Water Resources • Flood Control • Water Rights

M E M O R A N D U M

DATE: December 15, 2011

TO: Northern California Water Association

FROM: Walter Bourez

SUBJECT: Relating Delta Smelt Index to X2 Position, Delta Flows, and Water Use

INTRODUCTION

There has recently been much interest in requiring higher instream flows through the Sacramento-San Joaquin River Delta (Delta) in an attempt to reverse the continuing decline of a number of fish species that reside in or migrate through the Delta. Last year, for instance, reports issued by the State Water Resources Control Board (SWRCB) and the California Department of Fish & Game (DFG) stated that additional flows in the form of increased Delta outflows would be needed to meet the needs of both pelagic and salmonid species. More recently, the United States Environmental Protection Agency (USEPA) issued an Advance Notice of Proposed Rulemaking, which also suggested that higher instream flows through the Delta may be necessary. These reports rely on the theory that, by increasing instream flows and restoring a more natural hydrograph, habitat conditions for the fish species in question will improve and, as a result, fish populations will also improve.

Examination of the data used in each of these reports, however, shows that there is little, if any, scientific basis for the claim that additional flows will enhance declining fish populations. Key findings are:

1. The data used to support the claim that additional flows will enhance fish populations compares a wetter period (1956-1987) with a drier period (1988-2003). This invalid comparison of periods with very different hydrology is a fundamental flaw in the claim that increasing flows through the Delta will result in increasing fish populations.

2. Moreover, the constantly changing nature of the operations of the federal Central Valley Project (CVP) and the State Water Project (SWP) during the period from 1988-2003, as well as the fact that Delta outflow requirements increased during that period, make it difficult to conclude that a lack of flows is responsible for the decline in Delta fisheries.

3. A comparison of Delta fish population with water use in the Sacramento Valley shows that there appears to be no relationship between that water use and fish populations.

Taken together, all of these factors suggest that the decline in Delta fisheries is the result of factors other than flow.

Both the SWRCB and the DFG reports advocate modifying instream flows in the Delta and its tributaries so as to more closely mimic the natural hydrograph (i.e. streamflows occurring prior to 1850). A “natural hydrograph” means that hydrology will mimic the variability that occurred prior to the construction of the CVP and SWP. This variability included both wet and dry years. Examination of the data discussed above, however, indicates that both reports are – in fact – advocating not a natural hydrograph but, rather, that the Delta and its tributaries be operated so that every year mimics a wet or above normal year. If the fundamental concept behind the “natural hydrograph” claim is correct, then it is likely that it is just as harmful to fish species for every year to be a wet year as it would be if every year were a dry year.

Lastly, examination of the hydrologic data for the Delta leads to the strong conclusion that hydrology is not destiny. The continuing decline in fish populations, notwithstanding continuing regulatory adjustments to project operations through increasing Delta outflow requirements, strongly suggest that there are other factors at play. Specifically, as described in depth by Dave Vogel in his April 2011 report entitled *Insights into the Problems, Progress and Potential Solutions for Sacramento River Basin Native Anadromous Fish Restoration*, it appears that predation (particularly by non-native species) and habitat degradation in the Delta is likely a major problem for Sacramento River basin anadromous fisheries. In addition, there may be alternative ocean harvest methods that could increase the reproductive capacity of Sacramento River basin anadromous fisheries. The data presented in this report make it clear; however, that increasing Delta outflow by means of X2 is not likely to reverse population declines in anadromous fisheries.

COMPARING HYDROLOGIC PERIODS DURING SPRING PERIODS

The SWRCB Delta Flow Report (at pages 104-106) compares average net Delta outflow for the January through June period from 1956-2009. The report then concludes that the “step-decline in the abundance X2 relationship that occurred after 1987 for many of these species . . . leads to uncertainty regarding the future response of these species to elevated flows.” (p. 107). Notwithstanding this caution, the report concludes that such elevated flows “are necessary to protect public trust resources and that the current flow regime has harmed native species and benefited non-native species.” (p. 108). Figure 1, below, contains “Figure 14, Net Delta Outflow Exceedance Plot – January through June” from page 106 of the SWRCB August 3, 2010 report titled: *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem*, prepared pursuant to the Sacramento-San Joaquin Delta Reform Act of 2009. The line representing “Actual” flow for the 1956-1987 period is above the line representing the 1988-2009 period, indicating flow during the 1956-1987 period was greater. Average net Delta outflow during the 1988-2009 period was approximately 5,000 cfs less than during the 1956-87 period, which means that during the 1956-87 period there was approximately an additional 1.7 million acre-feet of net Delta outflow (5,000 cfs x 1.98 af/cfs x 180 days) than during the 1988-2009 period.

