State & Federal Contractors Water Agency
1121 L Street, Suite 802, Sacramento, CA 95814

October 18, 2010

Mr. Chad Dibble
Department of Fish and game
1416 9th Street, 12th Floor
Sacramento, CA 95814

RE: Critique of DFG Draft Report: Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta

Dear Mr. Dibble:

The State and Federal Contractors Water Agency ("SFCWA") is pleased to provide comments on the California Department of Fish and Game's ("DFG") draft report "Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta" ("DFG Report"). SFCWA is a [describe].

SFCWA recognizes that the timeframe provided by the Legislature in the Delta Reform Act was short and the narrow mandate of that legislation to develop and recommend to the State Water Resources Control Board ("State Water Board") flow needs for aquatic and terrestrial species. Both the State Water Board and the DFG, in their respective flow criteria reports, have constrained themselves by not addressing any of the other stressors impacting aquatic and terrestrial species, including predation, food supply, and nutrient discharges. Without addressing these other stressors, it cannot be said that the DFG's draft flow criteria will increase abundances of any aquatic species or advance the co-equal goals of the ecosystem and water supply.

The DFG Report recognizes that flow is not the only factor affecting ecosystem health and fish population declines and that other factors such as non-native species, habitat loss and contaminants also adversely affect ecosystem productivity, nutrient discharges, and the food web must be addressed before any of the flow criteria could be implemented. SFCWA appreciates this admission.

Summary of Technical Review of Draft Flow Criteria

SFCWA assembled a team of technical experts in biology, statistics and ecosystem science to review the DFG Report. The following summary observations are offered.

1. The DFG Report made no distinction in determining best available science to support their recommendations by distinguishing between unpublished data submitted in the report's development process, peer reviewed papers, and papers published in scientific journals. Unsupported statements often appear to be taken at face value.

2. Review of the scientific support for flow for various species shows that in many instances the best available science was not used, that findings in the cited studies often contradict conclusions of the report, and citations that were selective or misinterpreted:

3. In several instances, the report relies on the same scientific analyses that have been criticized by a federal court as being arbitrary, not rational, or not scientifically justified.

4. Ignores the abundance of data showing exports do not influence San Joaquin salmon survival and incorrectly concludes the need for inflow/export ratio controls.

5. Ignores the impact of other stressors, including predation, food supply, invasive and introduced species, and nutrient discharges on the Bay-Delta's ecosystem.

Based on these failures, SFCWA must reject the DFG Report as not representing the current understanding of the flow needs of the species described in the Report.

The legislative limitations on the timeframe and the focus of the DFG Report underscores the impracticality of implementing its flow recommendations due to, among other things, clearly unacceptable water supply impacts. This underscore the need for a comprehensive approach that achieves the coequal goals of water supply reliability and Delta ecosystem health. For California's economy to recover and thrive, investments need to be made in ecosystem restoration projects, alternative water supplies, reduction in nutrient discharges, suppression of non-native predators, modification of Delta conveyance, and increasing storage opportunities for both water supply and environmental flows. Ensuring a flow regime that works with other investments in ecosystem restoration and water supply reliability is imperative in assuring such recovery.

Sincerely,

Byron M. Buck
Executive Director

STATE AND FEDERAL CONTRACTORS WATER AGENCY REVIEW OF THE DEPARTMENT OF FISH AND GAME DRAFT REPORT "QUANTIFIABLE BIOLOGICAL OBJECTIVES AND FLOW CRITERIA FOR AQUATIC AND TERRESTRIAL SPECIES OF CONCERN DEPENDANT ON THE DELTA"

The Department of Fish and Game ("DFG") issued its draft report entitled, Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta ("DFG Report"), on September 21, 2010, and requested public review.

In response, the State and Federal Contractors Water Agency ("SFCWA") brought together a team of experts from a variety of disciplines to review the DFG Report.[1] They concluded that the DFG Report is scientifically flawed and cannot be reasonably relied on as a basis for future decision-making.

DFG provided much of the analysis used by the State Water Resources Control Board's ("State Water Board") in its Report on Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem ("Flow Criteria Report"). As SFCWA explained in its written critique of the Flow Criteria Report, the State Water Board did not adhere to standard scientific principles for use and reliance on technical information. The DFG Report relied on the Flow Criteria Report without correcting the information DFG and others provided to the State Water Board; rather, DFG further perpetuated those errors, and DFG did so without providing the necessary qualifying statements to acknowledge substantial scientific uncertainty and inherent limitations of the report.

The DFG Report must be revised to address substantive technical errors, failures to follow standard scientific protocols, and the perpetuation of unfounded assumptions or hypotheses, as follows:

I. The DFG Report did not provide a biological basis for the underlying assumption that a new flow regime, without any other actions, would increase species abundance.

The State Water Board's Flow Criteria Report and the DFG Report were developed based on an assumption by the Legislature that a new flow regime, without any other actions, could increase species abundance. However, as William E. Fleenor, William A. Bennett, Peter B. Moyle, and Jay R. Lund, explained in their written report to the State Board:

> The performance of native and desirable fish populations in the Delta requires much more than fresh water flows. Fish need enough water of appropriate quality over the temporal and spatial extent of habitats to which they adapted their life history strategies. Typically, this requires habitat having a particular range of physical characteristics, appropriate variability, adequate food supply and a

[1] The *curriculum vitae* for the experts have been provided in Attachment A.

> diminished set of invasive species. While folks ask "How much water do fish need?" they might well also ask, "How much habitat of different types and locations, suitable water quality, improved food supply and fewer invasive species that is maintained by better governance institutions, competent implementation and directed research do fish need?"[2]

Therefore, the Legislature asked DFG the wrong question. In its response, the DFG Report is trying to use flow to dilute pollution and nutrient loading, to compensate for the lack of available physical habitat for species, and to reduce the effect of predation, among other uses. But there is no single flow regime that can do all of those things (and even if there was, it would result in the waste and unreasonable use of water). The experts testifying at the State Board's flow proceedings earlier this year agreed, and told the State Water Board that:

> "If you look at only outflow criteria, I think it will be a fragmentary and insufficient response for the native fish."
>
> Jay Lund, UC Davis, Day 1

> "It's not just the flows. . . . I think with making modifications to the habitat such that at any given point in time you have more variable habitat conditions across the delta overall will give you a much higher probability [of success].")
>
> Bill Bennett, UC Davis, Day 2

> "Delta outflow alone can't do the job."
>
> Don Stevens, CSPA, Day 2

> "Just to reiterate, everybody pretty much hit the main points, is that flow alone is not going to do the trick."
>
> Fred Feyrer, DOI, Day 2

The actual flow regime that could provide additional benefits to Delta species is not contained in the DFG Report; rather, it will be developed through the development of the Bay Delta Conservation Plan ("BDCP"). The BDCP will ultimately determine the appropriate flow recommendation as it develops its plan for water project operations, thousands of acres of new habitat, and measures to control and minimize other stressors such as pollutants and predators. It is only through this holistic approach will it be possible to determine the appropriate flow regime for protecting the fishery.

II. The DFG Report did not acknowledge its substantial effect on the available water supply, effectively shutting down the water system for a state with 36.96 million people, and counting.

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[2] William E. Fleenor, William A. Bennett, Peter B. Moyle, and Jay R. Lund, *On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta*, pp. 28-29.

DFG states, "Before any specific flow criteria are implemented, the following should be considered…Balancing of the need to protect the Delta's aquatic and terrestrial ecosystem with the need for reliable water supply."[3] The fact the available water supply was not considered in the DFG Report's development is significant. The water supply effect of the State Water Board's proposal, which is quite comparable to DFG's, would reallocate 5.5 million acre-feet from human consumption to outflow and the sea. This would be a 69% reduction in consumptive use in the upper watershed and the Delta, leaving all of northern and portions southern California, including the Bay-Area, with only 30% of their current supply. A loss of available water supply of this magnitude would be devastating to the economy and communities across the state.

Moreover, the experts agree that this massive reallocation of water resources away from human communities would not be expected to measurably increase fisheries abundance. In his oral testimony before the State Board during the flow proceedings, Dr. Bill Bennett stated, "…anyone recommending an outflow number at this time would be doing the species a 'disservice,' because there is no magic outflow number that can reasonably be expected to result in a measureable increase in species abundance."[4] The logic behind DFG's proposal is therefore difficult to understand.

III. The DFG Report provides no support for its conclusion that flow stabilization harms native species and encourages non-native species.

Nowhere does the DFG Report discuss which season(s) suffer from harmful flow stabilization. Figure 1 (from Moyle *et al*. 2010 at p. 16) shows that the more recent hydrologic period 1986-2005 is not significantly different than previous historical periods when fish reportedly did much better.

[3] DFG Report at p. 103.

[4] SWRCB Flow Proceedings, Oral Testimony, Day 2

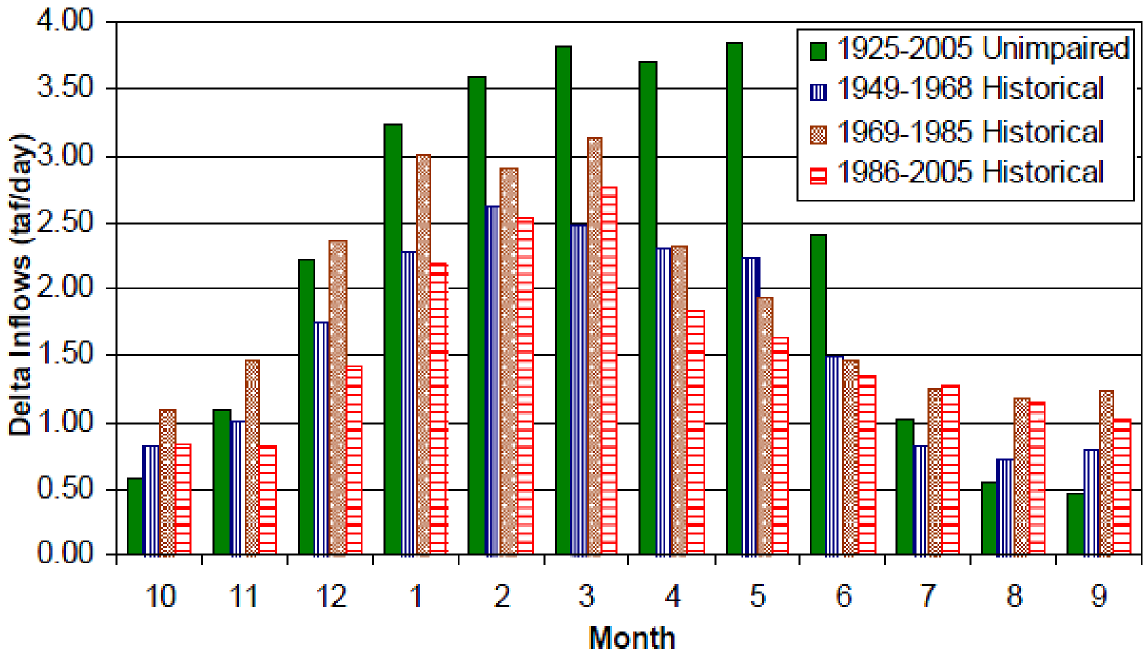

Figure 1. Averaged daily inflows in thousands of acre feet each month from Sacramento and San Joaquin Rivers showing unimpaired flows (solid green bar) and three historical periods, 1949-1968 (vertically-striped blue), 1969-1985 (brown) and 1986-2005 (horizontally-striped red), illustrating progressive changes to inflow from unimpaired conditions. Note increases in summer inflow during recent decades. Data from unimpaired boundary conditions (DWR) and historical boundary conditions (DAYFLOW).

Therefore, it is simply not apparent what the basis is for DFG's conclusion that recent flow stabilization has negatively affected the Bay-Delta's biological communities. Nor does the finding make sense when one considers the multitude of other stressors in the Bay-Delta that are also harmful to native species and independent of flows, such as contaminants and the *Corbula amurensis* invasion, which have historically gone unregulated or under-regulated by State and Federal agencies, including DFG.

IV. The DFG Report did not acknowledge the trade-offs amongst protected species.

The DFG Report focuses on protecting species like longfin smelt and unlisted species like Starry flounder, California bay shrimp, Sacramento splittail, American shad, and zooplankton. These species are attributed to have a biological importance above that of the endangered winter-run Chinook salmon, the threatened spring-run Chinook salmon, and fall-run Chinook salmon, because, if implemented, the DFG Report would decimate the thermal protection for these salmonid species during spawning on the mainstem of the Sacramento River.

The DFG Report states that, "The criteria contained in the report should be balanced by the need to maintain cold water resources in reservoirs on tributaries to the Delta…." [5] The fact that the

[5] DFG Report at p. 93.

cold water needs of Chinook salmon were not considered in the DFG Report's development is significant; because the flows being proposed by DFG would create harmful thermal conditions on the mainstem of the Sacramento River that would be highly detrimental to spawning Chinook salmon. This would also create an inability to meet existing regulatory requirements for species protection. For example, the loss of storage in Shasta reservoir would cause carryover storage requirements imposed by the RPA in the National Marine Fishery Service's ("NMFS") biological opinion on the joint operation of the Central Valley Project ("CVP") and the State Water Project ("SWP") (herein "NMFS BiOp") to be violated in about three of every four years.

The causal mechanisms of elevated temperatures on spawning and rearing of Chinook salmon is well documented, whereas the causal mechanisms of delta outflow on longfin smelt abundance are not.

V. The DFG Report relies on unpublished analyses and speculation to support conclusions regarding the importance of flow to Longfin smelt (*Spirinchus thaleichthys*) abundance

The Longfin smelt's relationship with X2 is often characterized as the strongest of the fish-flow relationships (Kimmerer 2002; Kimmerer *et al*. 2008; Dege and Brown 2004). It hypothesizes that the population abundance of longfin smelt is positively related to Delta outflow during winter and spring (p. 62) and that its population abundance as measured by the FMWT is inversely related to the number of fish salvaged (p. 62). Based on this purported relationship, the DFG Report concludes that more outflow will result in more fish.

a. Longfin abundance is more strongly correlated with food availability than with Delta outflow (X2)

The DFG Report relies heavily on the statistical correlation between the Fall Mid-Water Trawl ("FMWT") and X2 to conclude that outflow will result in increased longfin abundance. Though the correlation between FMWT and average X2 does exist, the FMWT is also well correlated with other factors, including average Suisun Bay turbidity and dissolved inorganic nitrogen. Further, when longfin smelt are observed over their entire lifecycle, there is only weak evidence for a relationship with flow, and stronger evidence that its abundance is linked to food supplies. Also, the relationship between longfin abundance and average spring X2 is weak and rapidly diminishing due to unknown causes.

Figure 2 shows log(age-0 longfin CPUE/age-2 longfin CPUE) versus annual average X2 in the same year. Unlike the standard log (FMWT) v. X2 or turbidity relationships, this relationship does not decay over time. The inference is that the relationship between the number of parents and the number of progeny as a function of flow-related variables has not shifted. What has shifted is simply the number of adults available to procreate. Since the FMWT is dominated by age-0 longfin, it has dropped as the number of adults has dropped.

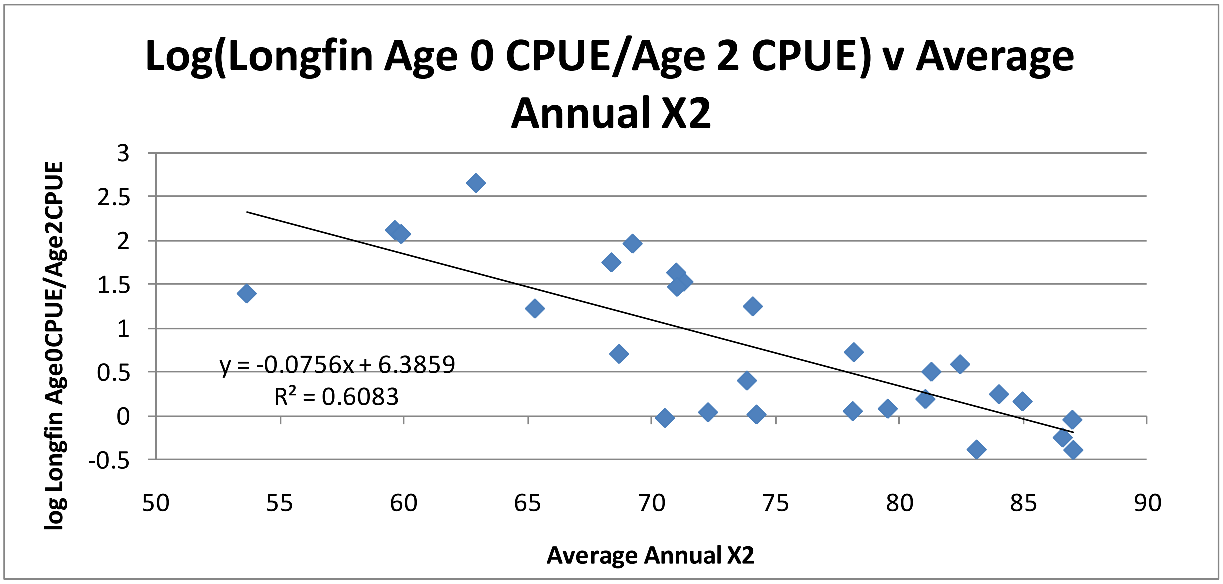

Figure 2. Average annual X2 location and age-0/age-2 longfin smelt catch per unit effort (CPUE) from Fall Midwater Trawl. The relationship demonstrates that longer term FMWT Indices are related to more landward X2. This is opposite of annual FMWT Index and X2.

The relationship between age-2 longfin CPUE and the same cohort of longfin two years earlier (PP age-0) is also interesting. Given a number of age-0 longfin, how many of these survive to become age-2 longfin? This relationship is shown as Figure 3, which shows that high outflows may be correlated with an increase in age-0 longfin compared to the number of adults, but the number of these YOY longfin that survive to become adults two years later is strongly and negatively correlated with the same outflow. In fact, the effect of outflow is largely canceled out by the time longfin reach adulthood.

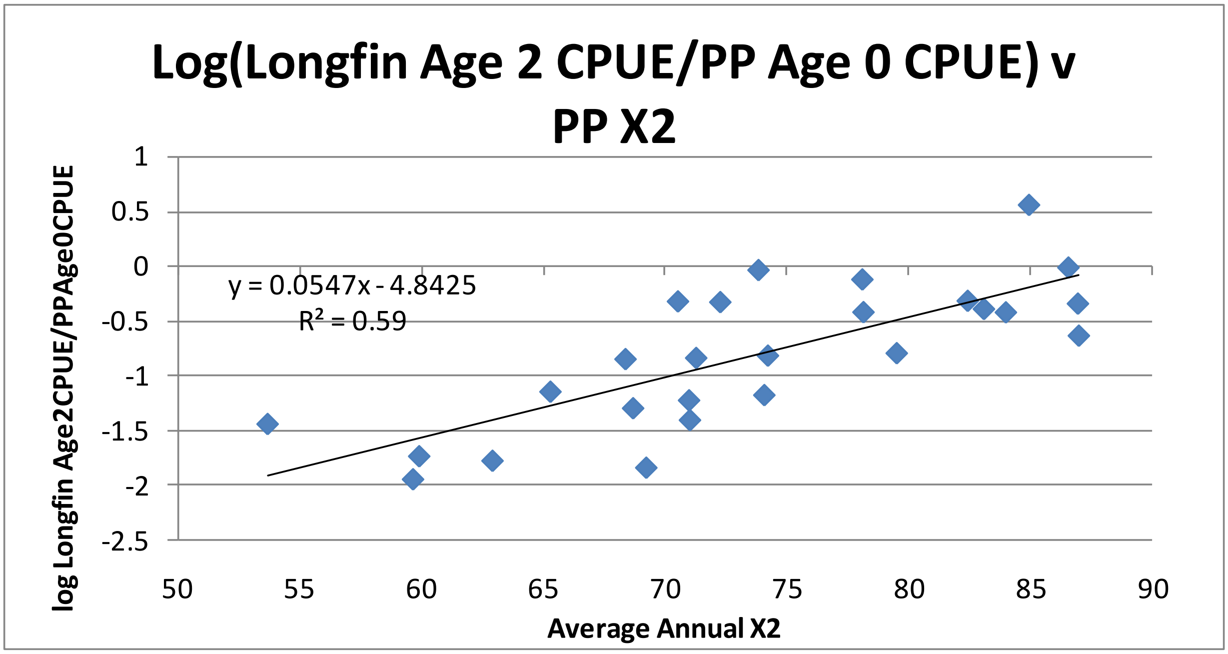

Figure 3. Average annual X2 location and age-0/age-2 longfin smelt. By the time longfin become adults, the relationship between age-0 longfin smelt and X2 has reversed, such that adults are negatively correlated with the same outflow.

One interpretation of these patterns is that the age-0/age-2 relationship with a variety of flow-related variables is largely spurious. High runoff tends to be associated with high turbidity. But the ability of age-0 longfin to avoid the trawling nets may be closely linked to turbidity. In clear water, most longfin may well be able to avoid capture. If this is the case, age-0 data is useless in the effort to understand what drives longfin abundance. Alternatively, higher turbidity could be associated with higher survival. However, as the turbidity subsides longfin mortality might increase, pushing longfin abundance back down toward its carrying capacity. In any case, there is little evidence that flow is closely correlated with longfin smelt over their entire lifecycle.

b. Published literature suggests that reduced food availability and not changes in outflow have been driving declines in longfin smelt abundance

DFG admits that the biological basis for the residual spring outflow relationship is unknown, while nevertheless citing speculation by Baxter *et al.* (2009) that the larvae benefit from increased downstream transport, increased food production, and reduction in entrainment losses at the export pumps.

There are numerous published works that DFG disregarded; sources pointing out the weakness of flow relationships with longfin smelt as well as identifying potential causes of declines, as follows:

(1) Rosenfield and Baxter (2007)[6] identified food limitation as a causative factor in the decline of longfin smelt.

(2) Baxter *et al.* (2008) identified grazing by *Corbula amurensis* on prey as the cause of the post-1987 decline in longfin smelt, especially a summer food decline as a major stressor on age-0 longfin juveniles.

(3) Kimmerer *et al.* (2001) suggests a reduction in ecosystem carrying capacity related to changes in the food web as a reason for declines in YOY striped bass.

(4) Kimmerer *et al.* (2005) found evidence of a decades-long chronic food limitation as the cause of declines in Acartiella spp. in the lower estuary.

(5) Sommer *et al.* (2007) noted food web changes caused by *C. amurensis* grazing may be responsible for reduced fall recruitment in 2003-2005.

(6) Moyle (2002) speculated that the continuing decline of longfin smelt abundance is attributable to multiple factors acting synergistically - the impact of introduced species on longfin food supply, extreme flooding during spawning, impacts of introduced predators, and toxic substances as possible contributors.

(7) The Bay Institute in its petition to list longfin smelt (2007) cited outflow, entrainment, food-related impacts of invasive species, toxic pollutants, water temperature increase, and physical disruption of spawning habitat and critical prey species habitat by dredging.

(8) Glibert (2010) performed CUSUM analyses on nutrient ratios and food web organisms and found a strong relationship between, among other things, declines in *E. affinis* and changing nutrient ratios.

(9) DFG (2009A) indicates that longfin smelt produced fewer eggs per unit of outflow after 1987 than they did previously, attributing this to *C. amurensis*.

In fact, the literature that DFG ignored, including its own, overwhelmingly indicates that an inadequate food supply, rather than outflow, is driving observed declines in longfin smelt abundance.

DFG does acknowledge the positive correlation between *E. afffinis* abundance and spring outflow, citing Kimmerer (2002), Fig. 7, reproduced here as Figure 4. However, DFG improperly relies on this analysis to support its argument that additional spring outflow is

[6] Rosenfield and Baxter (2007) also plotted age-1 and age-2 average percent presence using the Bay Study and Suisun Marsh Survey data compared to average winter-spring outflow and found a positive but weak signal. The predictive power of the relationship was especially weak for age-2 (spawning) fish, which Rosenfield and Baxter pointed out could be explained by their anadromy.

necessary. (DFG Report at p. 65.) DFG reaches its conclusion by misconstruing Kimmerer (2002).

