The Bay Institute

Protecting and Restoring San Francisco Bay from the Sierra to the Sea

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March 21, 2005

Arthur G. Baggett, Jr., Chair
State Water Resources Control Board
P. O. Box 100
Sacramento, CA 95812-0100

RE: BAY-DELTA PLAN PERIODIC REVIEW/VERNALIS FLOWS

Dear Mr. Baggett,

This letter is submitted as the opening comments of the Bay Institute regarding Workshop Topic 8 (River flows: San Joaquin River at Airport Way Bridge, Vernalis: February – April 14 and May 16 – June) for the State Water Resources Control Board's (SWRCB) public workshops to consider potential amendments or revisions of the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan).

We recommend that the SWRCB adopt more protective Vernalis flow objectives during the February – April 14 and May 16 – June period.

Ensuring adequate San Joaquin River flows at Vernalis during the February – April 14 and May 16 – June period provides fundamental and critical protections for San Joaquin Basin anadromous fishes (including fall-run Chinook salmon and Central Valley steelhead) and for estuarine habitat in the southern and central Delta, which is essential for many native resident fishes (including delta smelt).[1] The Bay-Delta Plan objective requires monthly minimum flow levels based on San Joaquin watershed hydrology (e.g., water year type) and monthly Delta outflow conditions (which are based on Sacramento-San Joaquin watershed hydrology and Bay-Delta Plan Delta outflow objectives). The ecological benefits of requiring flows during this period are to improve estuarine habitat conditions, particularly in the southern and central Delta, and to facilitate downstream movement and improve survival of larval and juvenile delta smelt and juvenile San Joaquin basin Chinook salmon.

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[1] Central Valley steelhead and delta smelt are both listed as "threatened" under the federal Endangered Species Act (ESA). Fall-run Chinook salmon is a candidate species under the ESA.

1. The Bay-Delta Plan's February – April 14 and May 16 – June Vernalis flow objectives do not sufficiently protect anadromous and native resident fishes and estuarine habitat.

The Vernalis flow objectives apply during the ecologically critical spring spawning, rearing and outmigration period. This is also the period of the year when San Joaquin Basin flows are subject to the greatest degree of alteration as a result of upstream water management operations. Figure 1 shows hydrographs for actual Vernalis flows and unimpaired flows for the four major San Joaquin Basin rivers for Water Years 2000 – 2004.[2] During these years, February-June flows were reduced by 61% (2000, an "above normal" year) to 82% (2003, a "below normal" year), compared to unimpaired flows.

Storage and diversion of San Joaquin Basin runoff and the associated drastic reduction in flow reaching the lower San Joaquin River have resulted in a significant reduction in the relative contribution of the San Joaquin Basin to freshwater inflows to the Delta and San Francisco Bay. Historically, the San Joaquin Basin contributed an average of 22.8% of the total runoff from the Sacramento-San Joaquin watershed. Actual flows from the San Joaquin are significantly less, averaging 12.6% of total Delta inflows, and have declined significantly during the 1930 – 2004 period (regression analysis, $p<0.05$).[3] Figure 2 shows the percent contribution of San Joaquin Basin runoff to total runoff and of actual Vernalis flows to total Delta inflow. For the two most recent years, the percent contribution of the San Joaquin Basin to total Delta inflow was the third and fourth lowest measured for the 75-year period (6.4% for 2003, 6.2% for 2004).

San Joaquin Basin Chinook Salmon Populations
For San Joaquin Basin fall-run Chinook salmon, flow conditions in the lower San Joaquin River during the spring are directly related to three of the four criteria for a "viable salmonid population": population abundance, population growth, and diversity (McElhany et al., 2000).

[2] Data for actual flows are from Dayflow, California Department of Water Resources (CDWR). San Joaquin Basin unimpaired flows are calculated as the sum of unimpaired flows of the four major San Joaquin Basin rivers (Stanislaus, Tuolumne, Merced, and San Joaquin), available from CDEC (CDWR).
[3] Percent contribution of the San Joaquin Basin runoff calculated annually for the 1930-2004 period as: (sum of annual unimpaired runoff from the four rivers in the San Joaquin Basin/sum of the annual runoff of the ten largest rivers in the greater water shed)*100. The ten rivers are: Sacramento, Feather, Yuba, American, Mokelumne, Cosumnes, Stanislaus, Tuolumne, Merced and San Joaquin. Data for unimpaired flows are from CDEC (CDWR). Percent contribution of the San Joaquin Basin for actual flows was calculated similarly using Vernalis flows and total Delta inflow, using data from Dayflow (CDWR).

Since the early 1950s, San Joaquin Basin fall-run Chinook salmon populations have fluctuated dramatically, exceeding 50,000 fish in some years and falling to a few hundred fish in other years. Figure 3 shows escapement and return ratios for fall-run Chinook salmon that spawn in San Joaquin tributaries upstream of Vernalis.[4] During the most recent five-year period, average escapement was 21,267 fish, just 58% of the doubling goal set by the U. S. Fish and Wildlife Service (USFWS, 1995a).[5] Further, salmon escapement in these rivers has been declining for five years and the return ratio[6] dropped substantially below 1.0 in 2003 and 2004, indicating the species is experiencing a multi-year population decline. For these last two years, the numbers of salmon returning to San Joaquin River tributaries has been substantially less than the 1967 – 1991 average upon which the doubling goal is based.

The persistent low numbers and multi-year population decline observed for San Joaquin Basin Chinook salmon are markedly different from the population trends observed for the same period for Sacramento Basin fall-, winter-, and spring-run Chinook salmon. While most of the Sacramento Basin populations remain below the doubling goals, and some are still at critically low levels, many populations have exhibited fairly consistent population growth, a response that is generally attributed to favorable ocean conditions and improvement in upstream habitat and flow conditions (Figure 4). Given that Chinook salmon from both basins spend similar amounts of time in the Pacific Ocean, these different population responses between the two basins strongly indicate that freshwater habitat conditions in the San Joaquin Basin are a limiting factor for San Joaquin Basin salmon.

Flow conditions in the lower San Joaquin River (and in its tributaries) during the spring are directly related to San Joaquin Basin fall-run Chinook salmon population abundance. Higher Vernalis flows during the March-June period, when juvenile salmon migrate downstream to the ocean, correspond to larger numbers of adult salmon returning to spawn in San Joaquin Basin tributaries 2.5 years later (Figure 5). This statistically significant relationship (based on 47 years

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[4] The salmon-producing streams tributary to the San Joaquin River upstream of Vernalis are the Stanislaus, Tuolumne, and Merced Rivers.

[5] Escapement data for San Joaquin Basin Chinook salmon are from "Grandtab", a regularly updated spreadsheet file maintained by the California Department of Fish and Game (CDFG) that compiles escapement data from all salmon-producing streams on the Central Valley. The salmon "doubling" goals for the Stanislaus, Tuolumne, and Merced Rivers are from USFWS (1995a).

[6] The return ratio, or cohort replacement rates, is calculated as the number of adults returning to spawn in a given year divided by the number of adults that produced them three years earlier.

of data) has continued to be strong during the years since the Bay-Delta Plan was implemented (see Figure 5, open symbols).

