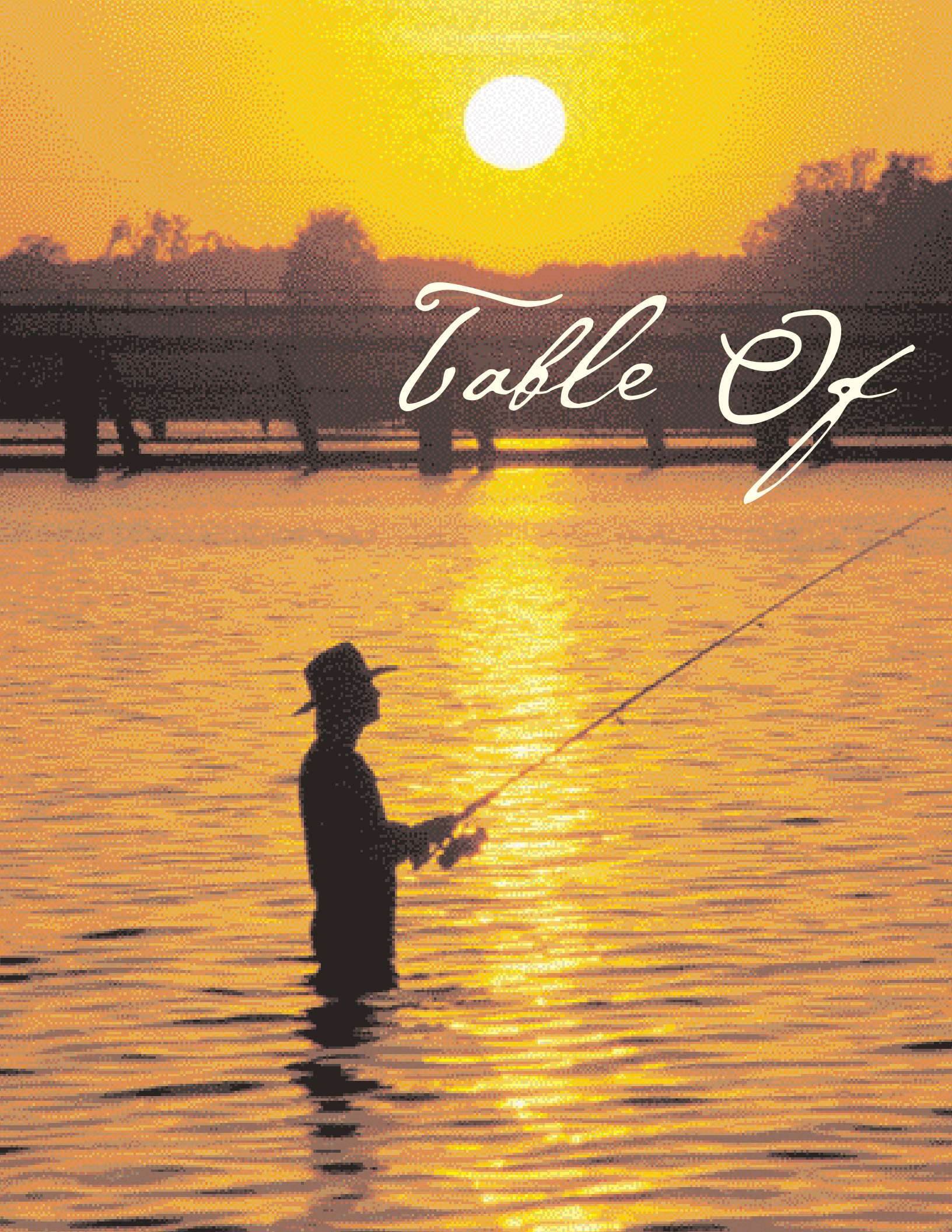
THE SAN JOAQUIN RIVER AGREEMENT

2000 TECHNICAL REPORT

Vernalis Adaptive Management Plan (VAMP)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Executive Summmary

THE SAN JOAQUIN AGREEMENT

The San Joaquin Agreement (SJRA or Agreement) is the cornerstone of a history-making commitment to implement the State Board's 1995 Water Quality Control Plan (WQCP) for the lower San Joaquin River and the San Francisco Bay-Delta Estuary (Bay-Delta). Using a consensus-based approach, the Agreement united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2000 Annual Technical Report comprises the consolidated annual San Joaquin River Agreement Operations and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. While exploratory studies were conducted in 1998 and 1999 to help establish the experimental protocols, the VAMP 2000 program represents the first year of formal compliance with State Water Resources Control Board (State Board) Decision 1641 (D-1641). D-1641 requires the preparation of an annual report documenting the implementation and results of the VAMP program.

Specifically, this report includes the following information on the implementation of the Agreement: the hydrologic chronicle; the management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (Old River Barrier); results of the juvenile Chinook salmon smolt survival investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director of the State Board the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the State Board approved combining these two reports into a single comprehensive report.