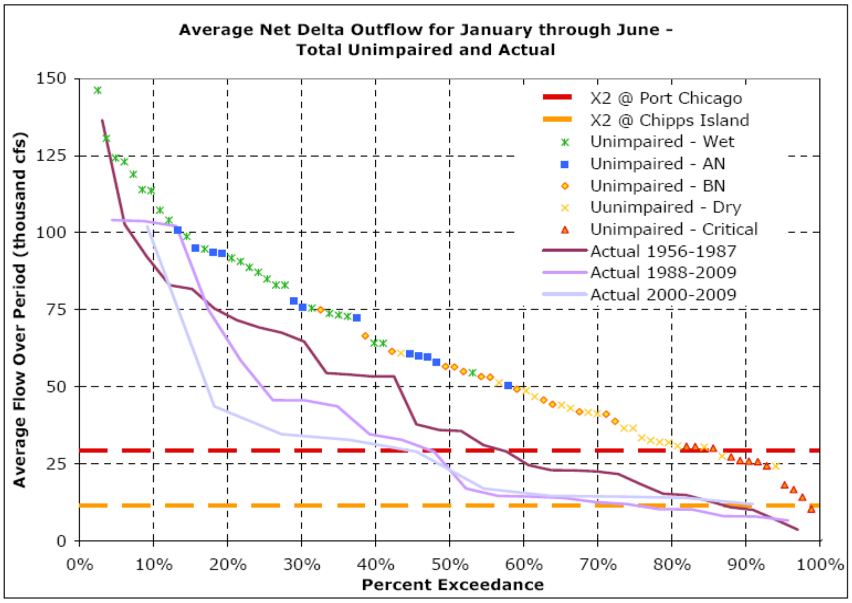

Figure 1 - Net Delta Outflow Exceedance Plot from SWRCB Report Page 106

Figure 2 shows probabilities of exceedance of historical ("actual") average Delta outflow for the DAYFLOW period of record (1930-2008) during January through June and the average Delta outflow for the periods 1930-1955, 1956-1987, 1988-2009, and 2000-2009. As in Figure 1, the 1988-2009 period is substantially drier than the 1956-1987 period.

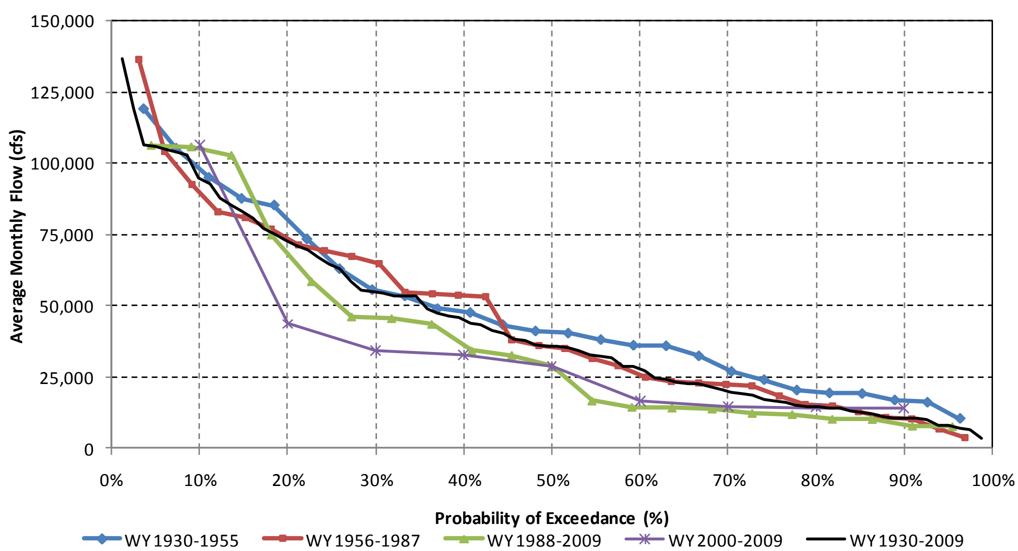

Figure 2 – Average January - June Historical Net Delta Outflow from 1930 - 2009

Figure 3 shows, for the January-June period, probabilities of exceedance of average unimpaired Delta outflow for the 1930-2003 period of record and the average unimpaired Delta outflow for those months during the component periods 1930-1955, 1956-1987 and 1988-2003. Unimpaired flow is runoff that would have occurred had water flow remained unaltered in rivers and streams instead of stored in reservoirs, imported, exported, or diverted. The data is a measure of the total water supply available for all uses after removing the impacts of most upstream alterations as they occurred over the years;

therefore, all variation in this data is due to natural causes. Although DWR has estimated unimpaired Delta outflow for the period of 1922-2003, this comparison uses the period after 1930 to be as consistent as possible with the DAYFLOW period.