Population growth of San Joaquin Basin Chinook salmon is also related to Vernalis flows during the spring: in 94% of years with average March-June flows greater than or equal to 5000 cfs, the return ratio is greater than 1.0 (indicating positive population growth), while in 60% of years with average March-June flows less than 5000 cfs, the return ratio is less than 1.0, indicating population decline (Figure 6). Based on this analysis, it is clear that average springtime Vernalis flows during each of the past four years, which ranged from 2380 cfs (2002) to 3270 cfs (2003), have been insufficient to protect San Joaquin Basin Chinook salmon. San Joaquin Basin Chinook salmon escapement measured in 2003 and 2004 confirm this finding for Water Years 2001 and 2002: return ratios for salmon that migrated downstream under these low Vernalis flow conditions were substantially less than 1.0 for both population cohorts (see Figure 6, open symbols and text annotation).

The effect of Vernalis flows on salmon populations is also related to export rates at the Central Valley Project (CVP) and State Water Project (SWP) Delta pumps. Figure 7 shows the effect of the ratio of March – June Vernalis flows to exports on return ratios for San Joaquin Basin Chinook salmon. In 95% of years with a Vernalis flow:export ratio greater than 1.0 (i.e., Vernalis flow is higher than the combined CVP and SWP export rate), the return ratio is greater than 1.0 (positive population growth). In contrast, in 67% of years in which the March-June Vernalis flow:export ratio is less than 1.0 (exports exceed Vernalis flow), the return ratio is less than 1.0 and the salmon population declines. On this basis, Vernalis flow:export ratios for the past four years (range: 0.71 in 2001 and 2002 to 0.34 in 2003) have been insufficient to protect San Joaquin salmon, a finding supported by the lower population abundance and negative population growth measured for the 2003 and 2004 adult returns (see Figure 7, open symbols and text annotation).

Central Valley Steelhead Populations
Juvenile Central Valley steelhead, which also migrate out of San Joaquin Basin tributaries during the February – June period, have environmental requirements that are very similar to those for Chinook salmon (McEwan, 2001; Moyle, 2002). The limited data available regarding the status of steelhead populations in the San Joaquin Basin suggests that the population is critically low (McEwan, 2001). In their Working Paper on Restoration Needs (USFWS, 1995a), the Anadromous Fish Restoration Program (AFRP) Core Group generally determined that flow

conditions that were limiting factors and insufficient to support San Joaquin Basin fall-run Chinook salmon were similarly harmful to steelhead in the basin. Further, flow conditions designed to benefit and facilitate doubling of Chinook salmon populations recommended to the USFWS by the Core Group would also benefit steelhead.

Salmonid Outmigration Timing and Duration
Both fall-run Chinook salmon and Central Valley steelhead migrate out of their natal rivers to the mainstem San Joaquin, the Delta, and the ocean over a period of several months during the spring (Moyle, 2002; McEwan, 2001; USFWS, 1995b; Healy, 1991). Chinook salmon smolts have been collected from the lower San Joaquin River (Mossdale) from April through July. Younger salmon (i.e., fry) have been collected from the mainstem San Joaquin River (at various locations downstream of the Merced River confluence) in January, February, and March. Timing of outmigration varies from year to year, often triggered by an increase in river flows and turbidity. In some years, there may be multiple pulses of outmigration among juvenile fish, which, based on spawning timing and duration during the previous fall, may vary in age by more than a month. This variation in outmigration timing is an important component of the genetic and phenotypic diversity of the population, the third of the four criteria for a viable salmonid population (McElhany et al., 2000). Populations with reduced genetic and phenotypic diversity are less capable of responding evolutionarily to adverse environmental changes and are more vulnerable to extinction. Present Vernalis flow conditions (and associated Delta export conditions), which are essentially intolerable except during the 31-day pulse flow period (April 15 – May 15) during most years, restrict juvenile salmonid outmigration to a narrow and fixed window during the spring. This has (and has had) the effect of "selecting" for a subset of the population that is genetically and/or phenotypically programmed to outmigrate during this specific four-week period in the spring; juvenile fish that attempt to migrate either before or after the 31-day pulse flow are subject to lethally inadequate flows in their natal tributaries (except possibly for the Stanislaus River, where additional water releases to meet Vernalis flow and salinity objectives may be made), the mainstem San Joaquin (e.g., where chronic, flow-related, low dissolved oxygen conditions exist in the Stockton Deep Water Ship Channel), and the Delta (where the Vernalis flow:export ratio is usually substantially below 1.0 (see Figure 8, and also our January 18, 2005, comments on Workshop Topic 6, Export Limits).

Estuarine Habitat and Native Resident Fishes
Fish assemblage structure, especially the prevalence and distribution of non-native species, is an accepted indicator of impaired aquatic habitat conditions,

which are usually the result of altered flow regimes, toxic urban and agricultural runoff, and reduced habitat (Wang and Lyons, 2003; May and Brown, 2002; Brown, 2000). Table 1 shows the average of percentage of fishes collected by the California Department of Fish and Game's (CDFG) Fall Midwater Trawl Survey (FMWT) in each of four regions within the Delta that are native species. Based on these results, the central and southern Delta , the areas of the estuary most influenced by lower San Joaquin River flows and where few to virtually no native fishes are found, are severely impaired.

Table 1. Percentage of fishes collected in different regions of the Delta that are native species. Data from CDFG Fall Midwater Trawl Survey (FMWT), 1967-2001.

Region	**% of fishes that are native species** 1967-2001 mean (±1 standard error)
South Delta	0.3% (±0.4)
Central Delta	10% (±2)
North Delta	29% (±3)
West Delta	49% (±4)

In a more detailed study focusing on the southern Delta, Freyer and Healey (2003) found that flow conditions in the lower San Joaquin River and in several southern Delta channels that receive flow from the mainstem river were the most reliable predictor of fish assemblage structure in the southern Delta. Over an 8-year period (1992 – 1999), the authors conducted monthly surveys (March – November, in most years) of fishes at several spatially distinct locations in Old River, Middle River, Grant Line Canal, and lower San Joaquin River in order to characterize fish assemblages and their associations with environmental variables. Of the 33 species collected, only 24% were native species and of more than 70,000 fishes collected, only 0.5% were native species. These results are similar with those of the larger scale FMWT survey, which is conducted later in the year (September – December) when San Joaquin River flows are even lower (see Table 1). Further, compared to fish surveys conducted thirty years earlier (Turner and Kelley, 1966, cited by Freyer and Healey, 2002), present estuarine habitat conditions as measured by the fish community are markedly worse: between the mid-1960s and the 1990s, two native species (hitch and starry flounder) were apparently extirpated from the southern Delta and eight non-native species have established reproducing populations. Freyer and Healey (2003) also found that the south Delta fish assemblage was structured along an environmental gradient of river flow: the few native species collected were strongly and significantly associated with areas of higher flows while the non-native species were associated with areas of lower flows.

For many estuarine species, freshwater inflows to the southern Delta (as well as export conditions) during the weeks before and after the 31-day pulse flow period are as, and for some species possibly more, important as the pulse flow period itself. For example, young delta smelt are present in the southern Delta as early as March (for example results of the DFG 20-mm survey and further discussion of this issue, see our January 18, 2005 comments on Workshop Topic 6, Export Limits) and as late as July (based on CVP and SWP fish salvage data). The multi-year population decline and the record low population abundance measured for delta smelt in 2004 (Figure 9) coincides with chronically low and worsening freshwater inflows from the San Joaquin River into the Delta (see Figures 1, 2, and 8).

2. Criteria used to develop recommendations for revising the Bay-Delta Plan's February – April 14 and May 16 – June Vernalis objectives.

