

Testimony before State Water Resources Control Board Delta Flow Criteria Informational Proceeding

Hydrodynamic – Operations: Fish Loss Due to Entrainment/Predation/Salvage

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My name is Thomas Grovhoug and I am providing this testimony regarding the direct loss of fish due to entrainment, predation and salvage in the South Delta associated with export pumping. My education includes a masters degree in civil engineering from the University of California at Davis. I have thirty-five (35) years of experience as an environmental engineer working on water quality issues, including over twenty (20) years specifically related to the San Francisco Bay and Sacramento-San Joaquin Delta.

Although there has been much discussion recently about the hypothetical effects of water quality and other factors as causative influences in the Pelagic Organism Decline, there is abundant information that a direct cause of significant fish mortality in the Delta is export pumping. This factor far outweighs other anthropogenic causes of fish mortality and thus should influence the State Board's decisions in developing flow criteria for the Delta. The following evidence has been prepared to highlight this issue and to assist the State Board in its determinations.

Background

In the SWRCB's revised water right decision D-1641, dated March 15, 2000, the adverse effects of State Water Project (SWP) and Central Valley Project (CVP) export pumping from the Delta on Chinook salmon and other listed fish species was acknowledged (pages 110 and 138). The decision also stated that "increased export pumping and changes in the timing of export pumping...may exacerbate those significant adverse effects." These adverse effects on fish have been recognized from the outset of SWP and CVP operations.

Since the issuance of D-1641 in 2000, the Pelagic Organism Decline has occurred, raising major concerns about "entrainment" of fish at the SWP and CVP pumping facilities as a possible cause of the decline.

For the purpose of this testimony, the following terminology pertaining to the salvage, entrainment and loss of fish in the South Delta is used. Daily *salvage* is the number of fish estimated to have entered either the SWP or CVP fish facility in a day. Daily *entrainment* is the estimated number of fish that arrived at the entrance to the fish facility

per day,(i.e., those that arrived and did not leave the area except via the fish facilities and salvage operation). Entrainment exceeds salvage because of mortality in the waterways leading to the export facilities and losses at and through the SWP and CVP fish protection facilities. Daily *loss* is the estimated number of fish entrained that were not subsequently salvaged and returned alive to the Estuary, which includes losses both before and after the salvage process. These losses are also termed “direct” losses because they are directly attributable to pumping operations. Losses due to altered hydrodynamic conditions or migration cues caused by export pumping are termed “indirect” losses. These losses may result from changes in the Delta habitat, food web, predation and invasive species occurrence.

In recent years, additional scientific information has been developed to provide a better understanding of the mechanisms and impacts of direct entrainment losses associated with the SWP and CVP pumping operations on Delta fish species.

Purpose of Testimony

The purpose of this testimony is to highlight key studies and findings pertaining to entrainment losses that the State Board should consider when determining the volume and timing of Delta exports and other Delta flow criteria.

Scientific Evidence that should be Considered by SWRCB

Strong evidence exists regarding the historic and continuing direct mortality of fish in the Delta due to entrainment. A brief listing of important recent scientific evidence regarding entrainment losses is as follows:

- Kimmerer (2008) – *Losses of Sacramento River Chinook Salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta.*
- Grimaldo et al (2009) – *Factors affecting Fish Entrainment into Massive Water Diversions in a Tidal Freshwater Estuary: Can Fish Losses be Managed?*
- USFWS (2008) - *Biological Opinion on the coordinated operations of the Central Valley Project (CVP) and State Water Project (SWP).*
- NMFS (2009) - *Biological Opinion and conference opinion on the long term operations of the Central Valley Project and the State Water Project.*
- Clark et al (2009) - *Quantification of pre-screen loss of juvenile steelhead in Clifton Court Forebay.*

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A brief summary of important findings from this scientific research is provided below.

Kimmerer (2008)

This publication was authored by Wim Kimmerer, an expert on the Delta ecosystem who has produced numerous publications on this system. In this document, Kimmerer provided a mechanistic analysis of the importance of entrainment losses to Delta fish populations.