Comparison of unimpaired flow for these various periods demonstrates variations due to hydrology alone, without human influence. Differences in the exceedance plots between the 1956-1987 and the 1988-2003 are solely due to natural variation in hydrology and cannot be attributed to project operations or water use.

As can be seen in the unimpaired flow chart in Figure 3, the 1956-1987 period was wetter than the average for the entire 1930-2003 period and was also generally wetter than the post-1988 period. On average, unimpaired Delta outflow during the January to June period during 1956-1987 seems generally to have been about 4,300 cfs greater than average January to June Delta Outflow during the period from 1988-2003. This means that, for the January-June period under unimpaired conditions, an average of about 1.5 million acre-feet more water would have flowed out of the Delta during the 1956-1987 period than during the 1988-2003 period. A flow difference of this magnitude can change X2 location and influence any conclusions based on this data. **Thus, the decline in the abundance-X2 relationship that occurred since 1987 is probably due, in significant part, to the fact that this period was substantially drier than the 1956-1987 period.**

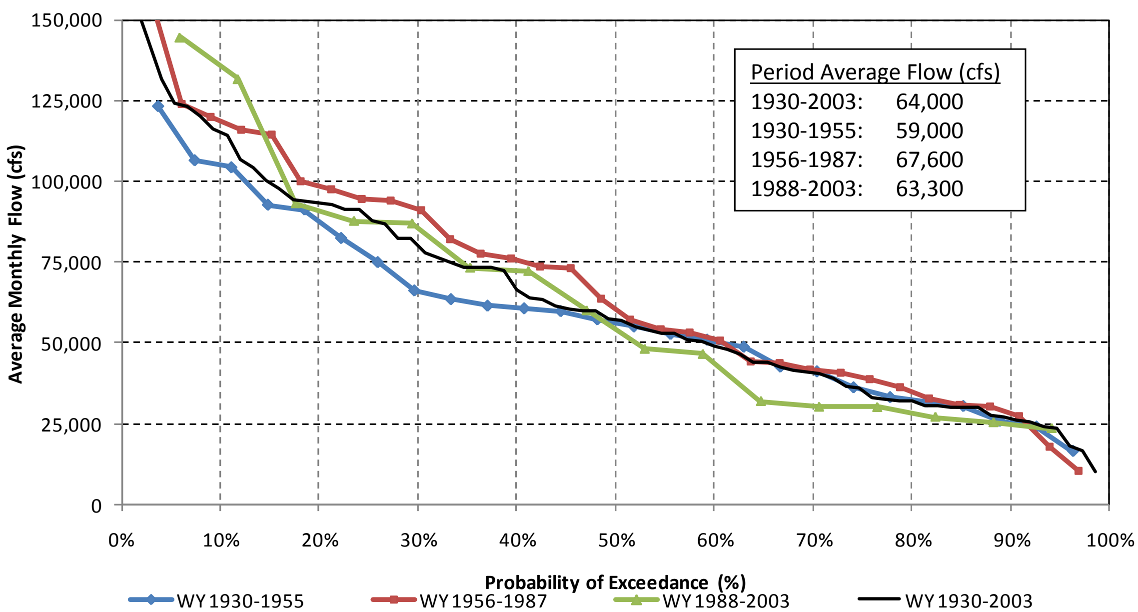

Figure 3 – Average January – June Unimpaired Net Delta Outflow from 1930 - 2003

COMPARING HYDROLOGIC PERIODS DURING FALL PERIODS

In discussing the proposed fall X2 action, the SWRCB Delta Flow report states that "the average position of X2 during fall has moved upstream, resulting in a corresponding reduction in the amount and location of suitable abiotic habitat." (p. 108). The report then refers to a period since 1987 and particularly since 2000 during which the fall X2 has moved upstream. (p. 109). The report continues by using data from 1960-2010 (report Figure 15) and data from 1956-2008 (report Figures 16-18). (pp. 110-112).

Again, these data seem largely to reflect the contrast between a relatively wet period from 1956-1987 and the relatively drier period since 1988. Figures 4, 5, and 6, below, compare average unimpaired Delta outflow for September, October and November, respectively. In each of those months, the period from 1956-1987 was substantially wetter than the long-term average (1930-2003) and very much wetter than the period from 1988 to 2003. Again, unimpaired flow is used for this comparison to demonstrate the differences due to hydrology alone, without human influence.

The purpose of these charts is to illustrate the importance of using representative periods when comparing fish abundance. Only if two periods being compared have the same hydrology can one attribute the increase or decline in abundance to factors other than hydrology (e.g., changes in exports, introduced species, etc.).