Vernalis flows recommended by the Anadromous Fish Restoration Program
In 1995, the AFRP Core Group developed a set of recommended monthly flows for the San Joaquin River at Vernalis that, based on statistical analyses of San Joaquin fall-run Chinook salmon population trends (Stanislaus and Tuolumne Rivers only), historical actual and unimpaired Vernalis flows, and Delta export rates, were predicted to be necessary to achieve the salmon doubling goal for this run (USFWS, 1995a). Table 2 compares those flow recommendations for the February-June period to flows presently required by the Bay-Delta Plan and the San Joaquin River Agreement (VAMP).[7] Clearly, the Core Group concluded that higher flows than those required by the Bay-Delta Plan would be needed to achieve and maintain San Joaquin salmon populations at levels mandated by the Central Valley Project Improvement Act (CVPIA) and by the Bay-Delta Plan's narrative salmon protection objective. It is also apparent, based on recent trends in San Joaquin Basin salmon population abundance and population growth rates, that flow objectives in the Bay-Delta Plan are insufficiently protective, at least in average (i.e., "below normal") and drier water year types.

[7] Flow levels recommended by the AFRP in Table 2 are taken from Table 3-Xd-10 in USFWS (1995a).

Table 2. Comparison of Vernalis flow objectives from the Bay-Delta Plan to flow recommendations developed by the Anadromous Fish Restoration Program (AFRP) Core Team to double San Joaquin Basin Chinook salmon populations. Water year types based on San Joaquin 60-20-20 Index: W=wet; AN=above normal; BN=below normal; D=dry; and C=critically dry. VAMP flows are based on unimpaired hydrology prior to April, but values presented in this table are assumed to reflect overall water year type.

Month	**Bay-Delta Plan (and SJRA)** (monthly average, cfs)					**AFRP Recommended Flow** (monthly average, cfs)				
	W	AN	BN	D	C	W	AN	BN	D	C
Feb	2130 or 3420	2130 or 3420	1420 or 2280	1420 or 2280	710 or 1140	5000	3900	2150	1450	1050
March	2130 or 3420	2130 or 3420	1420 or 2280	1420 or 2280	710 or 1140	5350	3900	2750	2100	1850
April	2130 or 3420	2130 or 3420	1420 or 2280	1420 or 2280	710 or 1140	12000	8250	7300	5850	4450
Apr. 15 to May15	VAMP (7000)	VAMP (5700)	VAMP (4450)	VAMP (3200)	VAMP (2000)					
May	2130 or 3420	2130 or 3420	1420 or 2280	1420 or 2280	710 or 1140	18600	13700	10200	7400	5200
June	2130 or 3420	2130 or 3420	1420 or 2280	1420 or 2280	710 or 1140	17300	9750	7650	4600	2950

Additional criteria for February – April 14 and May 16 – June Vernalis flow objectives
Based on our analyses above, the more detailed analyses conducted by the AFRP Core Team (USFWS, 1995a, b), and the Vernalis Adaptive Management Plan experimental design developed by the San Joaquin River Agreement planning team (SJRGA, 2005), we suggest that flow objectives for the lower San Joaquin River during the February – April 14 and May 16 – June period should, at a minimum, be based on the following criteria:

i. Required flow levels should be based on or, at a minimum, reflect variation in annual and monthly hydrology in the upper watershed.

ii. Required flows level should increase the relative contribution of the San Joaquin Basin to total minimum required Delta freshwater inflows during the February-June period to no less than 20% during all below normal, dry, and critically dry years. Required flow levels should be no less that 10% of total actual Delta freshwater inflows during the February-June period in all wet, above normal, and below normal years.

iii. Required flows levels should provide an average of 5000 cfs for at least three consecutive months (not including the 31-day pulse flow) in all wet and above normal years, and for a minimum of two consecutive months (not including the 31-day pulse flow) in all below normal years.

iv. Required flows levels in all months and all water year types should be greater than or equal to 1500 cfs, a level that should be sufficient to provide tolerable dissolved oxygen conditions in the Stockton Deep Water Ship Channel.

v. Minimum required flow levels in wet and above normal years should be capped at 7000 cfs to allow installation of the Head of Old River Barrier for the protection of outmigrating juvenile salmonids (as based on recommendations by the state and federal fisheries agencies).

vi. Required flows levels should be linked to maximum Delta export rates to provide an average Vernalis flow:export ratio for the March – June period that is greater than or equal to 1.0.

Recommendation: The SWRCB should revise the Bay-Delta Plan to adopt the more protective Vernalis flow objectives contained in Table 3.

Based on the clear evidence of population declines of anadromous and estuarine fishes and poor estuarine habitat conditions, indicating that the fish and wildlife beneficial uses are not being adequately protected, and on the criteria discussed above, we recommend that the SWRCB adopt more protective Vernalis flow objectives during the February – April 14 and May 16 – June period. These proposed new monthly Vernalis flow objectives, presented in Table 3 and for Water Years 2000 – 2004 in Figure 10, were developed assuming, and should be considered in conjunction with, the new export limits recommended in our January 18, 2005 comments on Workshop Topic 6, Export Limits.

Table 3. Proposed Vernalis flows (monthly average) for the protection of estuarine habitat and resident and migratory fishes during the February – April 14 and May 16 – June period for each water year type. Water year types based on San Joaquin 60-20-20 Index: W=wet; AN=above normal; BN=below normal; D=dry; and C=critically dry.

Month	Water Year Type[a]				
	W	AN	BN	D	C
February	3420	3420	2280	2280	1500
March	5000	5000	3420	2280	1500
April 1-14	7000	5000	5000	5000	2000
April 15-May 15	31-day flow objective as determined by VAMP experimental design				
May 16-31	7000	5000	5000	3420	2000
June	5000	5000	3420	2280	1500

[a] Water year type in the San Joaquin Basin to be determined using the 60-20-20 San Joaquin Valley Index with preliminary determinations of year type classification to be made in February, March, and April, with a final determination made in May. Monthly flow objectives should be based on monthly updates of San Joaquin Basin unimpaired runoff and water year type forecasts using the 50% exceedence.

It should be noted that implementing new Vernalis flow objectives before and after the 31-day pulse flow period will not affect the VAMP experiment, because outmigrant survival rates are measured for marked hatchery-produced salmon released at specific locations during the 31-day period rather than for wild juvenile salmon migrating out of the tributaries. Furthermore, improved flow conditions will also contribute significantly to improving dissolved oxygen and salinity conditions during the February – June period.

Finally, it is important to re-emphasize that the SWRCB should not constrain the adoption of a fully protective Vernalis flow objective, based on the best available science regarding protection of the fish and wildlife beneficial uses, as a result of perceived constraints on the amount of CVP water available to meet San Joaquin Basin and Delta flow requirements. (See our February 5, 2004, letter regarding the periodic review of the Bay-Delta Plan for further discussion of this issue.)

Thank you for considering our recommendations regarding potential amendments and revisions to the Bay-Delta Plan objective for Vernalis flows during the February – April 14 and May 16 – June period. Please contact us if you have any questions regarding these comments.

