california water impact network



# C-WIN 2

# Testimony on Optimal Conditions for Public Trust Resource Protection and Recovery in the San Francisco Bay-Delta Estuary Before the State Water Resources Control Board

**Submitted by**

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In passing Senate Bill X7 1 (SB 1) Section 85086 of the California Water Code the California Legislature last November assigned the State Water Resources Control Board to answer the question: what river flows (among other regulatory criteria) are needed to provide both protection and an opportunity to recover the San Francisco Bay-Delta estuary's ecosystems and declining fisheries? The State Water Board is to address water quality concerns, and the Board is to use the best available scientific information.

Such an evaluation of flows is long overdue.

The poor track record of the policies and regulations established by the 1995 Bay-Delta Accord and CalFED Record of Decision actions is well-established through substantial research into both the Pelagic Organism Decline and the multi-year closure of commercial salmon fisheries.

The California Water Impact Network's (C-WIN) testimony will provide direct answers to the State Water Board's questions contained in the proceeding notices issued in December 2009, and summarizes our recommendations in Table 4 (starting on page 30) for optimal ecological conditions relating to flows for the Delta portion of the estuary, extending out to western Suisun Bay. C-WIN also testifies about the considerable scientific record that was developed over 20 years ago that established conceptual and empirical foundations for an earlier draft water quality control plans and water rights decision that were not adopted due to political intervention in Board deliberations, as well as much of the research that has occurred since 1995.

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C-WIN testimony also incorporates by reference testimony presented to this proceeding of the California Sportfishing Protection Alliance, with its more detailed focus on scientific support for optimal flow regimes for anadromous salmonids.

The risks to Delta ecosystems and fisheries were evident to the State Water Board as early as 1978 when it stated in D-1485: "To provide full mitigation of project impacts on all fishery species now would require the virtual shutting down of the project export pumps." (C-WIN 3: 13, ¶1)[1]

In its Draft 1988 Water Quality Control Plan for the Bay-Delta Estuary concerning its own preferred alternative 5, the State Water Board wrote: "A safe level of exports is not known." (C-WIN 4: 7-32, ¶1)

Federal resource agencies have provided the public and water managers with sound scientific biological opinions addressing the necessity under federal law of avoiding extinction of Delta smelt and salmonids. These opinions provide copious amounts of information about the life histories, behavior, critical habitat needs of salmonids and Delta smelt, but their purposes are to prevent species extinction. C-WIN and other participants in this proceeding believe that the flow criteria the Legislature wants The State Water Board to develop should deal with establishing optimal conditions for recovery of these and other listed species in the Bay-Delta Estuary.

In the aftermath of the Delta Water decision issued by the Third District Court of Appeals in California (and which the California Supreme Court sustained in July 1986), the State Water Board took up the question of what are the ecosystem needs of the Bay-Delta estuary methodically, taking thousands of pages of sworn scientific testimony from numerous participants. To read through this older body of scientific work one quickly sees that both the scientists conducting empirical research and the State Water Board had greater species abundances to work with in devising strategies for their protection than exist today, particularly for Delta smelt, longfin smelt, striped bass, and anadromous salmonids. What they may have lacked in intimate understanding of causal interrelationships among variables, they made up for with doing the detective work to identify correlations among historical fish abundances, salinity conditions, and river flows to and out of the Bay-Delta Estuary. For example, out of this period of scientific research emerged the estuarine standard, now part of D-1641 and the 2006 Water Quality Control Plan, known as "X2."

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[1] C-WIN's paragraph numbering convention cites the number of the paragraph on the page where the paragraph starts. Partial paragraphs are not numbered in this convention.

C-WIN understands that the State Water Board did not retain its own administrative record of exhibits and testimony from this earlier period. Fortunately, others did retain exhibits and testimony from this period. Many scientific exhibits and testimony on ecological, salinity, and fishery conditions were accepted into evidence by the State Water Board at the time during hearings associated with developing both the Draft 1988 Water Quality Control Plan and the Draft 1992 Water Right Decision 1630 (issued in December 1992, but subsequently revised for adoption in April 1993 as an interim decision).

C-WIN takes this opportunity now to thank the State Water Board for accepting these exhibits into the record of this proceeding now, and for saving our groups thousands of dollars in copying costs by accepting them electronically.

**State Board Question:** *What can the State Water Board reasonably be expected to accomplish with respect to flow criteria within the nine months following enactment of SB 1? What issues should the State Water Board focus on in order to develop meaningful criteria during this short period of time?*

The California Water Impact Network believes The State Water Board can reasonably expect to develop and complete your recommendations with respect to flow criteria by your August 2010 deadline to the Legislature set by SB X7 1. The State Water Board must accept that it will have to make challenging professional and political judgments in an environment of scientific uncertainty. Human institutions must nearly always make decisions without complete information. The Legislature has directed the State Water Board to rely upon the best available science and that is your charge.

C-WIN believes the Board has organized the general themes well (e.g., hydrology, hydrodynamics, anadromous fisheries, pelagic fisheries and food web, and stressors).

The 1988 Draft Water Quality Control Plan provides a useful example of how your report could be structured to satisfy the Legislature's request for flow criteria to benefit Bay-Delta Estuary public trust resources. The Board at that time received into evidence recommendations for optimal fishery and flow conditions, and provided tables summarizing this work. Many of the various optimal condition recommendations appear in Tables 1 through 3 below. These tables summarize 1987-1988 recommendations on flow criteria from:

- State Water Contractors, the California Department of Water Resources, and the US Bureau of Reclamation (Table 1);

- US Fish and Wildlife Service, the National Marine Fisheries Service, and the California Department of Fish and Game (Table 1);
- The Bay Institute of San Francisco (Table 1);
- The State Water Resources Control Board's summary of optimal conditions for salmon (Table 1) and striped bass (Table 2); and
- Romberg Tiburon Center for Environmental Studies (Table 3).

As can be seen in Table 1, Delta outflow recommendations of the water agencies are typically about half the magnitudes of recommendations from fishery agencies and environmental participants. Comparison of the various recommendations you receive through this proceeding should be straightforward and can be used to distill out the Board's own recommendations.

Table 2 also includes flows from D-1485 (which in the 1987 proceeding, the State Water Contractors, DWR and the Bureau preferred to keep for May and June; they preferred deleting D-1485's July flow regime) which were intended to benefit striped bass. Criteria from D-1641 are also included for comparison. That water right decision omitted a Delta outflow regime that would benefit estuarine resource values in favor of sole reliance by the State Water Board to support use of an X2 estuarine standard for February 1 through June 30.

**State Water Board Question:** *How should the State Water Board address scientific uncertainty when developing the Delta outflow criteria? Specifically, what kind of adaptive management, monitoring, and special studies programs should the State Water Board consider as part of the Delta outflow criteria, if any?*

The State Water Board will likely never have enough information to make perfectly correct decisions about how to regulate flows and protect and restore the Delta's estuary and listed fish species. Someday soon the Board will still need to act on behalf of these resources.

C-WIN recommends that the State Water Board apply a precautionary and protective approach in developing Delta outflow criteria that takes account of the Estuary's flows—and the timing, quality (e.g., temperature), and volume of flows—needed to enable listed fish species to recover to their former abundance. In essence: first, do no harm, or in the Delta's current situation, relax the stressors as the State Water Board the Delta with provides needed base and pulse flows. We urge the Board not to "pre-balance" the flow needs of the fish with some impression of whether water contractors or water project operators would accept the flows or not. The estuary and the species in them evolved in the midst of a hydrological regime that has been dramatically altered. Recovering these resources to health—and to meet the Anadromous Fish Restoration Program's "fish doubling" targets called for in the 1992 Central Valley Project Improvement Act—will require returning to a flow regime that much more closely resembles what natural flows occurred (in timing, volume and quality) prior to completion and operation of the Central Valley Project and the State Water Project, conditions in which these public trust resources evolved. The Legislature assigned the Board of identifying what flows are needed to protect and recover Delta estuarine ecosystems and listed species. The needed flows may be large, or large for what we currently think of as critical and dry years; that does not mean they would be wrong for recovering these resources. The State Water Board should confront and put forward such criteria.

C-WIN also believes the Board should address uncertainty by identifying areas in your flow criteria where important uncertainties do exist. Once identified, the Board should encourage adaptive management approaches to addressing them. The quest for greater scientific understanding of these resources must not paralyze the Board from exercising its authority to act on behalf of protecting these species.

C-WIN recognizes that the State Water Board will need to maintain and expand relationships with state and federal agency, academic, and scientific funders of estuarine and hydrological research. The Board's analysis of uncertainties associated with having developed Delta flow criteria should provide ample opportunity for the State Water Board to guide directions for future scientific and policy-relevant research by the community of scientists engaged with the Bay-Delta Estuary.

**State Water Board Question**: *What methodology should the State Water Board use to develop flow criteria for the Delta? What does that methodology indicate the needed minimum and maximum volume, quality, and timing of flows are for different hydrologic conditions under the current physical conditions of the Delta?*

From C-WIN's review of scientific exhibits from the 1987 through 1992 period as well as more recent scientific literature, the Bay-Delta estuary needs:

- **Base flow criteria** that provide an overall hydrologic regime to support a thriving estuary. The estuary must serve as a rich and highly diverse nursery for the young of species, with diverse habitats to encourage greater niche specialization and more successful survival strategies.

- **Pulse flow criteria** to encourage transport in and through the Delta and production of anadromous fish, because anadromous (migratory) fish use the Bay-Delta Estuary as a migration corridor at select times of year.

- **Temperature criteria** for source tributaries because anadromous fish need cold water conditions in the Delta's major tributaries to survive their migration down the Sacramento and San Joaquin rivers to the Delta. Sources of flows are discussed below.

- **Estuarine criteria** correlated with base flow criteria that simultaneously delineate the region of greatest nursery function and freshwater species and biomass productivity. When X2—the aquatic region estuarine scientists refer to as either the "entrapment zone" or the "low salinity zone" (see discussion below)—is located in Suisun Bay for extended periods of time, productivity of a variety of species is often significantly increased. Larger freshwater flows of greater duration past Chipps Island are needed to sustain this productivity over time and enable recovery. These larger freshwater flows can also be instrumental in eliminating species with higher tolerance for saline conditions, and over time can help expand habitat for estuarine species with lower salinity tolerances, thereby enlarging the overall size of freshwater food webs, including pelagic and anadromous fish species.

