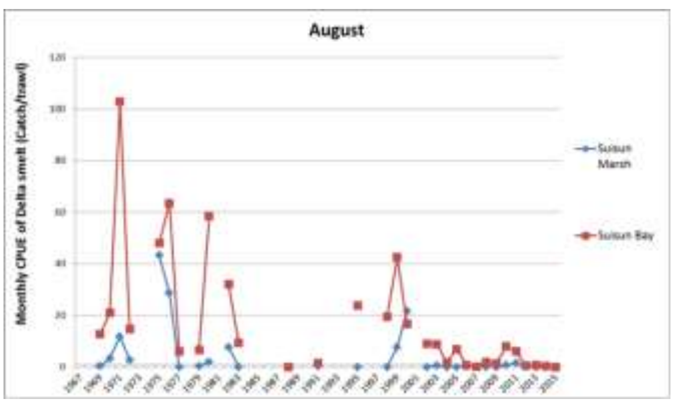


Figure 21. Monthly CPUE of Delta Smelt catch in Suisun Bay and Marsh, August, 1967-2015.

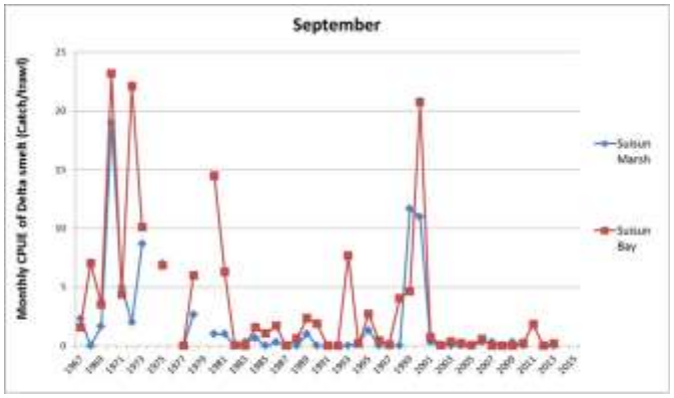


Figure 22. Monthly CPUE of Delta Smelt catch in Suisun Bay and Marsh, September 1967-2015.

The likelihood that Delta Smelt moving downstream would go into Suisun Bay rather than Suisun Marsh is relevant because, as described below, researchers have found that Suisun Bay may have poorer food quality and quantity, and Delta Smelt caught in this region often have poor body condition, including poor nutrition and growth indices, and lesions that may indicate exposure to contaminants.

C. If Delta smelt are moved downstream, species survival and fecundity could be effected negatively.

Evidence suggests that Suisun Bay may be poorer quality habitat than the lower Sacramento River. If the summer flow action successfully moves Delta Smelt downstream, a large portion of the Delta Smelt in the lower Sacramento River may be expected to end up in Suisun Bay, thereby exposing them to poorer habitat conditions than they would have otherwise experienced if they stayed upstream.

The Interagency Ecological Program's synthesis of 2005 work to evaluate the pelagic organism decline (POD) includes investigations of the so-called "bad" Suisun Bay hypothesis.[25] The 2005 POD synthesis report cited multiple lines of evidence supporting the hypothesis that Suisun Bay was bad Delta Smelt habitat. For example:

- Dr. Swee Teh (UC Davis) completed a health assessment of Delta Smelt caught in 2005.[26] There was no evidence of food limitation except for the Delta Smelt

[25] Armor, C., Baxter, R., Bennett, B., Breuer, R., Chotkowski, M., Coulston, P., Denton, D., Herbold, B., Kimmerer, W., Larsen, K., Nobriga, M., Rose, K., Sommer, T., Stacey, M. 2005. Interagency Ecological Program Synthesis of 2005 Work to Evaluate the Pelagic Organism Decline (POD) in the Upper San Francisco Estuary (2005 POD Synthesis Report).

[26] Teh, S. 2007. Title: Pilot study of the health status of 2005 adult delta smelt in the upper San Francisco estuary, Final report of histopathological evaluation of Starvation and/or toxic effects on pelagic fishes, prepared for the California Department of Fish and Game.

collected in the Deepwater Ship Channel. Delta Smelt caught in Suisun Bay ranked low in the health assessment, having one of the highest lesion scores, indicating contaminant stress. The other areas where contaminants appeared to be a concern included Suisun Marsh and the south Delta.

- Dr. Bill Bennett (UC Davis) analyzed Delta Smelt otolith from 1999 and 2004 and he found that residual Delta Smelt growth was poorer in Delta Smelt caught downstream of the confluence and in Suisun Bay.[27]

The "bad" Suisun Bay hypothesis has not been rejected and more recent evidence provides further support. Hammock *et al* 2015[28] evaluated the relative health of Delta Smelt in Suisun Bay, Suisun Marsh, the confluence, Cache Slough, and the Sacramento Deepwater Ship Channel in 2012 and 2013. In those two water years, Delta Smelt in Suisun Bay were in the poorest condition, exhibiting evidence of contaminant exposure and food limitation. See Figure 23, below.

[27] 2005 POD Synthesis Report, see full citation above.
[28] Hammock, B.G., Hobbs, J.A., Slater, S.B., Acuna, S., Teh, S. 2015. Contaminant and food limitation stress in an endangered fish. *Science of the Total Environment*, 532(316-326).

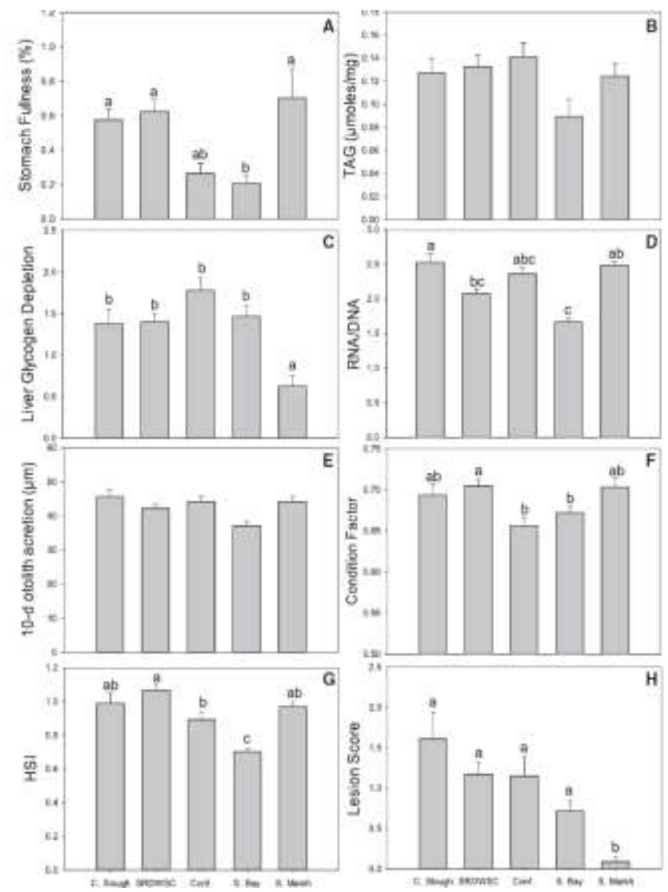


Figure 23. Hammock et al. 2015, Figure 2.