Sincerely,

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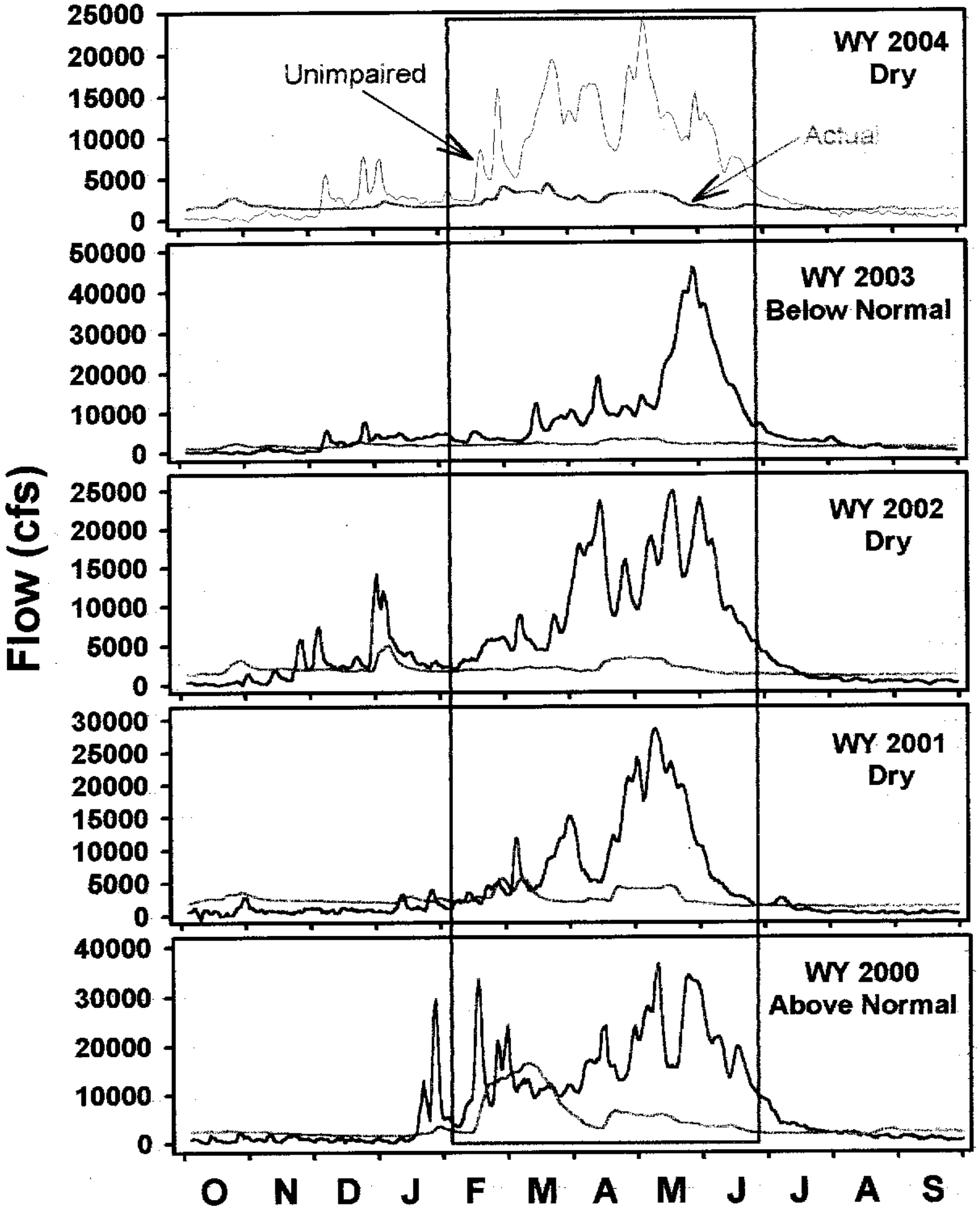

Figure 1. Unimpaired runoff (blue line) from the San Joaquin Basin (Stanislaus, Tuolumne, Merced, and San Joaquin Rivers) compared to actual flows in the lower San Joaquin River at Vernalis (red line) for Water Years 2000-2004. Water Year classification is based on the 60-20-20 San Joaquin Valley index. San Joaquin River flows are subjected to the greatest alteration during the ecologically important springtime period (green box). Data Sources: California Department of Water resources, Dayflow (actual flows) and CDEC (unimpaired flows).

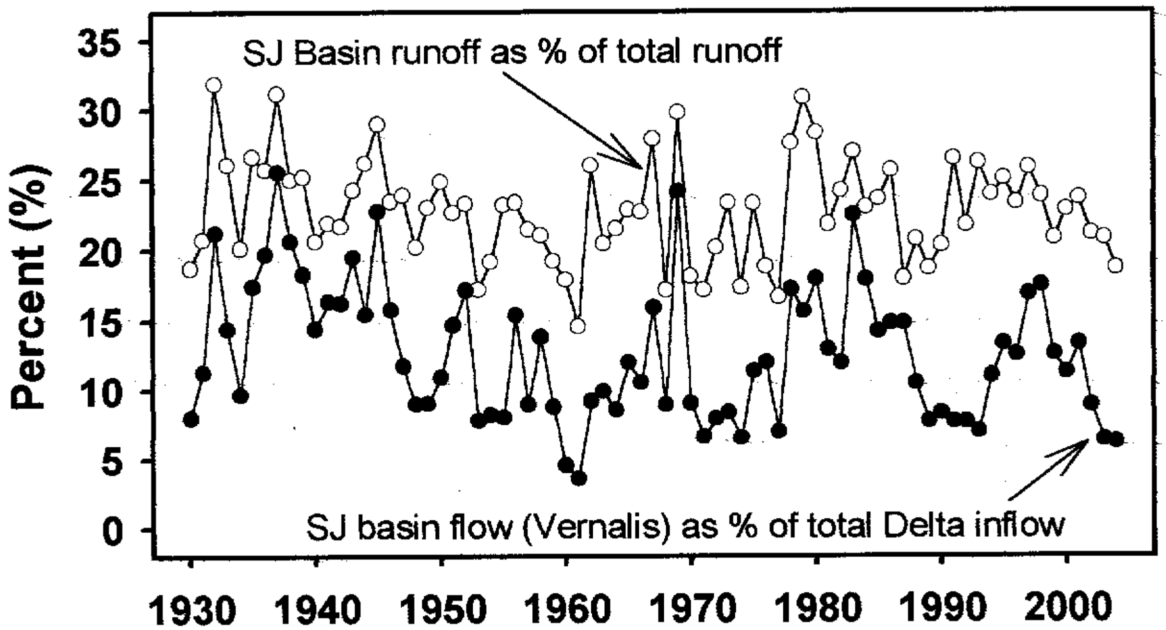

Figure 2. Percent contribution of San Joaquin Basin unimpaired runoff to total unimpaired runoff (open circles) and percent contribution of actual San Joaquin River flows (at Vernalis) to total Delta inflow (closed circles). While unimpaired runoff from the San Joaquin Basin has not changed during the 75–year period (mean: 22.8%), the actual contribution of the San Joaquin River to freshwater inflows to the Delta has declined significantly. In 2003 and 2004, San Joaquin inflow to the Delta (as percent contribution to total inflow) was the third and fourth lowest on record (less than 7% in both years). San Joaquin Basin unimpaired runoff was calculated as the sum of unimpaired runoff from the Stanislaus, Tuolumne, Merced, and San Joaquin Rivers. Total unimpaired runoff is calculated from the ten largest rivers in the watershed: Sacramento, Feather, Yuba, American, Mokelumne, Cosumnes, Stanislaus, Tuolumne, Merced and San Joaquin Rivers. Data Sources: California Department of Water resources, Dayflow (actual flows) and CDEC (unimpaired flows).