Kimmerer estimated the proportional losses of Sacramento River Chinook salmon and delta smelt that have occurred as a result of entrainment using data for the period 1995-2006. Kimmerer pointed out that the challenge for the scientific community is how to detect and quantify population effects in the absence of strong correlative relationships. This requires an analysis of mechanisms, rather than an analysis based on correlative relationships alone. His mechanistic analysis was the first of its kind in the Delta.

Kimmerer found that for delta smelt, pelagic larvae and juveniles in the southern Delta are vulnerable from the time they hatch until they move seaward into brackish water. Together with adult entrainment, export pumping causes a continuous mortality that acts on the population over time during two life stages. Kimmerer estimated that losses of adult delta smelt were 1-50% (median 15%), although the highest value may have been biased upward. Estimated daily losses of larvae and juveniles were 0-8%, and seasonal losses accumulated were 0-25% (median 13%). For delta smelt during the dry years of 2001–2003, the estimated losses were ~ 25% of the population.

For Chinook salmon, Kimmerer found that the estimated proportion of migrating fish salvaged at the export facilities increased with increasing export flow. From a population maintenance standpoint, the calculated loss rate at the export facilities would be a significant component of direct anthropogenic mortality. Kimmerer stated that this level of additional mortality at the export facilities may place constraints on the rate of recovery of the listed winter- and spring-run stocks, and on ocean harvest of stocks (such as the fall run) that are not listed. Furthermore, these constraints may grow for winter Chinook if export flows continue to be kept high in winter to reduce impacts in spring.

Grimaldo et al (2009)

This paper was co-authored by Delta fisheries experts representing the Department of Water Resources, University of California at Davis, USEPA and USGS. The authors investigated factors affecting fish entrainment at the SWP and CVP.

The authors found that patterns of entrainment vary substantially with the life history of different fish species and with season. The authors also found that entrainment interacts in complex ways with Delta hydrodynamics, water quality and biological variables.

For delta smelt, long fin smelt and striped bass, the authors found that entrainment was primarily determined by seasonal occurrence of life stages near the export facilities. The

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direction and magnitude of flows through the estuary and toward the export pumps was found to be a reasonable predictor of entrainment for these species.

Based on daily salvage data collected by DWR and USBR at the fish facilities in the South Delta, the authors found that between December 1992 and July 2005, the SWP and CVP salvaged 590,310 delta smelt, 122,747 long fin smelt, and over 32 million striped bass. The authors noted that delta smelt are likely to have low survival rates in the salvage and handling process, leading to a determination by federal fisheries agencies that such fish are considered to be lost from the population upon collection.

The authors concluded that exports (as indexed by Old and Middle River flows) play a major role in the salvage (and therefore loss) of pelagic fishes. Relatively strong relationships between flows in Old and Middle River and annual entrainment of adult delta smelt and long fin smelt and age-1 striped bass indicate that fish are at least partially moving with reverse net flow toward the export facilities.

The authors noted that the degree to which water exports have population level effects on delta smelt is poorly understood. The authors point out that the losses of delta smelt are perhaps greatest during the winter, which represents the period of adult migration and spawning and that recent increases in winter salvage (entrainment) of delta smelt were associated with higher exports and reverse Old and Middle river flows.

In concluding remarks, the authors note that improvements in fish louver or screen designs could reduce losses of some of the species, since the SWP and CVP fish louvers were designed primarily for Chinook salmon. A number of the fish species and life stages of present concern have not been adequately addressed in the design of the existing fish facilities.

USFWS (2008)

The USFWS issued its biological opinion regarding the effects of the operation of the SWP and CVP in December, 2008. As the result of its analysis regarding the relationship between export rates and delta smelt entrainment, USFWS found that the population level effects of entrainment vary and are best characterized as a sporadically significant influence on population dynamics. They found that major delta smelt population declines in the 1980's and during the recent POD years were both associated with hydrodynamic conditions that greatly increased delta smelt losses. USFWS acknowledged that entrainment is likely not driving population dynamics in every year [page 209].

USFWS found that delta smelt entrainment is a function of Old and Middle River flow conditions and the location of X2. As such, entrainment is predicted to be lower during periods of lower exports and higher flows through the Delta. USFWS stated that "Increased pumping at the Banks and Jones export facilities corresponds to the decline of the delta smelt population during the period both prior to and following its listing under the Act." [page 276].