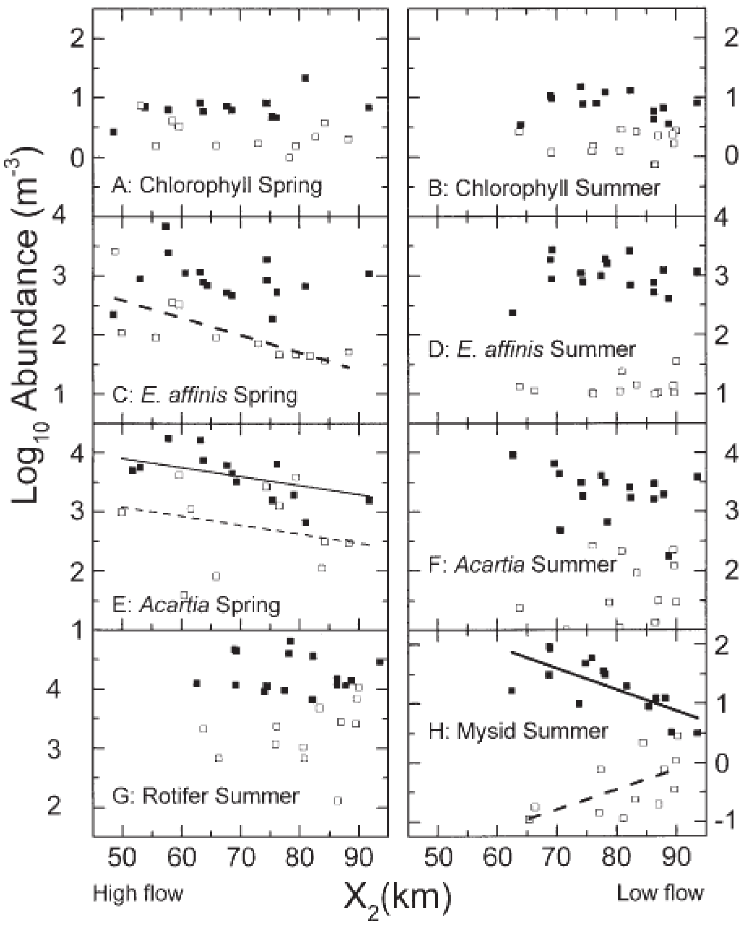

Figure 4 from Kimmerer (2002) Figure 7. Plankton abundance plotted against X_2 and lines, data up to 1987; and dotted lines, 1988 to 1999.

Kimmerer (2002) explained that potential causes of the above relationships could involve higher nutrient levels associated with higher flows (the agricultural model) or through stratification. However, the response of phytoplankton (chl-*a* concentration) has shown little response to freshwater flow either before or after *Corbula amurensis* became abundant (Fig. 4A, B). In the Delta, in spring, chl-*a* has actually decreased with increasing flow, apparently because of decreasing residence time (Jassby *et al.* 2002 *in* Kimmerer 2002). Kimmerer (2002) further noted that without an increase in food supply with flow, there is no reason to expect any specific growth rate to increase with increasing flow for any of the taxa shown in Figure 4 above. The food supply for zooplankton such as *E. affinis* is mostly phytoplankton (i.e., diatoms). Yet increasing flows stifle phytoplankton growth. This conundrum offers little help in establishing spring outflow criterion, and certainly does not support DFG's flow recommendation.

c. The evidence does not support DFG's hypothesis that longfin smelt annual production is related to negative OMR flows/salvage at the SWP and CVP

The DFG Report suggests that longfin "annual production" is related to negative flows in Old and Middle Rivers.[7] Specifically, DFG concluded: "The population abundance of juvenile and adult longfin smelt is … inversely related to the number of fish salvaged at the SWP and CVP facilities."[8]

Correlations may exist, but there is no evidence of a cause and effect relationship. Many factors in the Bay-Delta system are correlated with each other. For instance, OMR flows are highly correlated with X2. Normalized salvage of longfin is also correlated with X2 and OMR flow. Therefore, it is no surprise to find that salvage and OMR are weakly correlated with longfin abundance. The existence of these correlations in no way implies some sort of causal connection.

Given the vanishingly small level of longfin salvage that occurs in most years, such a relationship between salvage and species abundance is extremely unlikely. Indeed, had the DFG Report taken the trouble to correlate longfin abundance against X2 and either OMR or normalized salvage it would have found that OMR and salvage are statistically insignificant.

In considering the speculated flow effects on longfin smelt, much credence is given to the unpublished and un-peer reviewed analysis prepared by The Bay Institute and the Natural Resources Defense Council ("TBI/NRDC"), which allegedly link spring Delta outflows to total fish salvage.[9] The TBI/NRDC Figure 8 at p. 17 inappropriately related total annual entrainment with spring outflows. Spring outflows obviously cannot affect entrainment during other seasons. When March-May salvage is considered (corresponding with spring), the result is an exponential relationship with Delta outflow, with salvage approaching zero when outflow is greater than about 10,000 cfs. (See Figure 5 below.) The existing X2 standard is sufficient to meet this outflow. TBI/NRDC does not demonstrate that higher outflows are needed or that salvage is an important stressor on longfin smelt.

[7] DFG Report at p. 62.
[8] DFG Report at p. 64.
[9] See TBI/NRDC flow criterion submission to State Board at pp. 4 to 17.

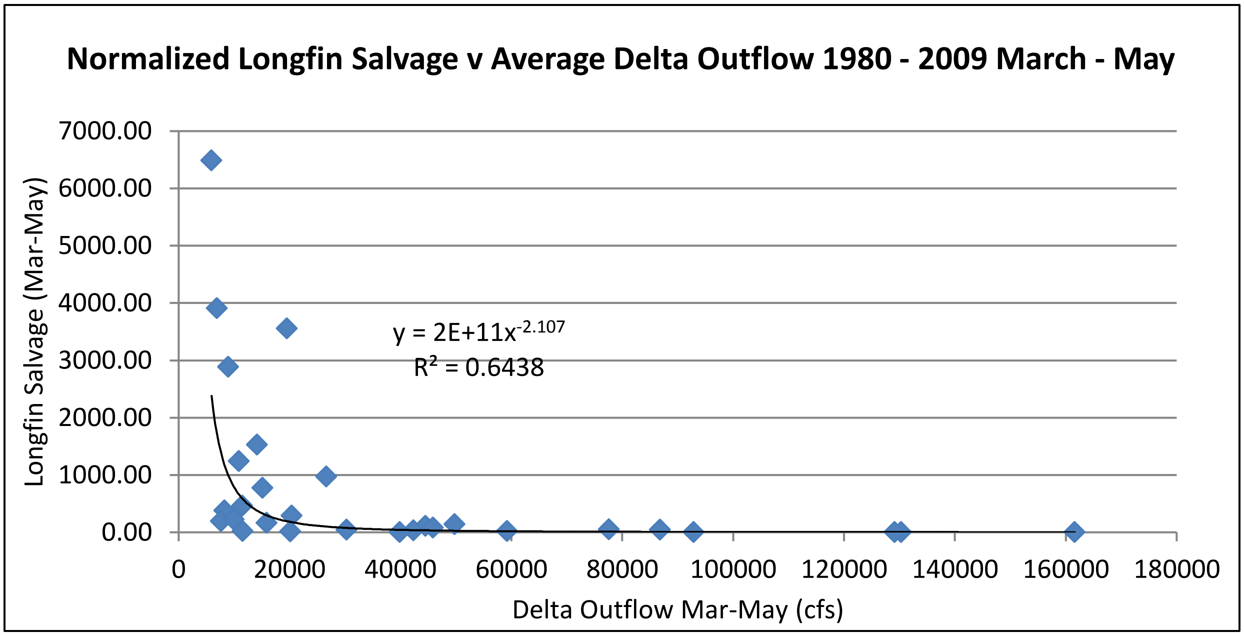

Figure 5. Longfin smelt salvage (March-May) as a function of Delta outflows (March-May). Outflows from DAYFLOW; structured salvage from ftp://ftp.delta.dfg.ca.gov/BayStudy/LongfinSmelt/ for the Bay Study and normalized using age-2 salvage from the same year.

TBI/NRDC's Figure 11 claims a significant relationship between the FMWT Index of spawning-age longfin and total salvage of longfin smelt from 1993-2007, explaining that their negative correlation indicates that increases in salvage are not a result of increased abundance. (TBI/NRDC flow criteria submission at p. 20) The biological mechanism for the FMWT Index in one year being inversely related to salvage the next year is unapparent, as is its predictive power. SFCWA reanalyzed the relationship from 1981-2007 (excluding the year 2006 which had zero longfin salvage) and found a very strong relationship ($p<0.001$) but with very weak predictive power ($R^2=0.09$) and a large range around the trend. (See Figure 6 below.) This indicates that no real conclusions can be drawn about long-term longfin salvage and abundance as measured by the FMWT.

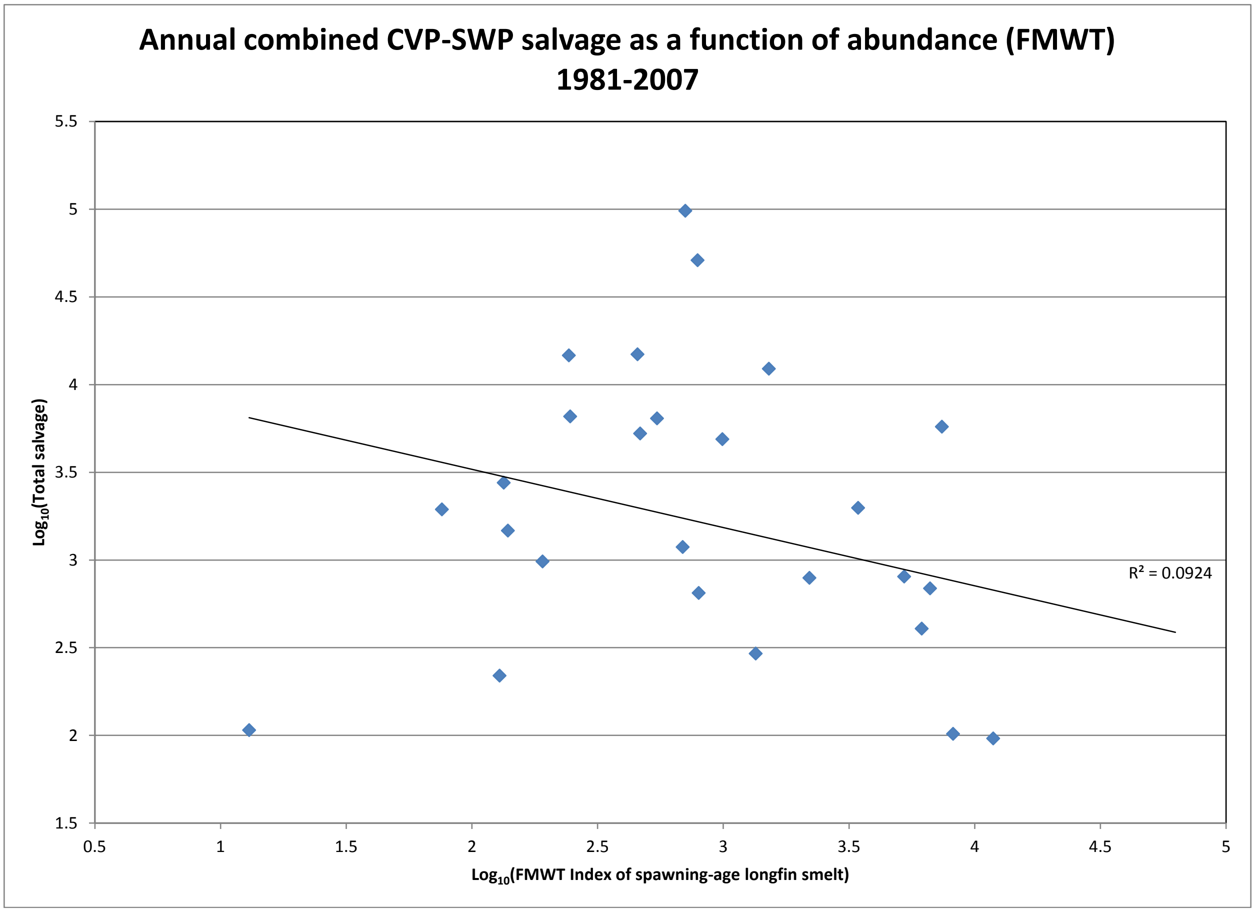

Figure 6. Total salvage as a function of abundance. CVP-SWP salvage from http://www.dfg.ca.gov/delta/Data/Salvage/. FMWT Index for longfin smelt from http://www.dfg.ca.gov/delta/data/fmwt/charts.asp.

If salvage was a significant factor affecting longfin population as expressed by the FMWT Index, the logical conclusion one would expect is that high relative entrainment would lead to a low FMWT Index. Figure 6 simply does not bear this out. In fact, an examination of longfin distributions show that they are rarely in the zone of influence as characterized by Baxter *et al.* (2009). The highest risk of entrainment for longfin smelt would occur if they were found in the lower San Joaquin River, near Franks Tract, in the southeast Delta, or the central Delta. Yet their distributions, both historically and at present, indicate they are infrequently found in these regions and, when found, are only in low numbers. (See Figure 7 below.)

In a further attempt to show that larval longfin smelt might be entrained in higher numbers, DFG uses the Delta Simulation Model (DSM2, particle tracking module) to predict the fate of larval longfin smelt (DFG 2009B). The results purportedly "might be substantial (2 to 10 percent)" during relatively low outflow conditions. [10] However, it is difficult to perceive how 90-98% of the particles were not entrained but that this is a "substantial" loss.

[10] DFG Report at p. 65.

DFG (2009B) cites Grimaldo *et al.* (2009) and various patterns of entrainment to demonstrate that OMR reverse flows result in an exponential increase in salvage loss. Without understanding the effect on the population of the salvaged fish, the actual significance of the patterns in DFG (2009B) or Grimaldo *et al.* (2009) are not apparent, especially when considering Figure 6 above.

Baxter *et al.* (2009) reached similar conclusions as Grimaldo *et al.* (2009) using a particle tracking model to predict the fate of larval longfin smelt. For PTM results to be valid, an assumption must be made that behaviorless particles adequately simulate larval fish, which is rarely the case. As well, the insertion points must reflect the actual areas where fish are found. The insertion points used by Baxter *et al.* (2009) were Stations 716, 711, 704, 809, 812, 815, and 906, the latter four of which are located in the south and eastern Delta. Appendix 1 attached hereto demonstrates that longfin smelt are seldom in these regions in large numbers. Therefore, the results of Baxter *et al*. (2009) do not match the actual data.

The absence of longfin smelt in the south Delta surveys is, as one would expect, reflected in the exceedingly low salvage rates actually recorded at the SWP and CVP pumping facilities. Figure 7, lifted from the IEP Newsletter of Spring 2009, shows annual salvage of longfin smelt at both the SWP and CVP fish facilities. Except for 2002, annual salvage has been extremely low for well over a decade. The data thus provide very clear evidence that SWP and CVP pumping operations are not a significant cause of the longfin smelt's decline in abundance.

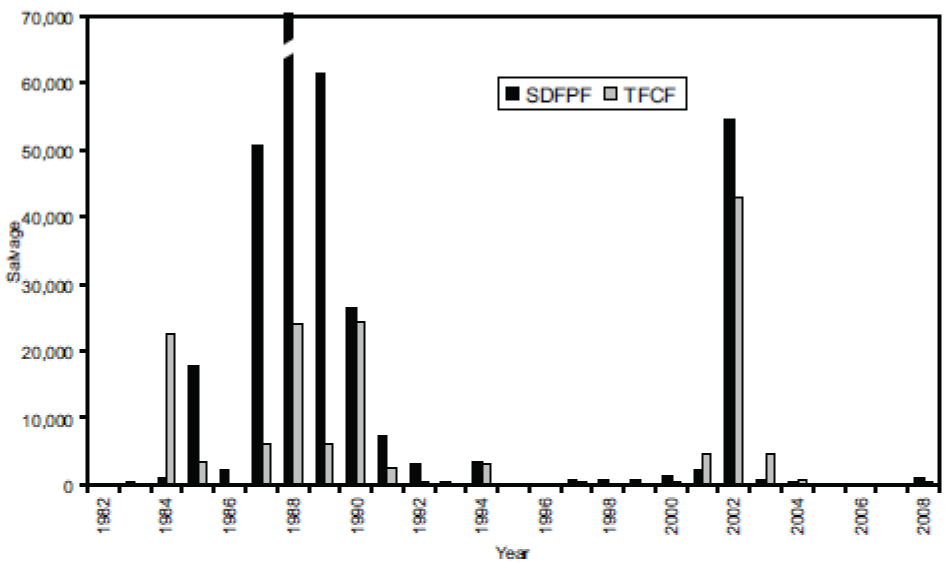

Figure 7. Annual salvage of longfin smelt at the Skinner Delta Fish Protection Facility and Tracy Fish Capture Facility, 1982-2008. Annual salvage for 1998 is truncated for scale considerations (140,040). From IEP Newsletter Spring 2009.

To further illustrate this lack of relationship, analysis of salvage data displayed in Figure 8, below, shows the relative change in longfin smelt abundance for each year between 1979 and 2008 versus the relative longfin smelt salvage for the corresponding year. In this figure, the relative change in longfin smelt abundance is plotted as a fraction comparing each year to the prior year. If there was no change in abundance from year to year, the value plotted is one. If there was an increase in abundance, the value plotted is greater than one. If there was a decrease, then the value plotted is less than one. This ratio of abundance from year to year is compared to the amount of entrainment, which is adjusted by the FMWT level the prior year to reflect relative entrainment impacts on population.

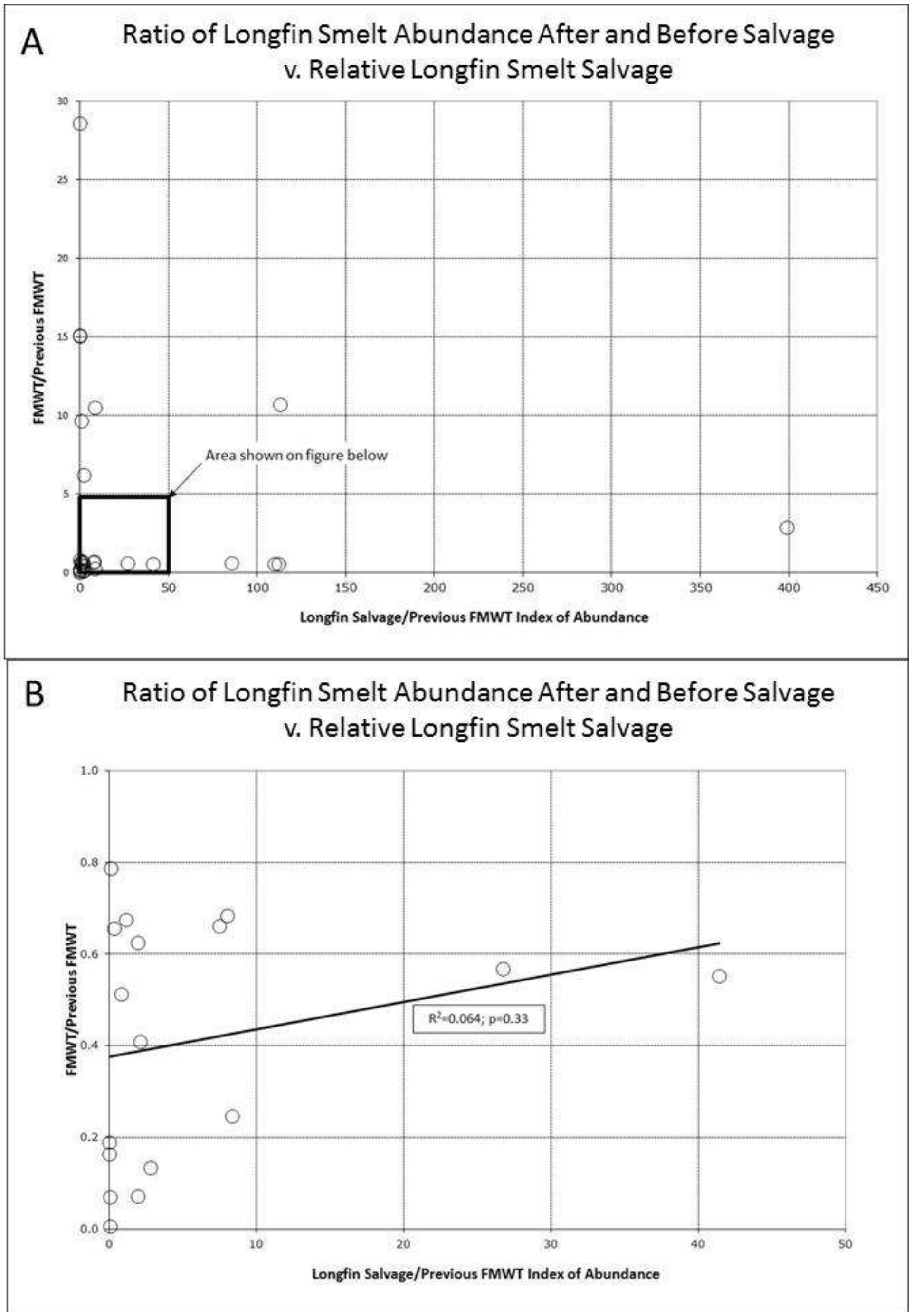

Figure 8. Ratio of longfin smelt abundance after and before salvage v. relative longfin smelt salvage. A. Data for 1981-2008. B. Blow-up of ratio < 1. The low coefficient of determination (R^2) and insignificance of the correlation ($p>0.05$) indicates the lack of relationship between salvage and longfin smelt abundance as measured by the FMWT Index.

If entrainment was a significant factor affecting population, one would expect to find that high relative entrainment (on the horizontal axis) would cause a low population level impact (on the vertical axis). Figure 8A shows that there is no such relationship. The year with the highest level of salvage relative to FMWT, with 398, had a slight increase in subsequent year FMWT Index. Put another way, longfin smelt abundance, as measured by the FMWT Index, actually increased in the year following the highest relative entrainment. Conversely, several years with near-zero entrainment were followed by years with decreased longfin smelt FMWT indices. This effect shows up most clearly in a closer examination of the data near the origin, as displayed in Figure 8B. This figure shows many years when abundance declined were preceded by years in which there was virtually no salvage or none at all. The most recent example of this effect was in 2006, when there were no longfin smelt taken and the longfin smelt FMWT fell from 1949 to 13 (in 2007).

The DFG Report references the generation-over-generation analysis by TBI/NRDC which suggests higher spring flows lead to growing populations of longfin smelt.[11] In its Figure 13, TBI/NRDC subtracted the previous FMWT Index from the Bay Study Index to calculate its population change and correlated this with March-May Delta outflows in the latter cohort (Bay Study Index). In its Figure 14, TBI/NRDC subtracted the previous FMWT Index from the FMWT Index and correlated this with January-March Delta outflows in the latter cohort (FMWT Index). TBI/NRDC also limited their analysis to post-1987 data because of a purported step decline in abundance after 1987.

The TBI/NRDC analysis is flawed in several ways. Since the Bay Study is age-structured, there is no reason to mix indices. Also, pre-1987 CPUE from the Bay Study does not show a step decline. TBI/NRDC's Figure 14 subtracted the previous FMWT Index from the FMWT Index and correlated this with January to March Delta outflows in the latter cohort (FMWT Index). Again, TBI/NRDC limited their analysis to post-1987. SFCWA re-plotted TBI/NRDC's Figure 13 using only the Bay Study data for age-0 and age-1 fish for 1981-2008, the full time period for the Bay Study. (See Figure 9A below). The results do not support TBI/NRDC's contention that higher flows lead to higher abundances. In fact, using the Bay Study data, higher flows are associated with declining abundances and lower flows are associated with increasing abundances. SFCWA also re-plotted TBI/NRDC's Figure 14 using 1981-2008 data. (See Figure 9B below.) The correlation between January-March outflows and population change as measured by the FMWT Index is highly insignificant with essentially no predictive power. No insights are gained with respect to the effect of spring flows on longfin smelt abundances using either the Bay Study or the FMWT datasets.

As has been shown, the TBI/NRDC statistical analysis that purported to show that longfin abundance has been significantly affected by entrainment in the water facilities is profoundly flawed. DFG should not have relied on it.

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[11] DFG Report at p. 65; TBI/NRDC 2 at p. 16.