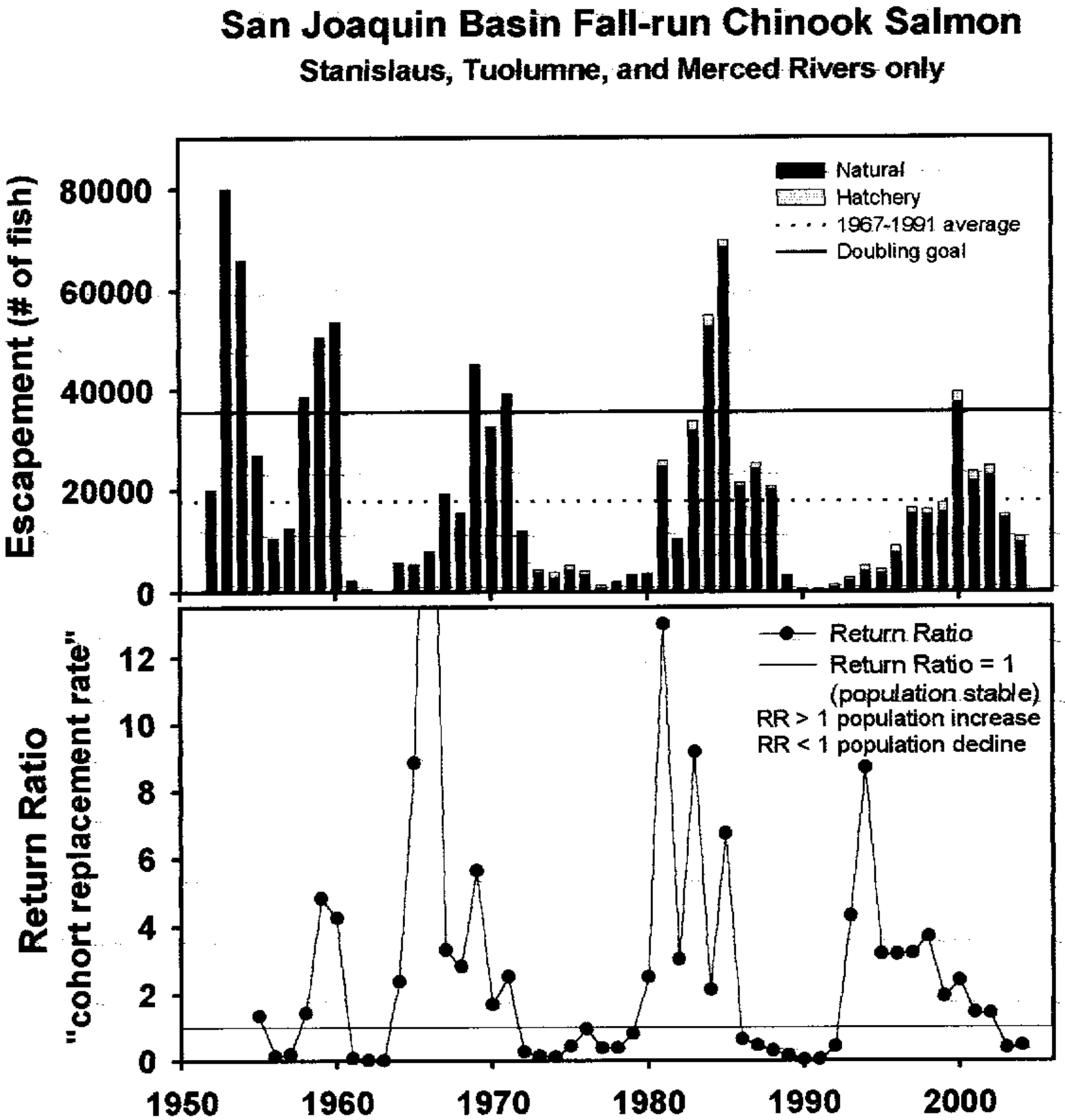

Figure 3. Escapement (number of adult fish returning to the rivers; upper panel) and return ratio (cohort replacement rate, a measure of population growth rates; lower panel) of fall-run Chinook salmon from the Stanislaus, Tuolumne and Merced Rivers. The return ratios for 2003 and 2004 were substantially less than 1.0, indicating a multi-year population-level decline to numbers that are lower than the 1967-1991 average upon which the doubling goal mandated by the CVPIA and the Bay-Delta Plan is based. Data sources: California Department of Fish and Game, "Grandtab", and USFWS, 1995a.