From a policy perspective, these data cast significant doubt on the efficacy of a proposed fall X2 action. Implementation of the fall X2 action is based on the concept that there have been man-made changes in project operations (perhaps to increase exports) since 1987 and that part of the suite of actions needed to restore Delta fisheries is the reversal of those changes. However, if the upstream movement of X2 during the fall since 1987 is largely a reflection of drier hydrology during the post-1987 period and if the goal of Delta restoration efforts is to replicate “natural” conditions to the extent feasible, then “fixing” natural hydrology may be a well-intentioned, but counter-productive, action that diverts attention from the actual causes of declining Delta smelt populations, such as invasive species or other ecosystem stressors of the type identified in the Vogel report referred to earlier. Attempting to impose historical wet-year hydrology on the Delta and its tributaries in all years also could severely reduce the amount of cold water available to support the needs of salmon and steelhead in Delta tributaries at important times of the year.

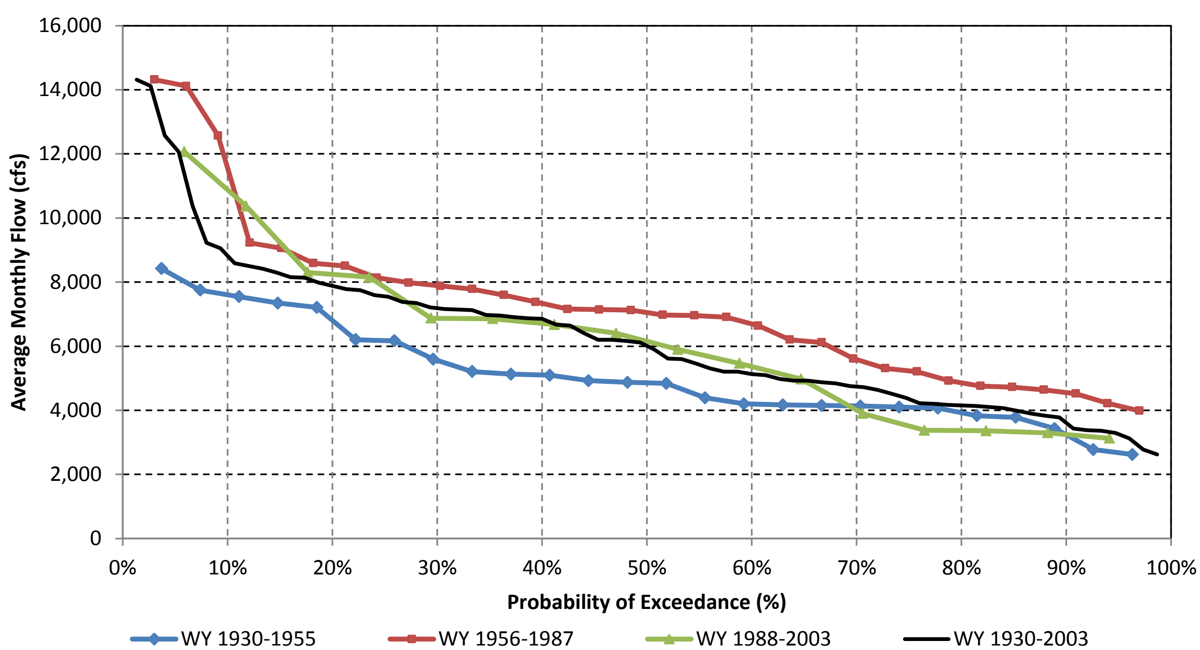

Figure 4 - Average <u>September</u> Unimpaired Net Delta Outflow from 1930 – 2003