Hammock *et al*. concluded that the observed nutritional stress of Delta Smelt in Suisun Bay could be contributing to the decline of Delta Smelt, as poor nutrition in juvenile fish leads to slower growth and slow growth is often tightly correlated with lower survival of juvenile fish and lower adult abundance. Slower juvenile growth leads to fewer, smaller adults and lower fecundity and recruitment. In contrast, Delta Smelt caught in Suisun Marsh, and upstream habitats, were in relatively good nutritional, growth, and morphometric status.

These results suggest that Suisun Bay, and potentially other downstream habitats, are poor habitat, being food limited with elevated contaminant levels. The FWS and DFW should not be trying to redistribute Delta Smelt downstream.

D. Summer habitat in Suisun Marsh is comparable to the lower Sacramento River.

The proposed summer flow action is at least partially intended to redistribute Delta Smelt out of the lower Sacramento River and into Suisun Marsh, but research and data suggests that Delta Smelt would be equally or better protected if they stayed in the lower Sacramento River.

The available evidence suggests that habitat conditions in the lower Sacramento River and Suisun Marsh are similar. Several relevant factors for assessing habitat quality include temperature, turbidity, salinity, and prey availability.[29] A comparison of these habitat conditions in the lower Sacramento River and in Suisun Marsh shows that the quality of the habitat in the two regions is comparable.

1. Summer water temperatures in the lower Sacramento River are similar to, or cooler than, Suisun Marsh.

Water temperatures in Suisun Bay, Suisun Marsh, and in the lower Sacramento River are within the species' tolerance from July-September. Figure 24 shows water temperatures in July. The Suisun Marsh water temperatures are generally the highest, meaning that Delta Smelt in Suisun Marsh are at the greatest risk for temperature stress. The next highest temperatures are in the lower Sacramento River. The lowest temperatures are in Suisun Bay.

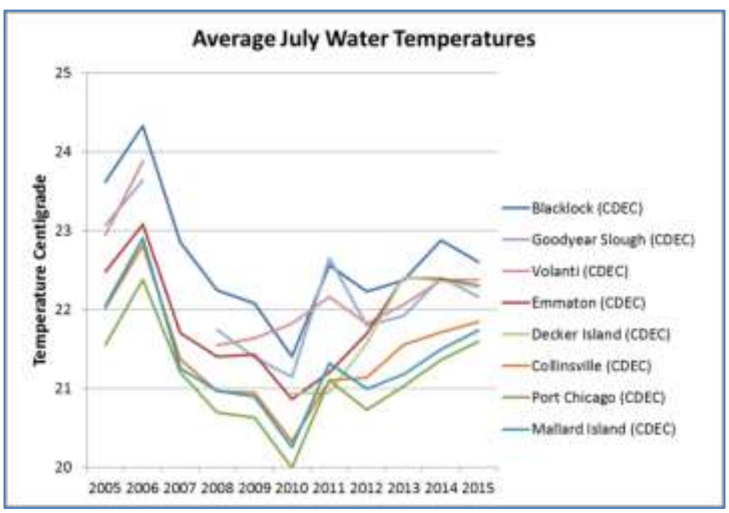


Figure 24. Temperature by region from 2005-2015 in July. Suisun Bay stations include Port Chicago and Mallard Island. Suisun Marsh stations include Blacklock, Goodyear, and Volanti. The lower Sacramento stations include

[29] There is insufficient available data to evaluate background contaminant levels so contaminants cannot be included in this assessment. We acknowledge that this list of abiotic variables does not represent a complete definition of Delta Smelt habitat.

Decker, Emmaton, and Collinsville.

In August, the same general pattern prevails, though temperatures at Emmaton and Decker Island are more comparable to Suisun Marsh in this month. Figure 25 shows average water temperatures in August.

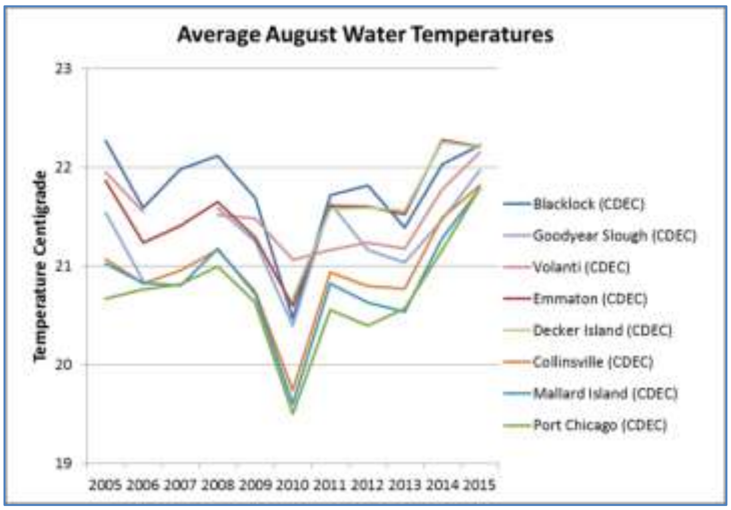


Figure 25. Temperature by region from 2005-2015 in August. Suisun Bay stations include Port Chicago and Mallard Island. Suisun Marsh stations include Blacklock, Goodyear, and Volanti. The lower Sacramento stations include Decker, Emmaton, and Collinsville.

In September, Suisun Marsh is arguably the warmest region, although still well within the Delta Smelt's temperature tolerance. Temperatures are generally dropping in all regions by this month.