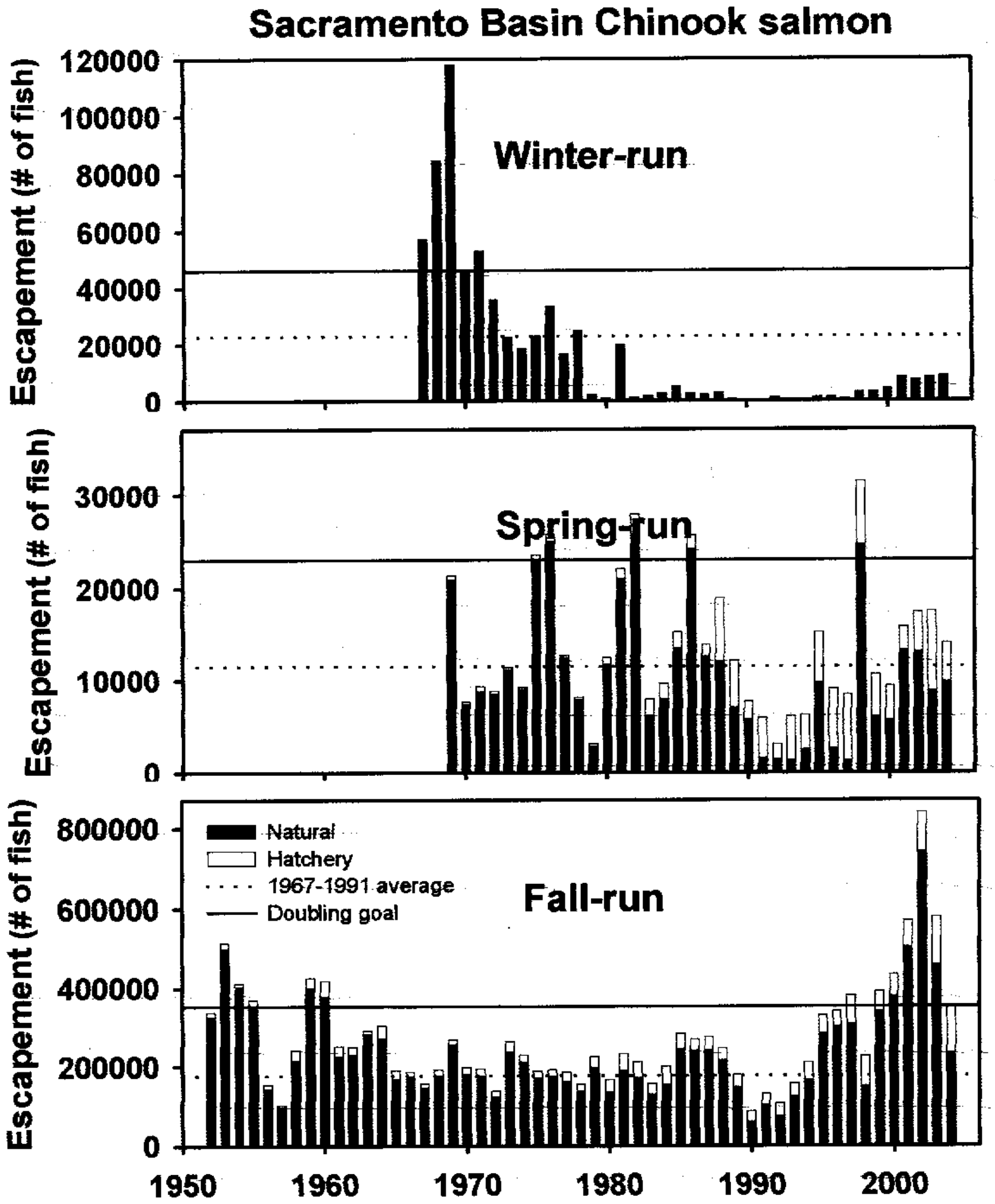

Figure 4. Trends in escapement for Sacramento Basin winter-, spring-, and fall-run Chinook salmon. In contrast to the declining population trend exhibited by San Joaquin Basin Chinook salmon, many Sacramento Basin salmon populations have shown steady increases during the past ten to 15 years. These population increases are generally attributed to favorable ocean conditions (which should have also benefited San Joaquin Basin salmon) and improved freshwater habitat conditions. Data sources: California Department of Fish and Game, "Grandtab", and USFWS, 1995a.

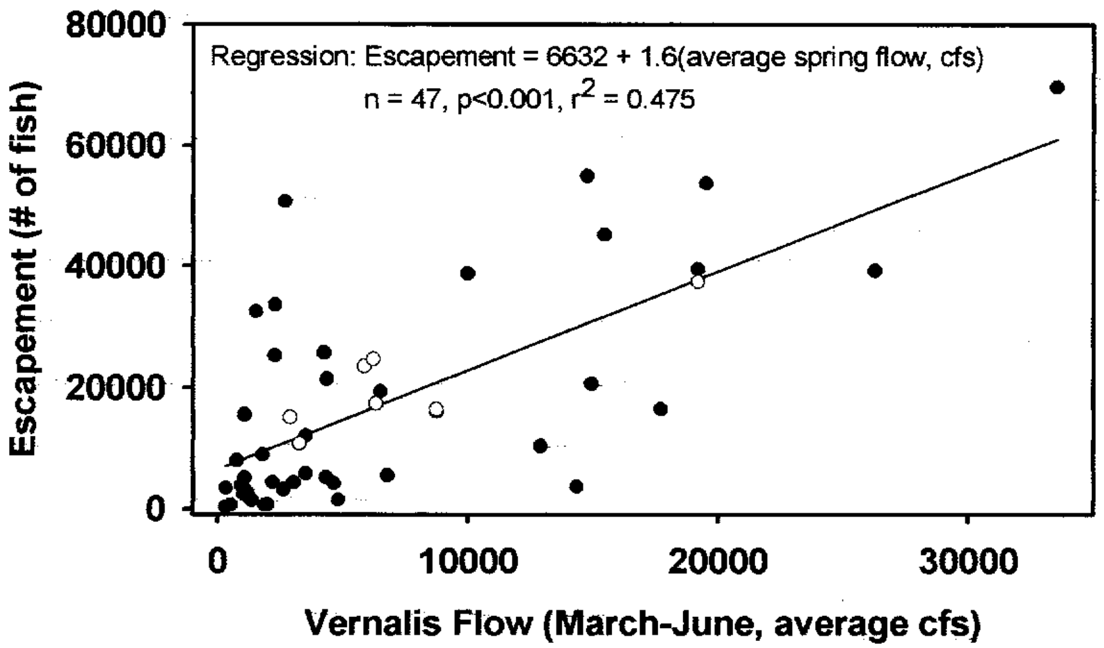

Figure 5. Escapement of San Joaquin Basin fall-run Chinook salmon (Stanislaus, Tuolumne and Merced Rivers only) plotted against average San Joaquin River flow (Vernalis) during the March-June period 2.5 years earlier when these fish migrated downstream as juveniles. Higher Vernalis flows during the juvenile outmigration period correspond to larger numbers of adult salmon returning to spawn in San Joaquin Basin tributaries 2.5 years later. The solid line shows the statistically significant linear regression for the relationship (and see regression equation above). Open circles are for years since the implementation of the 1995 Bay-Delta Plan. Data sources: California Department of Fish and Game, "Grandtab"; California Department of Water Resources, Dayflow.

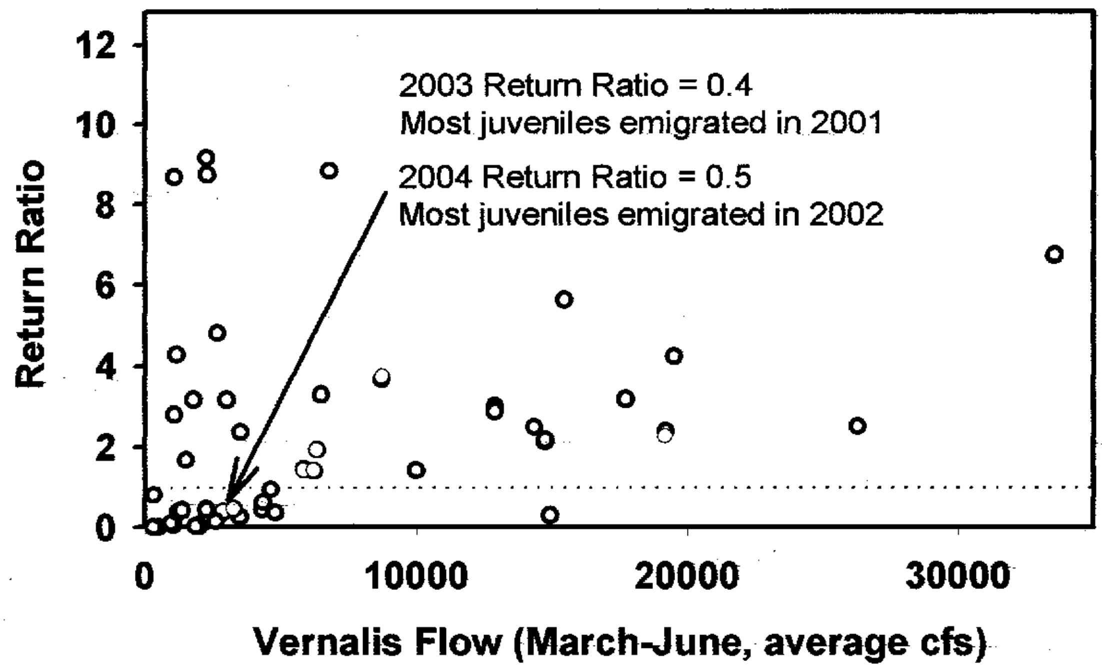

Figure 6. Return ratio (cohort replacement rate; the ratio of the number of adults returning to the river in a given year to the number of adults that produced them three years earlier) of San Joaquin Basin Chinook salmon (Stanislaus, Tuolumne, and Merced Rivers) plotted against average San Joaquin River flow (Vernalis) during the March-June period 2.5 years earlier when these fish migrated downstream as juveniles. In 94% of years with average March-June Vernalis flows greater than 5000 cfs, the return ratio was greater than 1.0, indicating population growth. In 60% of years with lower flows, the return ration was less then 1.0 and the population declined. The horizontal dotted line shows a return ratio value of 1.0 (stable population). Open circles are for years since the implementation of the 1995 Bay-Delta Plan. Data sources: California Department of Fish and Game, "Grandtab"; California Department of Water Resources, Dayflow.