A key part of this landmark agreement is the Vernalis Adaptive Management Plan (VAMP). VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. VAMP is also a scientifically recognized experiment to determine how salmon survival rates change in response to alterations in San Joaquin River flows and State Water Project (SWP)/Central Valley Project (CVP) exports and the installation of the Old River Barrier.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future.

In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2000 included:

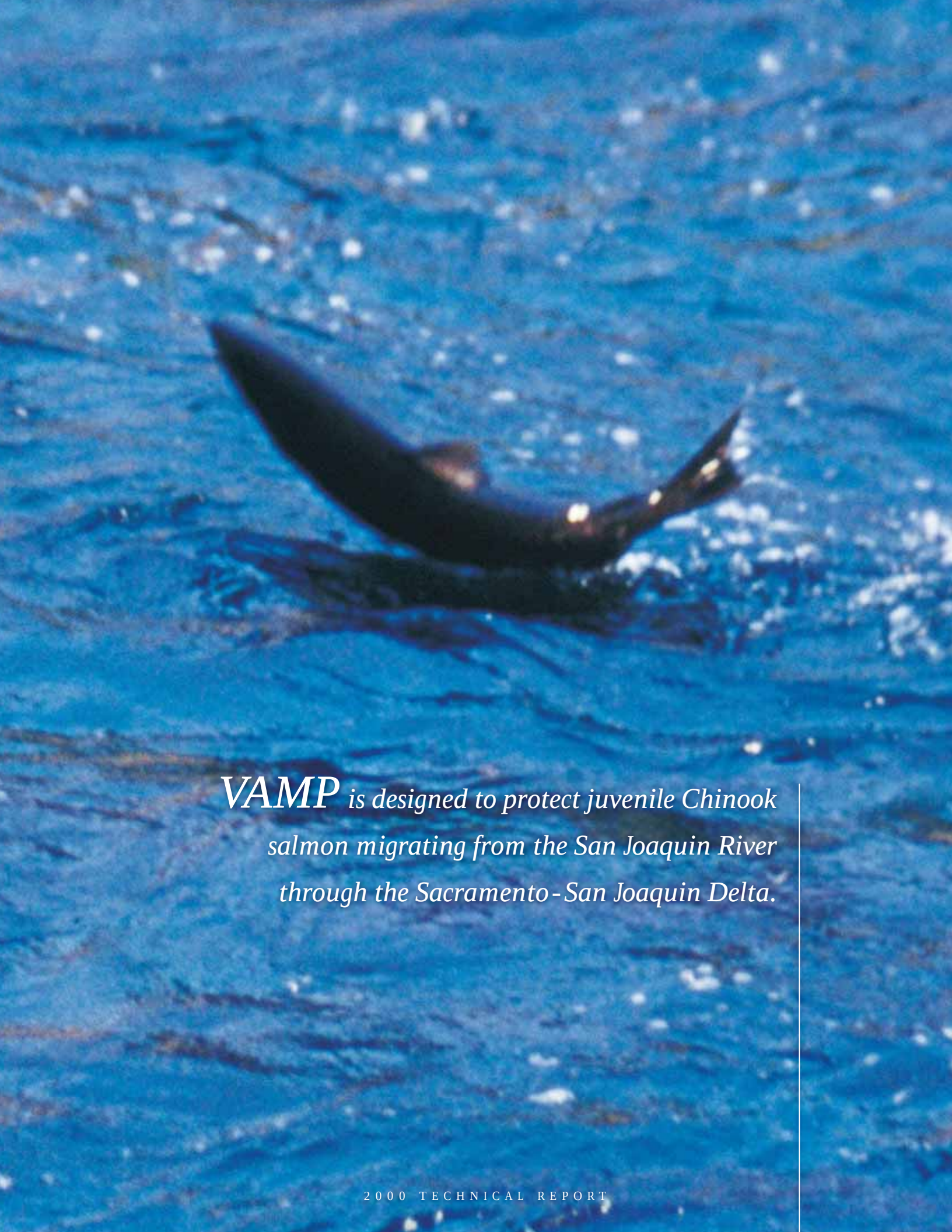
- *Quantification of Chinook salmon smolt survival between Durham Ferry and Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 5,700 cfs, with an installed Head of Old River Barrier, and SWP/CVP export rates of 2,250 cfs; and*
- *Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2000 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.*

A secondary objective of the VAMP 2000 experimental salmon smolt survival studies is the comparison of the survival of juvenile Chinook salmon of Merced and Mokelumne River origin released at Jersey Point.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2000, a set of conclusions and recommendations have been developed. These conclusions and recommendations, described in detail on pages 34–35 of this report, provide guidance and a foundation for design and implementation of future VAMP operations.