- **Source flow criteria** for all major Delta tributary rivers, and we recommend the State Water Board employ pro rata allocation flow factors that would support Delta outflows that address the other criteria we recommend to you. These flow factors should be based at a minimum on the capacity of each tributary stream, given climatic, hydraulic, and habitat characteristics relevant to anadromous fish survival and migration behavior, to provide flows to the Delta estuary and transport migrating fish safely in the process.

C-WIN believes that the State Water Board's methods should focus on these basic interrelationships between Central Valley watershed hydrology and water quality, estuarine hydrodynamics, and pelagic and anadromous fishery life histories to design Delta flow criteria that would protect and recover the Delta's ecological productivity and someday de-list species at risk of extinction.

The Board has also appropriately identified "stressors" as another category of analysis for these proceedings. This category includes temperature specifically, but it also extends to the problem of polluting contaminants such as pesticides, low dissolved oxygen (most pronounced at the Stockton Deep Water Ship Channel), and other toxic contaminants such as mercury, selenium, boron, arsenic, and salinity in agricultural drainage from the San Joaquin Valley. These are particular difficult problems during times of low flow in any year, and in critically dry and dry water years. In hydrodynamic terms, the California Water Impact Network urges the State Water Board to look to methods that reduce residence times of water and constituent contaminants throughout the year. The best ways to lower residence times of water and reduce the effect of attendant pollution and contamination problems during low flow periods is to identify and aggressively implement source control programs—for instance, encouraging further land retirement of salt- and selenium-laden lands in the western and southern San Joaquin Valley. Low flow periods are a large part of the Bay-Delta Estuary's overall flow as surely as are flood periods, as discussed below.

The Board's methods for developing Delta flow criteria should:

- Identify ways to expand and sustain the size of the freshwater estuary on an ongoing basis. Its apparent shrinkage in the last few decades from reservoir and export pump operations appears to be a significant causal factor in deterioration of Delta ecosystem performance and the collapse of pelagic and anadromous fisheries.

- Mimic natural flow (i.e., hydrograph timing and volume) conditions within which native anadromous and pelagic fish species evolved, including sufficient tributary cold water and pulse flows that signal appropriate times for migration to and from the ocean.

- Address the deleterious effects of contaminant and temperature stressors during low flows, and identify an optimal source control program that would limit contaminant bioaccumulation due to longer hydrologic and hydraulic residence times.

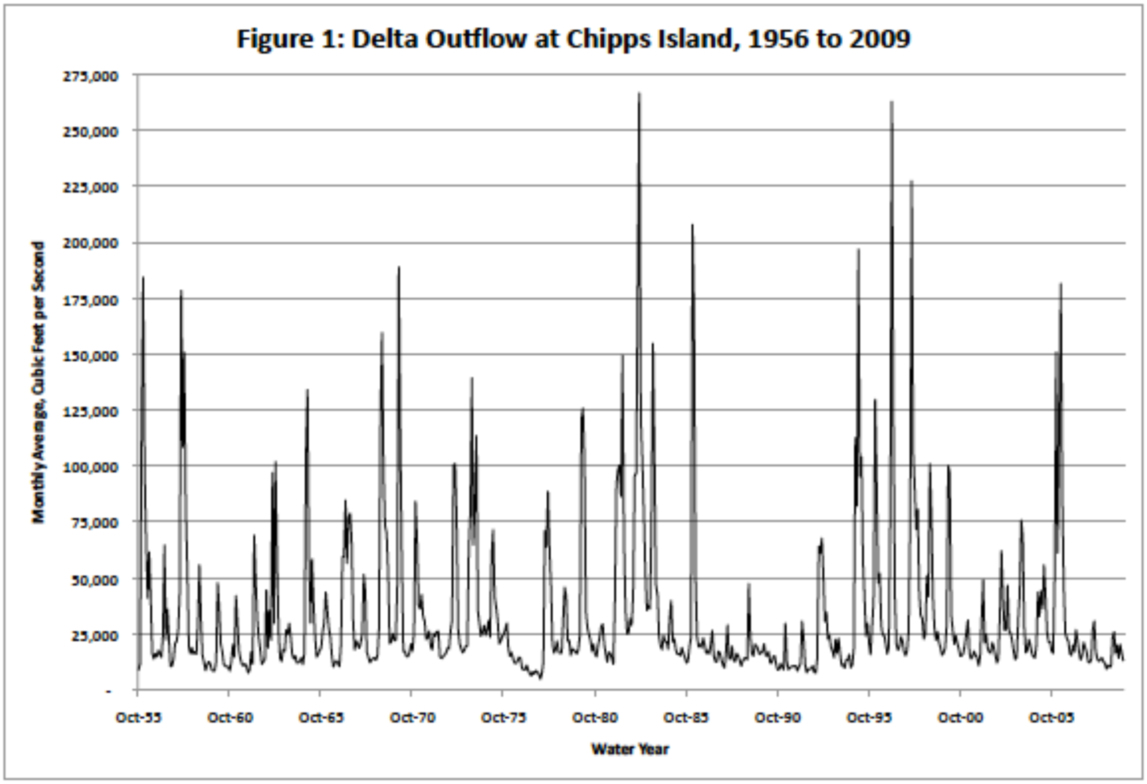
- Identify flow factors that address effects of rising sea levels on water levels and in turn the size of flows needed to sustain the Bay-Delta Estuary. Such incremental flows would be the water cost of climate change on the Bay Delta Estuary, and would also be extremely important for statewide water planning purposes. C-WIN acknowledges this information need, but has not attempted to model or identify recommendations about the effects of sea level rise due to time and resource constraints.

**State Water Board Question:** *What key information, in particular scientific information or portions of scientific information, should the State Water Board rely upon when determining the volume, quantity, and timing of water needed for the Delta ecosystem pursuant to the board's public trust obligations? For large reports or documents, what pages or chapters should be considered? What does this scientific information indicate regarding the minimum and maximum volume, quality, and timing of flows needed under the existing physical conditions, various hydrologic conditions, and biological conditions? With respect to biological conditions, what does the scientific information indicate regarding appropriateness of flow to control non-native species? What is the level of scientific certainty regarding the foregoing information?*

The Board should seek out and rely on scientific information that establishes and explains the relationships among flow, salinity, food web productivity and species abundance for improving estuarine conditions to a point that listed species recover, invasive species are better controlled and suppressed, and overall biomass productivity increases.

**Flows.** The State Water Board should examine the record of monitored in-Delta flows—both positive and negative (upstream) flows—in the Delta contained in DayFlow (www.water.ca.gov/dayflow/). DayFlow tracks flows in the Delta by water year from 1956 through 2009. Unimpaired runoff data will also be important for sources of flows to the Delta, and is discussed later.

Delta outflows over the last 54 years of DayFlow records have declined by nearly 50 percent. Figure 1 indicates the seasonality and highly variable character of Delta outflows at Chipps Island between 1956 and 2009. Outflows in this record range from below 3,000 cfs (about 1959) to in excess of 260,000 cfs in 1983.




Source: DayFlow, Interagency Ecological Studies Program.

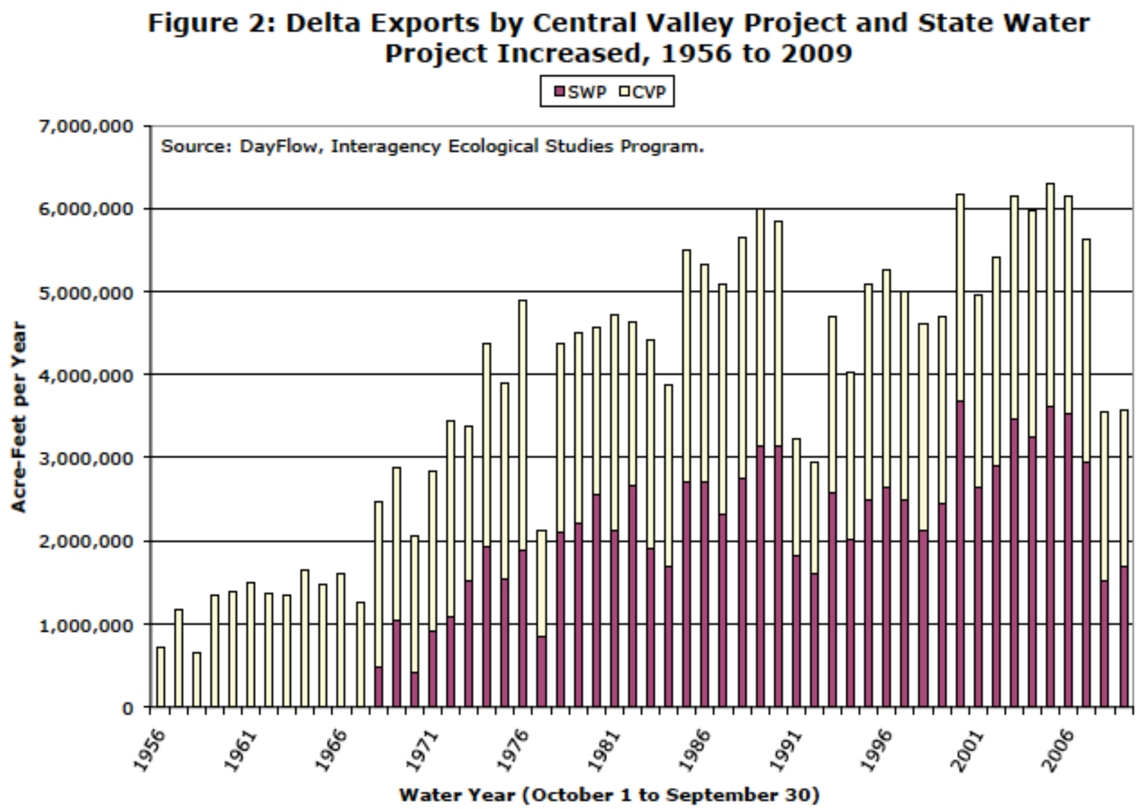
An important cause for decreasing Delta outflow is water project operations at upstream reservoirs and in the Delta. DayFlow reveals an increase in export pumping by the federal Central Valley Project (CVP) and the California State Water Project (SWP). During this period, Delta exports (Figure 2, below) have increased steadily since 1956, with notable but brief decreases during drought or dry year restrictions (1977, 1991 and 1992, and 2008 and 2009). Between 2000 and 2006, pumped exports by the CVP and SWP ranged from 5 million acre feet to about 6.4 million acre-feet. In five of these years (2000, and 2003 through 2006) pumped exports from the Delta hovered near or exceeded 6 million acre-feet. Only in one previous year (1989) did pumped exports from the Delta reach 6 million acre-feet.