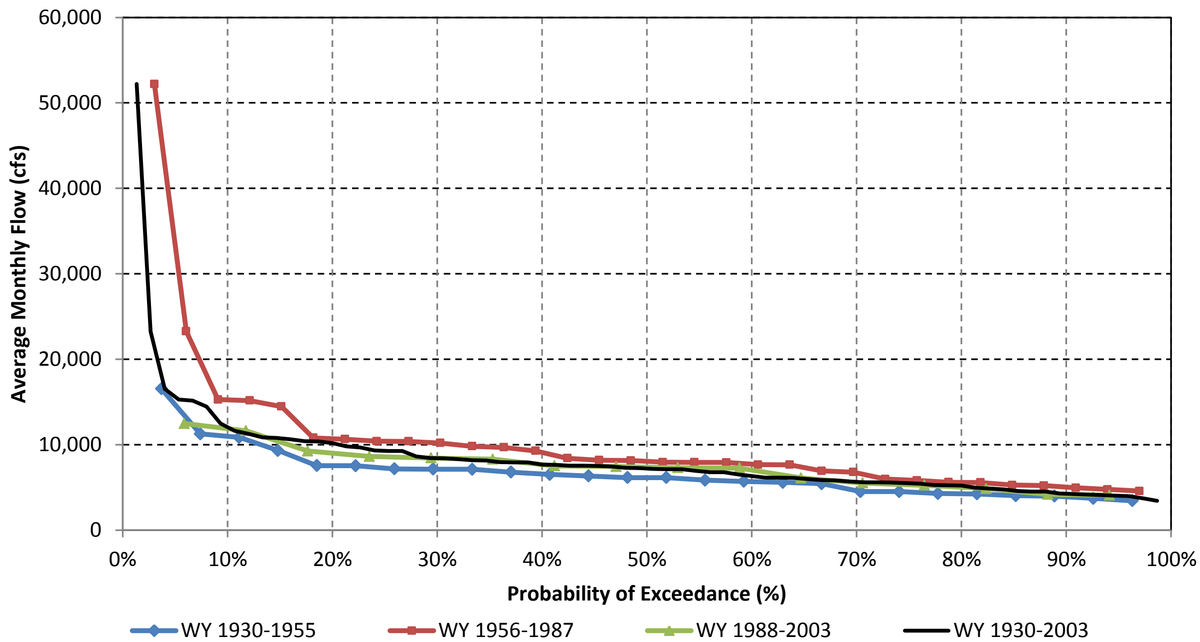

Figure 5 - Average <u>October</u> Unimpaired Net Delta Outflow from 1930 - 2003

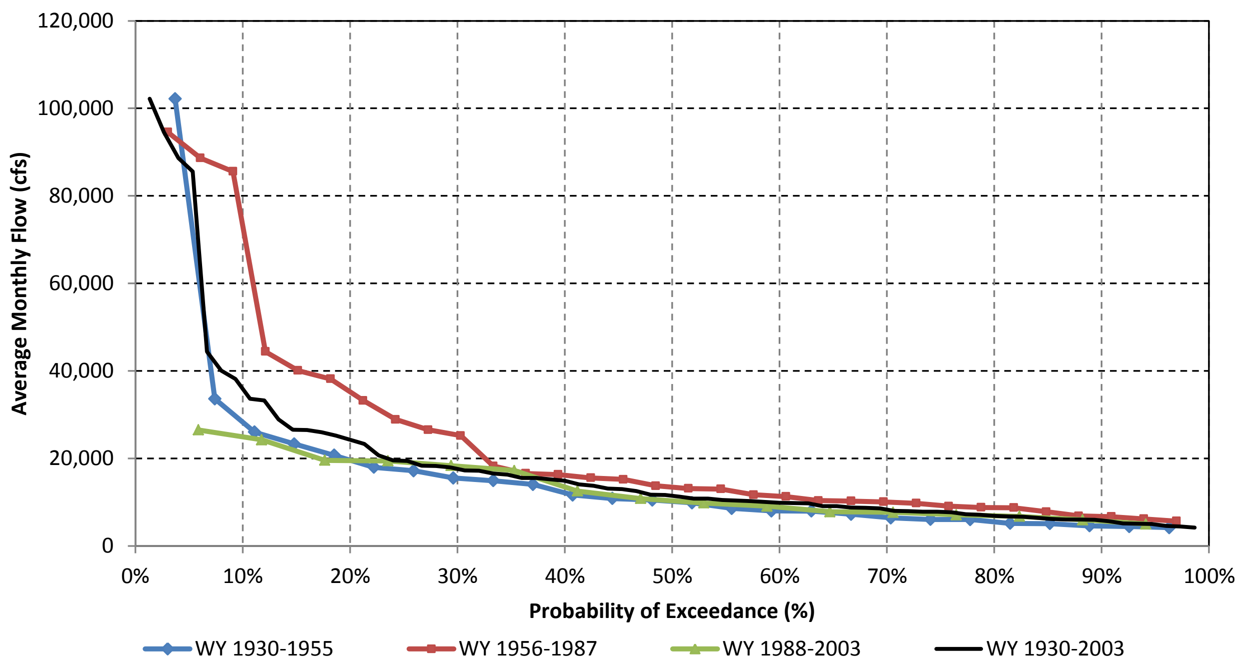

Figure 6 - Average <u>November</u> Unimpaired Net Delta Outflow from 1930 - 2003

The USEPA's Advanced Notice of Proposed Rulemaking ("ANPR") concludes that the "low salinity zone in the fall has moved upstream, especially after 2000." (p. 53). This statement is almost identical to the statement in the SWRCB's 2010 Delta Flow Report and is subject to the same criticism: it compares a wetter period (1956-1987) with a drier period (1988-2008) and attempts to draw conclusions regarding the status of delta smelt without acknowledging that the species is likely to do more poorly in a drier period. Similarly, the ANPR states there has been a “dramatic decline in the variability of the location (and therefore the extent) of low salinity habitat.” (p. 53). The ANPR also states “In the late 1990’s, the median areal extent of this low salinity estuarine habitat was about 9000 hectares in the fall; since 2000, that habitat declined by about 78 percent.”(p.52). This statement compares a few very wet years in the late 1990’s to a drier period that contains a mix of year types, including several very dry years, to conclude there has been a 78 percent decrease in habitat. The decline is in part due to hydrology, but may also be due to changes in regulatory standards. The increased Delta outflow requirements in the spring contained in SWRCB D-1641 have mandated increased reservoir releases during the spring months and lower upstream reservoir storage during the summer and fall period. This reduction in upstream reservoir storage has resulted in decreased reservoir releases during fall months, which in turn has resulted in X2 moving upstream in the fall. **In other words, the ANPR is correct to note that the location of X2 during the fall has moved upstream since the year 2000; the ANPR, however, fails to understand and acknowledge that the cause of that upstream movement is the requirement for increased spring Delta outflow contained in D 1641 as well as dry conditions throughout California. The lesson here is that it is important to recognize that measures to benefit one life stage or one species can have unintended effects on other life stages or other species.**