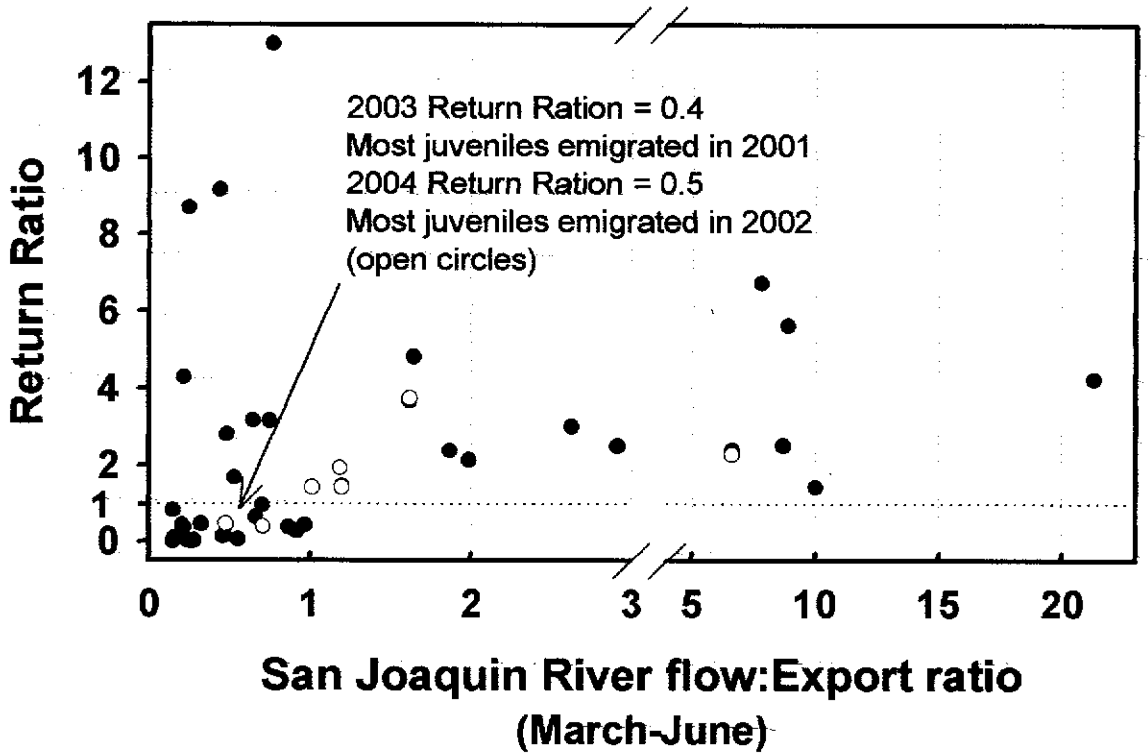

Figure 7. Return ratio of San Joaquin basin fall-run Chinook salmon plotted against the average March-June San Joaquin River (SJR) flow to export ratio. Return ratios below 1.0 indicate declining salmon populations; return ratios greater than 1.0 indicate increasing salmon populations. In 95% of years in which the SJR:Exports ratio was greater than 1.0, the return ratio for San Joaquin Chinook salmon was greater than 1.0. In 67% of years in which the SJR:Exports ratio was less than 1.0, San Joaquin salmon populations declined. The horizontal dotted line shows a return ratio value of 1.0 (stable population). Open circles are for years since the implementation of the 1995 Bay-Delta Plan. Data sources: California Department of Fish and Game, "Grandtab"; California Department of Water Resources, Dayflow.

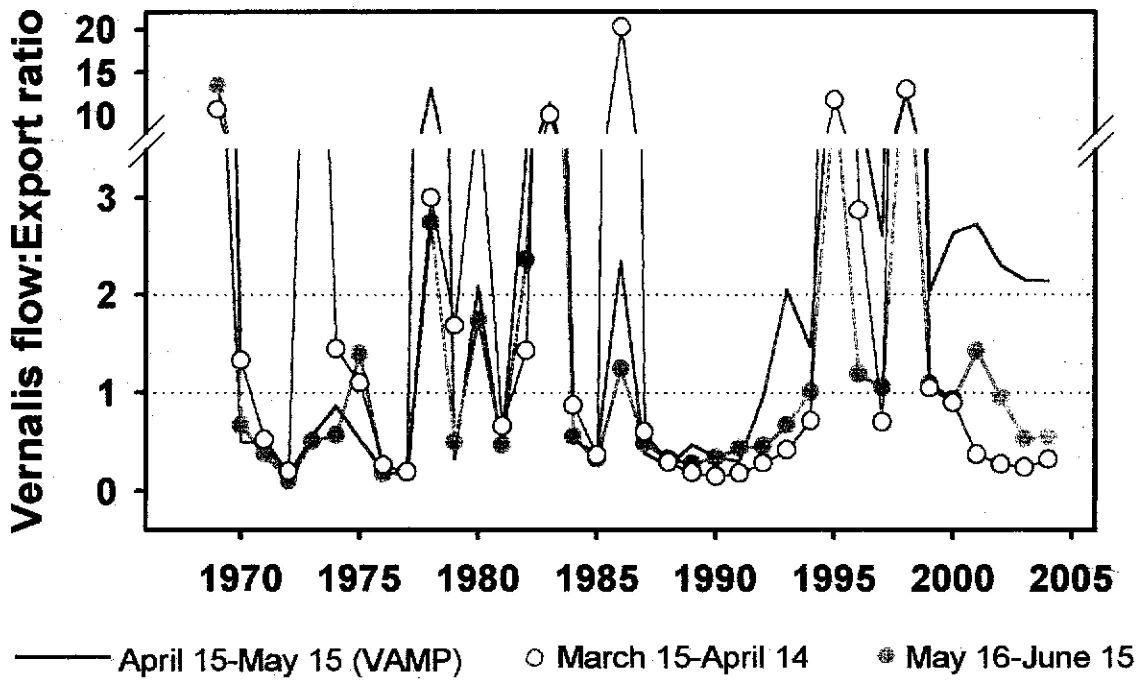

Figure 8. The ratio between San Joaquin River flow (Vernalis, 3-day running average, cfs) and combined exports (CVP + SWP, cfs) during the April 15-May 15 "VAMP" period (green line), the one-month period before VAMP (March 15-April 14, open blue circles), and the one-month period after VAMP (May 16-June 15, closed red circles), 1969-2004. While the flow ratio during the VAMP period has improved substantially, flows immediately before and after the 31-day period remain critically low. Return ratios (or cohort replacement rates) of San Joaquin Basin Chinook salmon that migrate downstream and through the Delta under low Vernalis flow:export ratio conditions are generally less than 1.0, indicating population decline (see Figure 7). Data source: California Department of Water Resources, Dayflow.