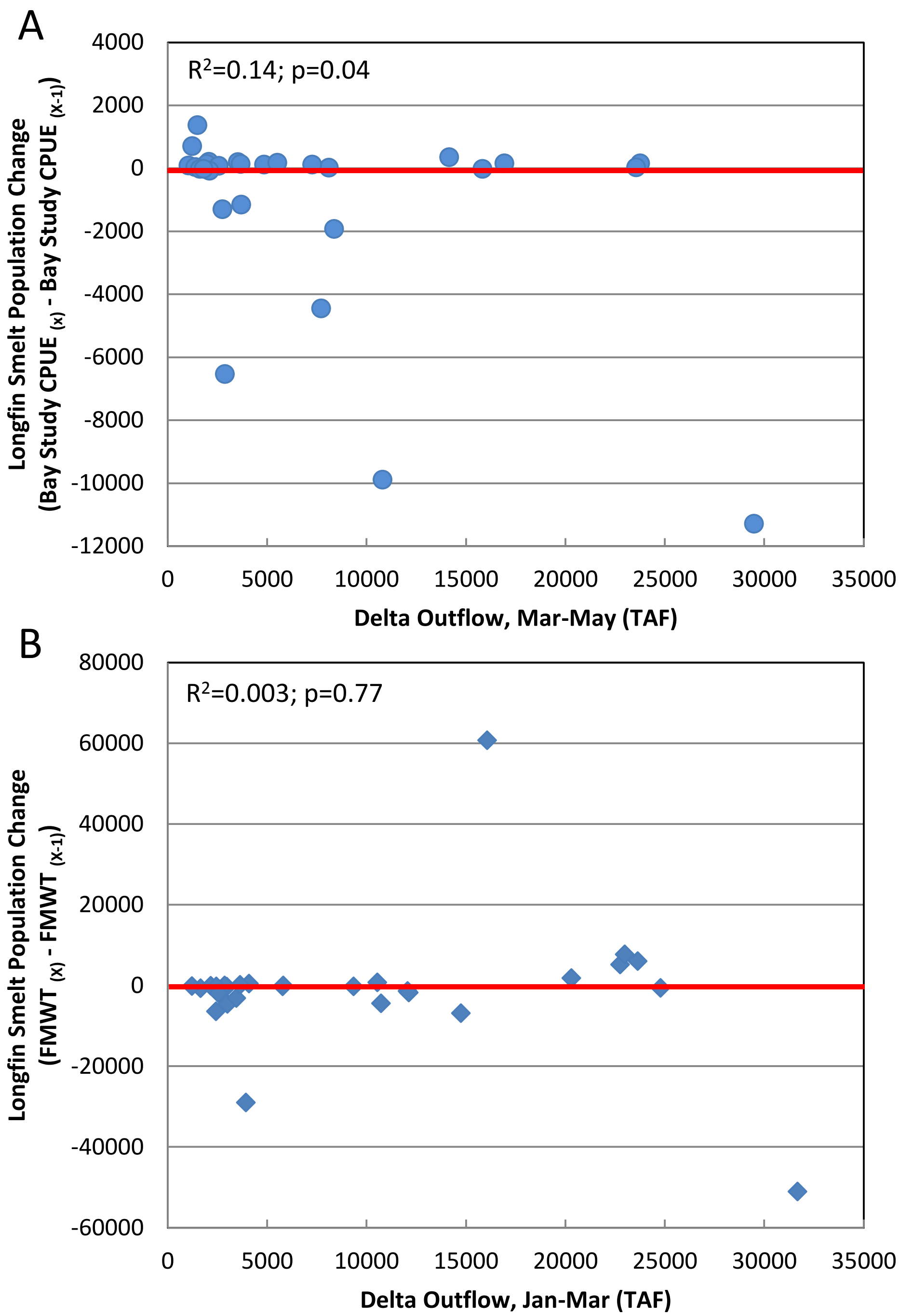

Figure 9. Generation-to-generation change in abundance for longfin smelt (1981-2008). A. March-May Delta outflow in the later cohort and Bay Study CPUE. Abundance data from Bay Study (ftp://ftp.dfg.ca.gov/BayStudy/LongfinSmelt/). B. January-March Delta outflow in the later cohort and FMWT Index. Abundance data from FMWT (http://www.dfg.ca.gov/delta/data/fmwt/charts.asp). Delta outflows from DAYFLOW. Horizontal lines divide growing populations from those that declined.

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VI. DFG failed to acknowledge the compelling science that establishes that new outflow criteria will not increase Delta smelt abundance

The DFG Report admits that, "Delta smelt abundance does not respond to freshwater outflow during springtime (Stevens and Miller 1983; Kimmerer 2002a)."[12] The DFG Report nevertheless attempts to find some relationship between outflow and abundance to rationalize the unrealistic outflow recommendation. DFG argues: (a) "Delta smelt distribution is influenced by outflow through its influence on the location of X2," which results in increased entrainment in the project facilities, (b) "Although outflow did not positively affect delta smelt abundance, outflow did have significant positive effects on several measures of delta smelt habitat [i.e., fall X2 hypothesis]," and (c) "…spring outflow significantly increased spring abundance of *E. affinis* (Kimmerer 2002a), an important delta smelt prey item."[13]

a. The fall X2 hypothesis is conceptually and technically flawed.

The Fall X2 hypothesis is conceptually and technically flawed for several reasons: (1) X2 is not an appropriate surrogate for delta smelt habitat, nor is it an especially strong predictor of delta smelt distribution; (2) X2 does not exhibit a strong, predictive relationship with delta smelt abundance; and (3) There is no empirical support for the hypothesis that changes in X2 are driving food web, species composition, and other stressor impacts.

1. The science does not support the conclusion that fall X2 is a useful measure of habitat.

The assertion that the lens of X2 and its location in the estuary constitutes habitat for delta smelt or can serve as a valid surrogate for delta smelt habitat is not supported by available information. Delta smelt do inhabit the Delta's low-salinity zone, where they have been recorded in estuary areas with salinities ranging from 0 of 16 ppt and more. Historically widespread in the Delta, the delta smelt is now largely restricted to its more northern sub-areas of its historical distribution, from Suisun Bay east up into the mainstem Sacramento River, with highest densities around Liberty Island, Cache Slough, and the Sacramento Ship Channel. The low salinity zone occupies

[12] DFG Report at p. 70.
[13] DFG Report at p. 70.

that and much of the historical area of delta smelt occupancy, and areas that appear to be currently more densely populated by delta smelt frequently experience low salinity conditions. But X2 neither defines delta smelt habitat, nor is it a valid surrogate for the actual habitat required by delta smelt.

Jassby et al. (1995) recognized the X2 zone as having "simple and significant statistical relationships with many estuarine resources," but explicitly noted that they could not find a "statistically verifiable relationship" between delta smelt and its preferred zooplankton prey *Eurytemora affinis* and X2. In their investigation of pelagic organisms, Kimmerer *et al*. (2009) found that just two of eight species associated with the low salinity zone exhibited population responses that suggest the volume of those waters is a measure of habitat quality. The delta smelt was not one of those species. Feyrer *et al*. (2007), in a study that asserted that a relationship between "fall stock abundance" of delta smelt and "water quality" was contributing to the decline in the species, advanced the idea that X2 was a surrogate for delta smelt habitat, which could also predict delta smelt abundance.

The habitat of a species includes the geographic areas it occupies and the resources it uses. Those resources include both physical resources and biotic resources; combined they provide the environmental elements necessary for the survival, persistence, and recovery of an imperiled organism. Habitat is a species-specific concept; no two organisms exhibit identical habitat requirements, because no two organisms use identical resources and require the same environmental conditions. While vegetation communities, like mixed-conifer forests, or aquatic zones with unique physical conditions, such as the brackish waters of estuaries, are often referred to as habitats. They are not habitats. They do, however, provide some or even all of the essential resources necessary to support specific species, and the habitat requirements of those same species may be met in part or in total in those forests or waters with their distinctive characteristics. Few species have all of their resource needs met in a single community or ecosystem type; fewer species still occupy the full extent of a community or ecosystem. Hence the concept of habitat is not co-equal to that of community, ecosystem, or land-cover type.

Habitat frequently includes areas that are suitable for a given species, but may not be occupied at a given time, as the presence or abundance of the species will vary dynamically in response to habitat condition or quality. Habitat quality is often inferred from the density of the targeted species, with areas supporting higher densities usually considered to be higher in habitat quality. But habitat quality should be inferred from data on fitness; the highest quality habitats are those that contribute to population persistence by maximizing species survival over mortality through time. The best habitat areas support stable or growing populations, not necessarily the highest densities of individuals at any given time. Because of the frequent discordance between habitat conditions and occupancy of or population density in an area of habitat, care must be taken when drawing conclusions regarding the resources and resource conditions that are necessary to assure the persistence of any target species.

The DFG Report is premised on an incorrect definition of delta smelt habitat, an inappropriate interpretation of habitat in the context of resource management, and associated management prescriptions that, based on the most reliable information, are unlikely to produce any affirmative responses in the declining delta smelt population. This misunderstanding was initiated with

Feyrer *et al*. (2007), which described the relationship between delta smelt and three physical attributes of the Delta ecosystem. Instead of acknowledging that those three abiotic parameters constitute just a few of the attributes that contribute to the complex, multidimensional habitat space that supports delta smelt, the authors define the combination of salinity, turbidity, and temperature as "abiotic habitat" for delta smelt. The authors conclude that of those three habitat variables, which collectively explain only 25.7% of the variance in distribution of delta smelt, X2 was best correlated with delta smelt abundance based on a correlation they detected between X2 and distribution using Fall Midwater Trawl data. On the basis of this article, the U.S. Fish and Wildlife Service concluded in the on the continued operation of the CVP and SWP (USFWS BiOp) that X2: (1) accurately defines the habitat space that is occupied by delta smelt, (2) therefore, can serve as a surrogate measure for the extent of delta smelt habitat, (3) in its volumetric extent measures habitat quality and availability for the species, and (4) therefore is a reliable predictor of delta smelt population dynamics. However, not one of those four assertions is supported by available data.[14] In light of emerging evidence that the disruption of the food web that supports the delta smelt and depredation of the species by multiple non-native predatory fishes may be better predictors of the decline of delta smelt than any one abiotic factor or any combination of abiotic factors that are now impacting the estuary, it appears that managing for a specific (downstream) position for X2 will have no positive impact on delta smelt.

2. X2 does not significantly affect delta smelt population dynamics, and the Feyrer *et al*. studies relied upon for the contrary proposition are fatally flawed.

Correctly establishing the nature of the fall X2-abundance relationship is crucial for the USFWS BiOp. If fall X2 has no statistically significant relationship with delta smelt abundance and population growth rate, then quantifying the extent of the shift in fall X2 and the amount of X2 "habitat" supposedly lost as a result of the proposed project is an unnecessary exercise since changes in X2 have no impact on the smelt population.

Feyrer *et al*. (2007, in review) provide the sole scientific support for the notion that a supposed upstream shift in fall X2 has constricted available delta smelt habitat and caused population declines in the species. But the analyses are fundamentally flawed because they use a linear additive model, which is biologically implausible and inappropriate, that is, it generates biologically implausible results, like obtaining stock from zero spawners, since additive terms are used, and it treats environmental variables as having a fixed, rather than a proportionate effect. Investigating the fall X2-abundance relationship with a multiplicative model instead of a linear additive one is superior, as Feyrer has conceded when testifying under oath.[15] Analyzing

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[14] Notably, the National Research Council (NRC) Committee on Sustainable Water and Environmental Management in the California Bay-Delta did not affirm any of these conclusions drawn by the Service. In fact, the NRC Committee explicitly questioned the penultimate conclusion linking the location of X2 to delta smelt population dynamics (NRC 2010, pp. 40-41).

[15] Feyrer testified as follows:

> Q. Let me put it another way. Wouldn't it be more appropriate to use a multiplicative model, in other words, a model that relates and deals with proportions rather than an additive model? If you're trying to determine the effect on the smelt population?

Feyrer *et al.*'s data with a multiplicative model (specifically, a Ricker stock-recruit model) shows that there is no statistically significant relationship between fall X2 and subsequent Summer Townet-derived delta smelt abundance.

Now that the Maunder-Deriso delta smelt life-cycle model has been developed and is available, the DFG Report should include an analysis of the Fall X2-abundance relationship using that (or a comparable) life-cycle model. There was agreement among the scientists testifying in the litigation concerning the biological opinions on the continued operations of the CVP and SWP,[16] the court-appointed experts retained by the Judge in that case, and a standing NRC Committee (2010, pp. 25-26),[17] that a life-cycle model represents the "best available science" for investigating the effect of various factors and stressors on the delta smelt population; therefore, life-cycle modeling of fall X2 (and of other habitat variables that may affect delta smelt population dynamics) must be conducted to inform the DFG Report. If it is not, then the DFG Report must include an explicit statement recognizing the significant shortcomings of the analysis contained therein.

Because Feyrer *et al.*'s investigation is limited to the effects of X2 on just one life stage, instead of throughout the complete life cycle (as would occur with a life-cycle model), its method cannot reliably evaluate the overall population-level effects of changes in fall X2. Indeed, it is precisely because a life-cycle model can integrate effects at one life stage over all stages, taking into consideration density dependent effects at different stages, that it is universally recognized as a superior analytical tool. If this tool is not used, despite the recognition that it constitutes the best available science under the ESA for investigating population-level effects, then the scientific credibility of the process by which the DFG Report was developed must be questioned.

Feyrer *et al.*'s fall X2 analysis was criticized in the 2010 report of the NRC Committee, which noted that "the weak statistical relationship between the location of X2 and the size of the smelt population makes the justification for this action [the fall X2 requirement in the delta smelt BiOp] difficult to understand" (NRC 2010, pp. 4, 40-41). The NRC Report also noted that Feyrer *et al.*'s analysis was based on a series of linked statistical analyses where "[e]ach step of the logic train of relationships is uncertain" and where "substantial variance [is] left unexplained at each stage."

A. Multiplicative model would have been a better way of doing that relationship, yes.

Tr. at 1028:18-24, April 5, 2010 Hearing, *In re Delta Smelt Cases*, No. 09-CV-409; *In re Salmonid Cases*, No. 09-CV-1053 (USDC, E.D.Cal) (Emphasis added)

[16] See *In re Delta Smelt Cases*, No. 09-CV-409, May 27, 2010, Findings of Fact and Conclusions of Law Re Plaintiffs' Request for Preliminary Injunction Against Implementation of RPA Component 2, ("Delta Smelt Findings") p. 60 ("All experts agree that application of a life-cycle model is accepted method for evaluating the effects of an action upon a population's growth rate."); *Id*, p. 61 ("Federal Defendants' expert, Mr. Feyrer, testified that, once developed, a life cycle model would be the best available science to evaluate the population-level impacts of the water projects on the delta smelt."); *Id.*, p. 112 ("The use of a quantitative life cycle model is the preferred scientific methodology.")

[17] In its report, the NRC stated: "The committee recommends that development of such models be given a high priority with the agencies."

Other habitat characteristics and variables, like prey density, have much stronger relationships with abundance than fall X2. Furthermore, whereas use of X2 as a surrogate for the suite of physical and biotic elements that constitute habitat is superficially parsimonious, a more robust surrogate that is derived by first assessing elements that directly affect the survival of the species, thereafter assessing elements that indirectly affect survival, then evaluating the combination of such elements most likely to represent habitat quality is preferable. The NRC Committee's report noted that because no study has shown that project operations are either the sole or most important effect on delta smelt population dynamics, "the multiple other stressors that are affecting fish in the delta environment … must be considered, as well as their <u>comparative importance</u>" (NRC 2010, p. 33). Feyrer *et al*. (2007) also suggested that future analyses of delta smelt habitat might be improved by including biotic variables, particularly food availability. Before X2 is deemed to be an indicator of delta smelt habitat, an assessment must be made, using life-cycle modeling, of the comparative importance of other variables, which current scientific information shows have a more powerful effect on delta smelt abundance than fall X2.

3. There is no empirical support for the hypothesis that changes in X2 are driving food web, species composition, and other stressor impacts.

Some have contended that X2 and outflow indirectly affect delta smelt habitat and population dynamics by encouraging growth of submerged aquatic vegetation and proliferation of *Microcystis* and by favoring invasive species over natives lacks. The contention is supported by speculative hypotheses about the relationship between X2/outflow and species composition and the food web. Thus, a suggestion that reductions in outflow may exacerbate the impact of other stressors lacks any empirical support. Claims that project operations have been exacerbating third-party stressor impacts lack any identifiable support in the available scientific data.[18] Moyle *et al*. (2010, p.20) also lacks any empirical evidence for the hypotheses offered therein about effects caused by changes in habitat "variability" and "complexity," and the article itself acknowledges that its discussion consists of "speculative" findings. In contrast, Glibert (in press) using empirical data finds that N:P ratios rather than hydrologic variables are driving changes in the Delta food web and species composition.

4. Increased spring outflow would have no effect on rate of entrainment

After admitting that no statistical relationships have been found between spring outflow and delta smelt population abundance, the DFG Report discusses Grimaldo *et al*. (2009), which argues that such a relationship does exist. (DFG Report at p. 70.) However, the DFG Report fails to discuss Rose *et al*. (2008), which notes that an unpublished version of Grimaldo *et al*. (2009) used in the USFWS BiOp should have normalized the salvage for population size (Rose *et al*. 2008 at p. 6). This is a fundamental error that compromises the validity of Grimaldo *et*

[18] See Delta Smelt Findings, p. 31-33.

al.'s conclusions. Since Grimaldo *et al*. (2009) failed to consider population size, it is of little use for establishing delta smelt flow criteria.

The DFG Report further accepts the Grimaldo *et al*. (2009) conclusion that minimizing reverse OMR flows during periods when adult delta smelt are migrating into the Delta could substantially reduce mortality. An evaluation of the distribution of delta smelt based on the Kodiak Trawl, which targets spawning delta smelt, does not bear this out. Table 1 lists the Kodiak Trawl distributions of adult delta smelt from 2002-2008. For fish to be entrained, they must be located in the southern or eastern portion of the Delta where the export projects are located.

year	survey	survey mid-date	Napa River	Car-quinez Strait	Suisun Bay	Chipps Island	lower Sacra-mento River	lower San Joaquin River	Suisun Marsh	Cache Slough	Sacra-mento Ship Chan-nel	upper Sacra-mento River	near Franks Tract	south-east Delta	east south-east Delta	east central Delta	sum for SE & E-SE Delta
2002	1	8-Jan	0%	5%	11%	6%	3%	19%	30%	1%		0%	21%	3%	0%	1%	4%
2002	2	5-Feb	0%	2%	3%	0%	7%	18%	47%	0%		1%	22%	0%	0%	0%	0%
2002	3	5-Mar	1%	0%	2%	0%	42%	2%	32%	12%		0%	6%	0%	3%	2%	3%
2003	1	19-Feb	0%	0%	27%	16%	8%	4%	14%	20%		0%	7%	1%	2%	0%	3%
2003	2	18-Mar	0%	0%	21%	10%	40%	0%	5%	16%		4%	2%	0%	0%	2%	0%
2003	3	15-Apr	0%	0%	5%	0%	33%	2%	0%	3%		8%	49%	0%	0%	0%	0%
2003	4	14-May	0%	0%	62%	0%	10%	8%	0%	18%		0%	0%	0%	0%	3%	0%
2004	1	13-Jan	1%	0%	1%	4%	0%	21%	35%	0%		0%	29%	1%	7%	0%	8%
2004	2	13-Feb	0%	0%	2%	1%	36%	8%	29%	0%		0%	23%	0%	0%		0%
2004	3	10-Mar	0%	0%	14%	5%	20%	2%	22%	0%		0%	35%	0%	1%	1%	1%
2004	4	6-Apr	0%	0%	3%	1%	45%	7%	0%	1%		2%	40%	0%	0%	0%	0%
2004	5	5-May	0%	0%	0%	0%	23%	40%	0%	5%		0%	33%	0%	0%	0%	0%
2005	1	26-Jan	0%	0%	24%	7%	34%	0%	23%	3%		0%	9%	0%	0%	0%	0%
2005	2	24-Feb	6%	0%	5%	4%	16%	1%	60%	7%	1%	0%	0%	0%	0%	0%	0%
2005	3	24-Mar	0%	0%	9%	19%	32%	0%	8%	8%	19%	5%	0%	0%	0%	0%	0%
2005	4	19-Apr	0%	0%	11%	8%	33%	0%	3%	5%	39%	0%	0%	0%	0%	0%	0%
2006	1	18-Jan	26%	9%	12%	7%	0%	8%	26%	2%	7%	0%	5%	0%	0%	0%	0%
2006	2	15-Feb	24%	4%	32%	5%	2%	2%	14%	3%	8%	0%	4%	2%	0%	1%	2%
2006	3	15-Mar	31%	0%	10%	9%	3%	0%	3%	4%	32%	0%	6%	0%	0%	0%	0%
2006	4	12-Apr	5%	0%	0%	2%	4%	3%	1%	0%	80%	0%	6%	0%	0%	1%	0%
2006	5	9-May	0%	0%	39%	39%	0%	13%	0%	3%	0%	0%	0%	0%	0%	6%	0%
2007	1	9-Jan	0%	0%	0%	21%	31%	5%	25%	3%	6%	0%	10%	0%	0%	0%	0%
2007	2	7-Feb		0%	0%	17%	34%	0%	6%	0%	43%	0%	0%	0%	0%	0%	0%
2007	3	8-Mar	0%	0%	6%	18%	11%	0%	29%	2%	34%	0%	0%	0%	0%	0%	0%
2007	4	4-Apr	0%	0%	0%	3%	9%	0%	2%	0%	86%	0%	0%	0%	0%	0%	0%
2007	5	2-May	0%	0%	0%	0%	10%	0%	3%	0%	87%	0%	0%	0%	0%	0%	0%
2008	1	9-Jan	0%	2%	11%	7%	58%	0%	1%	1%	19%	0%	1%	0%	0%	0%	0%
2008	2	6-Feb		0%	0%	8%	4%	0%	0%	5%	77%	0%	4%	0%	0%	1%	0%
2008	3	12-Mar	0%	0%	0%	3%	5%	0%	3%	1%	82%	0%	6%	0%	0%	0%	0%
2008	4	9-Apr	0%	0%	0%	0%	39%	0%	0%	0%	61%	0%	0%	0%	0%	0%	0%
2008	5	7-May	0%	0%	0%	0%	26%	0%	0%	3%	71%	0%	0%	0%	0%	0%	0%
		avg.	3%	1%	10%	7%	20%	5%	14%	4%	24%	1%	10%	0%	0%	1%	1%

Table 1. Distribution of adult delta smelt based on Kodiak Trawl data, 2002-2008. Data from http://www.dfg.ca.gov/delta/projects.asp?ProjectID=SKT.

As illustrated by Table 1, delta smelt are seldom found in these regions, suggesting that smelt are seldom at risk of entrainment by reverse OMR flows.

5. The science does not support the conclusion Delta smelt require additional outflow to support migration

The DFG Report accepts the hypothesis that delta smelt undergo an annual upstream migration to spawn, triggered by first flush turbidity events or Sacramento River flows in excess of 25,000 cfs. (DFG Report at p. 74.)

The actual monitoring data tells a different story, revealing a year-round, non-migrating sub-population in the west Delta and Liberty Island region of Cache Slough (Nobriga *et al*. 2005; Sommer *et al*. 2009). These regions are similar to the historical habitat conditions that existed in the Bay-Delta prior to its reclamation into agricultural lands and flood control corridors. Catch of delta smelt in these regions is thought to be a substantial portion of the population; ~42% of the Spring Kodiak Trawl catch during March-May since 2005 has been in the Cache Slough complex (Sommer *et al*. 2009). Therefore, establishment of flow criteria specific to migration of delta smelt from or to the south Delta ignores the accumulating data that a large portion may not migrate at all. In fact, with such a substantial portion of the population spawning, rearing, and maturing in the west Delta and Cache Slough regions, it is not known whether high south Delta flows to elicit migration may in fact inhibit their reaching these upstream regions.

Moreover, as Delta smelt prefer turbid conditions, it would be a mistake not to consider turbidity in any proposal regarding smelt migration. Turbidity in the Bay-Delta is not a function of flows, *per se*, but rather a function of storm activity that induces erosion (Wright and Schoellhamer 2004). In fact, sediment loads have been dropping for the Sacramento River. Grimaldo *et al*. (2009) evaluated whether salvage followed first flush precipitation events. Such first flush events are not typically long-lasting. Therefore, recommendation of a specific flow as a migration trigger without considering turbidity is not supported by the best available science and could result in large flows without biological benefit for delta smelt because these are not necessarily related to turbidity.