Figure 1 clearly shows that Delta outflow timing varies from year to year and from season to season (within years shown on this hydrograph). Smith's US Geological Survey exhibit to the 1987 Bay-Delta hearings stated:

> ...[A]ddition of a number of reservoirs and diversion structures have changed the freshwater discharge of the delta. Although no reasonable amount of storage can

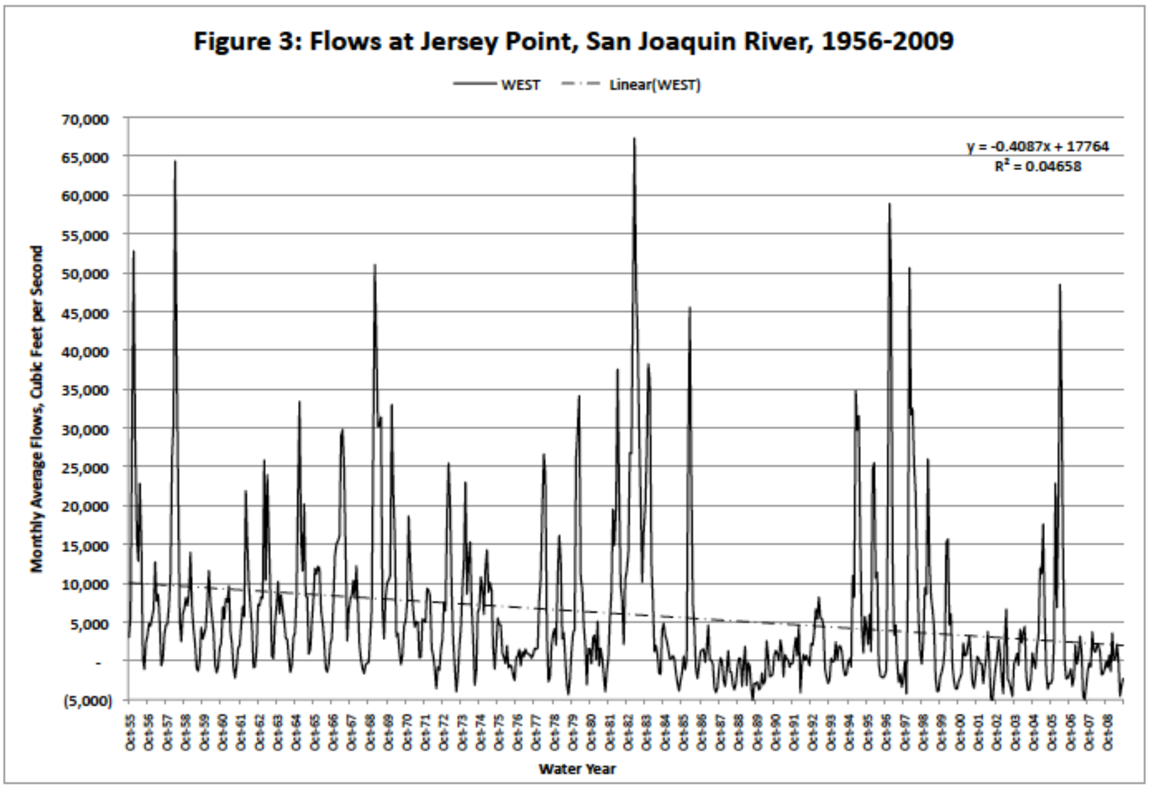
> overcome extreme floods and droughts, the additions of upstream storage have had a significant influence on delta discharges [cite]. A principal effect has been to delay discharge from winter and spring until summer and fall, permitting consumption of 40 percent and export of an additional 24 percent of the historical annual freshwater discharge of 34 $km^3$ (27.6 million acre-feet) [cite]. Summer flows are maintained now by reservoir releases whose purposes are to supply users and to suppress salinity intrusion into the delta [cite]. Upstream storage has also reduced the discharge peaks of winter storms [cite]. (C-WIN 6, 7, ¶3)

Figure 2 indicates Delta exports by the Central Valley Project and the State Water Project have increased steadily since operations began.




Source: DayFlow, Interagency Ecological Studies Program.

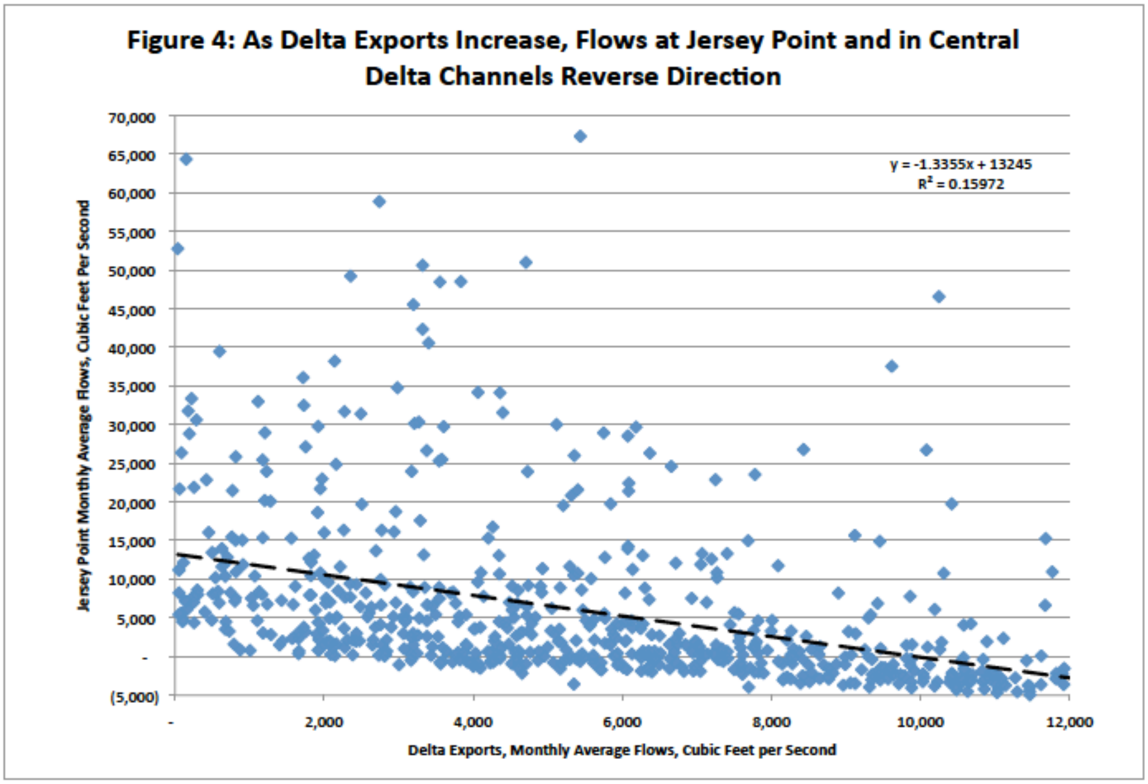
Delta export pumping is an important factor creating negative, or reverse, flows in Old and Middle Rivers, and DayFlow records these flow patterns as they occur at Jersey Point on the San Joaquin River. Figure 3 (below) indicates the historical variability and decreasing trend of monthly average flows at Jersey Point. Trendline averages suggest that San Joaquin River flows in Water Year 1956 averaged about 10,000 cfs (a net downstream flow) decreasing to a net positive flow by 2009 of just over 2,000 cfs. Visual inspection of this Jersey Point hydrograph indicates that since the onset of Water Year 1986, reverse flows as measured at Jersey Point have increased in frequency, with extensive periods of reverse flows during the Water Years 1987 through 1994, 2000 through 2004, and from 2006 through 2008.




Source: DayFlow, Interagency Ecological Studies Program; trendline by California Water Impact Network.

C-WIN prepared a simple scatter plot (Figure 4) of monthly average flows correlating Delta exports with flows at Jersey Point for all months from 1956 through 2009. Inspection of the scatter plot shows that as Delta exports rise, flows at Jersey point decrease. Average flows at Jersey Point, suggested by the trendline, have decreased from about 13,000 cfs to about -3,000 cfs. In short, over time, as exports have increased, there is an increasing frequency and size of reverse flows at Jersey Point.

**Flow Dynamics and Salinity.** Flow dynamics (hydrodynamics) in the Delta portion of the Bay-Delta estuary are driven by the interaction of tidal currents and river inflows. Tidal currents bring dissolved salts from the Pacific Ocean and San Francisco landward; freshwater flows from the Delta's major tributary streams push back against these saltier upstream flows, creating a freshwater barrier against tidal influence.




Source: DayFlow, Interagency Ecological Studies Program; trendline by California Water Impact Network.

Smith notes that the hydrodynamics (the relative strength of tidal flows upstream versus river flows downstream) of the Delta are different in low versus high discharge conditions (C-WIN 6, 18, Table 2, "Northern Reach"). In conditions of low discharge (outflow) circulation (less than 14,000 cfs) in the Delta is characteristically a combination of gravitational circulation (generated by density and directional differences of salty and fresh water flows), tidal and wind-induced currents. Fresh and salty water meet at the "null zone" typically in Suisun Bay or landward (to the east). Smith reports mean residence times for water under low discharge conditions as lasting from two to three months, depending on levels of delta discharge and mixing activity.

By contrast, under high Delta discharge conditions (greater than 35,000 cfs), there is intense gravitational circulation seaward of the null zone and "river-like" flow landward of the saltier bottom waters of the null zone. The null zone, Smith noted, moves seaward into Carquinez Strait, with particularly rapid seaward movement in channels during runoff events, followed by slow landward movement afterward.