NMFS (2009)

In its biological opinion pertaining to the impact of the project operations, issued in June, 2009, NMFS stated that "...the long term operations of the CVP and SWP are likely to jeopardize the continued existence of Sacramento River winter run Chinook salmon, Central Valley spring run Chinook salmon, Central Valley steelhead,..." and other fish species [page 575]. This finding was due in part to the impact of increased frequency of greater pumping rates by the SWP, which will result in substantial numbers of additional Chinook salmon and steelhead losses in Clifton Court Forebay due to predation. NMFS estimates loss rates in the forebay for listed Salmonids to be 75 to 80%. With increased pumping, NMFS stated that additional salmonids would be drawn into the forebay during the months when the species are most present in the system. NMFS stated that "The proposed near term and future operations of the SWP, through the operations of the Clifton Court Forebay, will exert additional adverse effects upon the listed salmonid populations."

Clark et al (2009)

DWR conducted a series of studies to assess and quantify pre-screen losses of juvenile steelhead in Clifton Court Forebay. The studies commenced in 2005 and continued through 2007. Tagged steelhead were released near the entrance gate to Clifton Court Forebay and their fate was studied by following the location of the tags. The study determined that pre-screen losses of steelhead in Clifton Court Forebay ranged from 78 to 82%, mainly due to predation by striped bass and birds. The 2009 report summarizing the study results indicated that similar and greater loss rates (63 to 99%) have been documented in the forebay for juvenile Chinook salmon since the 1970's.

Additional supporting evidence, including historic and recent research and papers, is summarized in the attached paper titled *A Review of Delta Fish Population Losses from Pumping Operations in the Sacramento-San Joaquin Delta* prepared by Larry Walker Associates in January, 2010.

The publications by Kimmerer and Grimaldo et al and the delta smelt and salmonid biological opinions all support the finding that, at a given level of abundance, entrainment losses increase with increased export rates and with reverse flows in Old and Middle River.

While more research is needed to understand the population-level effects of the direct mortality resulting from entrainment, reasonable steps to reduce the severe entrainment losses that have been documented should be considered as part of the development of flow criteria.. Estimates by Kimmerer suggest that entrainment losses can at times be very important to the populations of delta smelt and other species. The determinations the SWRCB makes regarding timing and volume of exports must take the recent evidence and information regarding the direct mortality of fish due to entrainment into account. The SWRCB must also consider feasible measures to avoid such mortality.

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Measures to reduce entrainment losses that have been previously identified and agreed upon as improvement alternatives that should be considered include:

- Constructing new or additional fish screens to improve the survival of fish drawn into SWP and /or CVP intakes.
- Reconfiguring the intake systems for the SWP and/or CVP to improve survival and reduce the number of fish drawn into the intakes.
- Eliminating or reducing reverse flows in Delta channels to reduce entrainment of fish in export pumps.
- Reducing predation in Clifton Court Forebay to improve survival of fish.
- Modifying limitations on SWP and CVP exports to reduce numbers of fish drawn into the export facilities.

[Reference: “Agreement Pursuant to Article VII Negotiations for Interim South Delta Facilities Concerning Fish in the Sacramento-San Joaquin Estuary” (1995).]

While the focus of this testimony deals with direct effects of entrainment on Delta fish species, as a related matter, the SWRCB should also seek and consider information and expert scientific opinion regarding the indirect effects of exports on food web, habitat, predation and other factors. Kimmerer (2008) points out that indirect losses due to the hydrodynamic changes associated with export pumping may be important, but that they remain largely hypothetical and un-quantified.

Summary

Strong evidence exists regarding the direct mortality of impacted fish species in the Delta due to entrainment. Recent research and publications have been identified which should be considered by the SWRCB in its Delta flow criteria determination.

While more research is needed to understand the population-levels impacts of this mortality, available information suggests that entrainment losses are important at the population level.

Numerous sources suggest that entrainment losses are related to export rates from the South Delta.

The SWRCB’s determinations regarding the recommended timing and volume of exports and Delta outflows should take into account the direct losses of fish due to entrainment and the indirect effects of exports on food web, habitat, predation and other factors.

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