6. SFCWA agrees that the use of a delta smelt life-cycle model is important

One of the recommendations in the DFG Report is development of a comprehensive life cycle model for delta smelt that would allow for assessment of population level impacts associated with entrainment. (DFG Report at p. 77) SFCWA applauds this recommendation and would like to point out that Drs. Richard Deriso and Mark Maunder have developed such a model, which is being finalized and a manuscript prepared for publication. A second multivariate statistical analysis of factors influencing delta smelt populations has also been done by Dr. Bryan Manly and others, covering all life stages of delta smelt. A manuscript for publication is also being prepared for this analysis. DFG should use these currently available models to examine, not just population level impacts associated with entrainment, but the suite of stressors that can impact the delta smelt population.

The best available science does not support the notion that entrainment at the SWP/CVP export facilities have a significant population level impact on delta smelt. The effects analysis done as part of the biological opinion the U.S. Fish and Wildlife Service prepared on the continue operations of the CVP and SWP states: "Currently published analyses of long-term associations between delta smelt salvage and subsequent abundance do not support the hypothesis that entrainment is driving population dynamics year in and year out (Bennett 2005; Manly and Chotkowski 2006; Kimmerer 2008)." (Effects Analysis at p. 5) This one statement summarizes the state of knowledge about population level effects of entrainment. Use of OMR flow restrictions aimed at improving delta smelt populations is unsupported by the available science and should be deleted from the DFG Report.

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VII. DFG misinterprets, or fails to provide, the scientific studies and research required to support its flow proposal

DFG misinterprets and misapplies the scientific research that it cites. As a result, its conclusion is without a strong scientific foundation and therefore cannot be used in agency decision-making.

a. DFG's assertion that high Sacramento River inflows are needed to prevent "reverse flows" harmful to juvenile salmonids is not scientifically justified.

In describing Sacramento River inflows needed for juvenile salmonids, the DFG Report states:

> Recent studies and modeling efforts have found that increasing Sacramento River flow such that tidal reversal does not occur in the vicinity of Georgiana Slough and at the Cross Channel Gates would lessen the proportion of fish diverted into channels off the mainstem Sacramento River (Perry et al. 2008, 2009). Thus, closing the Delta Cross Channel and increasing the flow on the Sacramento River to levels where there is no upstream flow from the Sacramento River entering Georgiana Slough on the flood tide during the juvenile salmon migration period (November to June) will likely reduce the number of fish that enter the interior Delta and improve survival. (DOI 1 as cited in SWRCB 2010). To achieve no bidirectional flow in the mainstem Sacramento River near Georgiana Slough, flow levels of 13,000 (personal communication Del Rosario) to 17,000 cfs at Freeport are needed (SWRCB 2010). (DFG Report at p. 44.)

The conclusion in the DFG Report is problematic for three reasons. First, the cited studies (Perry *et al*. 2008, 2009) do not support or even address the claim that increasing Sacrament River flows reduce tidal reversals in the stated areas. Rather, Perry *et al*. (2008, 2009) describes behavior and survival of acoustically tagged juvenile salmonids. Nowhere do these papers evaluate or describe Sacramento River flows necessary to prevent tidal reversal.

Second, the other source for this claim of Sacramento River inflows necessary to prevent tidal reversals at the DCC and Georgiana Slough is a personal communication with Del Rosario (DOI 1 at 24). However, DOI does not provide any data or citation to support this claim, rather it only repeats citations to Perry *et al*. (2008, 2009, and in press) and to the same personal communication with Del Rosario.

Third, in contrast to the faulty (or absent) citations provided in the report, detailed hydrodynamic data and modeling tools are available to assess the occurrence of tidal reversal and to assess flows necessary (if any) to prevent such events. The DSM2 Hydro simulation model is one such example. Though a thorough hydrodynamic model based simulation evaluation is beyond the scope of this review, a cursory analysis illustrates that reverse flows do not occur in Georgiana Slough for Sacramento River flows at least as low as 10,312 cfs (Figure 10). Though tides do cause flows to wax and wane, flows in Georgiana Slough never go negative or reverse within the range of Sacramento River inflows considered by Kimmerer and Nobriga (2008).

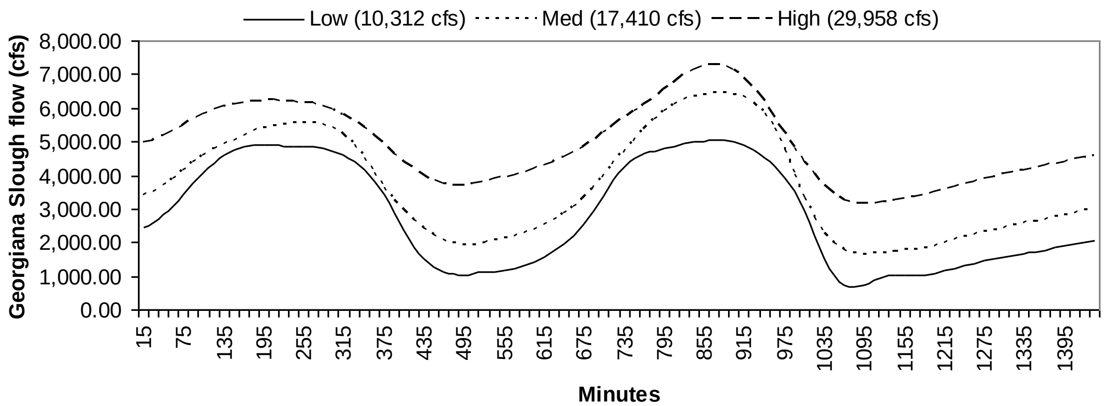

Figure 10. Sacramento River flow effect on tidal flux. Flows predicted by DSM2 Hydro (15 minute increments) for Georgiana Slough at three different levels of Sacramento River inflows (Low, Medium, High) with the Delta Cross Channel closed. Based on DSM2 Hydro data from Kimmerer and Nobriga (2008). See Kimmerer and Nobriga (2008) for a description of assumptions for physical modeling.

DSM2 Hydro simulations do indicate that Sacramento River flows influence the proportion of Sacramento River water entering Georgiana Slough (Figure 11), but the effect is rather subtle and does not approach the dramatic flow reversals cited in the Report. As discussed by Kimmerer and Nobriga (2008), closure of the Delta Cross Channel gates also has a dramatic influence on flows into Georgiana Slough. Closing the DCC gates increases flows into Georgiana by as much as 32% and thus acts to reduce benefits which might be achieved by increasing Sacramento River flows.

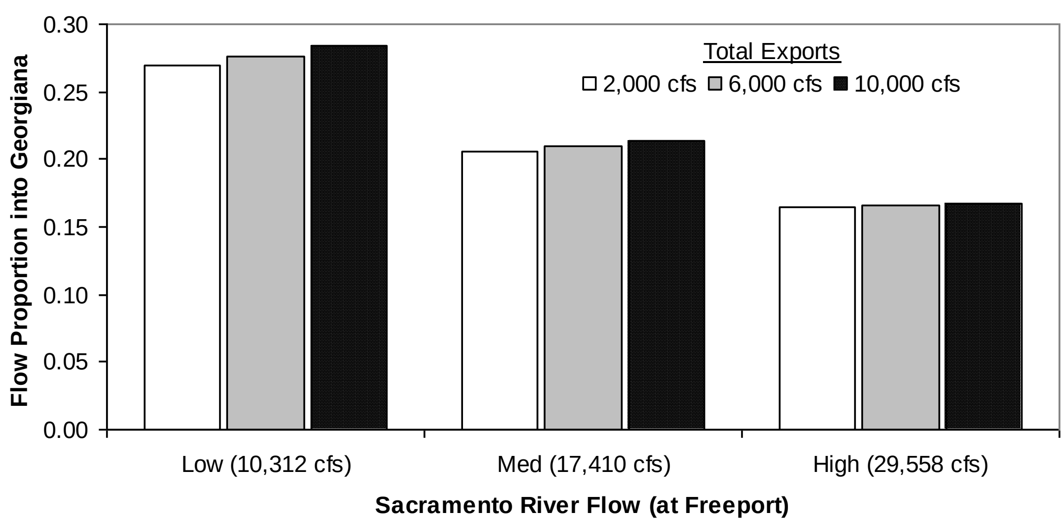

Figure 11. Proportion of Sacramento River entering Georgiana Slough as a function of Sacramento River inflows and exports. Based on DSM2 Hydro data from Kimmerer and Nobriga (2008). See Kimmerer and Nobriga (2008) for a description of assumptions for physical modeling.

In describing its flow recommendations, the DFG Report concludes: "To achieve no bidirectional flow in the mainstem Sacramento River near Georgiana Slough, flow levels of 13,000 (SWRCB 2010) to 17,000 cfs at Freeport are needed." (DFG Report at p. 44.) However, Figures 10 and 11 above show that Sacramento River flows cannot "prevent" salmonids from entering Georgiana Slough.

The "reversal" event referred to in the Report and related citations are not reverse flows such as occur in Old and Middle River as a result of exports. Rather, it is likely a transitory event occurring on some flood tides when the Sacramento River stage gets ahead of river stage on Georgiana Slough. The result is that flows into Georgiana Slough will be higher until the tidal stage equalizes. However, this event is not a reverse flow in the sense used elsewhere in the report. The duration and biological significance of the flood tide stage balancing at Georgiana Slough is uncertain. Given this uncertainty, flood tide stage balancing should be the subject of detailed hydrodynamic and biological assessment, not personal communications and unpublished papers, if it is to be used as a justification for increasing Sacramento River flows. Operations of the DCC should also be considered as part of any assessment for factors influencing flows and entrainment risk at Georgiana Slough.

b. DFG selectively used rotary screw trap data unadjusted for trap-efficiency to support high Sacramento River flows in the fall

In describing fall Sacramento River inflows needed for juvenile salmonids, the DFG Report states:

> Juvenile Chinook salmon outmigration on the lower Sacramento River near Knights Landing also shows a relationship between timing and magnitude of flow in the Sacramento River and the migration timing and survival of Chinook salmon approaching the Delta from the upper Sacramento River basin (Snider and Titus 1998, 2000a, 2000b, 2000c, and subsequent draft reports and data as cited in DFG 2010a). Outmigration timing of juvenile late-fall, winter, and spring-run Chinook salmon from the upper Sacramento River basin depends on increases in river flow through the lower Sacramento River in fall, with significant precipitation in the basin by November to sustain downstream migration of juvenile Chinook salmon approaching the Delta (Titus 2004). Sacramento River flows at Wilkins Slough of 15,000 to 20,000 cfs following major precipitation events are associated with increased outmigration (DFG 2010a, NMFS 7 as cited in SWRCB 2010). Delays in precipitation producing flows result in delayed outmigration which may result in increased susceptibility to in-river mortality from predation and poor water quality conditions (DFG 2010a). Allen and Titus (2004) suggest that the longer the delay in migration, the lower the survival of juvenile salmon to the Delta. To encourage and support outmigration, Juvenile Chinook salmon appear to need

> increases in Sacramento River flow that correspond to flows in excess of 20,000 cfs at Wilkins Slough by November with similar peaks continuing past the first of the year (DFG 2010a). Pulse flows in excess of 15,000 to 20,000 cfs may also be necessary to erode sediment in the upper Sacramento River downstream of Shasta to create turbid inflow pulses to the Delta that hide young salmon from predators (AR/NHI 1 as cited in SWRCB 2010). (DFG Report at p. 45.)

This analysis and rationale for fall Sacramento River flows in excess of 15,000 cfs is flawed in two significant ways. First, the data and reports cited here are based upon DFG's operation of rotary screw traps (RST) at Knights Landing. The ability of RSTs to capture outmigrating juvenile salmonids is itself highly sensitive to factors like river flow, turbidity, and fish size (see Montgomery *et al*. 2007). It is inappropriate to report and analyze raw RST catch data as indicative of survival or abundance without specifically accounting for the efficiency of the RST. Unfortunately, DFG does not conduct such trap efficiency experiments for Knights Landing RSTs, nor do they generate estimates of juvenile salmonid passage which account for factors like river flow, turbidity and fish size. Thus, raw catch at Knights Landing cannot appropriately be used to draw the conclusions indicated in the draft report.

Second, analyzing catch from Sacramento River trawls (at Sherwood Harbor) conducted by the U.S. Fish and Wildlife Service provides another information source. Trawl data is particularly valuable because it is thought to be less subject than RSTs to very low and variable capture efficiency. Figure 12 depicts Sacramento Trawl catch from 1995-2001 (based upon publicly available data from the BDAT website). This data shows, for example, that Jan-Apr winter-run Chinook emigrants are consistently detected in the Sacramento Trawl. Low catch in the Knights Landing RST during this period was presented in the draft report as evidence of poor survival or delayed emigration of juvenile salmonids due to low flow conditions. The more reliable catch data from the Sacramento River trawl illustrates that poor and unknown trap efficiency is a more reasonable explanation for observed patterns of juvenile salmonid catch at the Knights Landing RSTs. It is not clear why the report or background materials by resource agencies did not properly evaluate available data on Sacramento River juvenile salmonid emigrants. However, it is clear that the analysis and rationale based upon Knights Landing RST catch to support high fall Sacramento River flows is significantly flawed and is scientifically insufficient to support higher Sacramento River flows in the fall.

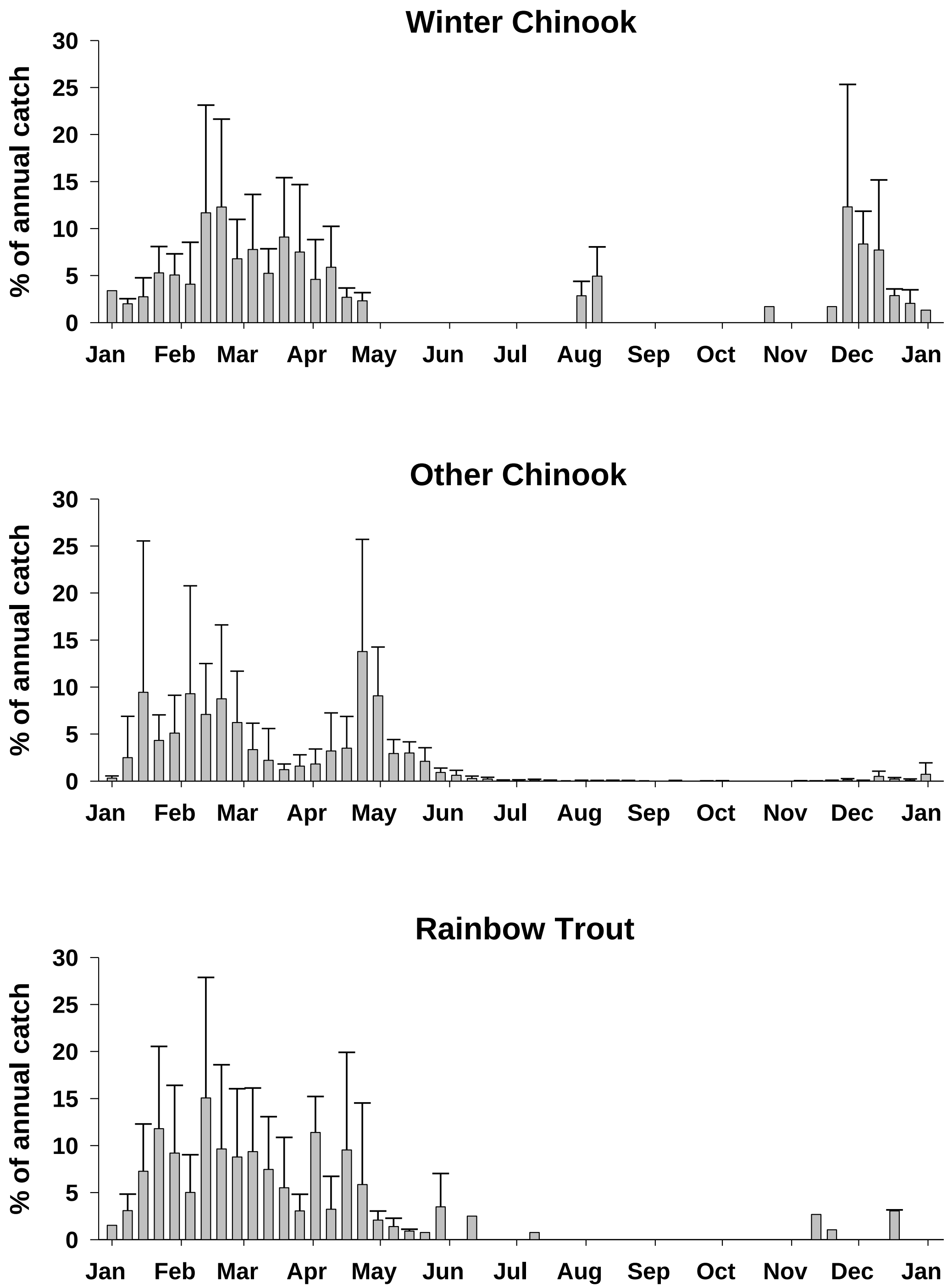

Figure 12. Average percentage of the annual catch taken each week for the specified race of juvenile salmonids in the trawl fished at Sacramento by USFWS, 1995-2001. Whisker lines are standard deviations.

c. DFG used incorrect temperature criteria cited for juvenile salmonids

In describing life history characteristics for salmonids, the DFG Report states, "Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54^{o}F to 57^{o}F (Brett 1952)." (DFG Report at p. 40) This statement is incorrect for two reasons. First, contrary to the clear implication, Brett (1952) provides no specific assessment of optimal temperatures of juvenile Chinook in the Sacramento-San Joaquin Delta. Second, more recent studies, including those specifically addressing Central Valley salmonids, show that Chinook juveniles can achieve optimal growth at temperatures as warm as 65^{o}F (see synthesis provided by Marine 1997; Zedonis and Newcomb 1997; Clark and Shelbourn 1995), while steelhead can achieve optimal growth at temperatures as warm as 68^{o}F (Cech and Myrick 1999; EPA 2001). The available data do not support the temperature criteria cited in the draft report.

d. DFG misuses Vogel (2004)

The DFG Report supports its view that project exports adversely affect salmonid survival by reference to a 2004 radio telemetry study conducted by David A. Vogel. Referring to this study, the DFG Report states (p. 55):

> Analyses indicate that tagged fish may be more likely to choose to migrate south toward the export facilities during periods of elevated diversions than when exports were reduced.

This interpretation conflicts directly with Vogel (2004), which concluded:

> "**These experiments could not explain why some fish moved off the mainstem San Joaquin River into south Delta channels.** Due to the wide variation in hydrologic conditions during the two central Delta studies, it was difficult to determine the principal factors affecting fish migration. Based on limited data from these studies, it may be that a combination of a neap tide, reduced exports, and increased San Joaquin River flows is beneficial for outmigrating smolts, but more research is necessary. (emphasis added)

This is a non-trivial error as no other studies support the hypothesized effect of increased exports, where migratory juvenile salmonids are drawn away from the mainstem San Joaquin River. The use of Vogel (2004) in the biological opinion the National Marine Fisheries Service prepared on the continued operations of the CVP and SWP was described as not rational nor scientifically justified by a federal judge (OCAP BiOp Preliminary Injunction Findings of Fact and Conclusions of Law, Doc 346 at 122-123) and should not be used to support specific flow recommendations in the DFG Report.

e. DFG unduly relied on particle tracking model (PTM) results to assess effect of exports on migratory juvenile salmonids.

The DFG Report relies directly on PTM results and interpretations from the biological opinion the National Marine Fisheries Service prepared on the continued operations of the CVP and SWP regarding the effect of exports on juvenile salmonids. (DFG Report at p. 55.) While a federal judge was unwilling to settle the difference in views held by scientists within NMFS and other scientists at a preliminary stage of litigation, that does not distract from the fact that the best available science shows the dispute over the use of PTM to model juvenile salmon movement is not a dispute among scientists., but instead is a dispute between NMFS' unsupported findings and virtually all of the scientific evidence currently available to DFG. Simply put, PTM is not a valid surrogate for movement of juvenile salmonids which are volitional and can swim at rates at least twice the level of currents in the Delta.

1. DFG fails to address the published scientific literature stating that the PTM does not explain salmon behavior

There available science does not support PTM as an appropriate tool for assessing migration behavior, yet there are at least two scientific studies that support the opposite – they strongly suggest PTM is an inappropriate vehicle to assess outmigrating salmon behavior. First, Baker and Morhardt (2001) compared the transit time and migration patterns of released coded wire tagged salmon and simulated neutrally-buoyant particles. Baker and Morhardt conclude that salmon smolt passage through the Delta "is considerably shorter than the transit time for neutrally-buoyant tracer particles, at least in hydraulic simulations." According to the authors, "Figure 5 (reproduced below as Figure 13) shows an example comparing the speed of smolt passage and the speed of tracer particles for a release made on April 4, 1987, in which 80% of the smolts were estimated to have been recovered after two weeks, but only 0.55% of the tracer particles were recovered after two months." Comparing smolt migration and particle distribution patterns, Baker and Morhardt (2001) remarked: "Not only do the tracer particles which reach Chipps Island take a long time to get there, but most of them go somewhere else." Baker and Morhardt (2001) reported: "That somewhere else is the CVP and SWP pumps, at least for the hydraulic simulations available to us. Figure 13 shows that for the April 27, 1987 simulations, 77% of the tracer particles ended up at the export pumps, while only 13% of the smolts arrived there." The authors characterize these differences as "striking" and explain that the results are due to the fact that "smolts actively swim toward the ocean, and the bigger they are the faster they do it."

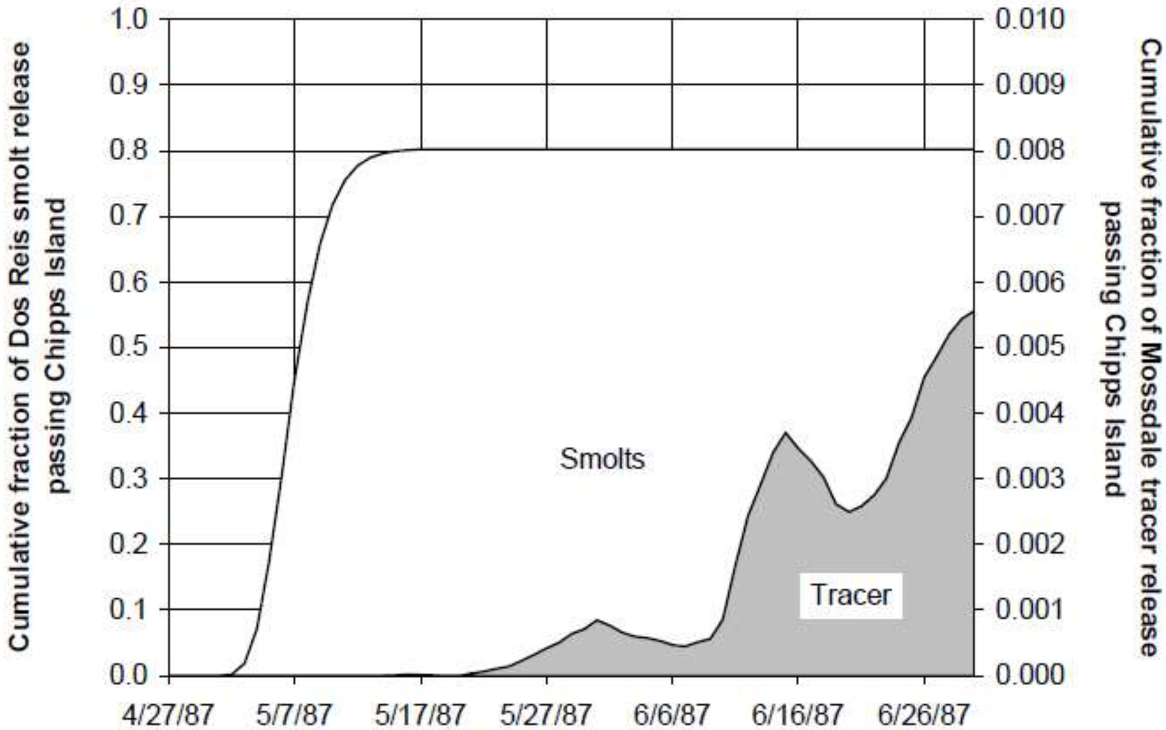

Figure 13 from Baker and Morhardt (2001). Comparisons of the movements of salmon smolts and passive particles released near the head of Old River on April 27, 1987. Cumulative recoveries at Chipps Island of smolts released at Dos Reis, and simulated mass flux past Chipps Island of tracer material released at Mossdale. The smolt recovery data have been fitted to an inverse Gaussian distribution. Hydraulic simulations by Flow Science (1998).