In estuaries, freshwater flows from rivers draining watersheds meet tidal flows and currents from the ocean. Where these flows meet, the waters are typically rich in sediments and nutrients from runoff, and light penetration is lowered due to turbidity of the waters. The presence of nutrients make this part of an estuary a good location as a nursery for many estuarine species. This region of mixing of salty, denser Bay water with fresher and more buoyant Delta outflow produces a rich area where nutrients collected from runoff in tributaries collects and circulates. Planktonic species and larval fish and other pelagic (open water) species congregate in this area, which makes it a rich nursery area. DFG wrote to the State Water Board in 1987 that:

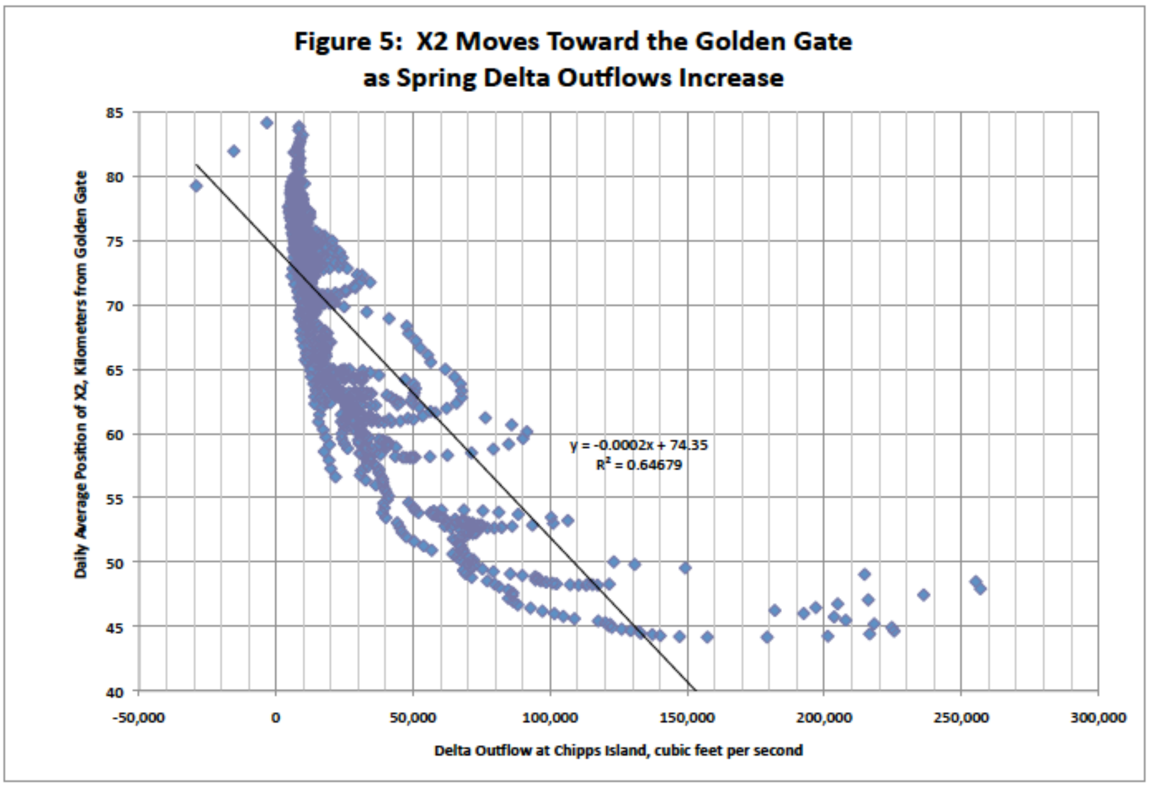
> Estuaries receive inflow from vast watersheds and are therefore usually rich in nutrients and other food sources. Such food is advantageous to young fish using the estuary as a nursery area. (C-WIN 7, 9, ¶5)

The entrapment of nutrients at the null zone in the San Francisco Bay-Delta Estuary typically occurs where salinity is at about 2 parts per thousand, nicknamed by scientists "X2" as an indicator of the fresh/saline boundary, "a convenient index of the physical response of the estuary to freshwater flow." (C-WIN 8, 27, column 2, ¶1)

From empirical research and analysis the San Francisco Estuary Project (SFEP) constructed a rating schedule that illustrates the required Delta outflow and monthly water volume required to maintain X2 at a position a specified distance from the Golden Gate. In describing the rating schedule, SFEP observed:

> An important consequence of the nonlinear relationship of X2 to delta outflow is the asymmetry in water requirement implied [ ]. A change in X2 takes the same proportional change in flow at any initial position, but the actual quantity of flow can vary. For example, it takes 18,000 acre-feet of water per month to move X2 donwstream from 110 km to 105 km, and 921,000 acre-feet per month to move it from 65 to 60 km. This has serious implications for management: keeping X2 at precisely the position set by the standard will always cost less water than allowing it to move about that position. Since one of the recommendations of [our research] is to all for variability, it is important that the standard be set in such a way as to prevent constancy of position. (C-WIN 9, A-10, Table 2 and ¶1)

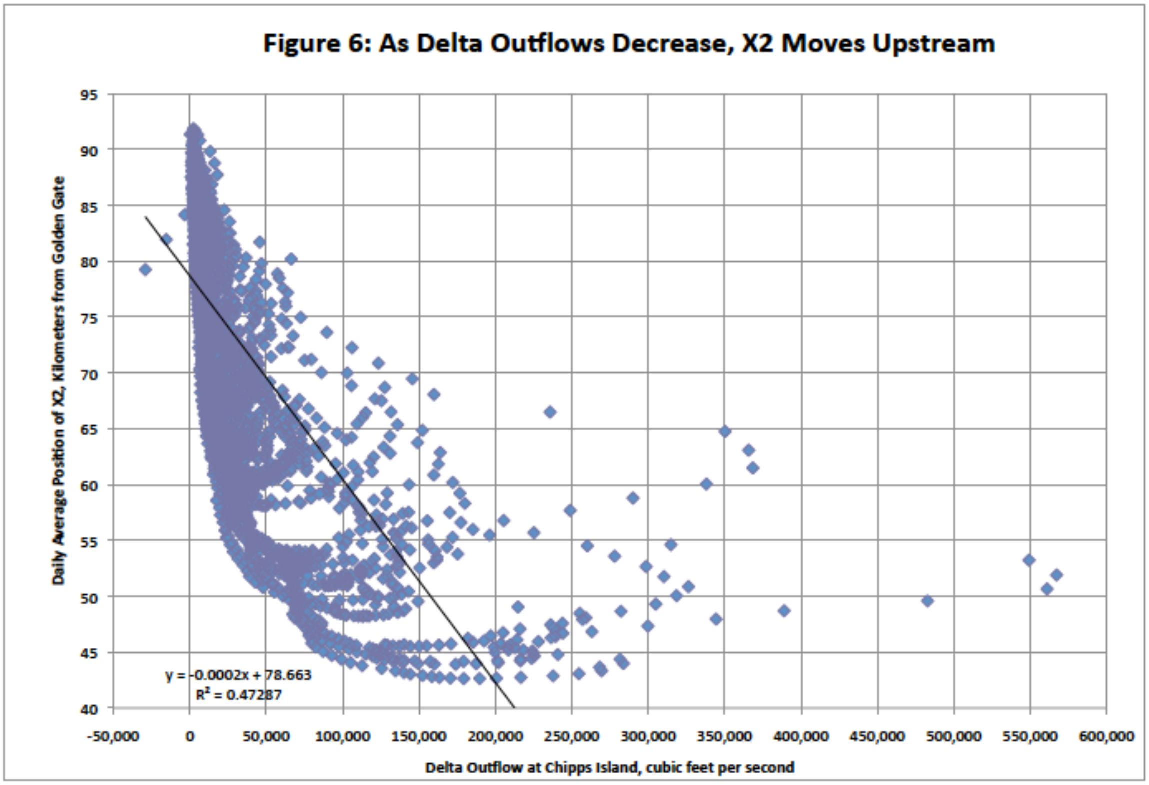
There are several reasons why X2 is an important indicator. First, the 2 parts per thousand value has a physical basis, resulting from dilution of ocean water, and represents salinity higher than that found in the south Delta where elevated salinity results from agricultural drainage. And it is low enough to mark the landward limit of salinity stratification away from the ocean. Second, X2 responds to a freshwater flow within about two weeks from when Delta outflows change (and which may differ somewhat between rising and falling hydrographs). Finally, for this testimony's purposes, X2 can be modeled and be made susceptible to management. (C-WIN 8, 27, column 2, ¶1) It is negatively correlated with Delta outflow at Chipps Island regardless of time of year, as shown in Figures 5 and 6.




Source: DayFlow, Interagency Ecological Studies Program; trendline by California Water Impact Network.

And, as importantly, Jassby, et al, 1995, found that the X2 region of interacting tidal and river flows "has extensive relationships with estuarine resources in the Bay/ Delta estuary.

The associations exist for benthic and pelagic organisms, planktivorous and piscivorous organisms, and a range of taxa from algae through molluscs and crustaceans to fishes. (C-WIN 10, 280-282; 281, column 2, ¶2; see also Figure 5, 280)




Source: DayFlow, Interagency Ecological Studies Program; trendline by California Water Impact Network.

More recently, according to Kimmerer, the scientific community has adjusted its conceptual model of where and how rivers meet tides in estuaries, since the gravitational circulation mechanism is observed in the Delta primarily during lower flows and in channels (as distinct from shallower embayments). Instead, Delta estuary scientists add to this version of the null zone a "low salinity zone" that captures bathymetric complexity and more diverse mechanisms of tidal and freshwater flow mixing. (C-WIN 6, 30, column 2, ¶1; 31, column 2, ¶1, 2). Kimmerer points out that the bathymetric mixing at work with the low salinity zone means first that pulse flows "must be large and long-lasting to affect the estuary." (Ibid.) It also means that:

> ...except under very high-flow conditions the [low salinity zone] is vertically well-mixed. This means that there is no way for river flow per se to penetrate the

> estuary west of Suisun Bay; the degree of stratification and gravitational circulation is directly related to the longitudinal density gradient [of salinity] but only indirectly related to river flow. The implication for biota is that river flow usually does not disperse organisms into seaward areas as previously hypothesized [cite]. This may happen under extremely high-flow conditions, however, when much of the area of the estuary is fresh. (C-WIN 10, ibid.)

This physical, hydrodynamic process helps to explain the relationship observed by the San Francisco Estuary Project in 1993 where 50+ percent greater flows required each time X2 is pushed westward 5 kilometers.

Kimmerer reports that prehistoric salinity records suggest an average annual inflow to the Delta estuary over the last two thousand years of about 1,250 m3 s-1 (about 43,750 cfs), similar to the current average unimpaired inflows to the Delta from 1906 to 2002 of about 42,000 cfs. (C-WIN 8, 16, column 2, ¶1) These flows would, on average, place X2 at approximately western Suisun Bay west of Roe Island.