Key policy and management conclusions and recommendations derived from VAMP 2000 include:

- *VAMP 2000 is the first year of full implementation of the program. No conclusions on the relative roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival can be made with this documented data. The report recommends that the VAMP experimental test program be continued;*
- *The design and installation of the temporary Old River Barrier in 2000 provided unreliable operations at San Joaquin River flows of 7,000 cfs. The report recommends resolution of concerns regarding the Old River Barrier design and operations and future VAMP test flows be maintained as a high priority item;*
- *Budgeting and planning for the VAMP program should be expanded beyond one year. The report recommends that a three-year plan and budget be developed, including anticipated capital and operation costs, to facilitate VAMP implementation.*



VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta.

Introduction

VAMP 2000

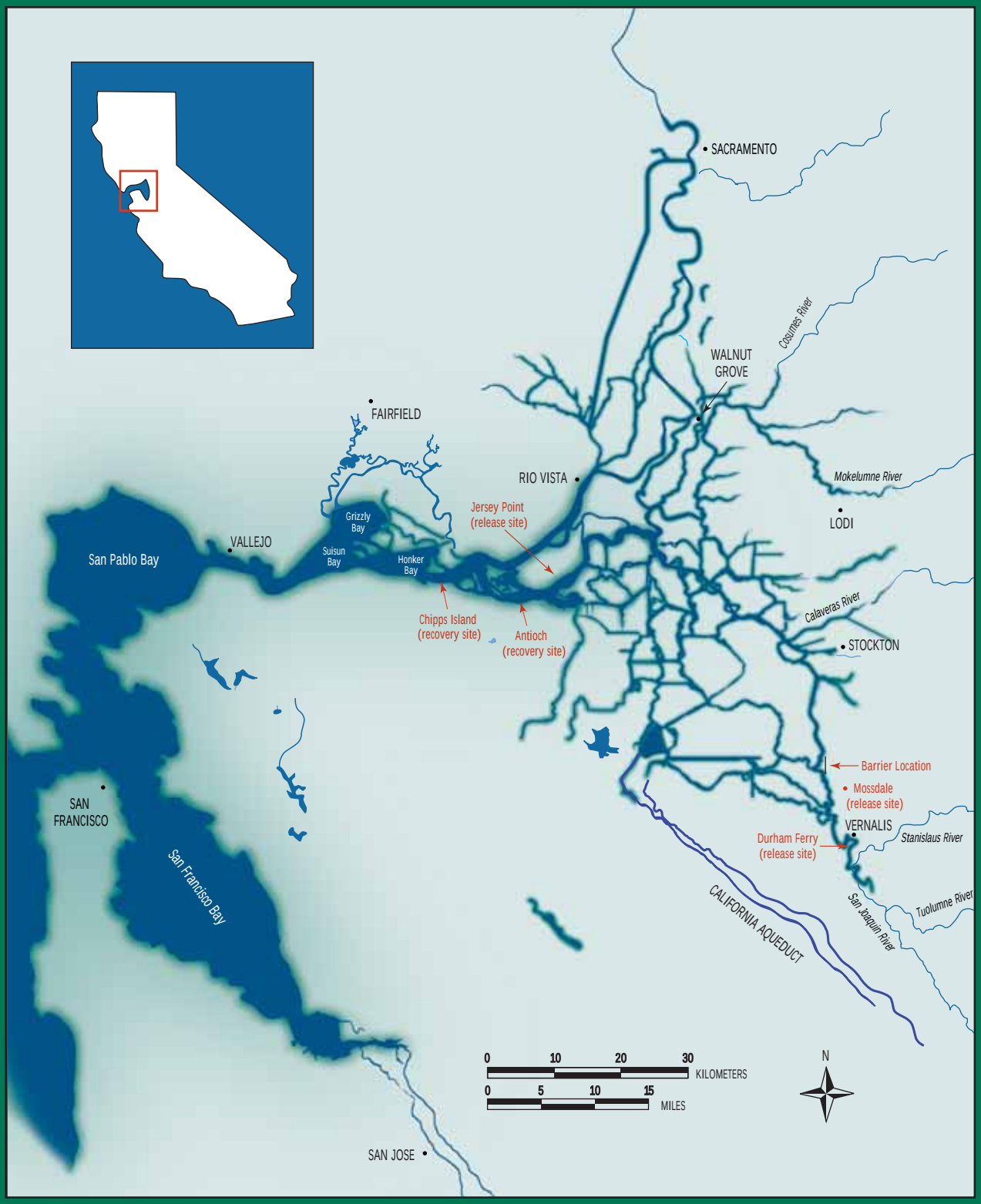
The VAMP experimental design measures salmon smolt survival rates under six different combinations of flow and export rates (see pages 6–13). The experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May out-migration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival rates under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured (see page 28).