Second, DWR also conducted analyses comparing observed coded wire tag recoveries with predicted recovery timing and location as predicted by PTM and concluded: "The result of the comparison of timing and magnitude of CWT Chinook recoveries and PTM particles passing Chipps Island shows that there is no correlation. There are factors other than hydrodynamics affecting juvenile Chinook emigration through the south Delta not accounted for in the PTM. Based on the 24 experiments graphed in this evaluation, the PTM results are an adequate surrogate for "timing" of salmonid emigration in only very high flow years like 1995, 1998 and 2006. But for the rest of the years, intermediate and low flow years, the PTM results would result in significant project regulation 3 to 6 weeks beyond emigration timing."

2. NMFS' and DFG's failure to address the PTM limitations described by Kimmerer and Nobriga (2008)

DFG relied on the biological opinion the National Marine Fisheries Service prepared for continued operation of the CVP and SWP, but the analysis of the PTM in that BiOp is flawed. In support of their Reasonable and Prudent Alternative (RPA), NMFS expressly relies upon the PTM results as described by Kimmerer and Nobriga (2008). The NMFS BiOp states: "NMFS considers this information useful in analyzing the potential 'zone of effects' for entraining emigrating juvenile and smolting salmonids." (NMFS BiOp at p. 361) A key failure of the NMFS BiOp is its failure to recognize and address the model's limitations as described by Kimmerer and Nobriga (2008).

Kimmerer and Nobriga (2008) note that the PTM model "has not been calibrated." (Kimmerer and Nobriga 2008 at p. 17) Calibration allows for the testing of model outcomes against the full array of evidence in the real world. Kimmerer and Nobriga further warn that "comparisons with field data described above do not constitute a sufficient calibration." (Kimmerer and Nobriga 2008 at p. 5) However, contrary to Kimmerer and Nobriga's warnings, NMFS' PTM technical memorandum asserts that "[t]he model has been calibrated with data from monitoring stations throughout the Delta." NMFS does not explain how it has transformed a non-calibrated PTM model into a calibrated PTM model that is consistent with Kimmerer and Nobriga (2008).

Third, NMFS' use of PTM does not apply a simulation period that corresponds to anticipated fish behavior. Given the rapid and directed movements of salmonid smolts, it is inappropriate to use the fate of particles integrated over weeks or months to even roughly assess salmonid smolt survival; they simply do not act like weightless, behaviorless particles. (Baker and Morhardt 2001) However, Kimmerer and Nobriga (2008) state that the PTM could be a "useful predictor of entrainment probability if the model were allowed to run long enough to resolve particles' ultimate fate." (Kimmerer and Nobriga 2008 at p. 1) Neither the analysis set forth in NMFS' PTM memorandum, nor the DFG Report, resolves this conflict between Kimmerer and Nobriga's concerns and the NMFS BiOp's application of the PTM to salmon behavior. Though several figures in the NMFS PTM memorandum depict the fate of particles at five day increments, the only instance where the memorandum specifically mentions PTM results over a short time horizon occurs on page 3 of the memorandum, where NMFS reports that "the typical pattern following injection at station 912 was a period of several days with little or no entrainment." Thus, in the one instance where a time horizon of only several days was discussed, which is more typical of emigrating smolts, the results indicated no material entrainment effect.

Finally, NMFS' underlying premise for using PTM conflicts with the recommendations of Kimmerer and Nobriga (2008). As noted above, NMFS invoked the PTM and the Kimmerer and Nobriga (2008) study because it "considers this information useful in analyzing the potential 'zone of effects' for entraining emigrating juvenile and smolting salmonids." (NMFS BiOp at p. 361) However, Kimmerer and Nobriga expressly stated that "[w]e are, furthermore, not inclined to define a 'zone of influence' of the pumps on the basis of our results." (Kimmerer and Nobriga 2008 at p. 18) Thus, NMFS chose to use the PTM precisely for the role that Kimmerer and Nobriga declined to recommend it for. The DFG Report makes a similar mistake.

f. DFG's reliance on the NMFS BiOp recommended OMR and San Joaquin River inflow/exports as restrictions are not supported by the best available science.

The DFG Report relies specifically on OMR and San Joaquin River inflow to export restrictions required by the NMFS BiOp. (DFG Report at pp. 55-56) As the summary below indicates, these recommendations are not supported, and in many cases, are directly contradicted by, the best available science.

1. Best available science does not support export restrictions contained in the NMFS BiOp San Joaquin River inflow-to-export ratio.

The biological opinion the National Marine Fisheries Service prepared for continued operation of the CVP and SWP contains two components related to exports and San Joaquin River flows: (1) a San Joaquin River flow requirement measured at Vernalis; and (2) a limit on export pumping operations in the southern Delta. (NMFS BiOp at 641-645) These same requirements have apparently been adopted as Delta flow recommendations in the DFG Report.

Depending upon flow conditions in the San Joaquin River, the biological opinion limits collective CVP and SWP pumping from April 1 to May 31 to a 4-to-1 Vernalis inflow/export ratio. NMFS contends that this export limit will benefit outmigrating San Joaquin River basin and Calaveras River steelhead and that reduced project pumping will assist the survival of Sacramento River salmonids. (NMFS BiOp at p. 645) However, the evidence collected during 10 years of experimental flows in the VAMP program and tagging and telemetry studies of salmon outmigration indicates that rate of pumping are not a significant factor in determining salmonid survival. Neither NMFS, the SWRCB, nor the DFG Report have provided any evidence to support the 4-to-1 Vernalis inflow/export ratio as being an appropriate export limit for the protection of salmonids. Also, a federal court found that the record reveals no biological explanation why NMFS chose to impose a 4-to-1 ratio as opposed to any other ratio and that this was a quintessential example of arbitrary action (Case 1:09-cv-01053-OWW-DLB Document 347 at p. 116).

Notwithstanding more than twenty years of scientific research and investigation directly focused on this precise subject, San Joaquin River fishery studies have not produced any evidence showing a negative relationship between salmonid survival and project pumping. A review of the multiple studies shows the relationship between salmonid survival and CVP and SWP pumping have either failed to establish any statistical relationship between exports and survival, or have surprisingly shown a positive relationship between pumping rates and survival. The excerpts below provide specific examples.

- Kjelson, Loudermilk, Hood, and Brandes. "The Influence of San Joaquin River Inflow, Central Valley and State Water Project Exports and Migration Route on Fall-Run Chinook Smolt Survival in the Southern Delta During the Spring of 1989," WRINT-USFWS 24 [WGCP - USFWS 4]) Stockton, CA, Fishery Assistance Office (1990):

  "**Survival of tagged smolts released under low export conditions was not greater than for those released under high export conditions** (Table 4). This was an unexpected result as we believed conditions for survival should have improved when exports were lowered, since direct losses at the Project facilities were decreased, flow in the mainstem San Joaquin was increased and reverse flows in the Delta were eliminated." (emphasis added)

- Brandes and McLain. "Juvenile Chinook Salmon Abundance, Distribution, and Survival in the San Sacramento-San Joaquin Estuary," Fish Bulletin 179, Vol. 2 (2001):

  "To determine if exports influenced the survival of smolts in the San Joaquin Delta, experiments were conducted in 1989, 1990 and 1991 at medium/high and low export levels. Results were mixed showing in 1989 and 1990 **that survival estimates** between Dos Reis and Jersey Point **were higher with higher exports** whereas in 1991 between Stockton and the mouth of the Mokelumne River (Tables 11 and 12) survival was shown to be lower (0.008 compared to 0.15) when exports were higher. . . . In addition, results in 1989 and 1990 also showed **that survival indices** of the upper Old River groups relative to the Jersey Point groups **were also higher during the higher export period**, but overall still about half that of the survival of smolts released at Dos Reis (Table 11)." (emphasis added)

- San Joaquin River Group Authority. "2005 Annual Technical Report":

  "Regression of exports to smolt survival without the HORB were weakly or not statistically significant (Figure 5-17) using both the Chipps Island and Antioch and ocean recoveries, **but both relationships indicated survival increased as exports increased**." (emphasis added)

- California Department of Fish and Game. "Final Draft 11-28-05 San Joaquin River Fall-run Chinook Salmon Population Model":

  "There is **no correlation between exports and adult salmon escapement** in the Tuolumne River two and one-half years later (Figure 24)." (emphasis added)

- Mesick, McLain, Marston and Heyne. "Draft Limiting Factor Analyses & Recommended Studies for Fall-run Chinook Salmon and Rainbow Trout in the Tuolumne River" (February 27, 2007):

  "[P]reliminary correlation analyses suggest that the combined State and Federal export rates during the smolt outmigration period (April 1 to June 15) **have relatively little effect** on the production of adult recruits in the Tuolumne River compared to the effect of winter and spring flows. Furthermore, **reducing export rates** from an average of 264% of Vernalis flows between 1980 and 1995 to an average of 43% of Vernalis flows and installing the head of Old River Barrier between 1996 and 2002 during the mid-April to mid-May VAMP period **did not result in an increase in Tuolumne River adult recruitment** (Figures 3 and 17)." (emphasis added)

- Ken B. Newman. "An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies" (March 31, 2008):

  "The Bayesian hierarchical model analyzed the multiple release and recovery data, including Antioch, Chipps Island, and ocean recoveries, simultaneously.... There was **little evidence for any association between exports and survival**, and what evidence there was pointed towards a somewhat **surprising positive association with exports**." (emphasis added)

- Lastly, in a published 2001 paper, biologists Brandes and McLain summarized the results of their export/salmon survival research by observing:

  "There is **no empirical correlation at all between survival in Lower San Joaquin River and the rate of CVP-SWP export**." Based upon their review of the evidence, Brandes and McLain concluded that "**no relationship between export rate and smolt mortality** suitable for setting day-to-day operating levels has been found." (emphasis added)

It might be argued that these examples are cherry picked; however, this is not the case. There are no statistical analyses that show a negative relationship between San Joaquin River salmonid survival and CVP and SWP pumping levels. As the SJRGA 2005 Annual Technical Report concluded, "[e]xports do not appear to explain additional variability in smolt survival over that using flow alone, in data obtained with the HORB in 1994, 1997 and between 2000 and 2004."

The DFG Report nonetheless implicates CVP and SWP pumping as a causal factor in salmonid survival by conflating San Joaquin River flow and pumping levels into a inflow/export ratio. This conflation of flow and export data does not provide scientific support for inflow/export restrictions. In fact, DFG has previously independently confirmed that San Joaquin River salmonid production does not correlate to CVP and SWP pumping. In a 2005 study entitled "San Joaquin River Fall-run Chinook Salmon Population Model", DFG observed:

> In every instance where salmon production was high, Vernalis flows are in excess of 10,000 cfs. Conversely when salmon production was low, Vernalis flow levels are less than 2,000 cfs (Figure 19). The question becomes is it the flow, or the exports?" In an attempt to answer this question, DFG took a close look at smolt survival data on the San Joaquin River. The DFG study found that "Smolt survival data collected during VAMP shows **that juvenile survival increases as exports increase** (Figure 19). In addition, smolt survival as a function of the exports to Vernalis flow ratio has a low correlation (Figure 20), indicating that **Delta export level, relative to Delta inflow level, does not influence juvenile salmon survival** on a regular, normal, or repetitive pattern. (emphasis added)

DFG further observed: "Here again, the variable that seems to be controlling salmon production (e.g. survival) is spring Delta inflow, not spring Delta export." (DFG 2005 at p. 14) DFG's San Joaquin River Fall-run Chinook Salmon Population Model Report then reviewed all available salmon smolt survival data and adult salmon escapement data available and stated, "In conclusion, while the influence of Delta exports upon SJR salmon production is not totally clear, overall it appears that **Delta exports are not having the negative influence upon SJR salmon production** they were once thought to have. Rather it appears that Delta inflow (e.g., Vernalis flow level) is the variable influencing SJR salmon production, and that increasing flow level into the Delta during the spring months results in substantially increased salmon production." (emphasis added) (DFG 2005 at p. 15)

DFG was sufficiently convinced of the "lack of substantial cause and effect relationships" between Delta exports and salmon survival that in developing CDFG's San Joaquin River salmon model, CDFG expressly excluded consideration of Delta exports as a factor in the model's development. (DFG 2005 at p. 17)

In Appendix 5 of the BiOp, NMFS purports to find biological support for its adoption of the 4-to-1 Vernalis inflow/export ratio from Figures 10 and 11 in the appendix. However, Figure 10 is a regression analysis that only considers the relationship between Vernalis flow and salmon smolt survival. Project exports are not a factor considered in the analysis. Figure 11 reviews the relationship between the Vernalis inflow/export ratio and returning adult escapement 2.5 years later, but nothing in the Figure 11 analysis or Appendix 5's summary of the analysis explains how NMFS derived the 4-to-1 ratio from the data displayed in Figure 11. Moreover, the DFG 2005 review of project exports and adult escapement 2.5 years later in the Tuolumne River

(Figure 24) discloses that "*no correlation*" can be found between these variables. Mesick *et al*. (2007) confirms DFG's 2005 assessment.

The DFG Report's reliance on the 4:1 inflow to export ratio required under the biological opinion the National Marine Fisheries Service prepared for the continued operation of the CVP and SWP is further undermined by a separate technical memorandum dated May 29, 2009, supplied with the biological opinion. There, NMFS attempts to justify the 4-to-1 ratio based upon a 1989 study by Kjelson and Brandes; however, this study did not find any correlation between CVP and SWP pumping and salmon survival. Instead, the study confirmed what other studies have shown, that a positive correlation exists between salmon survival and San Joaquin river flow at Vernalis, again without identification of causal factors. The technical memorandum also cites to the SJRGA 2007 Annual Technical Report in support of the 4-to-1 ratio. (Technical Memorandum at p. 20) However, the 2007 report declines to reach this conclusion and instead states: "The relationship of survival to exports is difficult to detect based on the data gathered to date." (SJRG 2007 at p. 6) The report continues by stating that "[t]he escapement data for adult salmon indicate that the flow/export ratio explains more of the variability in the adult escapement than flow alone without the HORB, but the smolt survival data is too limited to detect these effects, if they are real." (SJRG 2007 at p. 6) Thus the 2007 report does not support the 4-to-1 ratio, but instead voices clear doubts as to whether the relationship between exports and salmonid survival is in fact "real." In short, neither Kjelson and Brandes 1989 nor the 2007 Annual Technical Report supports NMFS's decision to adopt a 4-to-1 inflow/export ratio.

In light of the above, the DFG Report's adoption of the NMFS BiOp's San Joaquin River 4-to-1 inflow/export ratio is not supported by the best available science.

2. Best available science does not support calendar based restrictions on Old and Middle River flows

The DFG Report proposes restrictions on Old and Middle River flows, which are not support by science. The DFG Report relies heavily upon the biological opinion the National Marine Fisheries Service prepared for the continued operation of the CVP and SWP for those restrictions. However, the biological opinion itself is flawed. According to NMFS, calendar based OMR restrictions are intended to "[r]educe the vulnerability of emigrating juvenile winter-run, yearling spring-run, and CV [Central Valley] steelhead within the lower Sacramento and San Joaquin rivers to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta." (NMFS BiOp at p. 648) The RPA purportedly achieves this objective by requiring the export projects to limit exports to a level that produces flows in Old and Middle River (OMR) no more negative than -5,000 cubic feet per second (cfs) to -2,500 cfs. (BiOp at 648-650). The action triggers for the OMR flow limits are either:

(1) A calendar based trigger that mandates the CVP and the SWP to achieve OMR flows of -5,000 cfs, starting on January 1st and ending on June 15th of every year. This trigger forces the CVP and SWP to reduce pumping to meet the OMR flow requirement even if the pumping operations fail to entrain a single salmon smolt during this six month period. (BiOp at p. 648.)

(2) A salvage based trigger that requires the projects to achieve OMR flows as low as -2,500 cfs depending upon the amount of salmonid salvage that has occurred at the export facilities.

In its May 18, 2010 Findings of Fact and Conclusions of Law re: Plaintiffs' Request for Preliminary Injunction, the federal court concluded: "NMFS's choice of -5,000 cfs as the calendar based ceiling is not scientifically justified and is not based on best available science." (Case 1:09-cv-01053-OWW-DLB Document 347 at p. 65)

The calendar based component of OMR restrictions should not be supported in the DFG Report for the following, previously presented, reasons: (1) evidence does not support NMFS' use of PTM as a tool to explain salmonid behavior; (2) evidence does not support NMFS' contention that project export operations alter salmon behavior and therefore adversely affect their survival; and (3) a federal court has already found that this restriction is not based on the best available science. (Case 1:09-cv-01053-OWW-DLB Document 347 at p. 65)

In addition to the PTM results, the NMFS BiOp, and therefore the DFG Report, relies upon a series of fishery studies to support the OMR limits. However, a close review of these studies show that, at best, they provide inconclusive or ambiguous support for the action.

Misattribution of Newman (2008). NMFS in Appendix 5 has cited to a 2008 paper prepared by Dr. Ken B. Newman for the proposition that the Delta Action 8 studies of Sacramento River coded wire tag releases, "…found a statistically significant negative association between survival of fish moving through the Delta interior and export volume." (Appendix 5 at p. 9) Based upon its review of this study, the BiOp states that "[t]here was a negative association between export volumes and the relative survival of released salmonids." (BiOp at p. 373) However, Dr. Newman did not use the word "*significant*" in describing the relationship because he concluded from his Bayesian analysis that there was very little difference in the model results with exports and without exports. Newman (2008) actually states, "The preferred model based on DIC [a measure of model fit] is the multinomial with log transformed θ and uniform priors for the [variances] (Table 11), but all the multinomial models yielded quite similar results. The DIC for this model, 427.0, however, was only slightly less than the DIC for the models without exports (the "Interior" models where minimum DIC was 427.7)." (Newman 2008 at p. 59)

Thus, Dr. Newman concluded that the DIC value for a model without exports was not much higher than the corresponding model with exports. In a follow-up analysis of the Delta Action 8 data, Newman and Brandes found that the "relationship between exports and the relative survival of Georgiana Slough releases seems relatively weak" and they could not conclude that "exports are the cause of this lower relative survival."

Improper extrapolation from Perry and Skalski (2009). NMFS (and therefore DFG) has similarly misapplied the 2009 study by Perry and Skalski. Specifically referring to the results of Perry and Skalski (2009), the BiOp explains that "[t]he probability of ending up at the Delta export facilities or remaining in the interior delta waterways increases with increased export pumping, particularly for those fish in the San Joaquin River system." (BiOp at 383). However, the Results and Discussion sections of Perry and Skalski (2009) do not contain any reference to project exports. Moreover, Perry and Skalski (2009) expressly recognizes that "[c]urrently, there is limited understanding of how water management actions in the Delta affect population distribution and route-specific survival of juvenile salmon." (Perry and Skalski 2009 at p. 3)

Misstatement of Vogel (2004) conclusions. As described previously, the NMFS BiOp and the DFG Report both misrepresent the findings of Vogel (2004) in an attempt to support OMR flow restrictions. As previously discussed, a federal court determined that NMFS' use of Vogel (2004) to support its BiOp was not rational and not scientifically justified.

In light of all the examples provided, it is clear that the DFG Report's acceptance of the OMR flow restrictions required by the National Marine Fisheries Service is not supported by the best available science.

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VIII. DFG failed to recognize that while there is a relationship between outflow (X2) and starry flounder abundance, no causal mechanism has been identified and species abundance has recovered.

Delta outflow criteria for starry flounder are based on the X2-abundance relationship asserted for delta and longfin smelt and bay shrimp, even though high outflows are noted as only indirectly correlating with bay shrimp abundance. Kimmerer (2002a, 2002b) and Kimmerer *et al.* (2009) are offered as the only support for an outflow-abundance relationship for starry flounder, none of which offers a causal mechanism. In the case of starry flounder, the State Water Board's Flow Criteria Report recognizes that DFG was the only participant to submit outflow recommendations and indicates that the proposed criteria are "consistent with California Department of Fish and Game recommendation for starry flounder." (SWRCB at p. 83) DFG's testimony and exhibits do state that starry flounder are associated with March-June outflows, offering several hypotheses for causal mechanisms, none of which are established by the best available science: (1) outflows can provide chemical cues to larvae and juveniles to facilitate locating estuarine nursery habitat; (2) high outflows generate bottom-oriented upstream-directed gravitational currents that assist immigration; and (3) flows enhance the area of low salinity habitat selected by young starry flounder.

Kimmerer (2002) has shown lower relative abundance per unit X2 after the invasion of *C. amurensis*, evidence of food limitation. Because of the profusion of *C. amurensis*, it cannot be stated that higher outflows will translate into more food. DFG admits in its written summary that flows alone are insufficient to sustain or recover the low salinity zone ecosystem. (DFG at p. 2) Without considering what other actions need to be taken as part of a suite of actions to maintain abundances of starry flounder, outflow recommendations are not supportable.

The DFG Report omits an important point about starry flounder that is contained in the SWRCB flow criteria report, which states: "Population abundance of young of the year and one year old starry flounder have been measured by the San Francisco Otter Trawl Study since 1980 and reported as an annual index (Kimmerer et al. 2009). The index declined between 2000 and 2002 but has since recovered to values in the 300 to 500 range. The median index value for the 29 years of record is 293." (SWRCB at p. 82) Hence, the available data suggests that existing flow criteria since 2002 (D-1641 as amended) are sufficient to maintain starry flounder abundances.

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IX. The net effect of Delta outflow indicates no actual increase in American shad abundance.

The DFG Report asserts that American shad year class strength correlates positively with freshwater outflow during spawning and nursery periods. DFG Report at p. 81) To support the assertion of an X2-abundance relationship for American shad, the draft report cites Kimmerer (2002) and Kimmerer *et al.* (2009). Stevens and Miller (1983) is also indirectly cited to argue for an increase in habitat as a possible causal mechanism for the X2-abundance relationship. Yet it is acknowledged that no causal relationship for an X2-abundance relationship is known. In the case of American shad, high outflow in one year is associated with an increased FMWT Index in that year, but high flow in one year is also associated with reduced FMWT Index in succeeding years. The net effect is essentially zero as the two relationships are basically mirror images and thus cancel each other out. Therefore, flow criteria for American shad are not supported by the best available science.

It is of interest that neither the DFG Report nor the State Water Board's Flow Criteria Report contains flow criteria for striped bass. American shad have many similarities to striped bass – both are anadromous, both are introduced species from the Atlantic seaboard at about the same time, both use the estuary for spawning and nursery, bay shrimp is a primary food item for both. If flow recommendations for other species are sufficient for striped bass, why would separate criteria be needed for American shad?

X. The abundance indices do not suggest that California Bay Shrimp are doing poorly under existing D-1641 outflow requirements.

Kimmerer *et al*. (2009) and Jassby *et al*. (1995) are offered as support for an outflow-abundance relationship for bay shrimp, although neither reference mentions causal mechanisms for the relationship. Nutrient and food web shifts explain the declines in bay shrimp as well or better than flows. Glibert (*in press*) advances a plausible linkage between these shifts and the explosion in the populations of numerous invasive species, including *C. amurensis*.

The abundance index for bay shrimp computed from the Bay Study does not indicate that the species is doing poorly at current regulatory flow levels (D-1641 as amended). Indices over the 29 years of record have varied from 31 to 588 with a median value of about 103. In wet years the indices tend to rise significantly. Indices over the last four years have been at or above the median value.

Based on the above, the best available science does not support specific flow criteria for bay shrimp at this time.

XI. The most significant relationship is between zooplankton and diatom abundance.

E. affinis densities and persistence are purported to relate to March-May position of X2 (DFG Report at pp. 86-87). The DFG Report, like the State Water Board's Flow Criteria Report, does not state the causal mechanism for the relationship between *E. affinis* and X2. In fact, the relationship between *E. affinis* densities and diatoms is far stronger than the X2 relationship, as shown on Figure 14. The causal mechanism here is the fact that diatoms are a primary food source for *E. affinis*. In turn, while the relationship between diatoms and X2 is very weak, the relationship between diatoms and ammonia/um is very strong. A robust literature exists (e.g., Dugdale *et al.* 2007, Glibert *in press*) explains why ammonia/um is likely to suppress diatoms, which in turn suppresses *E. affinis* production.