Other salinity research confirms the Delta was typically fresher in historic and prehistoric periods than it is under today's water project regime. Recent paleoclimatic research indicates that the Delta has been predominantly a freshwater estuary for the last 2,500 years. (C-WIN 11, 4, ¶1-3, Figure 1) Historical records analyzed by the Contra Costa Water District indicate that Suisun Bay was historically fresher in the winter and spring and experienced less salinity intrusion during low fall flows at the beginning of the 20th century than occurs during comparable periods of similar hydrologic conditions. (C-WIN 11, 5, ¶1-3, Figure 2)

The prevalence of decreasing Delta outflows and inflows means that the water that does enter the Delta stays longer. Mean residence time for water at low Delta outflows (about 2700 cfs) could exceed 350 days from entry to the Delta to exit out the Golden Gate; at high Delta outflows (about 45,000 cfs) residence time might reach three weeks. (C-WIN 6, 28-31; see Figure 15, p. 30) Kimmerer summarized research indicating that residence times in the Delta range from 2 to 14 days in the wet season and 19 to 29 days in the dry season. Residence times in the south Bay ranged from 8 to 51 days in the wet season and "effectively infinite" in the dry season." (C-WIN 8, 33-34, starting column 2, ¶3)

**Food Web Productivity and Pelagic Fish Abundance.** Basic ecological interactions with physical estuarine processes of mixing and circulation in the Delta have been understood for decades. There are, broadly speaking two distinct, if sometimes overlapping and interacting, food webs in the Delta Estuary growing from phytoplankton as the foundation.

A "benthic" food web is built via the filter-feeding strategy of benthic (bottom-dwelling) organisms which use suction to filter out food particles from the water column. The bivalves may be consumed by bottom feeding fish (such as young starry flounder), which are preyed on by other piscivorous fish, etc. Another foodweb is built from small pelagic fish larvae (such as Delta smelt, longfin smelt, striped bass) and zooplankton consuming phytoplankton directly through interaction in turbid (often higher flow) conditions.

The State Water Board received into evidence in 1987 exhibits jointly submitted by the Contra Costa County Water Agency and the Environmental Defense Fund by Phil Williams and Associates urging the Board to adopt a flow standard to maximize phytoplankton abundance by positioning an entrapment zone in San Pablo Bay, calling for a 28-day running average of Delta outflow at Chipps Island of not less than 20,000 cfs during the period of April through June, to apply in all years except specified dry years. (C-WIN 12, 3-4, ¶A-J) This proposal anticipated the congealing of the X2 concept by several years. Its main purpose would have been to limit incursion of more salinity-tolerant marine benthic organisms (clams and other bivalves) into Suisun Bay and the Delta.

An additional proposal in 1987 called for a flow-based salinity standard not to exceed 5 parts per thousand for 28 consecutive days during the period October 1 through April 1 each year of flows of approximately 40,000 cfs. (C-WIN Exhibit 13, 3-4, ¶A-K) The State Water Board has not adopted these type of salinity standards for explicit protection of phytoplankton. But these proposals build on the idea that freshwater flows through the Delta have a role to play not only in stimulating entrapment or low-salinity zone biomass productivity among the lower trophic levels but in controlling marine benthic organisms that have now invaded Suisun Bay and the Delta. These organisms have thrived in part as a result of the complex interplay of reduced average Delta outflows, increasing freshwater exports from the southwestern Delta, and upstream diversions to storage that withhold winter and spring runoff from the Delta for release later in summer and fall when temperatures of released water are warmer.

Zooplankton primarily feed on phytoplankton. In 1987 DFG studied their long-term trends, they included opossum shrimp (*Neomysis mercedis*, a primary food for striped bass young), small crustaceans called copepods and cladocerans, and rotifers. Of the native species DFG studied, only two (including *Neomysis*) did not undergo a long-term decline (C-WIN 14, 1987, 61,¶1). DFG reported to the State Water Board in 1987 for *Neomysis* that:

> Increased salinity in the drier years reduces the habitat available to *Neomysis*. This shrimp can be regarded as being in a box, the sides of which expand and contract with the volume of river outflow. The location of the box also moves, oscillating up and downstream with the tides and with river outflow. Tides cause minor daily displacements; changes in river outflow bring about major movements.
>
> Basically, *Neomysis* tends to be most abundant in the entrapment zone and immediately upstream from there....The high outflows of wet and normal winters and springs push the entrapment zone and *Neomysis* seawards into Carquinez Strait and even San Pablo Bay. Shrimp located in the main Delta channels are scoured out by these flows. By late spring, outflow has diminished and the entrapment zone has been pushed into Suisun Bay by intruding marine water. Once again, the mysids move with the zone and begin to appear in increasing numbers in the Delta. (C-WIN 14, 83, ¶2)

For pelagic fishes, however, habitat requirements can be more complex than that of *Neomysis*. Delta smelt present a more complex and mysterious example. They are a small pelagic fish species that usually inhabit salinity ranges of the Delta estuary of less than 2 parts per thousand, though they are occasionally found at salinities greater than 1 percent. Rising flows and repulsion of salty water enables Delta smelt to migrate to Suisun and San Pablo bays further from the Delta. For winter and spring, however, they disperse into Delta channels as their spawning period arrives and water is fresher. Historically, as a species their habitat is the channels of the Delta and west into Suisun Bay.

DFG surveys summarized in 1987 demonstrated that the geographical distribution of Delta smelt during the summer and fall is strongly influenced by Delta outflow. Its abundance was estimated for 1985 by DFG as numbering several hundred thousand fish, a figure subsequently revised to twice that level. (C-WIN 15, 1992, 5, ¶2) In January 1978 alone, following California's first drought, some 134,000 individual Delta smelt were salvaged at the export pumps. (C-WIN 15, 24, Table 5) While once abundant, they individually are not very fertile; females have on average only about 2000 eggs, ranging from just 1200 to 2600, and most individual smelt live for just one year. They are water column consumers of zooplankton.

Their low fecundity and narrow habitat range from Suisun Bay to lower Delta river channels render them vulnerable to extinction from alterations to nearshore habitat, river flow volume and timing alterations from water project operations, and competition for prey from invasive benthic species.

Prior to 1983 researchers found Delta smelt recruitment success linked to the position of X2, but as its abundance has declined so much since 1983, that linkage has weakened. Still, these fish rely on turbidity for cover from predators, which circulation and mixing in the vicinity of X2 can provide, especially during high Delta outflows. Moreover, Bennett concludes of Delta smelt's relationship to X2:

> Although recent abundances have been lower than anticipated, adult abundance is always low when X2 is located in the lower Sacramento and San Joaquin Rivers. (C-WIN 16, 32, column 1, ¶1-2)

Bennett suggests that changing habitat volume may be a key mechanism by which Delta smelt cope with density (proximity to predators and competitors for food); they are not a schooling fish, despite their small size. Bennett observes:

> With the invasion of the overbite claim *Corbula amurensis* in 1987, a voracious filter feeder, the Delta smelt has faced competition for its favored copepod prey, *Eurytemora affinis* and for other less nutritious copepods like *Pseudodiaptomus forebesi*. But even before the arrival of *Corbula*, DFG found Delta smelt declining in abundance, possibly due to extreme Delta outflows from an El Nino winter in 1983. Subsequently, a six-year drought also is believed to have reduced their habitat and their abundance, and because they frequent central and southern Delta channels in fall and winter months, they are vulnerable to entrainment and destruction at the export pumps. Contaminant exposures also may stress the species.
>
> Larger habitat volume may be a key mechanism underlying density dependence....Larger habitat volume reduces crowding and provides opportunities to avoid localized sources of mortality, allowing for the 'spreading of risk' over space [cite]. (C-WIN 16, 32, column 1-2, ¶3; column 2, ¶1)

Nobriga et al (2008) found that summertime habitat for Delta smelt factors included salinity, clarity of water, and temperature. Specifically, water clarity associated with cross-Delta (that is, reverse) flows in Old and Middle River

> had increased due to significant long-term reductions in total suspended solids during most months between March and November. Thus we propose that increased San Joaquin region water clarity has constricted delta smelt habitat, and is a major reason for its regional absence during summer. (C-WIN 17, 9, column 2, ¶2)

Echoing Bennett, they conclude that "there has been a long-term habitat constriction for delta smelt." (C-WIN 17, 9, column 2, ¶3) Estuary-wide habitat changes are more apparent in fall than in summer because delta smelt habitat suitability progressively deteriorates over the course of the year:

> Adult and juvenile delta smelt use the San Joaquin region during winter through early summer, sometimes causing conflicts between water export schedules and Endangered Species Act-mandated take levels [cite]. Presumably, cooler water temperatures and lower water clarity during winter-spring flow pulses allow delta smelt to occupy the San Joaquin region early in the year. By July, the San Joaquin region is no longer suitable delta smelt habitat, and by fall, habitat suitability declines further due to a separate long-term trend toward elevated salinity in the Suisun region [cite]. (C-WIN 17, 9-10, ¶2, 3)

Decreased turbidity is also a function of reduced sediment accompanying river inflows as well as washout from very high flows and proliferation of submerged invasive macrophytes, particularly in the San Joaquin region of the Delta. Macrophyte beds (such as the invader *Egeria* densa) may trap and filter out suspended sediment from river flows, leaving the water clearer, and less suitable as Delta smelt habitat. (C-WIN 17, 10, column 1, ¶2)

In sum, the geographical extent of Delta smelt's spawning habitat and distribution of its larvae and juvenile life stages depend on freshwater inflow to expand the estuary westward to reduce its density and take advantage of turbid conditions with greater access to favored copepod prey. With drier years, smelt habitat is constrained further east back into the Delta as X2 retreats under pressure from saline tidal currents, and Delta smelt face increased risk of destruction at the export pumps during winter months. Their habitat shrinks as water clears up from cross-Delta flows to export pumps, as temperatures increase in the summer and fall, and salinity intrudes.

The portrait of a constriction of Delta smelt habitat painted by these researchers is reminiscent of DFG's portrayal of *Neomysis mercedis*' habitat in 1987 to the State Water Board. The parameters driving life stages and feeding behavior are different for each species, but they strongly suggest that for key estuarine species like *Neomysis* and Delta smelt, the volume, timing and quality of flows (e.g., greater turbidity and cooler temperatures in smelt's case) is vital to expanding its habitat, offering alternatives for recovering Delta smelt that are controllable by water project operations on major Delta tributaries as well through increased controls on export operations.