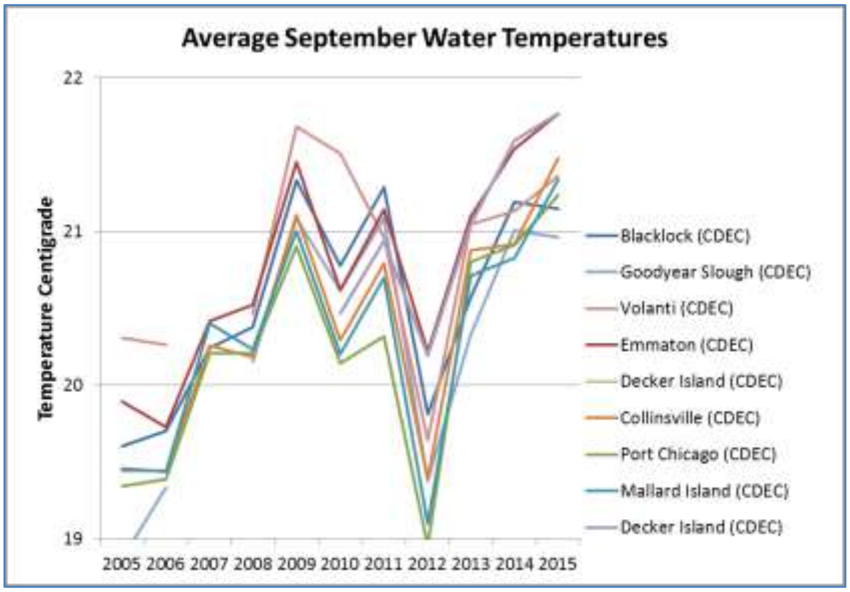


Figure 26. Temperature by region from 2005-2015 in September. Suisun Bay stations include Port Chicago and Mallard Island. Suisun Marsh stations include Blacklock, Goodyear, and Volanti. The lower Sacramento stations include Decker, Emmaton, and Collinsville.

Additional summer flows would not affect water temperatures in the lower Sacramento River, Suisun Bay or Suisun Marsh, as water temperatures during summer in the lower Sacramento and downstream are largely driven my air temperatures (Cloern *et al.* 2011[30], Wagner et al. 2011[31]).

2. Summer turbidity is good in the lower Sacramento River and Suisun Marsh.

Turbidity in the lower Sacramento River is within the species' tolerances from July-September. Turbidity in Suisun Marsh is higher than in the lower Sacramento River.

Figures 27-29 show recent turbidity in the lower Sacramento River and Suisun Marsh. Continuous turbidity data in the lower Sacramento River, Suisun Bay and Suisun Marsh is quite sparse so stations were selected based on available data. Figures 16-18 show data from the four most relevant turbidity monitoring stations for July-September. Rio Vista is in the upper Sacramento River. Few Delta Smelt are found near Rio Vista. The more relevant station for the

[30] Cloern J.E., N. Knowles, L.R. Brown, D. Cayan, M.D. Dettinger, T.L. Morgan, D.H. Schoellhamer, M.T. Stacey, M. van der Wegen, R.W. Wagner, and A.D. Jassby. 2011. Projected evolution of California's San Francisco Bay-Delta river system in a century of climate change. *PLoS ONE* 6(9).

[31] Wagner, R.W., M. Stacey, L.R. Brown, and M. Dettinger. 2011. Statistical models of temperature in the Sacramento–San Joaquin Delta under climate-change scenarios and ecological implications. *Estuaries and Coasts* 34:544–556.

lower Sacramento River is Decker Island. Mallard Island is near Pittsburg and may be representative of turbidity in the confluence and eastern Suisun Bay. Turbidity at Decker Island and Mallard Slough are comparable, and both are at acceptable levels for Delta Smelt in July and August, being significantly greater than 12 NTU. In September, in some years, both Decker Island and Mallard Island approach the lower end of the Delta Smelt turbidity tolerance range (around 12 NTU). Turbidity at Rush Ranch, which may represent Suisun Marsh, is significantly higher in all years and easily meets Delta Smelt turbidity requirements.

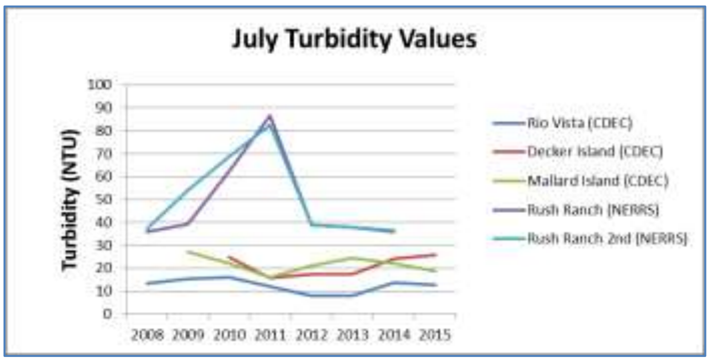


Figure 27. Turbidity by region, July (2008-2015).

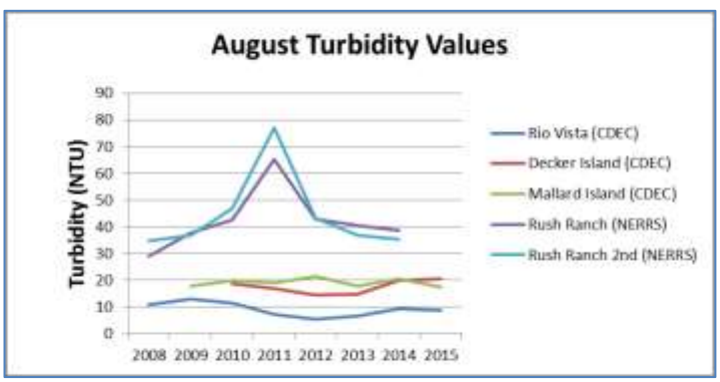


Figure 28. Turbidity by region, August (2008-2015).