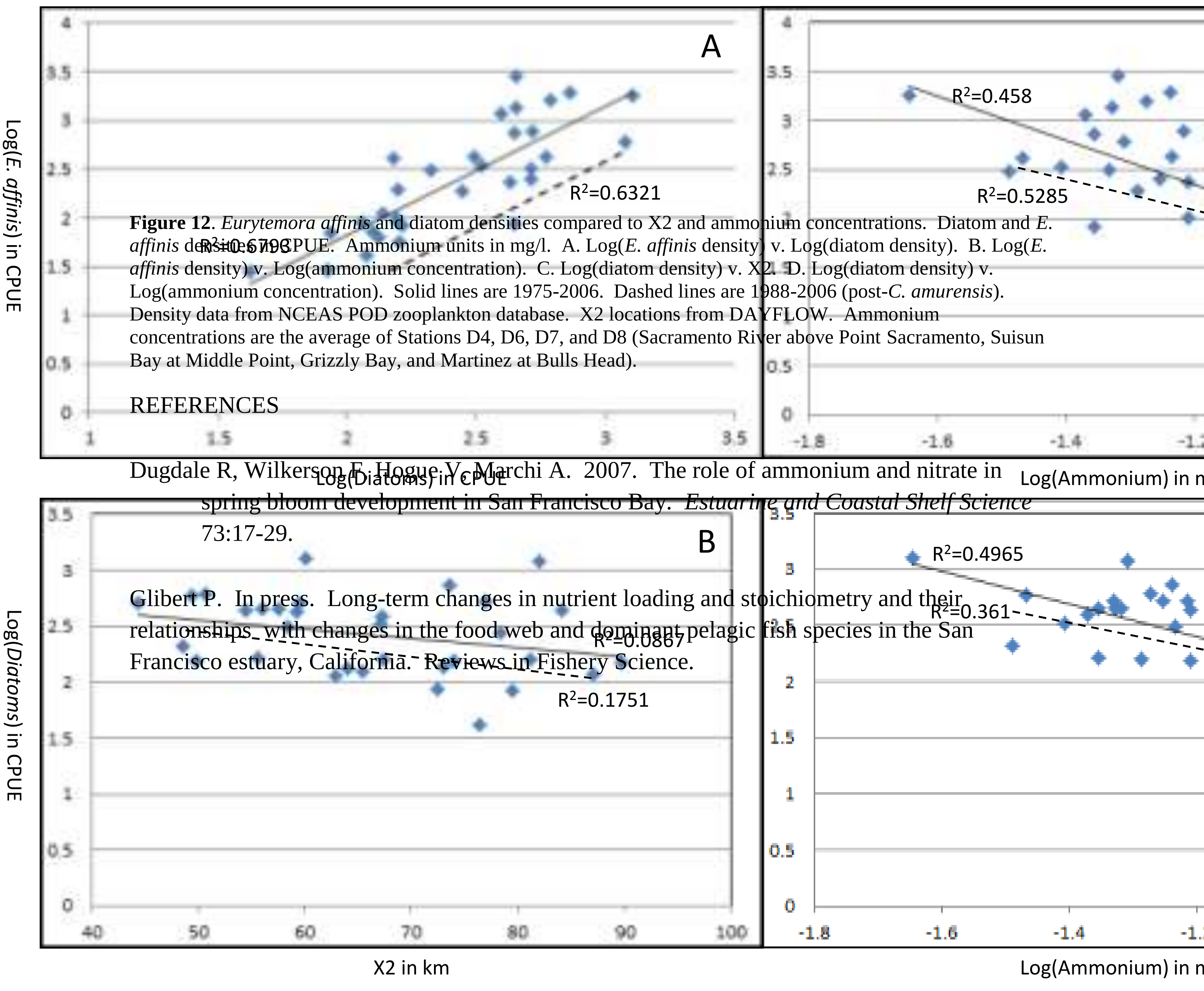

Figure 12. *Eurytemora affinis* and diatom densities compared to X2 and ammonium concentrations. Diatom and *E. affinis* densities in CPUE. Ammonium units in mg/l. A. Log(*E. affinis* density) v. Log(diatom density). B. Log(*E. affinis* density) v. Log(ammonium concentration). C. Log(diatom density) v. X2. D. Log(diatom density) v. Log(ammonium concentration). Solid lines are 1975-2006. Dashed lines are 1988-2006 (post-*C. amurensis*). Density data from NCEAS POD zooplankton database. X2 locations from DAYFLOW. Ammonium concentrations are the average of Stations D4, D6, D7, and D8 (Sacramento River above Point Sacramento, Suisun Bay at Middle Point, Grizzly Bay, and Martinez at Bulls Head).

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XII. The abundance indices do not suggest that Sacramento splittail are doing poorly under existing D-1641 outflow requirements.

The DFG Report mentions splittail are a species of special concern to DFG and under review as a candidate species for protection under the federal Endangered Species Act. Now that the U.S. Fish and Wildlife Service published its 12-month finding on the petition to list splittail and has found that its listing is not warranted at this time, the DFG Report should exclude the reference to the splittail being a candidate species (USFWS 2010).

The DFG Report describes the need for adequate flows to achieve inundation of floodplain habitat in the Yolo Bypass in above-normal and wet years. The science supports this general finding. It may be useful to review some background information on splittail that is not mentioned in its life history within the draft report.

Splittail are very fecund, with each female producing up to 150,000 eggs (Feyrer and Baxter 1998). Splittail spawning occurs over flooded vegetation in tidal freshwater and brackish water habitats of estuarine marshes and sloughs and slow-moving, shallow reaches of large rivers (Sommer *et al.* 2007). The Yolo and Sutter Bypasses, Butte Creek, Butte Sink, and Cosumnes River floodplains serve as important splittail spawning and early rearing habitat (Sommer *et al.* 1997), as they approximate the large, open, shallow water areas in which splittail prefer to spawn. In wet, high flow years when these areas tend to flood, splittail abundance can increase dramatically. The years 1998 and 2005 had particularly high abundances following multiple dry years when abundance was reduced.

Survey data other than the FMWT have not shown declines in splittail abundance or distribution. The FMWT is not efficient at sampling splittail because it samples portions of the water column that are generally not used by splittail. For instance, the FMWT samples in open channels, whereas splittail are primarily found in shallower near-shore waters. Also, the FMWT does not sample the upstream range of splittail (Sommer *et al.* 2007). Other survey data, such as the U.S. Fish and Wildlife Service's beach seine survey, have shown greater abundances of splittail than the FMWT, especially in wet years. The beach seine survey is designed to sample near-shore waters where splittail are typically found.

It is not unusual for splittail abundance to drop in dry years when inundation events do not occur. If one investigates alternative sampling data to the FMWT, which is inefficient at catching splittail (see Sommer *et al.* 2007), there is no evidence that splittail abundance has shown an unusual decline. Its life history is closely linked with flow events which inundate floodplains and riparian areas (Daniels and Moyle 1983; Sommer *et al.* 1997; Harrell and Sommer 2004; Moyle *et al.* 2004; Kratville 2008). Even though their primary spawning activity is associated with wet years, some spawning takes place almost every year along the river edges and backwaters created by small increases in flow (Kratville 2008). When one focuses on surveys that sample floodplains and riparian areas, such as the Suisun Marsh Survey, the State Water Project salvage index, and the U.S. Fish and Wildlife Service's Beach Seine Survey (see Moyle *et al*. 2004 for a summary of sampling data), one finds that splittail abundance is not unusually low (see Sommer *et al.* 2007).

Historically, splittail reportedly were found throughout the central valley, extending as far north as Redding, CA, and as far south as the historic Tulare and Buena Vista Lakes (Moyle *et al.* 2004). Except for these historic lakes, splittail are still distributed below dams throughout the San Joaquin River and Sacramento River watersheds, as well as the Bay-Delta (Kratville 2008). Sommer *et al.* (2007) Table 1 explains that splittail are still widely distributed and that their distribution has not changed substantially since the 1970s.

Several ecosystem restoration efforts are underway, including several CALFED-sponsored projects, CVPIA habitat restoration efforts, USACE restoration efforts on Prospect Island, CDWR restoration on Decker Island, and several other smaller efforts. Since 2003, additional restoration activities have been completed or are on the near-term horizon. Both the BDCP and the biological opinion the National Marine Fisheries Service prepared for the continued operation of the CVP and SWP contemplate changes to the Fremont Weir on the Sacramento River in order to increase both the area and frequency of Yolo Bypass seasonal inundation. A range of 17,000-20,000 acres will be seasonally inundated under these proposals, with benefits to splittail as well as salmonids.

The BDCP also anticipates restoring at least 5,000 acres in the Cache Creek complex, at least 1,500 acres in the Cosumnes/Mokelumne River regions, at least 2,100 acres in the western Delta, at least 5,000 acres in the southern Delta, and at least 1,400 acres in the eastern Delta. Much of these areas are within the distribution of splittail. While the Delta Stewardship Council's Delta Plan is not yet developed, it will be based on the Delta Visions report (1/29/2008) which called for developing a more heterogeneous estuarine environment, including expanded seasonal and tidal wetlands. Based upon the ongoing and anticipated habitat restoration projects, splittail spawning and rearing habitat will be greatly expanded at a wide range of flows.

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XIII. DFG fails to respond to science that supports a finding that the Bay-Delta ecosystem is suffering from significant water quality impairment, which has devastated the food web and overall health of the ecosystem.

DFG failed to evaluate the water quality that would be needed to support the aquatic species in the Delta ecosystem. Specifically, DFG did not consider the overwhelming evidence that ammonia discharges are suppressing the primary productivity of the food-web, which is having a profound effect on species abundance.

In its tentative NPDES permit ("Tentative Permit") for the Sacramento Regional County Sanitation District ("Sanitation District"), the Central Valley Regional Water Quality Control

Board ("Regional Board") concluded that the Sanitation District is a major source of ammonia loading into the Delta, having a significant effect on the food-web, as well as causing direct toxicity in the near field mixing zone on the Sacramento River. It is unlikely that species abundance can improve significantly until the ammonia loading from the Sanitation District is reduced through the adoption of advanced wastewater treatment technology. The DFG Report should have considered this information.

a. The Regional Board Determined that the Discharge of Ammonia/um and Other Nutrients From the Sanitation District is Adversely Affecting Beneficial Uses.

The Tentative Order documents why the Sanitation District must nitrify and denitrify its wastewater in order to remedy the harmful effects caused by the discharge. Tentative Order, Att. F at F-54 – F-56. The Regional Board's reasons are well documented by the record, including previous submissions by the Water Agencies. *See* Water Agencies' Comments on Aquatic Life and Wildlife Preservation Issues Concerning the Sacramento Regional Wastewater Treatment Plant NPDES Permit Renewal (June 1, 2010). The data and scientific literature establish that the Treatment Plant's nitrogen load, particularly in the form of ammonia/um is both having direct toxic effects on aquatic species in the Sacramento River and Bay-Delta and altering the aquatic food web—the foundation of the Sacramento River and Bay-Delta ecosystem. Accordingly, following the reasons already documented in the Tentative Order, we provide our comments in support of the determination that the discharge of ammonia/um and other nutrients is adversely affecting beneficial uses of water:

1. The Treatment Plant is a major source of ammonia/um to the Bay-Delta.

The Tentative Order accurately states that a "consensus of scientific experts concluded the SRWTP is a major source of ammonia/um to the Delta." Tentative Order, F-55. This conclusion is not surprising. The Plant currently disposes an estimated *10,000,000 pounds of ammonia/um* into the Sacramento River each year, or about 14 tons per day and this amount has been increasing over time (*See* Figure 1).[19] The Tentative Order correctly cites some of the extensive data supporting this conclusion, including data collected by Regional Board staff and by the San Francisco Regional Board. Tentative Order, Att. K at K-5, K-6.

[19] 14 tons x 2000 lbs. x 365 day = 10,220,000 lbs./year. That could double to more than **20 million pounds**, if the interim daily limit in the Tentative Order is not reduced and other interim measures are not required, as outlined elsewhere in these comments.

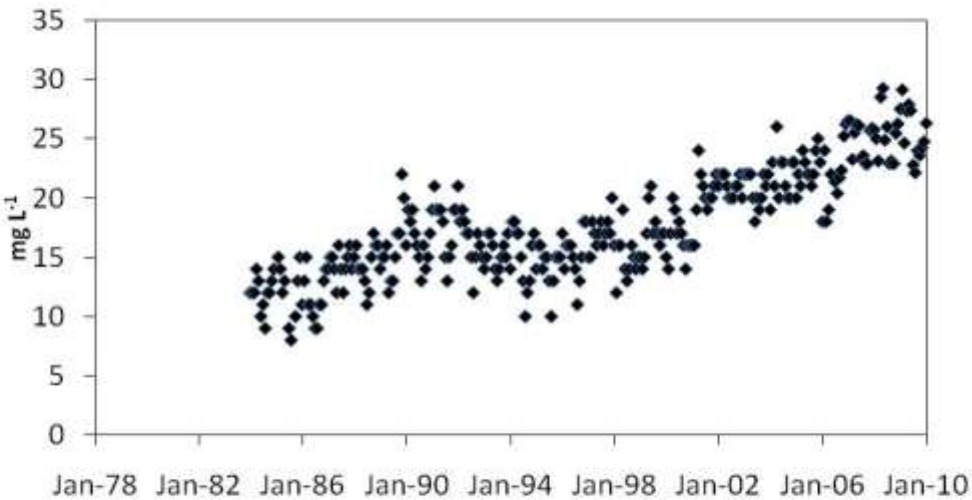

Figure 1 Change in effluent ammonium concentration (mg L^{-1}) over time, based on data reported to the Regional Board. Note that although the Treatment Plant came on line in 1982, data are available from 1984. All data are monthly averages.

In addition to the studies referenced, additional scientific analyses add further support to the consensus that the Treatment Plant is a significant source of ammonia/um to the Bay-Delta. For example, modeling by Resource Management Associates (2009) indicates that changes in nutrient concentrations due to the Treatment Plant's nutrient discharges can be seen along the Sacramento River corridor to Suisun Bay, as well as at Jersey Point, Potato Point and Georgiana Slough.[20] Dr. Patricia Glibert of the University of Maryland has found that changes in ammonium concentration in the Treatment Plant's effluent are highly correlated with changes in ammonium concentrations in the Sacramento River at Hood and with concentrations in Suisun Bay.[21] Dr. Carol Kendall of the United States Geological Survey determined that nutrients and organic matter downstream of the Treatment Plant are isotopically distinguishable from upstream Sacramento River and Cache Slough tributary nutrients. The differences become even more distinctive further downstream as more ammonium is nitrified; the Treatment Plant's ammonium is distinguishable from other sources of ammonium all the way to Suisun Bay.[22] Mass balance calculations with the available chemical and isotopic data from the Cache Slough tributaries show that the confluence area between the sloughs and the mainstem river at Rio Vista acts

[20] Resource Management Associates. 2009. Modeling the fate and transport of ammonia using DSM2-QUAL, Draft final report, October 2009. Prepared for State Water Contractors.

[21] Glibert, P., 2010a. "Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco Estuary, California," *Reviews in Fisheries Science.*

[22] Kendall, C., Silva, S.R., Young, M.B., Guerin, M., Kraus, T., and Parker, A., 2010. Stable isotope tracing of nutrient and organic matter sources and biogeochemical cycling in the Sacramento River, Delta, and Northern Bay. U.S. Geological Survey Open-File Report 2010-XX, preliminary draft for colleague review, 52 pages; Kendall, C. 2010a. Causes of seasonal and spatial variation in water chemistry in the Sacramento River, Delta, and Eastern San Francisco Bay and their effects on chlorophyll levels. Oral Presentation at 6th Biennial Bay-Delta Science Conference, Sacramento, CA. September 27-29, 2010.

mainly as a sink, not a source, of slough-derived nutrients and organic matter to sites downstream of Rio Vista[23]. Parker *et al*., (2010b) were also able to track ammonium from Treatment Plant discharges along the entire Sacramento River transect to Suisun Bay.[24]

2. The ammonia discharge is toxic to copepods and fish and does not meet the most current EPA aquatic life criteria for ammonia.

The SFCWA agrees with the Tentative Order finding that the 14 tons of ammonia/um discharged every day "has reasonable potential to cause or contribute to an exceedance of the Basin Plan's narrative toxicity objective in the receiving water." Att. F. at F-54. The Tentative Order thus appropriately concludes that the Sanitation District's request to continue to use the River to further treat its discharge must be denied. Att. F. at F-54. The Tentative Order properly prevents the continued impairments to water quality and the beneficial uses of the water.

In support of its findings, the Tentative Order correctly reasons that "[r]ecent studies suggest that ammonia at ambient concentrations in the Sacramento River, Delta and Suisun Bay may be acutely toxic to the native *Pseudodiaptomus forbesi* (copepod)." Tentative, Order, Att. F at F-54. The Tentative Order supports this important conclusion by referencing studies by Werner, Johnson, and Teh, including Dr. Teh's finding that "ten percent mortality occurred to both invertebrate species at ambient ammonia concentrations present in the river below the SRWTP." Att. K at K-2. Thus, as the Tentative Order also states, "[r]egardless of whether ammonia is directly or indirectly contributing to the [pelagic organism decline], ammonia is shown to affect adult *Pseudodiaptomus forbesi* reproduction at concentrations greater than or equal to 0.79 mg L^{-1}. And nauplii and juvenile *Pseudodiaptomus forbesi* are affected at ammonia concentrations greater than or equal to 0.36 mg L^{-1}. These ammonia concentrations can be found downstream of the discharge. The beneficial use protection extends to all aquatic life and is not limited to pelagic organisms." Tentative Order, Att. F at F-55.

The SFCWA strongly supports this analysis. Ammonia/um concentrations above 0.36 mg L^{-1} were measured by the Regional Board all the way to Isleton, *27 miles downstream of the Treatment Plant*. In fact, ammonia/um exceeded 0.36 mg L^{-1} in *44% of the samples* collected at stations between Hood and Isleton on the Sacramento River in 2009-2010.[25] The Tentative Order has correctly noted these toxic impacts are real and provides ample support for the ammonia/um effluent limits and nutrient removal required by the Tentative Order, regardless of the other effects of the discharge.

The Tentative Order also appropriately acknowledges EPA's 2009 Ammonia Criteria Update which relies on current science to define updated ammonia criteria to protect aquatic life. *See* "Draft 2009 Update Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater" in

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[23] *Id.*

[24] Parker, A.E., Dugdale, R.C., Wilkerson, F., Marchi , A. 2010b. Biogeochemical Processing of anthropogenic ammonium in the Sacramento River and the northern San Francisco Estuary: consequences for Pelagic Organism Decline species. Oral Presentation at 6th Biennial Bay-Delta Science Conference, Sacramento, CA. September 27-29, 2010.

[25] Data provided by Chris Foe, Central Valley Regional Water Quality Control Board, collected between March 2009 and February 2010.

December 2009. Att. F at F-55, Att. K at K-3, K-4. Considering these proposed criteria as part of its evaluation of the actual impact of the Treatment Plant's discharge would be a reasonable application of the Regional Board's authority to protect water quality in this State. Viewing the Treatment Plant's discharge through the lens of these most current criteria, the serious adverse effect on beneficial use of the proposed discharge is clear, as the Treatment Plant's discharge regularly exceeds those criteria. In fact, the EPA draft ammonia criteria would have been exceeded 29% of the time in 2008 at R3 downstream of the Treatment Plant and 16% of the time from January 2007 to April 2010.[26]

Moreover, it is well established that endangered Delta smelt spawn just downstream of the Sanitation District's outfall. As the United States Fish & Wildlife Service noted in its biological opinion regarding the threatened Delta smelt, the Sanitation District's "discharge places it upstream of the confluence of Cache Slough and the mainstem of the Sacramento River, a location just upstream of where Delta smelt have been observed to congregate in recent years during the spawning season."[27] This recognized "potential for exposure of a substantial fraction of Delta smelt spawners to elevated ammonia levels" that have repeatedly been found to be toxic, is further support for the conclusions of the Regional Board.[28]

There is substantial additional support documenting the toxic impacts of the Treatment Plant's continuing discharge of ammonia/um on which the Regional Board should rely. For example, Parker *et al*. (2010a) conducted parallel tests with ammonium chloride and the Sanitation District's effluent on primary production and phytoplankton nitrogen uptake.[29] Compared to controls, primary production and ammonium uptake rates were reduced 20 to 36% and phytoplankton nitrate uptake was reduced 80% at effluent ammonium concentrations greater than 8 μmol N L^{-1}, equivalent to a river:effluent dilution greater than 200:1. This dilution rate greatly exceeds actual river:effluent dilutions. According to the Regional Board's "NPDES Permit Renewal Issues: Drinking Water Supply and Public Health" paper dated December 14, 2009, flow ratios nearing 14:1 are not uncommon during dry years under the existing plant capacity. In other words, during dry years, approximately 7% of the river can be effluent.

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[26] These values differ from those provided in the Water Agencies' Comments on Aquatic Life and Wildlife Preservation Issues Concerning the Sacramento Regional Wastewater Treatment Plant NPDES Permit Renewal (June 1, 2010) at 22 because the data provided by the Regional Water Board at the time of the previous comments only included monitoring through 7/22/2008. The calculations in these comments are based on a data file provided by Kathy Harder, Regional Board, entitled "Compilation of SRCSD Effluent and Receiving Water Concentration Data," dated July 13, 2010.

[27] USFWS. 2008. Biological opinion on the proposed coordinated operations of the Central Valley Water Project ("CVP") and the State Water Project ("SWP"), December 15, 2008 ("Delta Smelt BiOp") at 245.

[28] *Id.*

[29] Parker, A.E., A.M. Marchi, J.Drexel-Davidson, R.C. Dugdale, and F.P. Wilkerson. 2010a. "Effect of ammonium and wastewater effluent on riverine phytoplankton in the Sacramento River, CA. Final Report to the State Water Resources Control Board.

3. The ammonium and other nutrients from the Treatment Plant are adversely altering the food web that supports aquatic life in the Sacramento River and Bay-Delta

A significant shift in the pelagic food web has occurred in the Bay-Delta; this has been identified as a significant factor in the well-documented Pelagic Organism Decline (POD). Primary productivity and phytoplankton biomass in the Bay-Delta are among the lowest of all estuaries studied and dropped even lower in the 1980s, and declines in several zooplankton species have followed the chlorophyll ("chl-*a*") declines. Research indicates that Delta-wide chl-*a* levels are now low enough to limit zooplankton abundance[30], and zooplankton are an essential prey item for endangered fish species in the Bay-Delta, including the Delta smelt[31].

The Bay-Delta's algal species composition has shifted from diatoms to flagellates, cryptophytes and cyanobacteria, which are a lower food quality, and to invasive macrophytes such as *Egeria densa*. *See* Water Agencies' June 1 Comments at 13. The shift from diatoms to smaller celled phytoplankton results in a less efficient food web. Cloern and Dufford state, "[s]ize is important because many metazoan consumers, such as calanoid copepods, cannot capture small particles, including the nutritionally-rich nanoflagellates (Fenchel 1988)." [32] Recent studies in the San Francisco Estuary's low salinity zone by Slaughter and Kimmerer (2010) observed lower reproductive rates and lower growth rates of the copepod, *Acartia* sp. in the low salinity zone compared to taxa in other areas of the estuary. They conclude that "[t]he combination of low primary production, and the long and inefficient food web have likely contributed to the declines of pelagic fish."[33] Cloern and Dufford (2005) also state, "[t]he efficiency of energy transfer from phytoplankton to consumers and ultimate production at upper trophic levels vary with algal species composition: diatom-dominated marine upwelling systems sustain 50 times more fish biomass per unit of phytoplankton biomass than cyanobacteria-dominated lakes (Brett & Müller-Navarra 1997)."[34]

In addition to the evidence presented in the Tentative Order, substantial field data have demonstrated the increasing decline of the phytoplankton in the Delta and Suisun Bay. For

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[30] Müller-Solger, A., A.D. Jassby and D.C. Müller-Navarra. 2002. Nutritional quality of food resources for zooplankton (*Daphnia*) in a tidal freshwater system (Sacramento-San Joaquin River Delta). *Limnol Oceanogr* 47(5):1468-1476.

[31] Sommer. T, C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga and K. Souza. 2007. The Collapse of Pelagic Fishes in the Upper San Francisco Estuary. *Fisheries* 32(6):270-277; Winder, M. and A.D. Jassby. In press. Shifts in zooplankton community structure: Implications for food web processes in the Upper San Francisco Estuary. *Estuaries and Coasts*. DOI 10.1007/s12237-010-9342-x.