The State Water Board should develop flow criteria that expand the estuarine freshwater habitat through increased outflows. In the cases of Delta smelt and anadromous salmonids, flows are necessary but not sufficient conditions for their recovery and de-listing. These species will also need expanded habitat in the form of nursery areas with shallow water and diverse nearshore feeding and cover opportunities to avoid prey. The State Water Board should develop these flow criteria bearing the need for habitat restoration—expressed as both flows and as reconfiguring of the aquatic and nearshore landscape to increase habitat diversity for rearing fish. The State Water Board should avoid the temptation to encourage habitat restoration without ensuring that optimal flows are provided to these habitat areas.

**Stressors.** C-WIN wants the Board to recognize that reducing the stressors of toxics, temperature problems, water clarity, and other water quality criteria usually have a flow component. These problems should be addressed by altering the timing and—most likely increasing—the volume of flows as part of a suite of controllable management tools available to the Board and to water project operators.

Increased runoff from the watershed is positively correlated with increased sediment load, increased turbidity, which in turn will decrease water clarity and residence times. Careful management of reservoir storage can ensure that water temperatures remain within optimal tributary parameters during pulse and attraction flows to ensure that salmon smolts and other anadromous fish (green sturgeon, steelhead, and American shad) get safely to and from their ocean habitat and spawning grounds.

The position of X2 is an important indicator of stress to estuarine freshwater species since they are relatively salt intolerant; increased duration and frequency of freshening flows over time will operate to increase critical aquatic habitat for the Delta's public trust resources. The further downstream on average X2 is positioned, the more likely California will see signs of recovery among the listed species and their supporting food webs.

The State Water Board is well positioned with legal authority and scientific and professional expertise to end the vicious cycle in which irrigation deliveries to the western San Joaquin Valley mobilize toxic stressors (such as selenium) and salts into drainage water that dramatically increases physical and toxicological stress on Delta fisheries and food webs. Particulate selenium is the most likely form of selenium in the water column to become biologically available. Linville et al (2002) found that high concentrations of selenium in the invasive overbite clam (*Corbula amurensis*) were observed toward the Delta's rivers compared with other shallow water locations in Suisun Bay or San Pablo Bay, and

> ...the higher concentrations toward the rivers in *P. amurensis* [overbite clam] could have reflected inputs from the San Joaquin River. (C-WIN 23, 56-57, ¶3)

The overbite clam's entry into the Delta estuary's benthic community is worrisome because this species bioaccumulates selenium from the water column and loses it only very slowly. Teratogenic effects among benthivore species (white sturgeon, diving ducks like scoters and scaup, and dungeness crab) are possible since these species were found by Linville et al to have high selenium concentrations in their tissues. (C-WIN 23, 61, column 1, ¶2) Once consumed in food, deformities in offspring have been noted, and Stewart et al found evidence of lordosis resulting from selenium contamination in Sacramento splittail individuals (C-WIN 24, 4525, Figure 5 and ¶2)

The US Fish and Wildlife Service surveyed potential effects of selenium contamination on federally-listed species resulting from delivery of federal water to the San Luis Unit (which provides irrigation water to western San Joaquin Valley growers). This survey noted:

> Selenium concentrations in agricultural drainwater from this area reach levels that, when bioaccumulated through food chains, cause adverse effects on aquatic and aquatic-dependent wildlife. (C-WIN 25, 1, ¶2)

The survey found that California Central Valley chinook salmon are among the most sensitive of fish and wildlife to selenium, especially during juvenile life states when they rear and migrate in selenium contaminated wetlands and rivers in the Central Valley and the San Francisco Bay-Delta estuary. (C-WIN 25, 18, ¶1) This study reported on toxicity studies from the 1980s and early 1990s that

> ...young salmon migrating down the San Joaquin River in 1987 bioaccumulated selenium to levels...that were likely to kill more than 25%.
>
> Concentrations of selenium in the San Joaquin River have been reduced since juvenile Chinook salmon were sampled in 1987. However, the relationship between selenium in water and in young salmon in 1987...indicates that there remains a substantial ongoing risk to migrating juvenile Chinook salmon in the San Joaquin River. (C-WIN 25, 20, ¶1-2; see also Figures 9, 10, and 11, pages 20 and 21)

The US Fish and Wildlife study also found from experimental results that larval survival and health and growth of young steelhead trout would be impaired by a concentration of selenium (about 8 μg/g) which are concentrations commonly exceeded in invertebrates, small prey fish, and larger predatory fish in San Luis Unit drainwater. (C-WIN 25, 28, ¶2) Selenium concentrations found in *Corbula amurensis* by Stewart, et al ranged from 5 to 20 µg/g in the Bay-Delta estuary. (C-WIN 24, 4522, column 1, ¶4)

Optimal conditions for recovery of the Bay-Delta Estuary's pelagic and anadromous fisheries must include source control actions that retire drainage-problem lands in the western San Joaquin Valley tainted with high concentrations of salt, selenium, boron, arsenic, molybdenum and other toxic constituents. Retirement of these lands would reduce pressure on the Delta for export flows, and would reduce transport of pollutants from these lands into the Delta especially during periods when flows are low and residence times of water rise. Retirement of the irrigation supply contracts to these areas of the western San Joaquin Valley would reduce agricultural drainage flows in the summer, but could free up supplies from the Sacramento Basin that could be assigned to instream flows to support Sacramento base inflow and reduce occurrence of reverse flows in the Central Delta further improving smolt migration survival rates on the San Joaquin and its western distributaries (i.e., Old and Middle Rivers). Reduced salt and contaminant loads in the San Joaquin system would further buttress smolt survival rates there as well.

**State Water Board Question:** *When determining Delta outflows necessary to protect public trust resources, how important is the source of those flows? How should the State Water Board address this issue when developing Delta outflow criteria?*

The source of Delta outflows is extremely important to determining what Delta outflows are necessary to protect public trust resources. It is an obvious observation that to even have Delta outflows there must be inflows that come from somewhere. Yet ongoing water quality problems with dissolved oxygen at the Stockton Deep Water Channel, South Delta salinity standard violations by the Department of Water Resources and the US Bureau of Reclamation in Old and Middle River, and the plummeting abundance of pelagic and anadromous fish species make it clear that flow sources must be addressed by the Board.

In particular, increased flows to the Delta from the San Joaquin River Basin should address these and other ecological and water quality issues in the Delta. C-WIN recommends that the State Water Board develop fair share methods for Delta inflow contributions from each of the major tributaries of both the Sacramento River and San Joaquin River basins at a time when allocations are briefed and testified to in evidentiary hearings preparatory to a water rights decision on Delta outflow.

In 1992 , the California Department of Fish and Game proposed a method to identify tributary contributions to Delta inflows based on the pro rata share of unimpaired runoff each tributary generates to the Delta, as identified in DWR's Bulletin 120 each year. Other allocation methods could be devised as well, such as one based on reservoir storage on these same tributaries. (C-WIN 18, 4-5, Tables 1, 2 and 3) The State Water Board in its Draft Water Right Decision 1630 presented such a method, but which excluded contributions from the San Joaquin River above Mendota Pool. In our recommendations on optimal ecological conditions for protective Delta flow criteria, we identify and recommend allocation factors for two distinct portions of the water year, based on unimpaired runoff (see below).

**Recommendations of the California Water Impact Network to the State Water Board on Optimal Environmental Conditions to Protect Bay-Delta Estuary Public Trust Resources**

C-WIN developed recommendations on optimal conditions to protect and restore Delta ecosystems and fisheries using broad flow and related criteria to the State Water Board. These include:

- Mean daily temperature of no higher than 59 degrees Fahrenheit based on Central Valley Regional Water Quality Control Board Basin Plan for five and a half months (December 1 through May 15) in all years. Such optimal temperature conditions are consistent with the temperature standards contained in the existing Central Valley Regional Board's plan.

- Based on recommendations originally submitted by DFG to the State Water Board in 1992 (C-WIN 20, Alternative C, 10-25, Tables 2-6, 8, and 9) and updated from research by fisheries biologist Carl Mesick into optimal pulse flows benefiting salmon smolts, we recommend significant positive pulse flows in Old River (C-WIN 19, 3, Table 1; see also C-WIN 2 [this testimony] Table 4 below). These flows would occur to encourage fall-run chinook smolt migration in the late winter and to provide attraction cues to fall run spawners from mid to late October.

- Base flows in the Sacramento at Rio Vista should be no less than 6,000 cfs in all years according to DFG in 1987 (C-WIN-20, 11, ¶1, item 3) from February 1 through October 31 in all water year types. Such flows will help not only fall run salmon but spring run salmon as well. (C-WIN-20, 7, ¶2) Spring pulse outflows at Chipps Island of between 20,000 and 43,000 cfs were recommended to the State

Water Board in 1987 (C-WIN-2, page and table citations in Table 1, below), and in the future should be characterized as flows sufficient at Freeport (above potential diversions to a peripheral canal) to be measured at that level at Chipps Island. We recommend that they be set at about 30,000 cfs as optimal flows, prior to any balancing with other beneficial uses. (C-WIN 22, 36, ¶2) Several participants including fisheries agencies.

- Positive base flows for the San Joaquin River at Jersey Point maintaining a 14-day average between February 1 through June 30 to increase Delta smelt habitat, early on for spawning period activity, and later for migrating to Suisun Bay before temperatures rise in the south and central portions of the Delta.

- Maintain positive net seaward flows at Jersey Point, of 1,000 cfs in critical and dry years, 2,000 cfs in below- and above-normal years, and 3,000 cfs in wet years from October 1 through June 30. This would increase survival of smolts migrating down the mainstem rivers, decrease the number of smolts diverted into the central Delta, increase the survival of smolts diverted into the central Delta, and provide attraction flows for San Joaquin Basin adults (October-December). (C-WIN 21, 3-Xe-19, ¶1-2)

- Optimal Delta outflows at Chipps Island by period of the year and water year type using a mean 14-day running average of the Net Delta Outflow Index. (C-WIN 20, Table 2 through 6). DFG identified flows for all months except January. C-WIN developed a method for January flows from DayFlow information.[2]

- Approximate X2 positions to be maintained during periods February 1 through March 31, April 1 through July 31, and August 1 through January 31, based on the optimal Delta outflows. (C-WIN 7, A-10, Table 2 applied to C-WIN monthly flows, not shown here.)