EXPERIMENTAL DESIGN ELEMENTS

The VAMP 2000 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries (Figure 1-1). Two sets of releases were made at Durham Ferry and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and one series of releases. The VAMP release (Durham Ferry and Jersey Point) and recapture locations (Antioch and Chipps Island) will be consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over a range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Old River Barrier. Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry) and the downstream (control) release at Jersey Point. The use of ratio estimates as part of the VAMP study design substantially reduces the bias associated with differential gear collection efficiency within and among years, improves the precision associated with the individual indices, and improves confidence in differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

Figure 1.1

SACRAMENTO-SAN JOAQUIN ESTUARY



Location of VAMP 2000 release sites (Durham Ferry, Mossdale, and Jersey Point), recovery locations (Antioch, and Chipps Island), and Upper Old River Barrier location within the Sacramento-San Joaquin River Delta/Estuary.

Hydrologic Planning

VAMP HYDROLOGIC PLANNING & IMPLEMENTATION

This section documents the planning and implementation of the VAMP 2000 investigations as undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC). Implementation of VAMP is guided by the framework provided in the Agreement and anticipated hydrologic conditions within the watershed.

The Hydrology Group was established for the purpose of forecasting hydrologic conditions and for planning, coordinating, scheduling and implementing the flows required to meet the test flow target in the San Joaquin River near Vernalis. The Hydrology Group is also charged with exchanging information relevant to the forecasted flows, and coordinating with others in the SJRTC, in particular the Biology Group, responsible for planning and implementing the salmon smolt survival study.

Participation in the Hydrology Group is open to all interested parties, with the core membership consisting of the designees of the agencies responsible for the water project operations that would be contributing flow to meet the target flow. In 2000, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (Exchange Contractors), and the U.S. Bureau of Reclamation (USBR). Though not a water provider, the California Department of Water Resources (DWR) was closely involved with the coordination of operations relating to the installation of the Old River Barrier and the planning of Delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP investigations are designed to collect data and information on the impacts of San Joaquin River flow and Delta exports (SWP and CVP pumping at the Tracy and Banks pumping plants) on the survival rates of juvenile Chinook salmon emigrating from the San Joaquin River system. The VAMP provides for a 31-day pulse flow at the Vernalis gage during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in Table 2-1. The magnitude of the pulse flow is based on San Joaquin River flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value ("double-step") or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The State Board San Joaquin Valley Water Year Hydrologic Classification ("60-20-20" classification) is given a numerical indicator as shown in Table 2-2.

"Double-step" flow years occur when the sum of last year's numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater. If the sum of the two previous years' numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, which is an extremely dry period, the San Joaquin River Group Authority (SJRG) members are not required to provide water above the existing flow. The USBR has a continuing obligation to meet San Joaquin River flows pusuant to the March 6, 1995 Biological Opinion.

Under the Agreement, the maximum amount of supplemental water to be provided to meet VAMP target flows in any given year is 110,000 acre-feet. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water (based on the targets outlined in Table 2-1, under double-step conditions, historically up to 157,000 acre-feet of supplemental water may be required), then additional water may be acquired on a willing seller basis.

VAMP 2000 HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2000, and continuing until early April, the Hydrology Group held five planning and coordination meetings (February 10; March 2, 16, and 30; and April 6). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly

Table 2.1

VAMP VERNALIS FLOW & DELTA EXPORT TARGETS

EXISTING FLOW (CFS)	VAMP TARGET PULSE FLOW (CFS)	DELTA EXPORT TARGET RATES (CFS)
0 to 1,999	2,000	
2,000 to 3,199	3,200	1,500
3,200 to 4,449	4,450	1,500
4,500 to 5,699	5,700	2,250
5,700 to 7,000	7,000	1,500 or 3,000
Greater than 7,000	Provide stable flow to the extent possible	

Table 2.2

SAN JOAQUIN VALLEY WATER YEAR
HYDROLOGIC CLASSIFICATIONS USED IN VAMP

60-20-20 CLASSIFICATION	VAMP NUMERICAL INDICATOR
Wet	5
Above Normal	4
Below Normal	3
Dry	2
Critical	1

Table 2.3

SUMMARY OF VAMP 2000 MONTHLY FORECASTS

VAMP FORECAST DATE	RUNOFF FORECAST DATE	RUNOFF EXCEEDENCE	VAMP CRITERIA	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER (1,000 ACRE-FEET (AF)
				SPRING PULSE PERIOD (APRIL 15 - MAY 15)		
Feb 09	Feb 01	90 %	Single step	2,895	3,200	19
		50 %	Double step	4,370	5,700	84
Feb 22	Feb 15	90 %	Single step	3,785	4,450	41
		50 %	Double step	4,940	7,000	127

operation forecast was prepared in early February. An additional monthly forecast was prepared using mid-February runoff forecast updates. The monthly forecasts are summarized in Table 2-3. Based upon the early forecast efforts, it was apparent that the planning for the 2000 VAMP would require consideration of a broad range of possibilities.