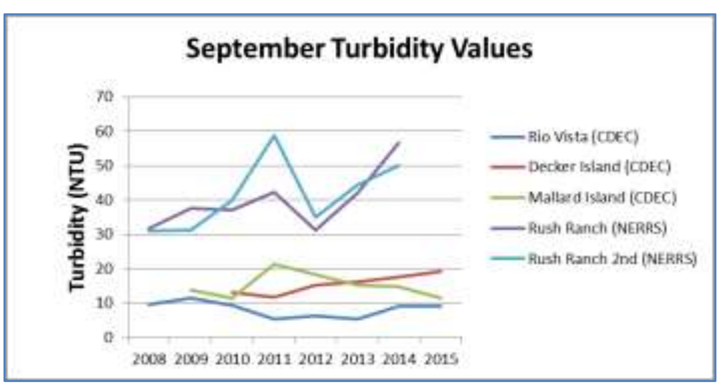


Figure 29. Turbidity by region, September (2008-2015).

New summer flows would not affect turbidity in the lower Sacramento, Suisun Bay, or Suisun Marsh as the new flow would not contain turbidity, primarily originating from reservoir releases.

3. Even without the proposed 2006 flow action, Suisun Marsh would be available to Delta Smelt as the low salinity zone would extend downstream of Chipps Island.

Suisun Marsh would likely be available to Delta Smelt in 2016 even if the proposed flow action was not implemented. Even without the proposed 2006 flow action, Delta Smelt would have access to Suisun Marsh, as low salinity habitat would likely extend downstream of Chipps Island (75 km).

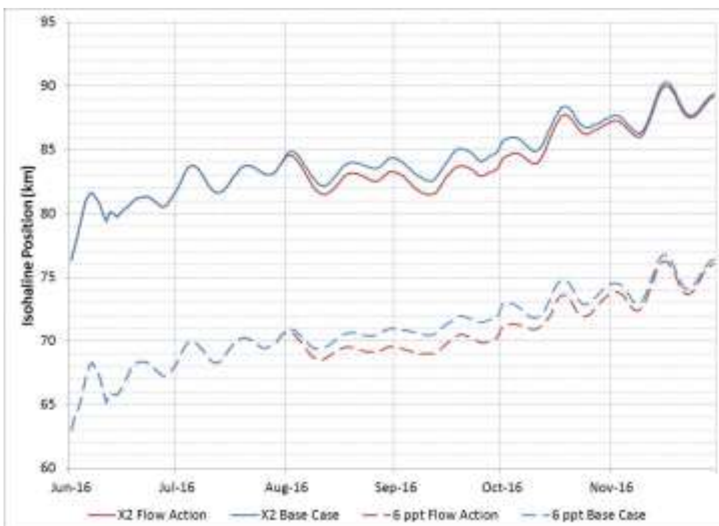


Figure 30. The forecasted position of the low salinity zone (km) from June through November, with and without the flow action, approximately bounded by X2 and the 6 ppt isolhaline. Collinsville is at 81 km. Chipps Island is at 75 km.

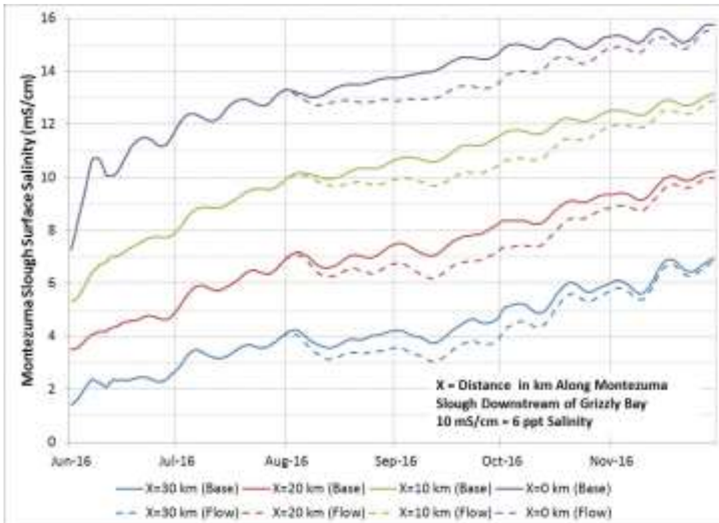


Figure 31. Forecasted salinity along Montezuma Slough from June through November 2016 with and without the flow action. Locations are geo-referenced in Figure 32.

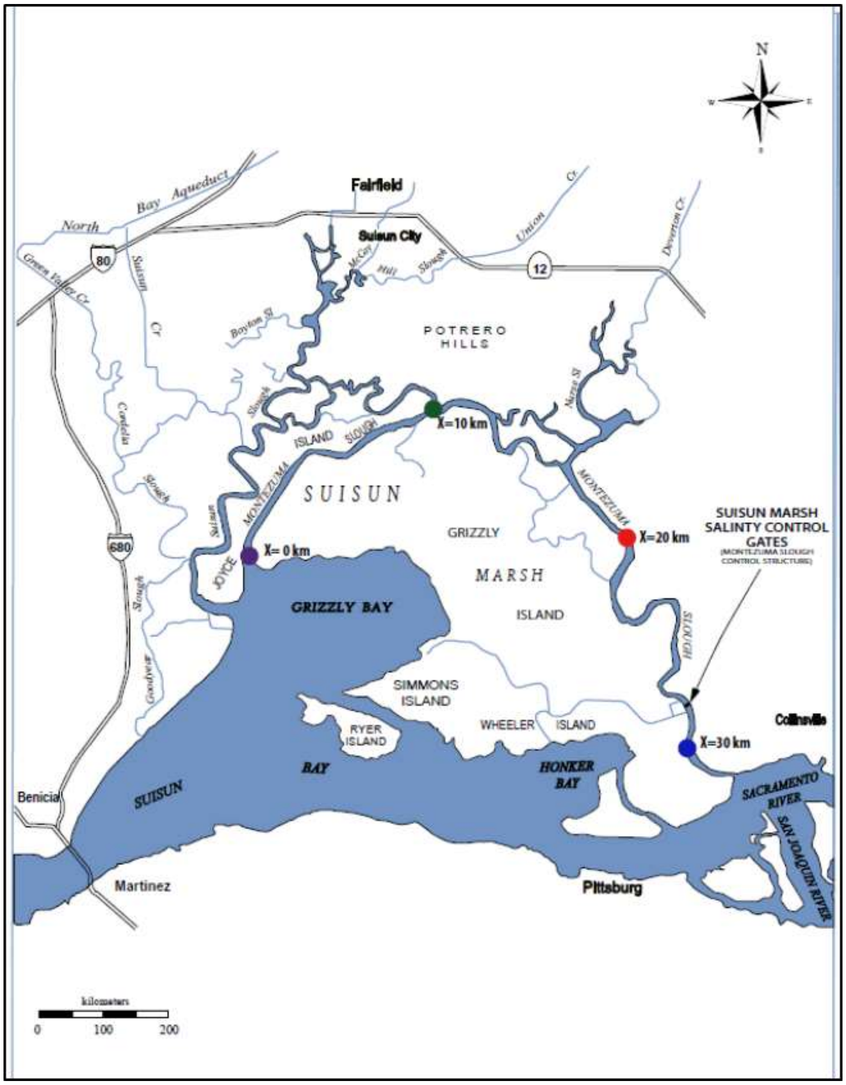


Figure 32. Map of Suisun Marsh with locations referenced in Figure 16 marked on Montezuma Slough.