- Optimal operations by water facilities to achieve optimal ecological conditions, including Delta Cross Channel gate closures, installation and operation of an acoustical barrier on Georgiana Slough to block fish entry from the Sacramento River, and two export restriction periods: from February 1 through March 15 when pumps may operate so long as minimum positive flows are retained in the

[2] C-WIN extracted monthly average Delta outflows from DayFlow, sorted them, and then allocated them to water years based on unimpaired runoff data from the California Data Exchange Center. The medians of the water year types were then used as January flows in developing our optimal conditions recommendations for mean Delta outflows in the August 1 through January 31 period.

San Joaquin River at Jersey Point according to our optimal conditions; and from March 16 to June 30, when no exports would be permitted to ensure safe passage of migrating salmonid smolts down Old River toward Jersey Point, as well as permit passage of pulse flows called for above without entrainment losses at the export pumps. Additional purposes of this objective are to encourage salmon smolts in the San Joaquin system to avoid the San Joaquin mainstem channel through the Stockton DWSC, and to reduce movement of Sacramento sysstem salmon smolts into the central Delta.

- Given serious problems with overbite clam (*Corbula amurensis*), we recommend suppression flows in excess of 115,000 cfs in 2 to 4 years out of every 10. Suppression flows recommended in 1987 (and C-WIN 12 and C-WIN 13) have not occurred and the problem of invasive benthic filter feeders is cited as an important competitor for zooplankton prey sought by Delta smelt. Higher flows are now needed to suppress a much larger problem than was anticipated in 1987 in order to reestablish freshwater estuarine habitat that would be optimal to Delta smelt, longfin smelt and other listed estuarine fish species.

| Table 1: Recommended Objectives for Salmon, 1987 | State Water Contractors, DWR and USBR - Delta Outflow Index | | USFWS, DFG, NMFS Recommendations for Salmon Smolt Protection | | Environmental Defense Fund Recommendations for Salmon Smolt Protection | | | Bay Institute of San Francisco Recommendations for Salmon Smolt Protection | |
|---|---|---|---|---|---|---|---|---|---|
| Salmon Flow Standards, by Water Year Type: | May 6-31 | June | April-June Rio Vista Flow (cfs) | April-June Vernalis Flow (cfs) | April June Rio Vista Flow (cfs) | April-June Vernalis Flow (cfs) | Estimated Delta Outflow | Controlling Year Type | April-June Delta Outflow (cfs) |
| Wet | 14,000 | 14,000 | 21,500 | 12,000 | 22,000 | 11,000 | 31,000 | Wet | 38,500-42,000 |
| Above Normal | 14,000 | 10,700 | 20,000 | 10,000 | 20,000 | 10,000 | 27,000 | Median Years (between wet and dry) | 38,500-42,000 |
| Below Normal | 11,400 | 9,500 | 18,000 | 8,000 | 18,000 | 9,000 | 23,000 | | |
| Dry | 4,300 | 3,600 | 16,000 | 6,000 | 16,000 | 8,000 | 19,000 | Dry Years (driest 10%) | 10,000 |
| Critical | 3,300 | 3,100 | 10,000 | 4,000 | 10,000 | 5,000 | 10,000 | | |
| Applicable USFWS Survival Index | **May 6-31** | **June** | **April - June Survival Index** | **April - June Survival Index** | **Annual Survival Index** | | | The protection levels shown are conceived as "combined Sacramento and San Joaquin River flows to meet outflow." As noted below, BISF endorsed other USFWS measures, presumably including survival indices. | |
| Wet | 0.53 | 0.53 | 0.95 | 0.95 | 0.95 | | | | |
| Above Normal | 0.53 | 0.34 | 0.85 | 0.85 | 0.86 | | | | |
| Below Normal | 0.38 | 0.27 | 0.75 | 0.75 | 0.75 | | | | |
| Dry | 0.00 | 0.00 | 0.65 | 0.65 | 0.65 | | | | |
| Critical | 0.00 | 0.00 | 0.30 | 0.30 | 0.30 | | | | |
| Note: | Existing Delta Plan striped bass flow standards should be maintained as salmon flow objectives until adequate data are available to determine whether changes are required. | | Keep smolts out of central Delta. Keep temperatures below 66 degrees F. Keep smolts out of upper Old River. Positive net flow in the San Joaquin, Old, and Middle rivers. For Central Valley adults migration, maintain unobstructed migration route. Dissolved oxygen should be >= 5 mg/L between Stockton and Turner Cut on the San Joaquin River. | | EDF recommendations include diversion standards above Rio Vista (4,000 cfs all years except Critical), flows at Freeport, and "estimated export + channel depletions" on the east side (ranging from 6,000 cfs in wet years in 1,000 cfs increments up to 10,000 cfs in Critical years). | | | Spring Delta outflows at Chipps Island, measured, as Sacramento and San Joaquin Rivers combined should not be less than 38,500 cfs averaged over three to five year periods. Outflows could be reduced in dry years provided compensating flows are available in other years. There should be objectives for wet, median, and dry year spring flows at levels greater than D-1485. BISF endorsed other measures proposed by USFWS. | |
| Exhibit Citation: | C-WIN 4: Pages 5-34 and 5-35, including Table 5.3.4.2-1. | | C-WIN 4: Pages 5-36 to 5-38, including Table 5.3.4.2-2. | | C-WIN 4: Pages 5-38 and 5-39, including Table 5.3.4.2-3. | | | C-WIN 4: Page 5-38 and 5-40, including Table 5.3.4.2-4. | |

| Table 2: State Water Resources Control Board's "Optimal Levels of Protection for Striped Bass," 1988 | | | | D-1485 Striped Bass Objective, 1978 | D-1641 |
|---|---|---|---|---|---|
| Time Period | Location | Recommendation | Intended Protection | | |
| April 1 - June 15 (all years) | San Joaquin River from Vernalis to Antioch Bridge | Maximum daily EC not to exceed 0.3 mmhos/cm | Adult striped bass migration and spawning | Average daily Delta outflow index, in cfs, for each period shown not less than: | Relies on X2 as a proxy for Delta outflow conditions as a broad estuarine water quality standard, built on premise that X2 position marks western boundary of the Delta freshwater estuarine habitat. Two locations are employed: Chipps Island and Port Chicago. |
| April 15 - July 31 (all years) | Delta Cross Channel gates | Closed | Reduce translocation of eggs and larvae | May 6–31 / June / July<br>Wet: 14,000 / 14,000 / 10,000<br>Ab. Normal: 14,000 / 10,700 / 7,700<br>Bl. Normal: 11,400 / 9,500 / 6,500<br>Subnormal Snowmelt: 6,500 / 5,400 / 3,600<br>Dry 6/: 4,300 / 3,600 / 3,200<br>Dry 7/ or Critical: 3,300 / 3,100 / 2,900 | |
| April 1 - July 31 (all years) | Statutory Delta channels | No withdrawals or exports (except for emergency) | Reduce egg and larva entrainment. | | |
| April 1 - May 31 (all years) | Chipps Island | Daily Delta outflow at least 33,900 cfs | More larvae to Suisun Bay nursery area and keep null zone at Honker Bay or downstream. | State Water Resources Control Board, D-1485, p. 39. | State Water Resources Control Board, D-1641, Table 4, p. 191. |
| June 1 - June 30 (all years) | Chipps Island | Daily Delta outflow at least 32,400 cfs | More larvae to Suisun Bay nursery area and keep null zone at Honker Bay or downstream. | | |
| July 1 - July 31 ( all years) | Chipps Island | Daily Delta outflow at least 29,100 cfs | More larvae to Suisun Bay nursery area and keep null zone at Honker Bay or downstream. | | |
| April 15 - July 31 (all years) | Vernalis | San Joaquin River component of Delta outflow equal to or greater than proportion under unimpaired flow | Maintain positive downstream flow in all Delta channels. | | |
| Comments and Exhibit Citation | **Problem 1**: Adult striped bass spawning is affected by limitations on the spawning area. **Recommend**: Maintain low salinity in the mainstem San Joaquin River from Vernalis to Antioch Bridge. **Problem 2**: Eggs and larvae are translocated into the Central Delta through the Delta Cross Channel and Georgiana Slough. **Recommend**: Keep DCC gates closed between April 15 through July 31 in all water year types. No withdrawals or exports of water from the statutory Delta for any purposes other than for emergency conditions should be permitted between April 1 through July 31. Daily Delta outflow (at Chipps Island, shown above) should be no less than the amounts shown above between April 1 and July 31. **Problem 3**: Striped bass eggs and larvae in the Central Delta are lost in large numbers. **Recommend**: San Joaquin River flows should contribute at least an equal proportion of Delta outflow which would be present under unimpaired flow conditions. **Problem 4**: Disruptions of the striped bass food chain have occurred. **Recommend**: Striped bass may be starving because of food lost from the Central Delta. No criterion recommended at this time. **Problem 5**: Pollutant burdens affect striped bass survival and reproduction potential. **Recommend**: To be taken up in the Pollutant Policy document later. **Problem 6**: Striped bass appear to be attracted to certain components of industrial effluent streams and suffer deterioration and starvation, even at low levels of dilution. **Recommend**: Additional study warranted, and is addressed in the Pollutant Policy document. Other problems identified: Suisun spring die-off, effects of upstream diversions on egg and larvae survival, hatchery production, and relationship of recommended outflows to unimpaired Delta outflow.<br>**C-WIN 4:** Pages 5-68 through 5-89, including Table 5.3.5.3-1, p. 5-82. | | | | |