DAILY OPERATION PLANS

The Hydrology Group developed a daily operation plan beginning in mid-March, updating it as hydrologic conditions and operational requirements changed. The daily operation plans calculated an estimated mean daily flow at Vernalis based on measured flows at the major tributary's control points and in the upper San Joaquin River with the following key assumptions:

(1) The travel times for flows from the tributary measurement points and upper San Joaquin River to the Vernalis gage are assumed as follows:

a. Merced River at Cressey to Vernalis	3 days
b. San Joaquin River above Merced River to Vernalis	2 days
c. Tuolumne River at LaGrange to Vernalis	2 days
d. Stanislaus River below Goodwin Dam (at Orange Blossom Bridge) to Vernalis	2 days

(2) Based upon a review of the historical flow record, the ungaged flow at Vernalis was assumed to be constant throughout the pulse period and equal to the trending value entering the pulse period. By definition, the ungaged flow is that unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungaged =

VNS - OBBlag - LGNlag - CRSlag - USJRlag

where:

VNS	=	San Joaquin River near Vernalis
OBBlag	=	Stanislaus River at Orange Blossom Bridge lagged 2 days
LGNlag	=	Tuolumne River at LaGrange lagged 2 days
CRSlag	=	Merced River at Cressey lagged 3 days
USJRlag	=	San Joaquin River above Merced River lagged 2 days (USJR is not gaged but is calculated as the difference between the gaged flows at the San Joaquin River at Newman (NEW) and the Merced River at Stevinson (MST)).

A summary of the daily operation plans developed during the planning of the 2000 VAMP is provided in Table 2-4. Copies of the daily operation plans are provided in Appendix A.

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Until the pulse flow is specifically defined, it is assumed for the purposes of planning to be April 15 through May 15. Flexibility of dates for the pulse flow period exists so that they coincide with the period of peak salmon out-migration. Other factors, including installation of Old River Barrier, availability of juvenile salmon at the hatchery, and manpower and equipment availability for fish releases and sampling fish also need to be considered in determining the timing of the pulse period.

Early forecasts indicated that 2000 would be a "double-step" year with a flow target of 7,000 cfs and concurrent combined CVP and SWP pumping at Tracy and Banks at 3,000 or 1,500 cfs. From a biological standpoint, 1,500 cfs was the preferred option. A wet February and early March resulted in high San Joaquin River flows and raised concerns about the chances of installing the Old River Barrier. The high San Joaquin River flows also caused speculation that the VAMP period would have to be delayed, however, a sustained dry period with essentially no rainfall in the San Joaquin basin between March 19 and April 12 reduced the forecasted flows such that the VAMP planning returned to the April 15 through May 15 nominal schedule. To ensure that the flows in the San Joaquin River remained below 5,000 cfs during installation of the Old River Barrier, Stanislaus River flows were reduced from 1,500 cfs to approximately 850 cfs. Tuolumne River flows were also reduced from about 1,200 cfs to 420 cfs. Construction of the Old River Barrier began on April 5.

Late March and early April operation plans indicated that supplemental water in excess of 110,000 acre-feet would be required to achieve the target flow of 7,000 cfs for the 31-day pulse flow period. This additional water could be supplied through purchases by the USBR from willing sellers. In preparation for this possibility, the SJRG and USBR prepared a draft Environmental Assessment and Initial Study for additional water acquisition.

By April 13, construction of Old River Barrier was nearly complete and upstream releases for the scheduled VAMP pulse flow had begun, timed to arrive at Vernalis coincident with the April 15 start of the target flow period. However, the flow at Vernalis as measured by USGS on April 13 indicated that the actual flow (3,210 cfs) was about 1,000 cfs less than that being reported on the California Data Exchange Center (CDEC) (4,280 cfs). The revised flow at Vernalis resulted in a revision of the projected existing flow from 5,018 cfs to 4,412 cfs—near the threshold of two VAMP target flows (5,700 cfs and 7,000 cfs). A base flow less than 4,450 cfs requires a target flow of 5,700 cfs and a base flow greater than

Table 2.4

SUMMARY OF VAMP 2000 DAILY OPERATION PLANS

VAMP FORECAST DATE	PULSE PERIOD	ASSUMED UNGAGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER 1,000 ACRE-FEET (AF)	NOTES
Mar 15	Apr 15–May 15 May 01–May 31	1,000 1,000	6,447 6,184	7,000 7,000	34.9 55.0	
Mar 23	Apr 20–May 20	1,000	4,934	7,000	127.0	Pulse period set at April 20 to May 20 to accomodate Head of Old River Barrier (HORB) construction.
Mar 29	Apr 20–May 20	1,000	4,934	7,000	127.1	
Apr 04	Apr 15–May 15	1,000	4,949	7,000	128.8	Pulse period changed to Apr 15 to May 15 due to revised HORB construction schedule.
Apr 05	Apr 15–May 15	1,000	4,949	7,000	128.8	
Apr 11	Apr 15–May 15	1,000–1,800	5,018	7,000	125.0	
Apr 13	Apr 15–May 15	550–700	4,412	5,700	86.0	Existing flow and ungaged flow at Vernalis reduced significantly due to rating shift at Vernalis gage.
Apr 14	Apr 15–May 15	500	4,320	5,700	89.5	
Apr 17	Apr 15–May 15	500	4,265	5,700	89.5	

4,450 cfs requires a target flow of 7,000 cfs. After convening a special session of the SJRTC to evaluate the latest data, the decision was made to set the VAMP 2000 flow target at 5,700 cfs with a Delta export target of 2,250 cfs. Important to this decision was the need for a target flow that could be sustained for 31 days as opposed to establishing a higher target that could not be sustained during the entire pulse flow period.