As shown in Figure 30, even without the proposed summer flow action, low salinity habitat would likely extend to the mouth of Suisun Marsh and upstream (blue and red lines). As Figure 31 shows, the proposed 2016 flow action would only marginally decrease salinity in Suisun Marsh, increasing the available habitat by about a kilometer. A specific conductance of 10 mS/cm is approximately equivalent to 6 ppt. salinity, i.e., the upper range of the low salinity zone. See Map, Figure 32, showing location of salinity lines shown on Figure 31. However, even without any action this year, Delta Smelt would be expected to have access to Suisun Marsh habitat up to about 10 kilometers from the top of Montezuma Slough throughout the summer.

As explained in detail below, there are alternatives to the summer flow action, like a summer operation of the Suisun Marsh Salinity Gates, which would significantly improve salinity throughout Suisun Marsh, providing low salinity habitat as far downstream as Grizzly Bay throughout the summer and fall. See section II, below.

4. Food availability in the lower Sacramento River is good, sometimes better than in Suisun Marsh.

Food availability in Suisun Marsh and the lower Sacramento River is comparable, with the lower Sacramento River often having greater prey abundance. Suisun Bay has the lowest prey abundance.

The 2015 MAST report[32] contains an analysis of the diet contents by percent weight of prey items found in age-0 Delta Smelt stomachs collected during routine surveys in the freshwater (<1ppt) region of the Delta, excluding Cache Slough and the Sacramento Deepwater Ship Channel for 2005. See Figure 33, below.

[32] An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish (MAST Report). 2015. Report to the Interagency ecological Program, Management, Analysis, and Synthesis Team.

Figure 42. Percentage by weight of prey types found in stomachs of age-0 Delta Smelt collected from < 1 ppt during April through December in A) 2005, B) 2006, C) 2010, and D) 2011. Number of stomachs examined are shown above the columns. Mean fork length (mm) of Delta Smelt is also shown.

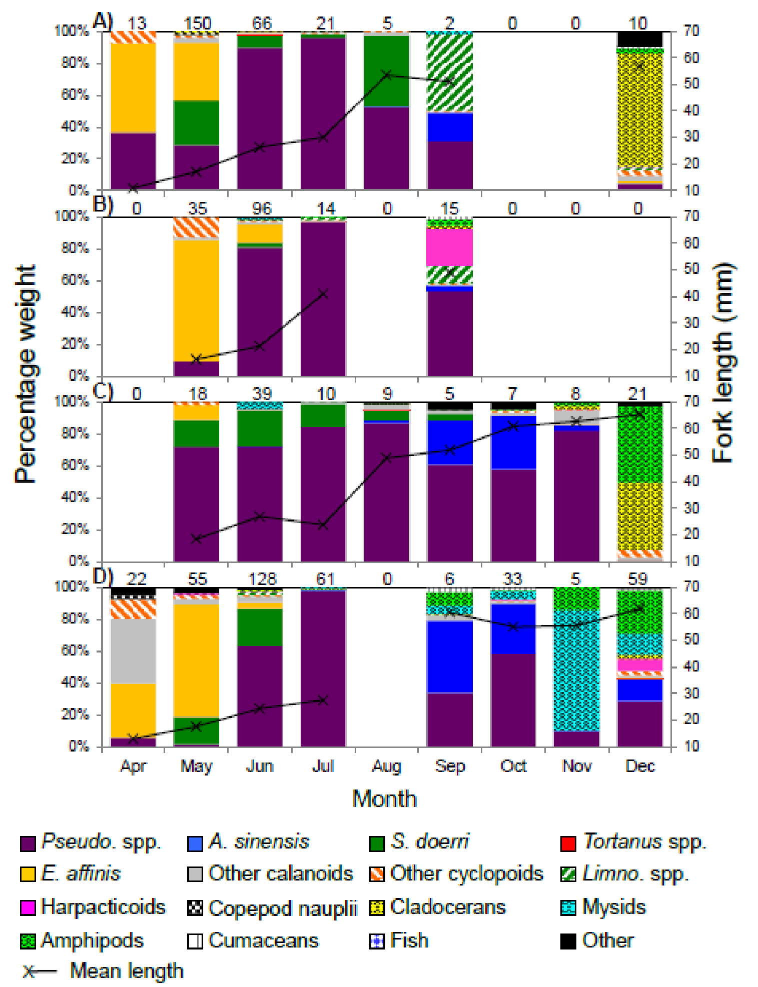


Figure 33. MAST Report (2015), Figure 42, p. 81, showing species abundance.

The 2015 MAST Report also contains an analysis of diet contents by percentage by weight of prey items found in stomachs of age-O Delta Smelt collected from the 1-6 ppt zone, April-December. See Figure 34, below.