| Table 3: Rozengurt, et al, 1987 Recommended Delta Outflow Criteria | | | |
|---|---|---|---|
| **Time Period** | **Location** | **Recommendation** | **Protection** |
| **April - June (all years)** | Measurement location not specified; presumably Chipps Island for Delta outflow | Mean spring regulated Delta outflows maintained for 2 to 3 consecutive years between 38,653 and 42,014 cfs; and total annual Delta outflow of no less than 17 to 19 MAF | Anadromous salmonids, striped bass and American Shad for smolt survival and optimizing estuarine habitat. |
| **Notes:** | Highest correlations between commercial catch and average spring and annual regulated outflows of the pre-project period of 1915-1943 (characterized by predominant upstream diversion) were obtained for catch of a given year against seasonal and annual regulated Delta outflow averaged for the preceding 3 to 5 years. "...[A]verage spring water supply for several consecutive years contributes significantly to the adequate ecological conditions for eggs, larvae, and juvenile survival. Therefore it is not surprising that these cumulative average regulated Delta outflows (with concomitant influence on nutrient level, salinity, temperature, dissolved oxygen, etc.) affect the overall estuarine environment and, as a result, the reproductive success of fish." | | |
| **Citation:** | C-WIN 5: Michael Rozengurt, Michael J. Herz and Sergio Feld, "Summary: The Role of Water Diversions of the Delta-San Francisco Bay and Other Estuaries," Technical Report Number 87-8 (Revision of Romberg Tiburon Center Exhibit #20 for the State Water Resources Control Board Bay-Delta Hearings), Tiburon, CA: September 1987, Table 8-1 and pp. 13, 14. | | |

| Table 4: Salmonid and Estuarine Protective Delta Flow Criteria Recommendations for Optimal Ecological Conditions | | | | | |
|---|---|---|---|---|---|
| **Location** | **Parameter** | **Description** | **Year Type(s)** | **Dates/Values** | |
| | **Anadromous Salmonid and Sturgeon Survival Recommended Optimal Conditions** | | | | |
| **Major Tributary Streams of the Sacramento River Basin: Sacramento, Feather, Yuba, American, Putah Creek, Cosumnes, Calaveras, Mokelumne, Stanislaus, Tuolumne, Merced, San Joaquin** | Temperature | Daily mean water temperature not to be exceeded in each Delta tributary stream, measured in degrees Fahrenheit | All | December 1 through May 15 | 59 |
| **Sacramento River at Rio Vista** | Base Flow | Maintain 14-day running average flows, measured in cfs. to provide positive flows for fall and spring run salmonid smolt outmigration. | All | **February 1 through October 30** | |
| | | | | 6,000 | |
| **Sacramento River from Freeport to Chipps Island** | Pulse Flows | Flows needed to sustain viable migration corridor for optimal smolt passage and survival, measured in cfs | All | **April 1 through June 30** | |
| | | | | 30,000 | |
| **Stanislaus, Tuolumne, and Merced Rivers at Confluences with the San Joaquin River** | Pulse Flows | Recommended flow releases for Stanislaus, Tuolumne and Merced rivers during dry, normal, and wet water year types to provide attraction cues for migrating adult salmon in October; | | **October 20 through 29** | |
| | | | All | 1,200 cfs | |
| **Stanislaus, Tuolumne, and Merced Rivers at Confluences with the San Joaquin River** | Pulse Flows | Recommended flow releases for Stanislaus, Tuolumne and Merced rivers during dry, normal, and wet water year types to provide attraction cues for migrating adult salmon in October; floodplain inundating flows beginning between Feb 15 and March 15, and to maintain mean water temperatures near 59 degrees F and maximum temperatures below 65 degrees F from March 15 to June 15 | | **Beginning Feb 15 to March 15** | |
| | | | Critical and Dry | 3,000 cfs, 2 days | |
| | | | Below Normal | 3,000 cfs, 19 days; 6,000 cfs 2 days | |
| | | | Above Normal | 3,000 cfs, 16 days; 6,000 cfs 5 days | |
| | | | Wet | 3,000 cfs, 12 days; 6,000 cfs 5 days | |

**Table 4: Salmonid and Estuarine Protective Delta Flow Criteria Recommendations for Optimal Ecological Conditions**

| Location | Parameter | Description | Year Type(s) | Dates/Values | |
|---|---|---|---|---|---|
| Stanislaus, Tuolumne, and Merced Rivers at Confluences with the San Joaquin River | Pulse Flows | Recommended flow releases for Stanislaus, Tuolumne and Merced rivers during dry, normal, and wet water year types to provide attraction cues for migrating adult salmon in October; floodplain inundating flows beginning between Feb 15 and March 15, and to maintain mean water temperatures near 59 degrees F and maximum temperatures below 65 degrees F from March 15 to June 15 | | **March 15 to 31** | **April 1 to 15** |
| | | | Critical, Dry, Blw and Above Normal | 1,000 cfs | 1,500 cfs |
| | | | Wet | 3,000 cfs | 3,000 cfs |
| | | | | **April 16 to 20** | **April 21 to 30** |
| | | | Critical and Dry | Base Flows | Base Flows |
| | | | Below and Above Normal | 2,000 cfs | 2,000 cfs |
| | | | Wet | 3,000 cfs | 3,000 cfs |
| | | | | **May 1 to 15** | **May 16 to June 15** |
| | | | Critical and Dry | Base Flows | Base Flows |
| | | | Below and Above Normal | 2,500 cfs | Base Flows |
| | | | Wet | 3,000 cfs | ≥3,000 cfs; ≥4,000 cfs |
| Old River between Head of Old River to Downstream Confluence with San Joaquin | Base Flows | Maintain daily flow measured in cfs, to provide an outmigration corridor | All | **March 15 through May 15** | |
| | | | | 2000 cfs | |
| San Joaquin River at Jersey Point | Base Flow | Maintain 14-day mean flows at Jersey Point, measured in cfs. In February and March, these flows would expand habitat for Delta smelt and other estuarine species, in addition to providing positive flows for salmonid smolt outmigration. | | **February 1 through June 30 - Delta smelt** | **October 1 through June 30 - salmon smolts** |
| | | | Critical | 1,000 | 1,000 |
| | | | Dry | 1,500 | 1,000 |
| | | | Below Norm | 2,000 | 2,000 |
| | | | Above Norm | 2,500 | 2,000 |
| | | | Wet | 3,000 | 3,000 |

| Table 4: Salmonid and Estuarine Protective Delta Flow Criteria Recommendations for Optimal Ecological Conditions | | | | |
|---|---|---|---|---|
| **Location** | **Parameter** | **Description** | **Year Type(s)** | **Dates/Values** |
| | **Recommended Estuarine and Salmonid Optimal Conditions** | | | |
| **Major Tributary Streams of the Sacramento River Basin and the San Joaquin River Basin: Sacramento, Feather, Yuba, American, Putah Creek, Cosumnes, Calaveras, Mokelumne, Stanislaus, Tuolumne, Merced and San Joaquin rivers.** | Inflow Contributions to Delta Outflow | Determine equitable shares of flow contributions allocated among named streams to determine inflows to the Delta sufficient to meet Delta outflow needs, to occur in all years. | | |
| **Chipps Island - Delta Outflow, Late Winter and Early Spring** | Flows (Net Delta Outflow Index) | Mean Period Delta outflow, measured as a 14-day running average | | February 1 through March 31 |
| | | | Critical | 9,100 |
| | | | Dry | 23,500 |
| | | | Below Norm | 41,000 |
| | | | Above Norm | 90,800 |
| | | | Wet | 91,800 |
| **Chipps Island - Delta Outflow, Mid-Spring and Early Summer Months** | Flows (Net Delta Outflow Index) | Mean Period Delta outflow, measured as a 14-day running average | | April 1 through July 31 |
| | | | Critical | 6,700 |
| | | | Dry | 10,800 |
| | | | Below Norm | 14,400 |
| | | | Above Norm | 23,000 |
| | | | Wet | 43,000 |
| **Chipps Island - Delta Outflow, Summer to Early Winter Months** | Flows (Net Delta Outflow Index) | Mean Period Delta outflow, measured as a 14-day running average | | August 1 through January 31 |
| | | | Critical | 4,100 |
| | | | Dry | 9,200 |
| | | | Below Norm | 12,100 |
| | | | Above Norm | 14,600 |
| | | | Wet | 29,000 |

| Table 4: Salmonid and Estuarine Protective Delta Flow Criteria Recommendations for Optimal Ecological Conditions | | | | |
|---|---|---|---|---|
| **Location** | **Parameter** | **Description** | **Year Type(s)** | **Dates/Values** |
| Optimal Range of X2 Positions in Winter and Early Spring (from Western Suisun Bay to Honkers Bay) | X2 | 14-day running average position of 2 parts per thousand salinity, measured 1 meter from channel bottom, expressed in kilometers upstream from the Golden Gate | | February 1 through March 31 |
| | | | Critical | 77 to 79 |
| | | | Dry | 68 to 69 |
| | | | Below Norm | 58 to 64 |
| | | | Above Norm | 52 |
| | | | Wet | 51 to 52 |
| Optimal Range of X2 Positions Spring to Mid-Summer (from Suisun Bay to Chipps Island) | X2 | 14-day running average position of 2 parts per thousand salinity, measured 1 meter from channel bottom, expressed in kilometers upstream from the Golden Gate | | April 1 through July 31 |
| | | | Critical | 80 to 83 |
| | | | Dry | 75 to 78 |
| | | | Below Norm | 70 to 77 |
| | | | Above Norm | 63 to 75 |
| | | | Wet | 54 to 73 |
| Optimal Range of X2 Positions in Late Summer Through Early Winter (from Suisun Bay to Antioch) | X2 | 14-day running average position of 2 parts per thousand salinity, measured 1 meter from channel bottom, expressed in kilometers upstream from the Golden Gate | | August 1 through January 31 |
| | | | Critical | 83 to 90 |
| | | | Dry | 70 to 87 |
| | | | Below Norm | 67 to 84 |
| | | | Above Norm | 64 to 87 |
| | | | Wet | 50 to 84 |
| | **Water Facilities Optimal Operations** | | | |
| Delta Cross Channel and Georgiana Slough at Walnut Grove | Closure of gates; installation of acoustic barrier in Geo. Slough | Gates closed; acoustic barrier operating at head of Georgiana Slough at Sacramento River. | All | February 1 through June 30 |

| Table 4: Salmonid and Estuarine Protective Delta Flow Criteria Recommendations for Optimal Ecological Conditions | | | | | |
|---|---|---|---|---|---|
| Location | Parameter | Description | Year Type(s) | Dates/Values | |
| | | | | **February 1 to March 15** | **March 16 to June 30** |
| Harvey O. Banks Pumping Plant (SWP); Jones Pumping Plant (CVP); and Contra Costa Pumping Plant (CVP) | Pumping rate | Combined export rate, expressed in cfs. | All | Combined export allowed provided flows at Jersey Point follow base flow schedule shown above. | 0 |

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