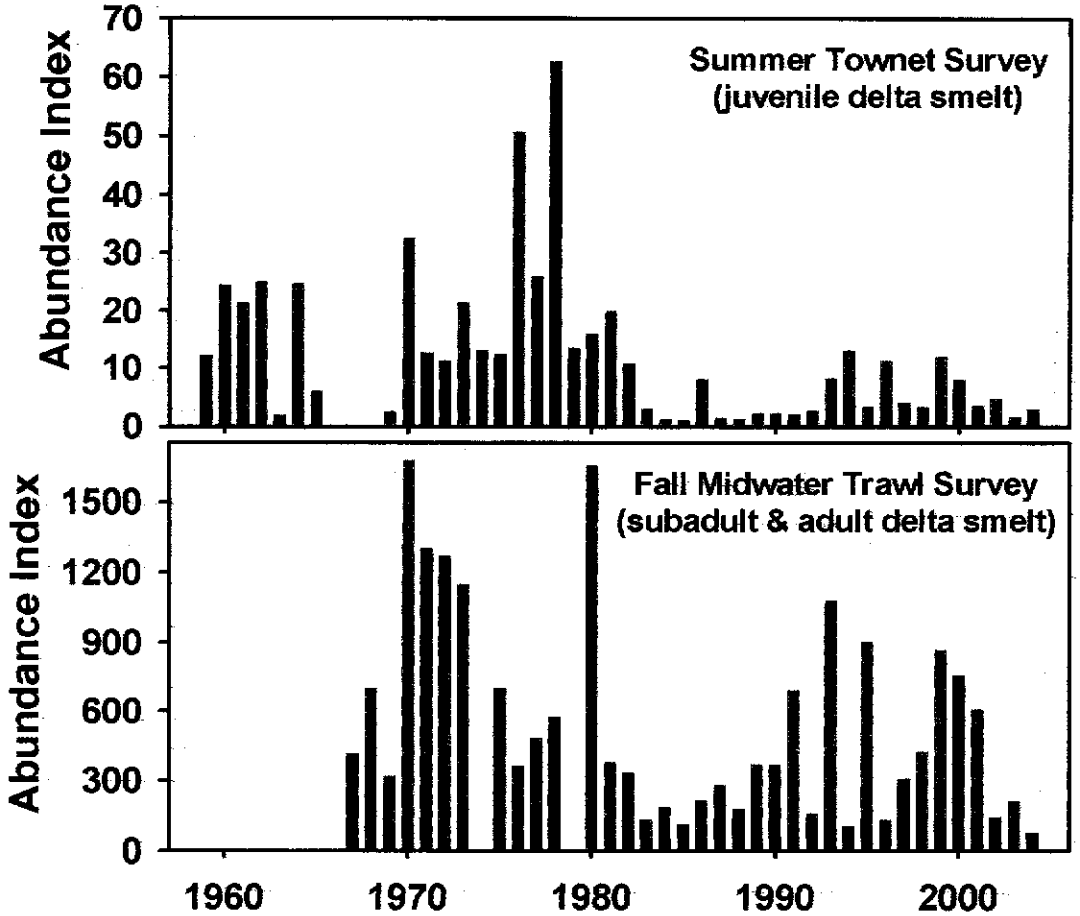

Figure 9. Abundance Indices for juvenile delta smelt (Summer Townet Survey, top panel) and sub-adult/adult delta smelt (Fall Midwater Trawl Survey, bottom panel). According to both of these surveys, delta smelt abundance has declined for the past five years. The 2004 Fall-Midwater Trawl Survey index, which assesses the breeding population and is used to evaluate recovery for this Endangered Species Act-listed species, was the lowest ever measured. Data Source: California Department of Fish and Game.

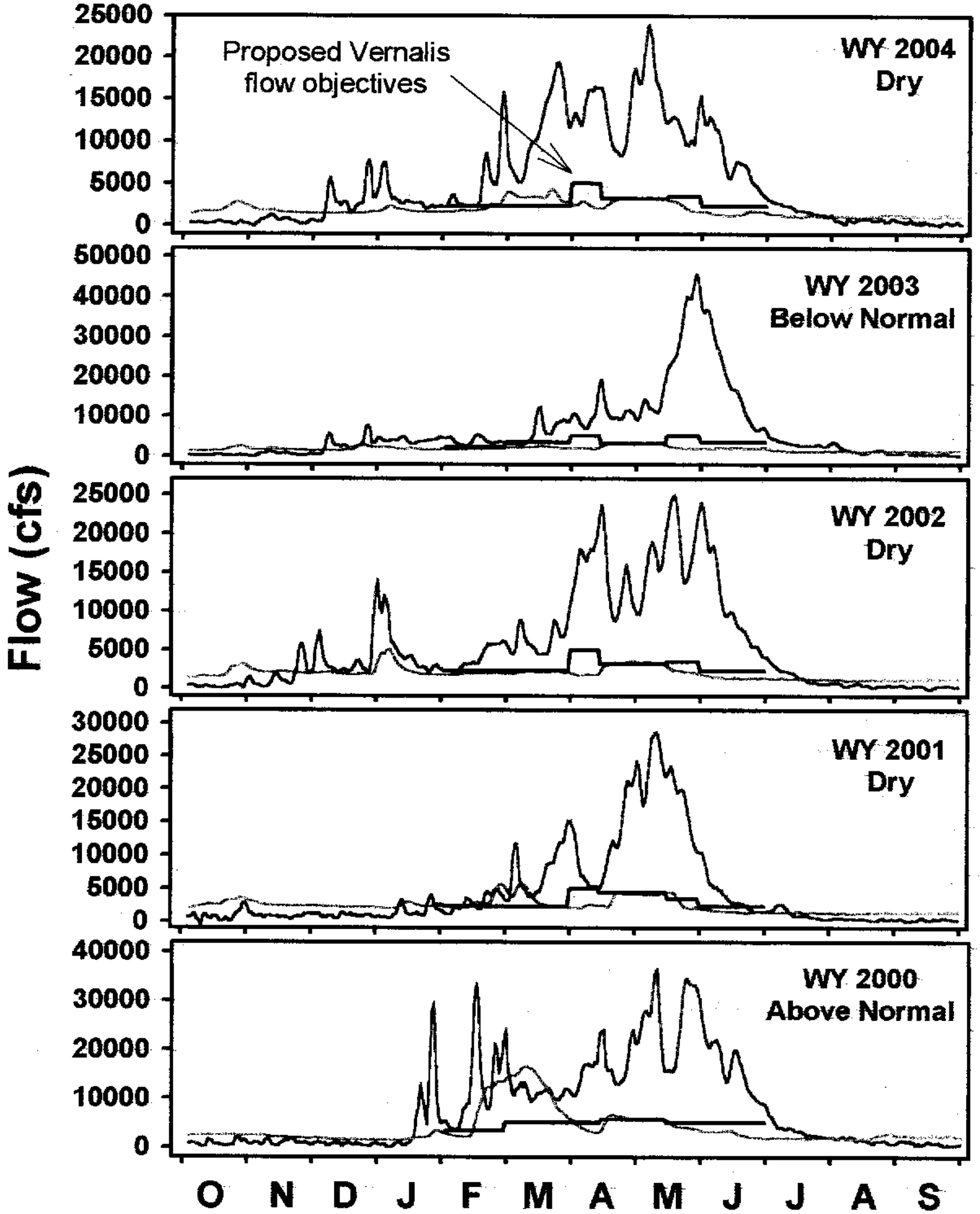

Figure 10. Proposed Vernalis flow objectives (black line) compared to San Joaquin Basin unimpaired runoff (blue line) and actual Vernalis flows (red line) for Water Years 2000-2004. Proposed flows during the 31-day pulse flow (April 15- May 16, VAMP) are shown as the actual flows implemented in each year. See Table 3 for proposed monthly flow objectives for wet and critically dry water year types.