[32] Cloern, J.E., and R. Dufford. 2005. Phytoplankton community ecology: principles applied in San Francisco Bay. *Mar. Ecol. Prog. Ser.* 285:11-28.

[33] Slaughter, A. and W. Kimmerer. 2010. Abundance, composition, feeding, and reproductive rates of key copepodsspecies in the food-limited Low Salinity Zone of the San Francisco Estuary. Poster Presentation at the 6th Bienniel Bay-Delta Science Conference, Sacramento, CA, September 27-29, 2010.

[34] Cloern and Dufford, 2005, *supra*.

example, Wilkerson *et al* (2010) categorized three different phytoplankton responses to increasing ammonium concentrations:

- Type I: healthy phytoplankton were able to drawdown all available dissolved inorganic nitrogen and accumulate chlorophyll in 2-3 days;
- Type II: phytoplankton were able to drawdown nutrients, but the chlorophyll accumulation was delayed in time; and
- Type III: phytoplankton were unable to drawdown the nitrate and accumulate chlorophyll by 6 days.[35]

In repeated phytoplankton grow out experiments from Suisun Bay and the River, almost none had healthy Type I responses. Instead, samples from Suisun Bay typically showed Type II responses while samples from the Sacramento River at Rio Vista, where ambient ammonium concentrations are higher, all exhibited Type III responses. In addition, Parker *et al* (2010b) observed predictable and reproducible patterns in phytoplankton rates in response to ammonium concentrations in Sacramento River transects in 2008 and 2009.[36] Increases in nutrient loading and changes in nutrient ratios over time are a primary driver of these observed changes in the food web[37] – and the Treatment Plant's discharge is the principal source of those loadings.[38]

The Treatment Plant is inhibiting nitrogen uptake by diatoms in the Bay-Delta.

The Tentative Order correctly concludes that "recent studies provide evidence that ammonia from the SRWTP discharge is contributing to the inhibition [of] nitrogen uptake by diatoms in Suisun Bay." Att. F at F-55. Inhibiting nitrogen uptake is one of the ways in which the nutrients discharged daily by the Treatment Plant have adversely affected the food web in the Bay-Delta. In support of its conclusion, the Tentative Order relies on peer reviewed articles by Parker *et al* (2010a), Wilkerson *et al* (2006), Dugdale *et al* (2007), and Sommer *et al* (2007). Att. K at K-5, K-6.

The fact that ammonium loading inhibits nitrogen uptake by phytoplankton is a phenomenon long established in the scientific community in research done over many decades and in a variety of systems. Moreover, it continues to be demonstrated in ongoing research, including new data collected in Suisun Bay in the spring of 2010 by the San Francisco Regional Board and by the Dugdale Lab at San Francisco State University's Romberg Tiburon Center.[39]

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[35] Wilkerson, F., R. Dugdale, A. Marchi, and A. Parker. 2010. "Different response types of phytoplankton to changing nutrient regimes in SF Bay/Delta: Bottom up effects of ammonium and nitrate." Oral Presentation at 6th Biennial Bay-Delta Science Conference, Sacramento, CA, September 27-29, 2010.
[36] Parker *et al*., 2010b, *supra.*
[37] Glibert, 2010a, *supra*; Parker, *et al*., 2010a, *supra*; Parker, *et al*., 2010b, *supra*; Wilkerson, *et al*., 2010, *supra.*
[38] Glibert, 2010a, *supra*; Resource Management Associates, 2009, *supra*; Kendall, 2010, *supra*; Parker *et al*., 2010b, *supra.*
[39] Marchi, A. 2010. "Spring 2010 phytoplankton blooms in Northern San Francisco Estuary: influences of climate and nutrients." Oral Presentation at 6th Biennial Bay-Delta Science Conference, Sacramento, CA, Sept. 27-29, 2010.

Accordingly, in addition to the studies referenced in the Tentative Order, the Regional Board should consider and reference the decades of scientific research that confirm that ammonium suppresses algae productivity, a phenomenon which was first observed by researchers as far back as the 1930's.[40] Some of the early field demonstrations were by MacIsaac and Dugdale (1969, 1972),[41] followed by research in the Chesapeake Bay by McCarthy *et al* (1975).[42] Lomas and Glibert (1999a) describe the threshold for inhibiting nitrate uptake at approximately 1 □mol L^{-1} (0.014 mg L^{-1}), many orders of magnitude below the level of the discharge.[43,44]

Ammonium suppression of nitrate uptake when both nutrients are in ample supply should not be confused with the preferential use of ammonium by phytoplankton when nitrogen is limiting. When nitrogen is limiting, phytoplankton will use ammonium preferentially because it requires less energy to use ammonium than nitrate. When both nutrients are in ample supply, the phytoplankton cells must cope with the excess; and in doing so, the phytoplankton metabolism is altered away from an ability to assimilate nitrate and thus their total primary productivity is suppressed. This is particularly problematic for the Bay-Delta as it is already a comparatively low producing estuary.[45] Laboratory data indicate that Delta-wide chl-*a* levels are now low enough to limit zooplankton abundance.[46]

4. The ammonium discharged by the Treatment Plant is impacting the food web by reducing diatom primary production

The Tentative Order likewise correctly finds that the ammonium discharge is contributing to reduced diatom production and standing biomass in the Suisun Bay. Att. F at F-55. This conclusion is supported by peer reviewed journal articles by Wilkerson *et al* 2006, Dugdale *et al* 2007, Glibert 2010a, and others, as well as by the sampling and research by the San Francisco Regional Board in 2010.[47] Att. K at K-5, K-6; F-92 *citing* Letter from San Francisco Regional Board, June 4, 2010 ("The ammonia from the SRWTP contributes to the water quality problems in the Suisun Bay."). The Tentative Order estimates, conservatively, that the ammonia/um loadings must be reduced by a factor of as much as 7 to eliminate the contribution from the Treatment Plant. *Id*.

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[40] See, e.g., Ludwig, C.A. 1938. The availability of different forms of nitrogen to a green alga (Chlorella) Am.J.Bot. 25:448-458; Harvey, H.W. 1953, Synthesis of Organic Nitrogen and Chlorophyll by Nitzschia Closterium. J. Mar.Biol. Res. Assoc. U.K. 31:477-487

[41] MacIsaac, J.J. and R.C. Dugdale , 1969. The kinetics of nitrate and ammonium uptake by natural populations of marine phytoplankton. Deep-Sea Res. 16:45-67; MacIsaac, J.J. and R.C. Dugdale, 1972. Interactions of light and inorganic nitrogen controlling nitrogen uptake in the sea. Deep-Sea Res. 19:209-232.

[42] McCarthy, J.J., W.R. Taylor and J.L. Taft, 1975. The dynamics of nitrogen and phosphorous cycling in the open water of the Chesapeake Way. In: T.M. Church (ed.) Marine Chemistry in the Coastal Environment. American Chemical Society Symposium Series 18. Washington D.C., pp. 664-681.

[43] Lomas, M.W. and P.M. Glibert. 1999a. Interactions between NH_4 and NO_3 uptake and assimilation: comparison of diatoms and dinoflagellates at several growth temperatures. Marine Biology 133:541-551

[44] The current average discharge concentration is 24 mg L^{-1} NH_4 which equates to 1,713 µmol L^{-1}.

[45] Jassby, A.D., J.E. Cloern and B.E. Cole. 2002. Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem. *Limnol. Oceanogr.,* 47(3): 698–712.

[46] Müller-Solger, *et al,* 2002, *supra*.

[47] Marchi, 2010, *supra*.

The data confirm that the ammonia/um reduction contemplated by the Tentative Order is necessary to reduce food web impacts. The Tentative Order's estimated reduction in ammonium loading is based on a threshold concentration of 0.056 mg L^{-1} (equivalent to 4µmol L^{-1}). However, ammonium concentrations of as low as 0.014 mg L^{-1} (1µmol L^{-1}) have been found to inhibit phytoplankton nitrate uptake by approximately 60% (Dugdale *et al* 2007). Studies of phytoplankton nitrogen uptake in the Sacramento River conducted in 2008 and 2009 showed values similar to the threshold values described by Dugdale *et al* (2007)[48] for ammonium inhibition of phytoplankton nitrate uptake (Parker *et al* 2010a).[49] Moreover, ammonium concentrations in excess of nitrate inhibition thresholds were consistently encountered at all locations sampled downstream of the Treatment Plant's discharge point by both the Regional Water Board sampling program and transects conducted by the Dugdale Lab at the Romberg Tiburon Center (Foe *et al* 2010 and Parker *et al* 2010a, respectively).[50]

The Tentative Order also acknowledges the recent studies that establish that ammonium in the discharge has reduced the phytoplankton biomass, another essential element in the Bay-Delta food web, as measured by the decline in chlorophyll-*a* concentrations in the River, citing Parker, *et al*. (2010a) and Glibert (2010a). Att. K at K-6. However, the Tentative Order questioned the degree to which plant discharges are causing these observed declines in chlorophyll-*a* levels because of certain data indicating an apparent decline in chlorophyll-*a* upstream of the Treatment Plant. The Tentative Order urges "caution" in concluding the discharge is causing the chlorophyll declines that have been observed downstream of the Plant. Att. K at K-6 ("The cause of the decline is not known, but has been variously attributed to algal settling, toxicity from an unknown chemical in the SRWTP effluent, or from ammonia.").

We respectfully submit that the Treatment Plant is the cause of the rapid declines that have been observed downstream of the discharge, as the Water Agencies described in previous comments to the Regional Board. *See* SLDMWA and SWC Comments on Draft Report Titled, Nutrient Concentrations and Biological Effects in the Sacramento-San Joaquin Delta (June 14, 2010). The dramatic decline in chlorophyll-*a* downstream of the discharge can be explained only by the millions of pounds of ammonium being discharged into the River by the Treatment Plant.

Foremost, the upstream differences between Tower Bridge and Garcia Bend are very small compared to the dramatic and significant changes downstream of the Plant.[51] When the Treatment Plant discharge increases Sacramento River ammonium levels by more than 0.3 mg L^{-1}-N, chlorophyll drops by a factor of one half to three quarters compared to chlorophyll above the Treatment Plant.[52] These kinds of results are compelling evidence of the contribution of the Treatment Plant.

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[48] Dugdale, R.C., F. P. Wilkerson, V. E. Hogue and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. *Estuarine, Coastal and Shelf Science* 73: 17-29.
[49] Parker ,. 2010a, *supra*.
[50] Foe, Chris, A. Ballard, S. Fong.. 2010. Nutrient concentrations and biological effects in the Sacramento-San Joaquin Delta. Report prepared for the Central Valley Regional Water Quality Control Board; and Parker *et al*. 2010a, *supra*.
[51] Foe, 2010, *supra*.
[52] *Id.*

Second, the chlorophyll decline that may be present upstream in the River between Tower Bridge and Garcia Bend may be explained by the incomplete mixing and dilution with high quality American River water. Several pieces of evidence support this, including the fact that salinity at Garcia Bend is lower than salinity at Tower Bridge. The most likely reason salinity would drop from upstream to downstream is that there is dilution from another source of water. The only other major source of water in this area is the American River. There is in fact a strong association between the difference in salinity between Garcia Bend and Tower Bridge and the difference in chlorophyll *a* at these locations.[53] The more that the salinity drops from Tower Bridge to Garcia Bend, the more the chlorophyll *a* drops between these two stations.

Finally, and most importantly, while phytoplankton biomass, as measured by chlorophyll *a*, may be declining above the Treatment Plant, phytoplankton rate processes such as carbon and nitrate uptake remain strong. In contrast, both phytoplankton biomass and rate processes are significantly disrupted in samples downstream of the treatment plant. In other words, phytoplankton are still growing upstream of the plant based on their continued uptake of nitrate and carbon; accordingly, something other than nutrients may be impacting their ability to accumulate biomass. However, beginning immediately downstream of the treatment plant, primary production and ammonium uptakes rates decline by 20 to 36% and nitrate uptake declines 80%.[54] Analogously, if one were to fertilize their garden daily, a common response would be reduction in production. Whereas some nutrients may stimulate production, adding more and more does not result in a sustained increase in production. The algae downstream of the Treatment Plant are no longer processing nutrients effectively.

5. The nutrient discharge is impacting the food web in the Sacramento River and Bay-Delta by causing a shift in algal communities by changing the nutrient ratios to favor harmful, invasive species.

The Tentative Order notes in Attachment F that "[d]ownstream of the discharge point, ammonia may be a cause in the shift of the aquatic community from diatoms to smaller phytoplankton species that are less desirable as food species." Tentative Permit, Att. F at F-55. The Tentative Order references some of the recent research in this area, including that of Dr. Dugdale, Dr. Glibert, and Dr. Lehman (*see* Attachment K at K-6 and K-7). However, while the Tentative Order documents and relies specifically on the toxic effects of ammonia on aquatic life in the River and Bay-Delta, the Tentative Order has not relied substantially on the effects of the discharge on the food web.

The Water Agencies submit that both existing and ongoing research support both the ammonium and nitrate removal required in Tentative Order. We previously detailed much of the data and research to the Regional Board in response to the Board's request for comments earlier this year. *See* Water Agencies' Comments on Aquatic Life, *supra*. Accordingly, we urge the Regional Board to revise Attachment K in the Final Order to document the impacts to the food web as further support for the Tentative Order.

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[53] *See* SLDMWA and SWC Comments on Draft Report Titled, Nutrient Concentrations and Biological Effects in the Sacramento-San Joaquin Delta at 3 (June 14, 2010) (Figure 2).
[54] Parker *et al*. 2010, *supra*.

The Treatment Plant's discharge has adversely impacted aquatic life in the River and Bay-Delta by increasing the ratio of nitrogen to phosphorus in the receiving water which triggers the impacts to the food web on which aquatic life depends. These impacts have contributed to the dramatic decline in pelagic organisms, directly impairing the protected beneficial uses of the Bay-Delta waters. The impacts on the food web are due to the fact that the ongoing discharge degrades water quality by changing the ratio between dissolved inorganic nitrogen and phosphorus in the River downstream of the Treatment Plant – the "DIN:DIP" ratio – as well as the Nitrogen (N) to Phosphorus (P) ratio – the ("N:P") ratio. These ratios are known to have profound influences on food webs (Sterner and Elser 2002).[55] Sterner and Elser (2002), state that, "Stoichiometry can either constrain trophic cascades by diminishing the chances of success of key species, or be a critical aspect of spectacular trophic cascades with large shifts in primary producer species and major shifts in ecosystem nutrient cycling." A low ratio is generally considered to cause nitrogen limitation, whereas a high ratio is generally considered to cause phosphorus limitation. When the N:P ratio nears 16:1 on a molar basis, it is recognized as the Redfield ratio, based on the classical observations of Redfield (1934; 1958)[56]. (The Redfield ratio does not, however, distinguish the importance of different forms of nitrogen, *i.e.*, whether that nitrogen is in the form of ammonium or nitrate.)

Historical data indicate that the N:P ratio of Treatment Plant effluent has increased significantly over time (Figure 2), due to the significant increase in the ammonia/um loading in the discharge, and corresponding declines in phosphorus, most likely because of decreases in phosphates in laundry detergent (Van Nieuwenhuyse 2007, Glibert 2010a).[57] The N:P effluent ratios have been above stoichiometric proportions since the early to mid-1990s, suggesting a tendency towards increasing phosphorus limitation.[58]

Glibert has examined the loadings from the Treatment Plant, the shifting nutrient ratios, and the composition of the base of the food web and found several significant trends.[59] Specifically, Glibert (2010a) reports that there has been a measureable change in the N:P ratio in the Bay-Delta, an increase in total N loading, a decrease in total P loading, and a change in the dominant form of nitrogen from nitrate to ammonium. Glibert found that the variation in these nutrient concentrations and ratios is highly correlated to variations in the nutrient composition of the Treatment Plant's discharges. These nutrient variations are in turn related to variations in the

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[55] Sterner, R.W. and J.J. Elser. 2002. Ecological stoichiometry: The biology of elements from molecules to the biosphere. Princeton University Press, Princeton, N.J.

[56] Redfield, A.C. 1934. On the proportions of organic derivatives in sea water and their relation to the composition of plankton. Reprinted from *James Johnstone Memorial Volume*, Liverpool University Press, Liverpool. 176-192; Redfield, A.C. 1958. The biological control of chemical factors in the environment. Reprinted from *The American Scientist*. 46(3):205-221.

[57] Van Nieuwenhuyse, E. 2007. Response of summer chlorophyll concentration to reduced total phosphorus concentration in the Rhine River (Netherlands) and the Sacramento-San Joaquin Delta (California, USA). *Can. J. Fish. Aquat. Sci.,* 64:1529-1542; and Glibert, 2010a, *supra*.

[58] *Figure **2*** was created with data reported by Sacramento Regional County Sanitation District in Monthly Discharge Reports to the Regional Board.

[59] Glibert, 2010a, *supra*.

base of the food web, primarily the composition of phytoplankton (Glibert 2010b)[60], to variations in the composition of zooplankton, and to variations in the abundance of several fish species. Thus, changes in Delta smelt and several other fish species' abundance are ultimately related to changes in ammonium load from wastewater discharge in the upper Sacramento River.

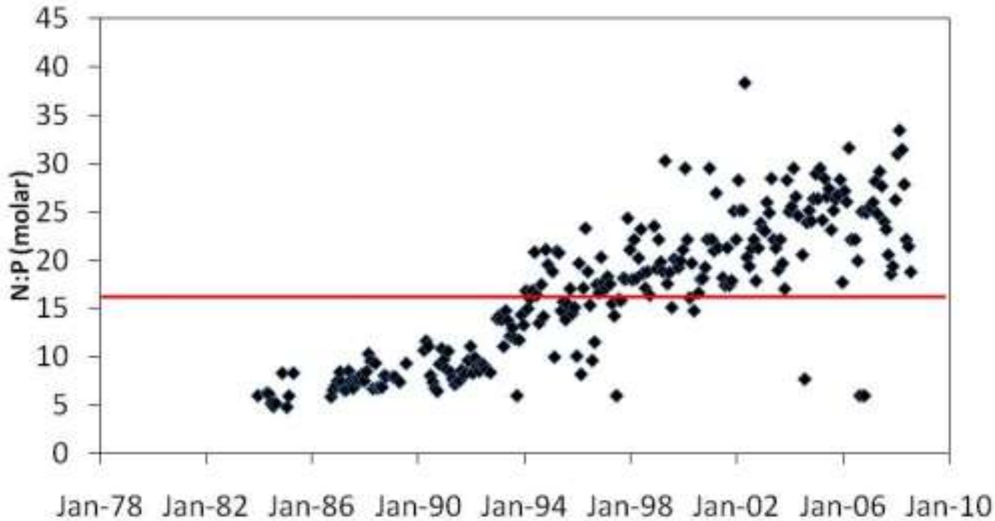

Figure 2 Change in molar ratio of nitrogen to phosphorus in Treatment Plant discharge over time. This ratio is calculated from nitrogen based on TKN and phosphorus from TP, based on data reported to the Regional Board. Note that although the Treatment Plant came on line in 1982, data are available from 1984. All data are monthly averages. The horizontal line is the "Redfield" ratio.

The data also indicate that the algal community that compose the Delta food web has been shifting at the same time that the nutrient ratios have been changing (Glibert 2010a,b).[61] The shift is seen both in the recent increase in annual blooms of *Microcystis*, and in the shift in the algal composition in the Bay-Delta from diatoms that are nutritious to the zooplankton that support the pelagic food web including the threatened Delta smelt,[62] to smaller and lower quality species such as flagellates, cryptophytes and cyanobacteria and to invasive macrophytes such as *Egeria densa*.[63] The shift away from diatoms, which disrupts ecosystem function, is well

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[60] Glibert, P. 2010b. Changes in the quality and quantity of nutrients over time and the relationships with changes in phytoplankton composition. Oral Presentation at 6th Biennial Bay-Delta Science Conference, Sacramento, CA, September 27-29, 2010

[61] Glibert, 2010a, *supra*; Glibert, 2010b, *supra*.

[62] The Tentative Permit stated that "[d]iatoms are assumed to be more nutritious to primary consumers like zooplankton than flagellates and bluegreen algae." Att. K at K-7. Respectfully, this is much more than an assumption. Numerous studies have found that diatoms support the pelagic food web.

[63] Lehman, P. W. 2000. The influence of climate on phytoplankton community biomass in San Francisco Bay Estuary. *Limnol. Oceanogr*. 45: 580–590; Lehman, P. W., G. Boyer, C. Hall, S. Waller and K. Gehrts. 2005. Distribution and toxicity of a new colonial *Microcystis aeruginosa* bloom in the San Francisco Bay Estuary, California. *Hydrobiologia* 541:87-99; Lehman, P.W., S.J. The, G.L. Boyer, M.L. Nobriga, E. Bass, and C. Hogle. 2010. Initial impacts of *Microcystis aeruginosa* blooms on the aquatic food web in the San Francisco Estuary.

documented in the literature in general, and in research specifically studying the Bay-Delta (Kimmerer 2005, Lehman 2000, Glibert 2010a,b, Winder and Jassby (in press), Slaughter and Kimmerer, 2010).[64]

Thus, the species-specific acute and chronic effects of ammonia/um described in the Tentative Order are not the only impacts caused by the Treatment Plant. There is also a more complex shift in communities that occurs when nutrient loading increases and nutrient stoichiometry is altered (Cloern 2001; Sterner and Elser 2002).[65]

The N:P ratio has long been shown to influence phytoplankton composition and the presence – or absence – of native species and vegetation, as extensive studies have repeatedly demonstrated in study after study across a range of systems in North Carolina, Hong Kong, Tunisia, Germany, Florida, Norway, Michigan, Spain, Korea, Japan, Washington DC (Chesapeake Bay), Tampa (Tampa Bay), and Denmark, to name just a few, as well as in the laboratory. Many of these findings are described in more detail below.

Studies have also suggested that the increased N:P ratio altered the native submerged aquatic vegetation in the Bay-Delta (Glibert 2010c).[66] The native vegetation has largely been replaced by invasive submerged and floating vegetation, including the Brazilian waterweed, *Egeria dense*, and the water hyacinth, *Eichhornia crassipes*. Although the water hyacinth was introduced some time ago (Finlayson 1983; Gopal 1987),[67] it has increased in abundance most significantly in recent decades (Finlayson 1983, Toft *et al*. 2003).[68] By the early 1980s, hyacinth covered approximately 500 ha, or about 22% of the waterways, in the Bay Delta (Finlayson 1983).[69] The exact timing of the invasion of the Brazilian waterweed is not well documented, but it too increased significantly during the decades of the 1980s (Jassby and Cloern 2000)[70] and 1990s (Anderson 1999),[71] the period after phosphate removal and the increasing of the N:P ratio. The

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Hydrobiologia 637:229-248; Jassby *et al*., 2002, *supra*; Glibert, *supra*; Sommer, *et al,* 2007, *supra*; Nobriga, M.L., F. Feyrer, R.D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies, and biomass. *Estuaries* 28(5):776-785; Jassby, A. 2008. "Phytoplankton in the Upper San Francisco Estuary: recent biomass trends, their causes, and their trophic significance." *San Francisco Estuary and Watershed Science*. 6(1): Article 2, February 2008.

[64] Kimmerer, W. 2005. Long-term changes in apparent uptake of silica in the San Francisco Estuary. *Limnology and Oceanography*. 50(3):793-798; Lehman, 2000, *supra*; Glibert, 2010a, *supra*; Glibert, 2010b, *supra*; and Winder and Jassby, In press, *supra*; Slaughter and Kimmerer, 2010, *supra*.

[65] Cloern, J.E., 2001. Our evolving conceptual model of the coastal eutrophication problem. *Mar. Ecol. Prog. Ser.* 210:223-253; and Sterner and Elser, 2002, *supra*.

[66] Glibert, P. 2010c. Nutrients and the food web of the Bay Delta. Oral Presentation to the National Academy of Sciences Committee on Sustainable Water and Environmental Management in the California Bay-Delta, Sacramento, CA. July 13, 2010.

[67] Finlayson, B.J. 1983. Water hyacinth: Threat to the Delta? Outdoor California 44: 10-14; and Gopal, B. 1987. Aquatic plant studies. 1. Water hyacinth. Elsevier Publishing, New York.