Figure 7, below, contains the average X2 location during the months of September, October, and November for the period of 1930 – 2008. The average X2 location presented in the ANPR’s Figure E on page 54 displays X2 locations for the period from 1967 – 2008. Figure E implicitly uses the late 1960’s and early 1970’s as the baseline against which to evaluate subsequent changes in X2 locations, and concludes that X2 has moved substantially upstream over time. However, as can been seen in Figure 7, analyzing X2 position for the entire period of record (1930-2008) leads to a different a conclusion. The periods before and after the 1967-1975 period are drier, therefore this period should not be used as a baseline from which to draw conclusions. The entire period of record should be used to better understand how the system has changed. In the earlier period from 1930 to the early 1940’s, before the Projects began operation, X2 position during the fall was farther upstream. When the Projects began operation, releases were made to satisfy instream flow requirements and Delta requirements causing Fall X2 to move downstream. The “natural” position for X2 during fall months is farther upstream than has occurred since the Projects began operations and releasing water to comply with environmental flow requirements. Because the delta smelt index is not available prior to 1967 it is not possible to determine if there is a relationship between fall X2 and the delta smelt index.

The consequence of these errors is that many of the effects that both the SWRCB’s 2010 Delta Flow report and the USEPA’s Advanced Notice of Proposed Rulemaking have attributed to reduced Delta outflows are, to a substantial extent, actually reflections of the variations in the natural hydrology of the Delta watershed since the late 1980’s. It is not clear what is actually causing that change in hydrology or whether it will continue. What is clear is that the pre-1987/post-1987 comparison that has been used to justify both proposals for increased Delta outflows during the springtime and the proposed fall X2 action is a comparison between a relatively wet period and a relatively dry period.