Figure 41. **Percentage by weight of prey types found in stomachs of age-0 Delta Smelt collected from 1-6 ppt during April through December in A) 2005, B) 2006, C) 2010, and D) 2011. Number of stomachs examined are shown above the columns. Mean fork length (mm) of Delta Smelt is also shown.**

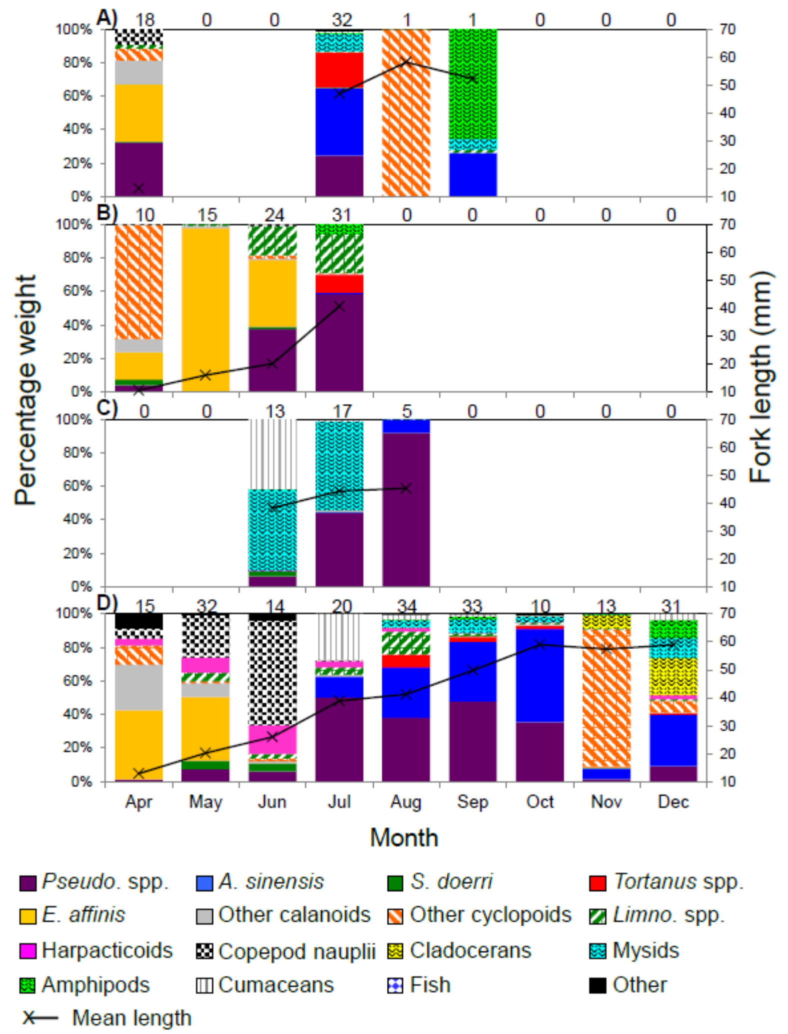


Figure 34. MAST Report (2015), Fig. 41, p. 80, showing species abundance.

Based on the MAST report results, Delta Smelt are predominantly consuming *Pseudo. Spp*., as well as *A. sinensis* and *S. doerri*, although to a lesser extent, in July-September. Delta Smelt may consume other species as well, but these three species appear fairly representative of the Delta Smelt's food supply during the summer.

As Figures 35-37 show, the lower Sacramento River (referred to as the west Delta in the figure) has the highest abundance of *S. doerri* and *A. sinensis*, with Suisun Marsh having the second highest average abundance for *S. doerri*. The lower Sacramento River has the highest average abundance of *P. forbesi* in August and September, and the second highest average abundance in July.

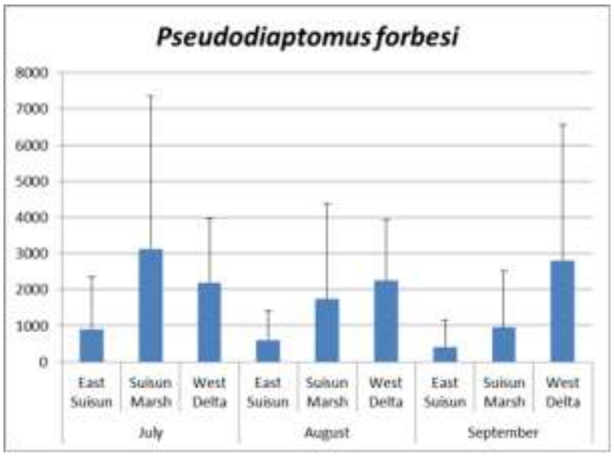


Figure 35. *P. forbesi* abundance by region, years (1994-2015)

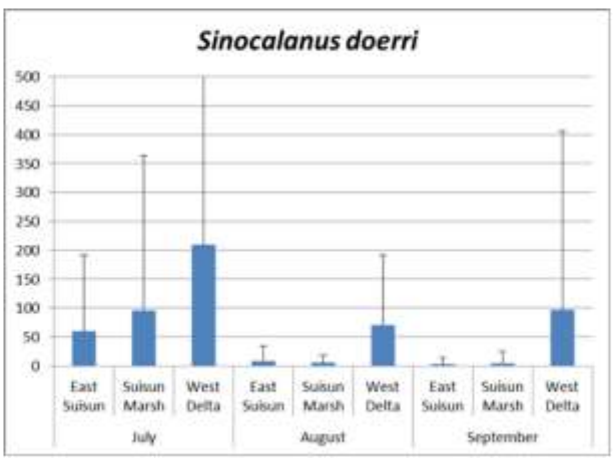


Figure 36. *S. doerri* abundance by region, years (1994-2015)

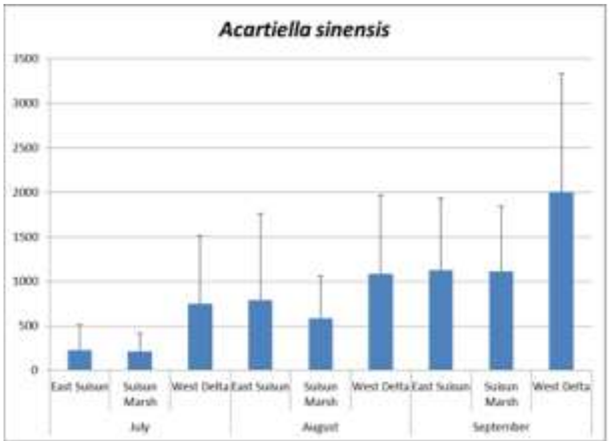


Figure 37. *A. sinensis* abundance by region, years (1994-2015)

As the food supply in the lower Sacramento River is generally similar to Suisun Marsh, Delta Smelt in the lower Sacramento River could be as well fed as those in Suisun Marsh.

The habitat in the lower Sacramento River is comparable to Suisun Marsh, which suggests that there is no benefit to moving Delta Smelt downstream.

II. The proposed summer flow action was developed without any vetting of the proposal with the scientific and stakeholder community, and without any discussion about alternatives to the proposed summer flow action that could be more effective and less costly.