[68] *Id*; and Toft, J.D., C.A. Simestad, J.R. Cordekk and L.F. Grimaldo. 2003. The effects of introduced water hyacinth on habitat structure, invertebrate assemblages and fish diets. *Estuaries* 26: 746-758.

[69] Finlayson, 1983, *supra.*

[70] Jassby, A.D. and J.E. Cloern. 2000.Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). *Aquat. Conser: Mar. Freshw. Ecosyst.*, 10:323-352.

[71] Anderson, L.W.J. 1999. *Egeria* invades the Sacramento-San Joaquin Delta. *Aquatic Nuisance Species Digest*. 3: 37-40

waterweed (*Egeria*), like *Hydrilla*, can reach high biomass levels and is well suited to thrive in a higher N:P environment (Reddy *et al*. 1987, Fiejoo *et al*. 2002).[72]

Invasive vegetation and other species have likewise been observed in other ecosystems that experienced an increase in the N:P ratio, just as in the Bay-Delta (Glibert 2010c).[73] The Potomac River (Chesapeake Bay) was invaded by submerged aquatic vegetation, *Hydrilla* and clams, *Corbicula*, when the N:P ratio of effluent from the large Blue Plains sewage treatment facility increased after phosphorus was reduced in the 1980s (Ruhl and Rybicki 2010)[74]. In the Ebro River estuary in Spain, as well, both *Hydrilla* and *Corbicula* invaded shortly after phosphorus was removed from effluent (Ibanez *et al*. 2008).[75]

Other food web alterations occur in an altered N:P environment. For example, the expansion of species, such as *Microcystis*, which are well adapted to thrive at a wide range of N:P ratios, further disrupts ecosystems, including normal predator-prey interactions. There is a broad scientific literature on the relationship between N:P ratio and *Microcystis.* The scientific literature supports the conclusion that the recent increase in *Microcystis* blooms is likely attributed to shifts in the nutrient ratios and resulting changes in nutrient forms in the Delta. This emerging relationship is complex because the established paradigm is that cyanobacteria increase in lakes when they are enriched with nutrients (e,.g. Paerl 1988, Downing *et al*. 2001).[76] A study by Downing *et al*. (2001), involving data from 99 lakes around the world, showed that total P or N were important predictors of cyanobacteria. Some cyanobacteria, especially those with the capability for nitrogen fixation, do well under low N:P ratios (e.g., Smith 1983, Stahl-Delbanco *et al*. 2003).[77] While there is a plasticity in the ability of cyanobacteria to grow in a wide range of environments, *Microcystis* is able to tolerate elevated N:P levels, and thus its dominance under high N:P may also reflect the decline in other species without such tolerances. Cyanobacteria do not have to grow faster at elevated N:P than at lower N:P values to become abundant, they merely have to grow faster than competing species groups (Glibert 2010a).[78] Glibert (2010a) observed highly significant correlation between ammonium concentration and changes in

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[72] Reddy, K.R., J.C. Tucker, and W.F. Debusk. 1987. The role of *Egeria* in removing nitrogen and phosphorus from nutrient enriched waters. *J. Aquat. Plant Management* 25: 14-19; and Feijoo, C., M.E. Garcia, F. Momo, and J. Tpja. 2002. Nutrient absorption by the submerged macrophyte *Egeria dense* Planch: Effect of ammonium and phosphorus availability in the water column on growth and nutrient uptake. *Limnetica* 21: 93-104.

[73] Glibert, 2010c, *supra*.

[74] Ruhl, H.A. and N.B. Rybicki. 2010. Long-term reductions in anthropogenic nutrients link to improvements in Chesapeake Bay habitat. www.pnas.org/cgi/doi/10.1073/pnas.1003590107.

[75] Ibanez, C., N. Prat, C. Duran, M. Pardos, A. Munne, R. Andreu, N. Caiola, N. Cid, H. Hampel, R. Sanchez, and R. Trobajo. 2008. Changes in dissolved nutrients in the lower Ebro river: Causes and consequences. *Limnetica.* 27(1):131-142.

[76] Paerl, H.W. 1988. Nuisance phytoplankton blooms in coastal, estuarine, and inland waters. *Limnol. Oceanogr*. 33(4, part 2): 823-847; and Downing, J.A., S.B. Watson, and E. McCauley. 2001. Predicting cyanobacterial dominance in lakes. Ca. J. Fish. Aquat. Sci. 58: 1905-1908.

[77] Smith, V.H. 1983. Low nitrogen to phosphorus ratios favor dominance by blue-green algae in lake phytoplankton. *Science* 221: 669-671; and Stahl-Delbanco, A., L.-A. Hansson and M. Gyllstrom. 2003. Recruitment of resting stages may induce blooms of *Microcystis* at low N:P ratios. *J. Plankt. Res*. 25: 1099-1106.

[78] Glibert, 2010a, *supra.*

cyanobacteria occurrence.[79] Based on stable isotope analyses of particulate organic matter and nitrate, Kendall observed that ammonium, not nitrate, is the dominant source of nitrogen utilized by *Microcystis* at the Antioch and Mildred Island sites in the summer 2007 and 2008.[80]

Studies in Korea and Japan, and laboratory experiments have also related increasing N, and increasing N:P ratios, with increasing toxicity of *Microcystis*. In Daechung Reservoir, Korea, researchers found that toxicity was related not only to an increase in N in the water, but to the cellular N content as well (Oh, *et al*. 2001).[81] A very recent report by van de Waal (2010) demonstrated in chemostat experiments that under high CO_2 and high N conditions, microcystin production was enhanced in *Microcystis*.[82] Similar relationships were reported for a field survey of the Hirosawa-no-ike fish pond in Kyoto, Japan, where the strongest correlations with microcystin were high concentrations of NO_3 and NH_4 and the seasonal peaks in *Microcystis* blooms were associated with extremely high N:P ratios (Ha *et al*. 2009).[83] Thus, not only is *Microcystis* abundance enhanced under high N:P, but its toxicity is as well (Oh *et al*. 2001).[84]

Support can also be found in studies of the Neuse River in North Carolina (Paerl 2009).[85] There, as in the Bay-Delta, phosphorus was controlled when phosphates were removed from detergents, but there was no contemporaneous reduction in nitrogen. The estuary ceased to function as an effective filter (e.g. Cloern 2001),[86] resulting in the displacement of nitrogen loads downstream and enhancement of cyanobacterial dominance in the plankton (Paerl *2009*).[87]

Cyanobacteria grow particularly well on ammonium while their competitors, such as the diatoms that are essential to the pelagic food web, do not.[88] Cyanobacteria are able to adapt to high N:P ratios, while diatoms are generally not. In contrast, the literature establishes that diatoms may

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[79] *Id.*

[80] Kendall, C. 2010b. Use of stable isotopes for evaluating environmental conditions associated with *Microcystis* blooms in the Delta. Oral Presentation at the 6th Biennial Bay-Delta Science Conference, Sacramento, CA, September 27-29, 2010.

[81] Oh, H-M., S.J. Lee, M-H. Jang and B-D. Yoon. 2000. Microcystin production by *Microcystis aeruginosa* in a phosphorus-limited chemostat. *Appl. Envir. Microbiol*. 66: 176-179.

[82] van de Waal, D.B. , L.Tonk, E. van Donk, H.C.P. Matthijs, P. M. Visser and J. Huisman. 2010. Climate Change And The Impact Of C:N Stoichiometry On Toxin Production By Harmful Cyanobacteria. Oral Presentaton at the 14th International HAB Conference, Greece.

[83] Ha, J.H., T. Hidaka, and H. Tsuno. 2009. Quantification of toxic Microcystis and evaluation of its dominance ratio in blooms using real-time PCR. *Envir. Sci. Technol*. 43: 812-818

[84] Oh *et al.*, 2000, *supra.*

[85] Paerl, H.W. 2009. Controlling Eutrophication along the Freshwater–Marine Continuum: Dual Nutrient (N and P) Reductions are Essential. *Estuaries and Coasts* 32:593–601

[86] Cloern, J.E., 2001. *supra*.

[87] Paerl *2009, supra*.

[88] Glibert, P.M., J. Boyer, C. Heil, C. Madden, B. Sturgis, and C. Wazniak. 2010. Blooms in Lagoons: Different from those of river-dominated estuaries. In: M. Kennish and H. Paerl, eds, *Coastal Lagoons: Critical habitats of environmental change*. Taylor and Francis.

have a nutritional requirement for, and under some circumstances even a preference for, nitrate[89] and diatoms are more often found to be abundant when nutrient ratios are at or near the 16:1 ratio. These relationships are well established from measurements of enzyme activities,[90] directly determined rates of nitrogen uptake using isotope tracers,[91] and growth studies, including Meyer *et al* (2009) who state that ammonia as nitrogen "produces the highest growth and primary production rates for *Microcystis aeruginosa* and other cyanobacteria…"[92]

Scientific literature based on studies in Hong Kong, Tunisia, Germany, and Florida, likewise report on the consequences of shifting the N:P ratio to the low side of the "Redfield" ratio. These studies provide further support for the finding that diatoms are more often found to be abundant when nutrient ratios are at or near the 16:1 "Redfield" ratio and that other species, such as dinoflagellates have an advantage at lower N:P ratios. In the Bay-Delta, flagellates are most abundant at low N:P ratios (Glibert 2010b).[93] In Tolo Harbor, Hong Kong, nutrient loading, particularly phosphorus loading, increased due to population increases in the late 1980's. The result was that a distinct shift from diatoms to dinoflagellates was observed in the harbor, coincident with a decrease in the N:P ratio from roughly 20:1 to <10:1 (Hodgkiss and Ho 1997; Hodgkiss 2001).[94] Once the phosphorous was removed from the sewage effluent that was being discharged into the harbor and stoichiometric proportions were re-established , there was a resurgence of diatoms and a decrease in dinoflagellates.[95] In Tunisian, aquaculture lagoons dinoflagellates have been shown to develop seasonally when N:P ratios decrease (Romdhane, *et al*. 1998).[96] Comparable results have been observed in systems in Germany and along the coast of Florida.[97]

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[89] See, e.g., Lomas and Glibert 1999a, *supra*. Lomas, M.W. and P.M. Glibert. 1999b. Temperature regulation of nitrate uptake: A novel hypothesis about nitrate uptake and reduction in cool-water diatoms. *Limnol Oceanogr* 44:556-572.

[90] Solomon, C. Gallaudet Univ, unpub. data.

[91] See, e.g., Glibert, P., C.A. Heil, D. Hollander, M. Revilla, A. Hoare, J. Alexander, S. Murasko. 2004. "Evidence for dissolved organic nitrogen and phosphorous uptake during a cyanobacterial bloom in Florida Bay." *Mar. Ecol. Prog. Ser.* 280:73-83.

[92] See, e.g., Meyer, J.S., P.J. Mulholland, H.W. Paerl, and A.K. Ward. 2009. "A framework for research addressing the role of ammonia/ammonium in the Sacramento-San Joaquin Delta and the San Francisco Bay Estuary ecosystem." Report to CalFed Science Program; and Berman, T and S. Chava, 1999. "Algal growth on organic compounds as nitrogen sources." *Journal of Plankton Research* 21:1423-1437.

[93] Glibert, 2010b, *supra*.

[94] Hodgkiss, I.J. and K.C. Ho. 1997. Are changes in N:P ratios in coastal waters the key to increased ref tide blooms?. *Hydrobiologia.* 352:141-147: Hodgkiss, I.J. 2001. The N:P ratio revisited. In: K.C. Ho and Z.D. Wang (Eds.), Prevention and Management of Harmful Algal Blooms in the South China Sea. School of Science and Technology, Open University of Hong Kong.

[95] Lam, C. W. Y. and K. C. Ho. 1989. Red tides in Tolo Harbour, Hong Kong, p. 49–52. In T. Okaichi, D. M.Anderson, and T. Nemoto (eds.), Red Tides: Biology, Environmental Science and Toxicology. Elsevier, New York.

[96] Romdhane, M.S., H.C. Eilertsen, O.K.D. Yahia, and Y.N.D. Daly. 1998. Toxic dinoflagellate blooms in Tunisian lagoons: causes and consequences for aquaculture. In: *Harmful Algae* Edited by B.Reguera, J.Blanco, M.L.Fern'andez & T.Wyatt, Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, pp. 80–83.

[97] *See* Water Agencies' Comments on Aquatic Life at 18-19, *supra*.

Other components of the food web are also affected by changes in N:P ratios (Sterner and Elser 2002).[98] Norwegian studies monitored lakes for many years and found that different zooplankton tend to dominate under different N:P ratios (Hessen 1997), due to the different phosphorus content of different species found in the lake.[99] Hessen (1997), for example, showed that a shift from calanoid copepods to *Daphnia* tracked N:P; calanoid copepods retain proportionately more N, while *Daphnia* are proportionately more P rich. Studies from experimental whole lake ecosystems found that zooplankton size, composition and growth rates changed as the N:P ratio varied (*e.g.*, Schindler 1974, Sterner and Elser 2002).[100]

Altered N:P ratios have also been shown to affect the relationships between piscivores and planktivores in freshwater systems (Sterner and Elser 2002), due to the differing demands for P-requiring bones and skeleton.[101] These differences, in turn, have implications for the ability of different components of the food web to grow on foods that vary in N:P content.[102] Many fish species in the Bay Delta have demonstrated a similarly strong relationship with N:P over time (Glibert 2010a,c).[103]

6. Where implemented in impacted ecosystems, nutrient removal has improved the natural ecosystem and aquatic life.

Requiring nitrification and denitrification of the Treatment Plant discharge would help restore balance between nitrogen and phosphorus in the discharge. This would not only reduce the ongoing degradation of water quality and impairment of beneficial uses, but would improve the health of the ecosystem and aquatic life in the Sacramento River and Bay-Delta. As the numerous studies cited above demonstrate, it is both the N:P ratios and the form of N that drive the algal community composition which has important effects throughout the food web. Simply nitrifying the ammonia/um and discharging high nitrate loads in its place will not restore the N:P ratios. Total nitrogen loads need to be reduced. Requiring similar nutrient removal on wastewater treatment plants in other ecosystems, such as in the Chesapeake Bay, Tampa Bay, and coastal areas of Denmark, have proven to be effective at reversing the harmful effects of previously undertreated discharges and restoring the native systems.

For example, nutrient removal at the Blue Plains treatment plant in Washington DC reduced the N:P ratios in the Potomac River and successfully reduced the invasive species, and native vegetation began to re-emerge in the river. Once a nitrification/denitrification system was installed at Blue Plains in the 1990s, with a goal of total N reductions to a maximum of 7.5 mg L^{-1} and an ammonia nitrogen effluent limit (now as low as 4.2 mg L^{-1}), within several years, the

[98] Sterner and Elser, 2002, *supra*.
[99] Hessen, D.O.. 1997. Stoichiometry in food webs – Lotka revisted. *Oikos* 79: 195-200.
[100] Schindler, D. W. 1974. Eutrophication and Recovery in Experimental Lakes: Implications for Lake Management. *Science*. 184(4139):897-899; and Sterner and Elser, 2002, *supra*.
[101] Sterner and Elser, 2002, *supra*.
[102] Many fish species in the Bay Delta demonstrate a strong relationship with N:P over time (Glibert 2010a, *supra*).
[103] Glibert, 2010a, *supra*; and Glibert, 2010c, *supra*.

abundance of the invasive *Hydrilla* began to decline and the abundance of native grasses increased (Ruhl and Rybicki 2010).[104]

Tampa Bay provides another important example. Eutrophication problems in the Bay were severe in the 1970s, with N loads approximating 24 tons per day, about half of which was due to point source effluent (less than the current Treatment Plant discharge of 14 tons per day) (Greening and Janicki 2006).[105] Full nitrification and denitrification of the discharge was required at the regional treatment plant in the 1980s, and P was also reduced due to other best management practices. The native seagrass increased following nutrient removal, but it took several years.

The Tampa Bay study highlighted several key conclusions:

- It will take time to see improvements in an impacted ecosystem, because there are internal, existing loads of nutrients in sediment reservoirs from historic discharges. These historic loadings can therefore effectively prolong the system's responsiveness to external reductions of total N. This highlights the need to act expeditiously and reduce interim loads, as further discharges will only make restoring the native species of the River and Bay-Delta all the more difficult.

- Initial N reductions must be continually followed by reductions in future loadings if water quality gains are to maintained.

- Continued and frequent monitoring of the system at environmentally relevant detection limits are required to allow managers to assess progress to water quality goals (Greening and Janicki 2006).[106]

Lower nutrient discharges also had positive effects on the coastal waters around the island of Funen, Denmark (Rask *et al*. 1999).[107] Since the mid 1980s, there has been a roughly 50% reduction in the loading of N and P in the region due to point source reductions. Again, native grasses returned and low oxygen problems were reversed.

These examples of successful nutrient removal are not provided to predict with certainty that the ecosystem of the River and Bay-Delta will return to exactly what existed decades before the impacts began. Researchers (Duarte *et al*., 2009)[108] have surveyed the literature for systems that have undergone nutrient loading and nutrient reductions and the trajectories of response were complex and varied. They attributed this to "shifting baselines," recognizing that systems have changed due to invasions, extinctions, overfishing, climate change and other factors. Yet, however difficult it may be to predict exactly how an individual system will respond, Duarte *et al*. (2009) concluded that "efforts to reduce nutrient inputs to eutrophied coastal ecosystems have

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[104] Ruhl and Rybicki, 2010, *supra*.
[105] Greening, H. and A.Janicki. 2006. Toward reversal of eutrophic conditions in a subtropical estuary: Water quality and seagrass response to nitrogen loading reductions in Tamp Bay, Florida, USA. *Environ. Mgt.* 38(2):163-178.
[106] *Id.*
[107] Rask, N., S. E. Pedersen, and M. H. Jensen. 1999. Response to lowered nutrient discharges in the coastal waters around the island of Funen, Denmark. *Hydrobiologia* 393: 69–81.
[108] Duarte, C.M., D.J. Conley, J. Carstensen, and M. Sánchez-Camacho. 2009. Return to Neverland: Shifting Baselines Affect Eutrophication Restoration Targets. *Estuaries and Coasts*. 32:29–36.

indeed delivered important benefits by either leading to an improved status of coastal ecosystems or preventing damages and risks associated with further eutrophication.” (Duarte *et al*. 2009).[109]

7. The Treatment Plant discharge is depleting dissolved oxygen in the Sacramento River and the Bay-Delta.

The Tentative Order properly finds that the discharge is depleting dissolved oxygen (DO) for 40 miles down the River and into the Bay-Delta. This is a further compelling reason that we urge the Regional Board to adopt full nutrient removal.

As the Tentative Order provides, the Treatment Plant’s “effluent contains ammonia and BOD at levels that use all the assimilative capacity for oxygen demanding substances in the Sacramento-San Joaquin Delta. This results in no assimilative capacity for other cities and communities to discharge oxygen demanding constituents, which is needed for them to grow despite the fact that most of these cities and communities are already implementing Best Practical Treatment and Control (BPTC) at their own facilities and SRWTP is not.” Att. F. at F-55. The Tentative Order based this analysis on standard calculations relying on the modeling and data provided by the Sanitation District. Att. F at F-91. Based on those calculations, the Tentative Order documents extensive impacts many miles away from the outfall. *E.g.*, F-92 (“Ammonia, along with BOD, from the SRTWP reduces the dissolved oxygen (“DO”) in the Sacramento River and Sacramento-San Joaquin Delta for nearly 40 miles below its discharge”).

Additional data in the record before the Regional Board that were gathered by other state agencies confirm the Tentative Order’s conclusion that the current discharge is contributing to depressed DO levels downstream of the Treatment Plant. The Department of Water Resources (DWR) observed several periods in 2008 and again in 2009 when DO levels were below the Basin Plan’s established objective of 7 mg L^{-1} at Hood.[110] The Sanitation District claims that these measured data are erroneous,[111] but DWR reviewed their data and found no problems during the periods in question.[112]

Moreover, that the daily discharge of thousands of pounds of untreated ammonia/um would deplete DO in the receiving waters is both standard chemistry and well established by observed data. Findings made by federal regulators in evaluating impacts to the salmon similarly concluded the increase in ammonia concentrations in the wastewater disposed of by the City of Stockton depressed DO levels causing impacts to aquatic life. In its Biological Opinion on salmon, NOAA’s National Marine Fisheries Service found that “increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility

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[109] *Id.*

[110] DWR monitoring data, 2008-2009, attached to, Department of Water Resources Office Memo from Sal Batmanghilich, Chief Real-time Monitoring Section to Kathleen Harder, Central Water Quality Control Board re Hood water quality station Dissolved Oxygen QA/QC data. July 22, 2010.

[111] Larry Walker Associates. 2009. Low dissolved oxygen prevention assessment- Administrative Draft. Prepared for Sacramento Regional County Sanitation District.

[112] Department of Water Resources Office Memo from Sal Batmanghilich, Chief Real-time Monitoring Section to Kathleen Harder, Central Valley Regional Water Quality Control Board re ood water quality station Dissolved Oxygen QA/QC data. July 22, 2010.

lowers the [dissolved oxygen] in the adjacent [deep water ship channel] near the West Complex. In addition to the negative effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations."[4] Davis *et al.* (1963) found that progressively lower DO concentrations below saturation had increasingly negative impact on juvenile salmonid swimming speed.[113] Impaired swimming ability impairs the ability of salmon to successfully feed, migrate, and avoid predation (Cramer, 2010).[114]

Moreover, the record before the Regional Board demonstrates the DO assessment proffered by the Sanitation District is not reliable. The Sanitation District uses a proprietary model in the Low Dissolved Oxygen Prevention Assessment ("LDOPA") to predict future DO concentrations and to identify various management options that could be pursued to maintain compliance with the DO objective. However, questionable methodologies used in model calibration and validation do not lend confidence to the Sanitation District's analysis. As the independent Tetra Tech reviewers of the model concluded:

> …no statistical analysis of the model fit is provided and the crowded multi-year plots tend to hide relatively large discrepancies between individual measurements and predictions that are often on the order of 2 mg L^{-1} or more.[115]

And:

> The modeling framework …seems to have been driven more by the desire to do a Monte Carlo statistical analysis across the range of upstream flows and effluent loads…than by an intent to accurately simulate DO in the lower Sacramento River.[116]

And:

> The 7 mg L^{-1} target is written as an instantaneous criterion. The LDOPA modeling, however, produces only daily average DO concentrations and is calibrated only at the daily average scale. This is an inevitable result of the approach to model development, which ignores tidal reversals, works with daily average travel times, and does not consider diurnal algal growth and respiration cycles. As such, the modeling cannot represent the intra-day variability in DO concentrations, and cannot assess the maximum intra-day DO depression that will occur during tidal reversals and near-reversal stagnation events when reaeration declines.[117]

[113] NOAA Fisheries. 2009. Biological opinion and conference opinion on the long-term operations of the Central Valley Project and State Water Project. National Marine Fisheries Service, June 4, 2009 at page 157.
[114] Cramer, Steve, Gaskill, Phil, and Vaughn, Jason. 2010. Impact of Sacramento Regional Wastewater Treatment Plant Effluent Discharges on Salmonids.
[115] Tetra Tech Memorandum, to Diana Messina, Central Valley Regional Water Quality Control Board, from Jonathan Butcher, Ph.D., P.H., Re: Sacramento Regional LDOPA, June 29, 2010, p. 6.
[116] Id at p. 4.
[117] Id. at p. 7.

With these uncertainties, the Sanitation District's modeling is unreliable and cannot be used as a predictive tool to determine either the magnitude or frequency of future violations of the Basin Plan. The Tetra Tech reviewers ultimately concluded that, "As presently formulated, the LDOPA does not ensure attainment of the water quality objective specified in the Basin Plan."[118]

DO levels already drop below the water quality standard in the Basin Plan, thereby indicating that protected beneficial uses, which are ESA listed species, are impaired, and the Sanitation District's model underestimates potential future impacts; these facts weigh heavily in favor of the proposed nutrient removal. Further, as the Tentative Order documents, many other cities and communities have already invested in advanced treatment to address nutrients. The Sanitation District, by far the largest contributor of ammonia/um and other nutrients, should likewise help protect the beneficial uses of water and invest in advanced nutrient removal.

XIV Conclusion

In light of the evidence presented above, the DFG Report cannot be used as a sound basis for informed decision-making. The report does not present the best available science, failing to adhere to standard scientific principles for use and reliance on technical information.

[118] Id. at p. 2.