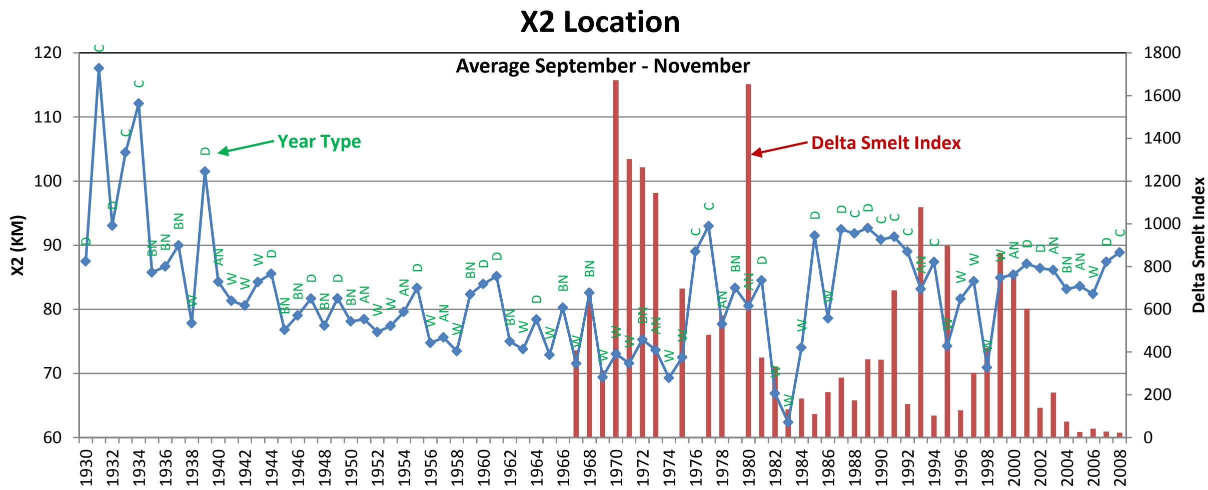

Figure 7 – Average September Through November X2 Location and Delta Smelt Index

CHANGES IN SACRAMENTO BASIN FLOWS AND DIVERSIONS DURING THIS PERIOD

Figure 8 shows Sacramento Valley irrigated acreage and combined annual diversions of water by the eight largest Sacramento River Settlement Contractors (SRSCs) for the period 1964 to 2008. Together, these eight diversions comprise about 90 percent of total settlement contract diversions in the Sacramento River Basin. These data indicate, that despite hydrologic variability, irrigated acreage has not increased and diversions by the SRSCs, while fairly consistent from year to year, have declined slightly over the past twenty to thirty years. This decline is probably due to changes in cropping mix, increased irrigation efficiency, and cultural practices.

Figure 9 contains a chart of historical diversions and consumptive use produced by the state's 2007-2008 Delta Vision Task Force. The data on the bottom of the bar chart is labeled "Estimated Sacramento Valley agricultural consumptive use of applied water + urban demand." This chart shows that upstream water use has been fairly constant over the past 40+ years.

Figure 10 shows the historical Delta smelt index from 1967 to present, Sacramento Valley irrigated area, and annual diversions by the Sacramento River Settlement Contractors. During the period between 1967 and 1980, the Delta smelt index varied significantly. During the 1980's, the Delta smelt index was largely stable, but relatively low. During the 1990's, the Delta smelt index was quite variable, but with little relation to hydrology. Since 2002, the Delta smelt index has been very low. This variability presents a clear contrast with Sacramento Valley irrigated area and diversions by the Sacramento River Settlement Contractors, which – as noted above – have been fairly consistent over the 40+ year period.

In summary, the available data indicate that the populations of the fish species that have been the focus of Delta restoration and recovery efforts for the past fifty years have been quite variable. There may be some relationship for some species to hydrology (e.g., the very low levels of Delta smelt during the 1976-77 drought) but those relationships are, at best, unclear. What is clear is that there does not appear to be a relationship between populations of Delta smelt and Sacramento Valley irrigated area or diversions by the Sacramento River Settlement Contractors, which were quite consistent over that period.

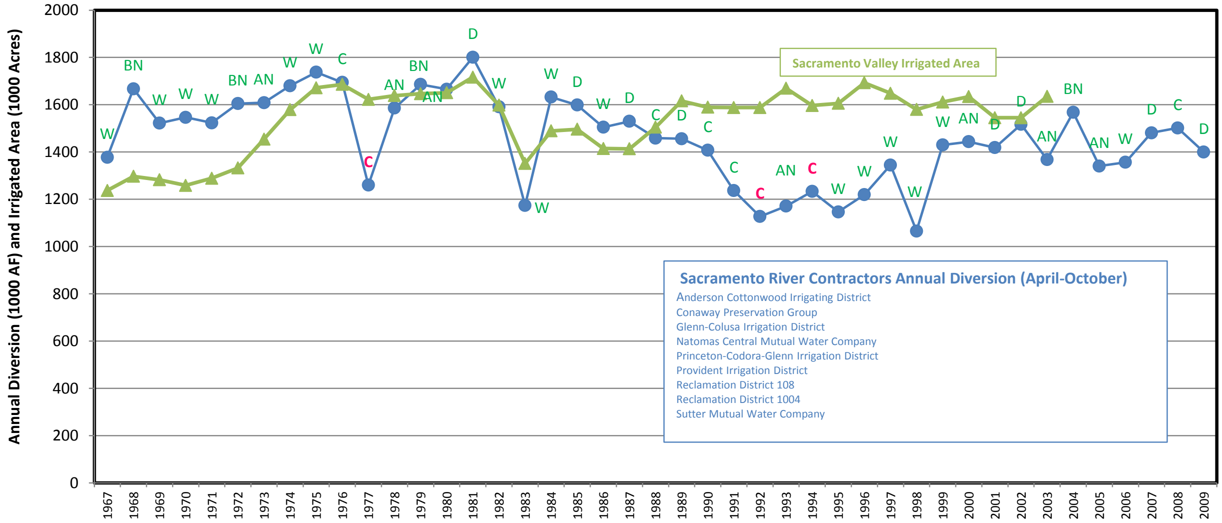

Figure 8 – Sacramento Valley Irrigated Area and Annual CVP Settlement Contract Diversions