Due to travel time considerations, releases were already underway to achieve the earlier 7,000 cfs Vernalis target flow, with a 3,800 cfs fishery study pulse flow under way on the Tuolumne River. In order to move the projected flow at Vernalis closer to the new target of 5,700 cfs without disrupting the Tuolumne River pulse flow, the flow in the Stanislaus River was reduced from 1,500 cfs to 1,100 cfs. Nevertheless, it was still anticipated that the flow at Vernalis would exceed the 5,700 cfs target flow to some degree for the duration of the first Tuolumne River pulse flow test period.

VAMP 2000 IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. Daily conference calls occurred from April 13 through April 19, excluding the weekend, and then every Monday, Wednesday and Friday thereafter through May 12.

Operation Monitoring

During the pulse flow period, supplemental water contributions from San Joaquin tributaries were continuously monitored using the available real-time data. Data at each of the measurement locations (Merced River at Cressey, Tuolumne River below LaGrange Dam, Stanislaus River at Orange Blossom Bridge, San Joaquin River near Vernalis, Merced River at Stevinson, and San Joaquin River at Newman) was compiled by CDEC. Monitoring was necessary to verify that supplemental water deliveries were adhering to tributary allocations contained in the Agreement to the extent possible. An example of the spreadsheet used to monitor the operation is provided in Appendix A.

Operational Highlights

On April 17, a strong storm moved into the San Joaquin basin and produced record or near record amounts of rainfall. It was anticipated that the storm would elevate flows at Vernalis by approximately 1,000 cfs. Preservation of the pulse on the Tuolumne River was deemed more important than modifying operations to attempt to maintain the Vernalis flow target. Since the Old River Barrier was designed to be safe with flows approaching 9,000 cfs, problems were not anticipated. As a result of storm runoff and irrigation cutbacks, the Vernalis flow responded dramatically, increasing to what was initially believed to be about 6,400 cfs. Just as the peak was reached, personnel on site at the Old River Barrier reported that the water level on the San Joaquin River side of the Old River Barrier was far closer to the crest than anticipated, and concern was expressed about the safety of the Old River Barrier at these flows. At nearly the same time, on April 18, USGS measured a flow of 7,140 cfs at the Vernalis gage, 730 cfs higher than the 6,410 cfs being reported on CDEC. As a result of these events, immediate reductions in reservoir releases were implemented. The Tuolumne River flow was reduced by about 1,000 cfs, and the Stanislaus River flow was reduced from 1,100 cfs to 800 cfs. The peak flow passed the Old River Barrier uneventfully, and the Stanislaus River flow was returned to its 1,500 cfs target. However, the slow recession of the storm hydrograph kept flows above the Vernalis target flow of 5,700 cfs for a longer period than expected.

After the effects of the April 17 storm subsided, San Joaquin River flows became fairly stable and predictable for the remainder of the VAMP pulse period. A small storm at the end of the first week in May caused some concern but proved to have a relatively small impact on the flow at Vernalis with an increase in flow of approximately 300 to 400 cfs. From April 15 through April 24, Vernalis flows averaged 6,360 cfs, ranging from 7,060 to 5,760 cfs. From April 25 through May 15, the mean daily flow at Vernalis averaged 5,750 cfs, ranging from 5,230 cfs to 6,050 cfs, a deviation of -8 percent to +6 percent from the target flow of 5,700 cfs.

RESULTS OF VAMP 2000 OPERATIONS

Planning and implementation of the VAMP spring pulse flow operation was accomplished using the best available real-time data which has not been reviewed for accuracy or adjusted for the long range impacts of rating shifts. The final accounting for the VAMP operation is accomplished using provisional mean daily flow data available from USGS and DWR. The provisional data, which is considered to be the best available information, has been reviewed and adjusted for rating shifts but is still considered provisional and is subject to change. To illustrate the differences between real-time and provisional data, plots of the real-time and provisional flows at the primary measuring points are provided in Appendix A.

Daily Vernalis flows during the VAMP 2000 test period are shown in Figure 2-1. The mean daily flow at the Vernalis gage ranged from 5,230 cfs to 7,060 cfs, resulting in an average of 5,869 cfs during the 31-day target flow period. The maximum mean daily flow of 7,060 cfs, which occurred on April 18, was the result of both the large amount of rain that occurred the previous day and the initial flow schedule that was based on a target flow of 7,000 cfs. The average flow for the target flow period absent the VAMP supplemental water was estimated to be 4,815 cfs. Figure 2-1 shows the flow at Vernalis and sources of that flow. Figure 2-2 compares the flow at Vernalis with and without the VAMP pulse flow. The VAMP resulted in a 25 percent increase in flow at Vernalis during the target flow period. A total of 77,680 acre-feet of supplemental water was provided to meet the VAMP target flow. A daily summary of VAMP operations, along with supporting data, is provided in Appendix A.