The FWS and DFW should consider alternatives to the proposed summer flow action. One alternative that should be considered and further studied is the reoperation of the Suisun Marsh Salinity Control Gates. As Figure 38 shows, the Suisun Marsh Salinity Gates are highly effective at reducing salinity, and could be used to reduce the salinity in the majority of the marsh.[33]

[33] The DSM2 model was used in preparing this analysis. It is acknowledged that DSM2 is less able to accurately model salinity in Suisun Marsh as compared to other areas of the Delta.

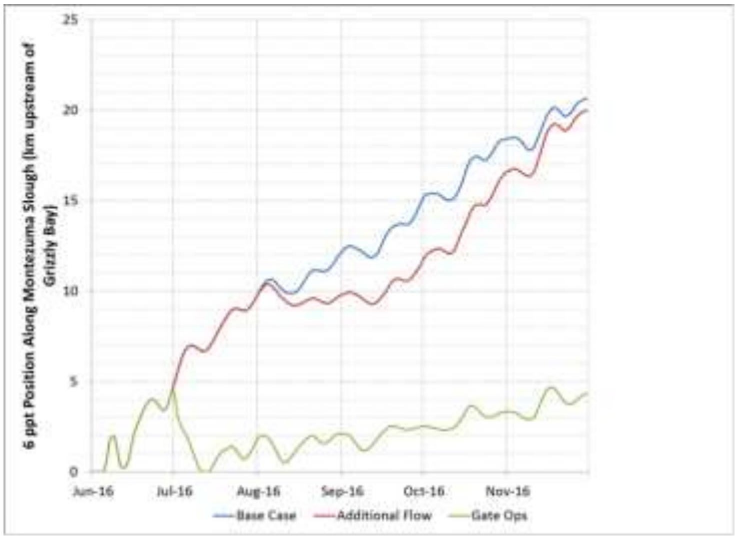


Figure 38. The forecasted position of the low salinity zone upper range (i.e. 6 ppt salinity) along Montezuma Slough, in km upstream from Grizzly Bay. A forecasted isohaline position is shown for the base condition (blue), the summer flow action (in red) and a scenario where the Suisun Marsh gates are operated (green).

In Figure 38, the y-axis is the modeled distance of the 6 ppt surface salinity isohaline upstream from Grizzly Bay (in km). Figure 38 shows that throughout July 2016, the majority of Suisun Marsh will be within the salinity range (6 ppt or fresher) that could be utilized by Delta Smelt. Figure 38 also shows that through the summer and fall, the extent of habitat within the optimal salinity range for the species progressively decreases. The difference between the blue and red lines in Figure 38 shows the forecasted change in salinity associated with the 2016 summer flow action, with the result being a small increase in available habitat as measured using the single variable of average monthly location of X2 as a proxy. This result should be compared to the change in salinity that could be achieved if the Suisun Marsh Salinity Gates were operated (difference between the blue and green lines). By operating the Suisun Marsh Salinity Gates, the majority of Suisun Marsh would have low salinity throughout the summer and fall.

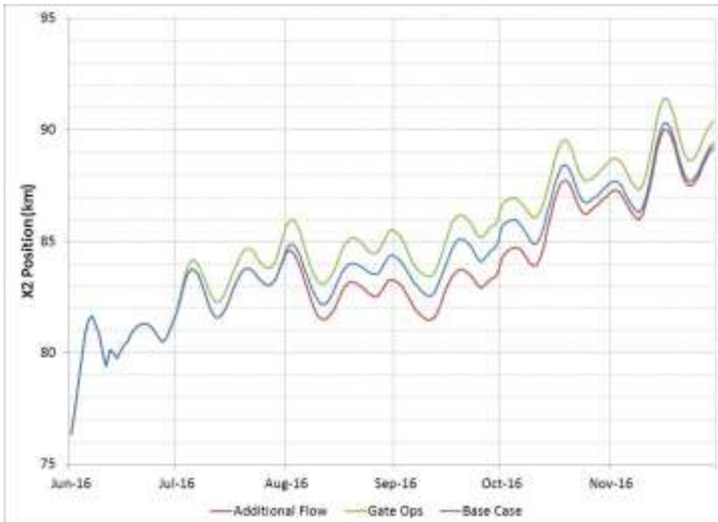


Figure 39. DSM2 runs for the location of X2 by month in 2016 using three scenarios: no action (base case), 2.) summer flow augmentation, and 3.) salinity control gate operation.

By operating the Suisun Marsh Salinity Gates, salinity may increase in lower Sacramento River. As the green line in Figure 39 shows, this alternative is forecasted to move X2 approximately 1 km upstream. However, this upstream effect could be mitigated (presuming mitigation is necessary) by operating the gates on a more intermittent basis (as the forecast in Figure 39 assumes a continuous operation), or by releasing sufficient flow to repel the effect. As the FWS and DFW is proposing 200,000 to 300,000 acre-feet of additional summer outflow in 2017/2018, operating the Suisun Marsh Salinity Gates as an alternative action in tandem with a modest flow release may provide a net water savings. Regardless, operating the Suisun Marsh Salinity Gates has the advantages of (1) being more effective than outflow in reducing salinity in Suisun Marsh (as illustrated in Figure 27); and, (2) containing salinity benefits to Suisun Marsh, thereby making it more likely that Delta Smelt could be kept out of the "bad" Suisun Bay habitat.

The reoperation of the Suisun Marsh Salinity Control Gates should be assessed in an adaptive management framework.

III. The proposed summer flow action is being implemented without a scientific framework of monitoring and hypothesis testing designed to determine whether the action did in fact provide any additional species benefits above baseline conditions.

The FWS and DFW have not adopted a monitoring and experimental framework. Without an experimental design, it will be impossible to determine the effectiveness of the summer flow action and managers will not have the information required for informed decision-making. At a minimum, the proposed summer flow action's monitoring plan should include a structured experimental framework covering critical habitat of Delta Smelt especially lower Sacramento

River, confluence, Suisun Bay, and Suisun Marsh. Modeling should be conducted to evaluate the action compared to no action and validate the model predictions. The framework should address how changes detected during the monitoring will result in detectable benefits. We agree with DFW that the current surveys will not have the detection limits needed for evaluating the effects of the action, but the Early Warning Trawl or use of environmental DNA (eDNA) could be effective alternatives. The Kodiak Trawl has been found to be more sensitive to detecting Delta Smelt than the Summer Townet or the Midwater Trawl and could be utilized to monitor changes in distribution and allow for collecting samples that could be used to assess biomarkers of stress exposure, such as contaminants. eDNA can detect presence of absence of Delta Smelt. Recent studies have suggested that use of eDNA can be utilized for tracking fish and even getting relative abundance by determining eDNA/biomass/length. In addition surveys on factors like prey abundance that has been proposed to improve survival should be monitored as well.