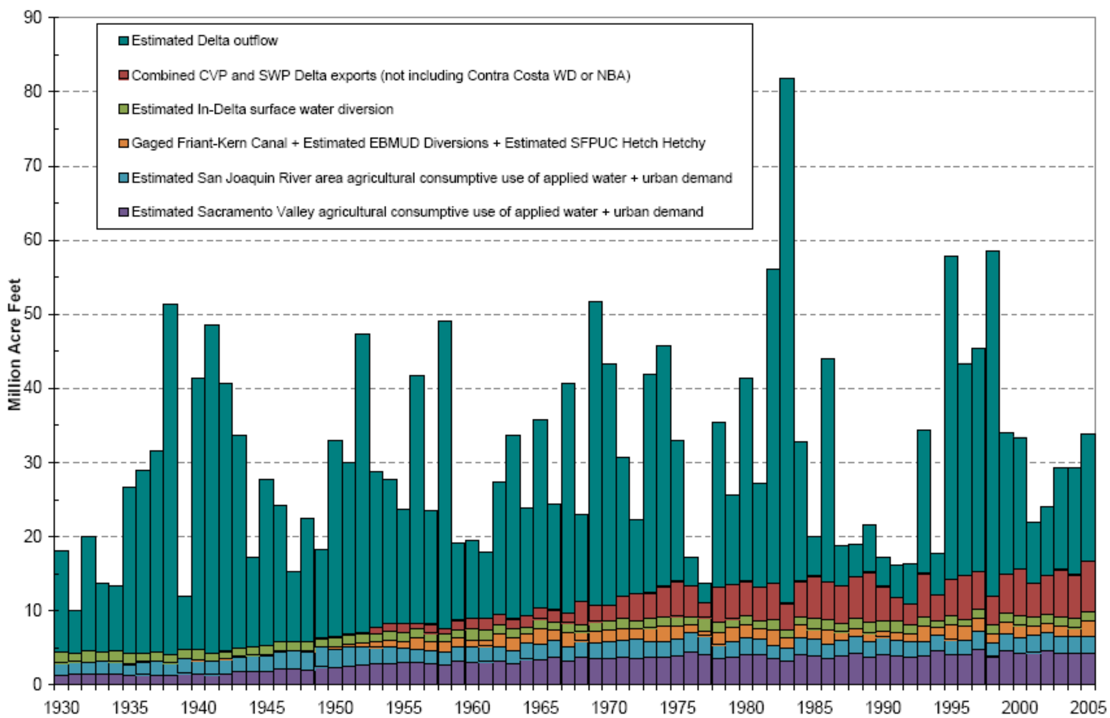

Figure 9 –Delta Vision "Revised Figure 7b – Historic Diversion from the Delta"

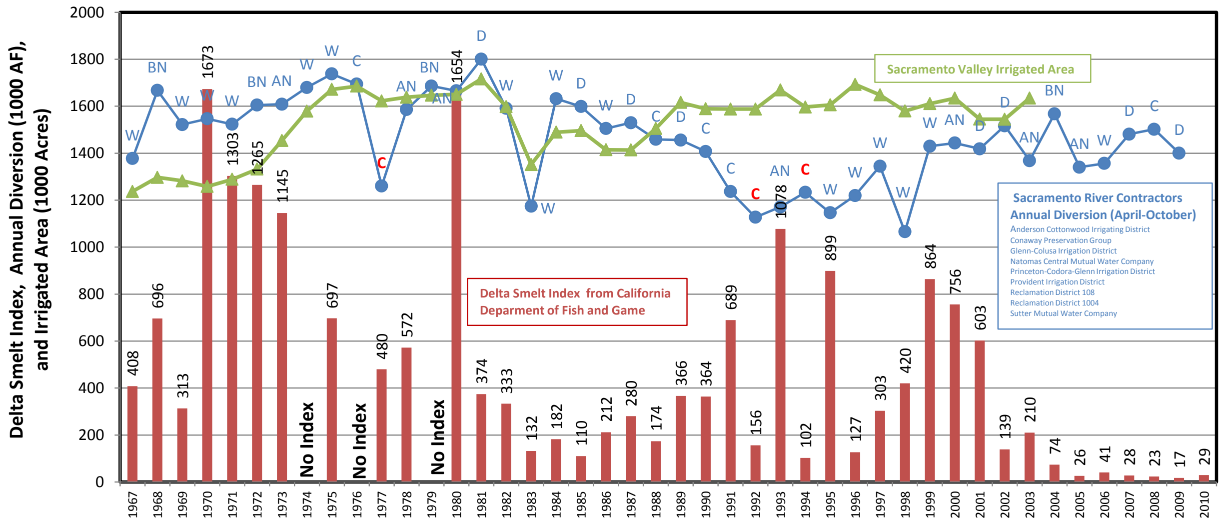

Figure 10 – Sacramento Valley Irrigated Area, Annual CVP Settlement Contract Diversions, and Delta Smelt Index