IV. There is no indication that the SWP/CVP have reduced summer outflow or otherwise affected the Delta Smelt in the summer in a manner not already covered by the existing 2008 biological opinion.

The Delta Smelt Resiliency Plan suggests that the new summer flow action could be implemented in 2017-2018 through regulatory action. As described above, there is a lot of uncertainty that Delta Smelt would benefit from the proposed action, making any discussion of a new regulatory requirement premature. Prior to any potential future regulatory action, the FWS and DFW should consider whether the SWP-CVP has had a historical effect on summer outflow, particularly if the volume of the low salinity zone is how the FWS will be defining Delta Smelt critical habitat. The CVP-SWP already significantly subsidizes summer outflow.

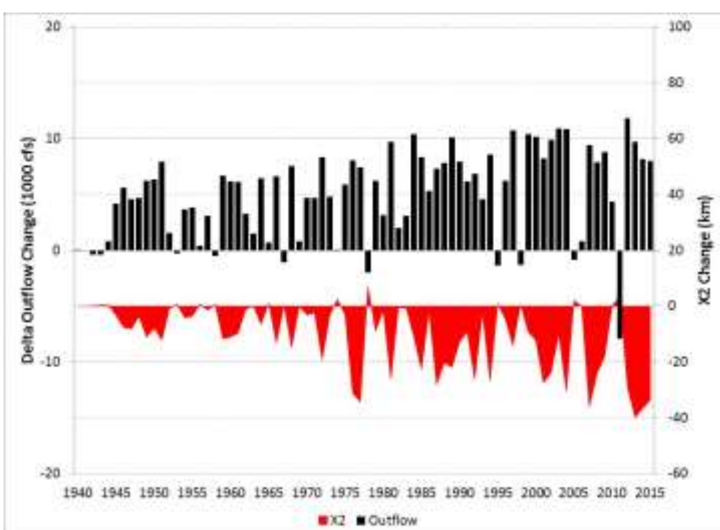


Figure 40. Historical change in July Delta outflow and salinity (X2 position) resulting from SWP/CVP operations between 1940-2015. Description of without project modeling assumptions available at:

http://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/byron_bethany/docs/exhibits/swcr/swc5
.pdf .

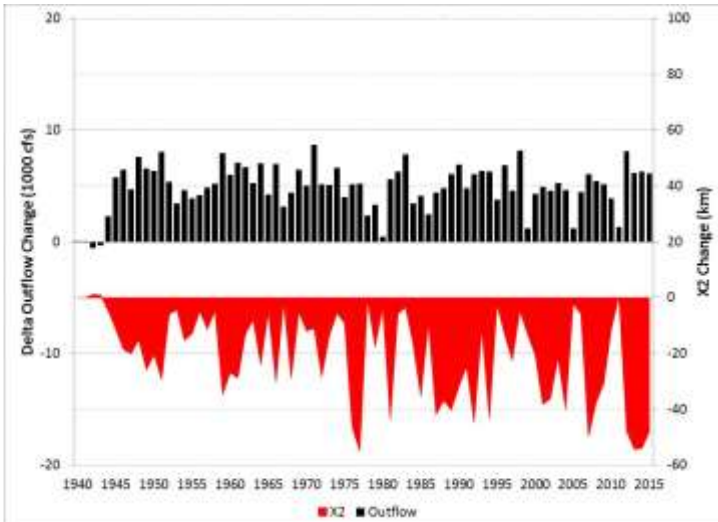


Figure 41. Historical change in August Delta outflow and salinity (X2 position) resulting from SWP/CVP operations between 1940-2015. Description of without project modeling assumptions available at:
http://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/byron_bethany/docs/exhibits/swcr/swc5
.pdf.

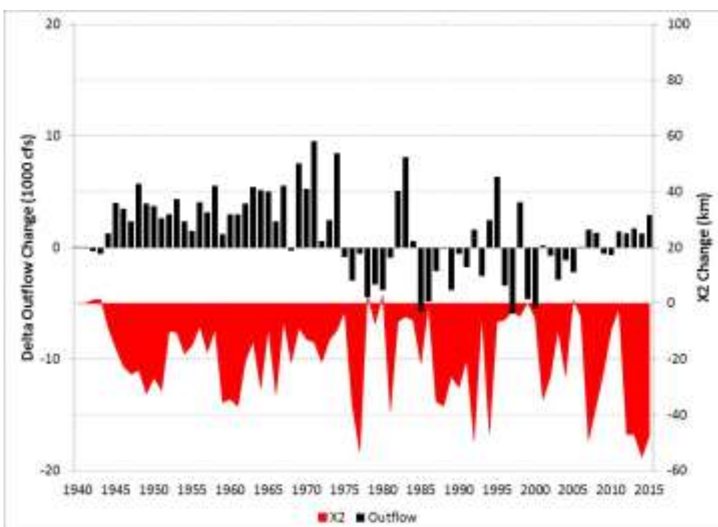


Figure 42. Historical change in September Delta outflow and salinity (X2 position) resulting from SWP/CVP operations between 1940-2015. Description of without project modeling assumptions available at:
http://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/byron_bethany/docs/exhibits/swcr/swc5
.pdf.

Figures 40-42 show the calculated difference between historical and "without project" Delta outflow and salinity (X2) for the months of July-September over the period 1940-2015. The black bars (scaled to the left vertical axis) above zero indicate years when the SWP/CVP supplemented outflow and the black bars below zero indicate years when outflow would have been absent without the projects. Similarly, the red area (scaled to the right vertical axis) below zero indicates years when SWP/CVP operations moved X2 further downstream, making the Delta fresher, and the red above zero indicates years when X2 would have been further downstream absent the projects.

These figures show that SWP-CVP operations have generally resulted in improved (rather than degraded) summer flow and salinity conditions. Moreover, salvage of Delta Smelt is non-existent from July-September, indicating no project effect. Therefore, if summer outflow is important to Delta Smelt, that flow should not come from SWP/CVP operations through new regulatory action as the SWP/CVP are not impacting the Delta Smelt during the summer.