The combined CVP and SWP export rate averaged 2,155 cfs during the 31-day period, about 4 percent below the target of 2,250 cfs. Figure 2-3 summarizes daily SWP and CVP exports.

SJRG member agencies have entered into the Division Agreement which allocates responsibility of the members for providing VAMP supplemental water. The members may also make additional agreements among themselves regarding delivery of the supplemental water. For VAMP 2000, SJRG contributing agencies agreed to provide the SSJID supplemental water as follows: 54.55 percent by Merced, 15.91 percent by OID, 15.91 percent by MID and 13.64 percent by TID. It was also agreed that the OID supplemental water would be provided entirely by MID due to the 1,500 cfs flow limitation on the Stanislaus River.

The distribution of supplemental water for the VAMP 2000 target flow, compared to the distribution as the Division Agreement, is summarized in Table 2-5.

Figure 2.1

SAN JOAQUIN RIVER NEAR VERNALIS

WITH LAGGED CONTRIBUTIONS FROM PRIMARY SOURCE

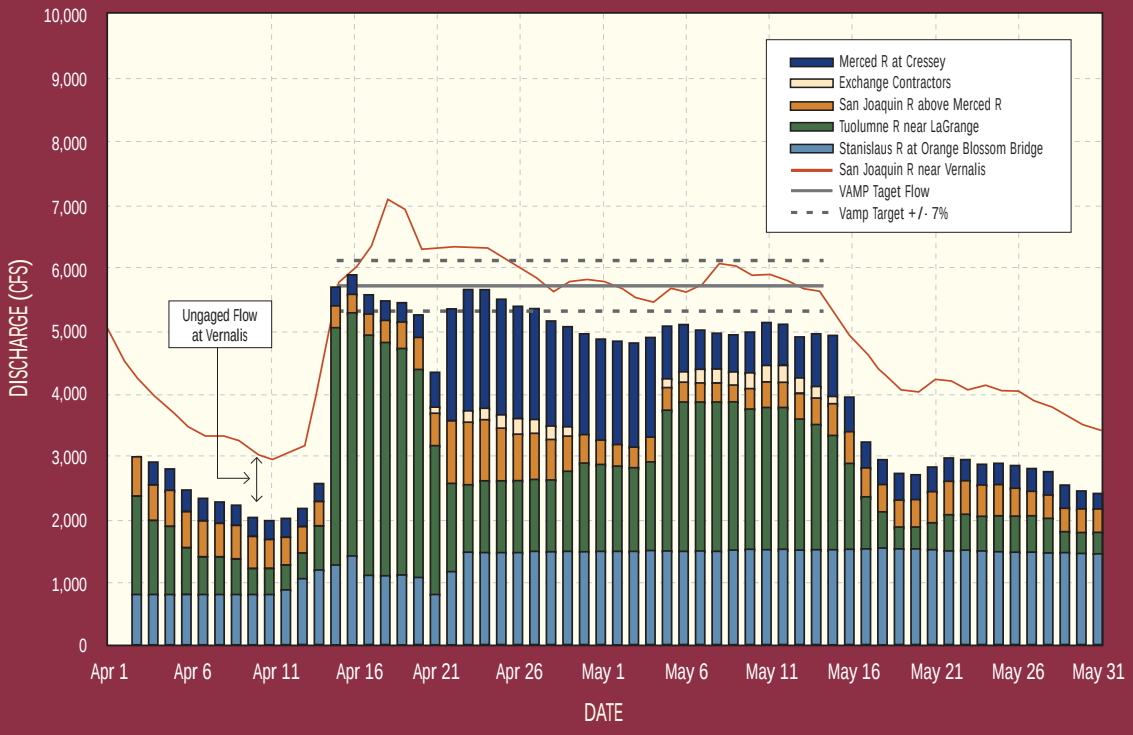


Figure 2.2

SAN JOAQUIN RIVER NEAR VERNALIS

WITH & WITHOUT VAMP

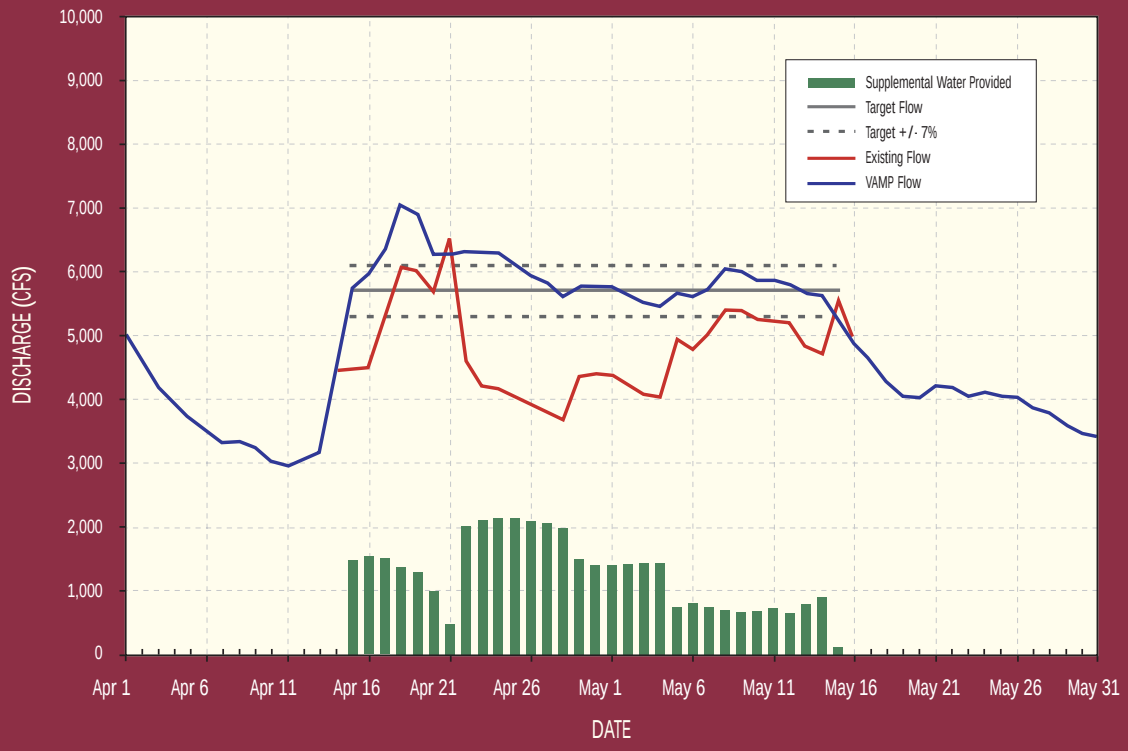


Figure 2.3

FEDERAL & STATE EXPORTS

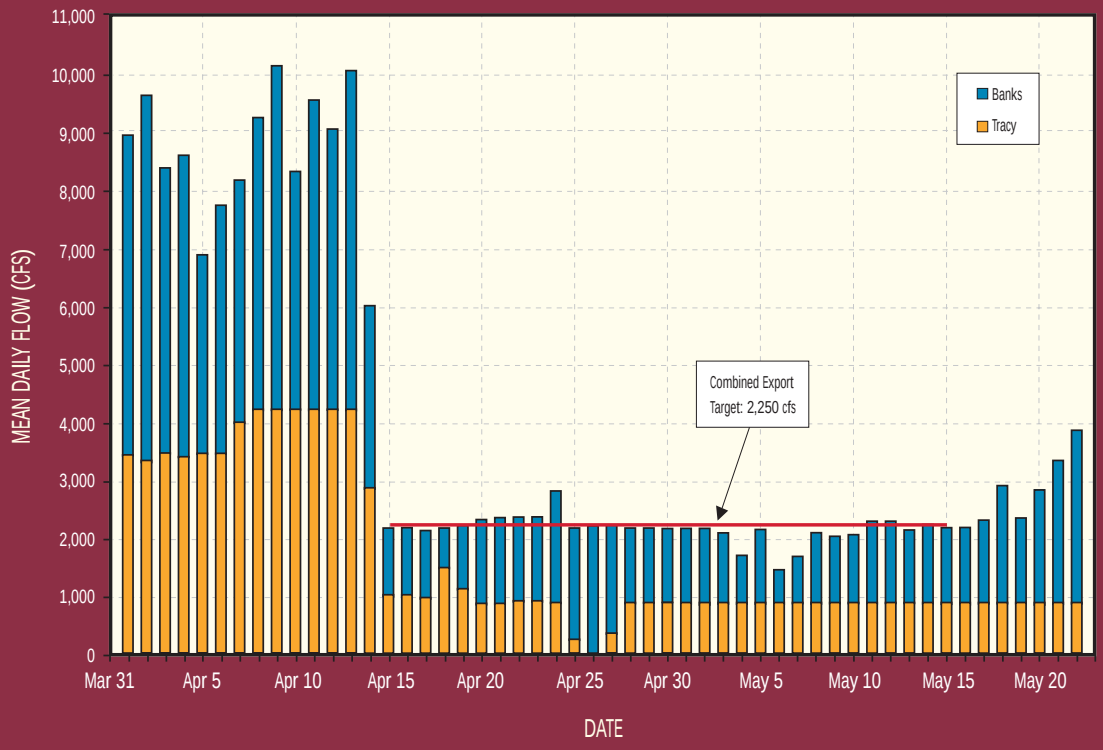
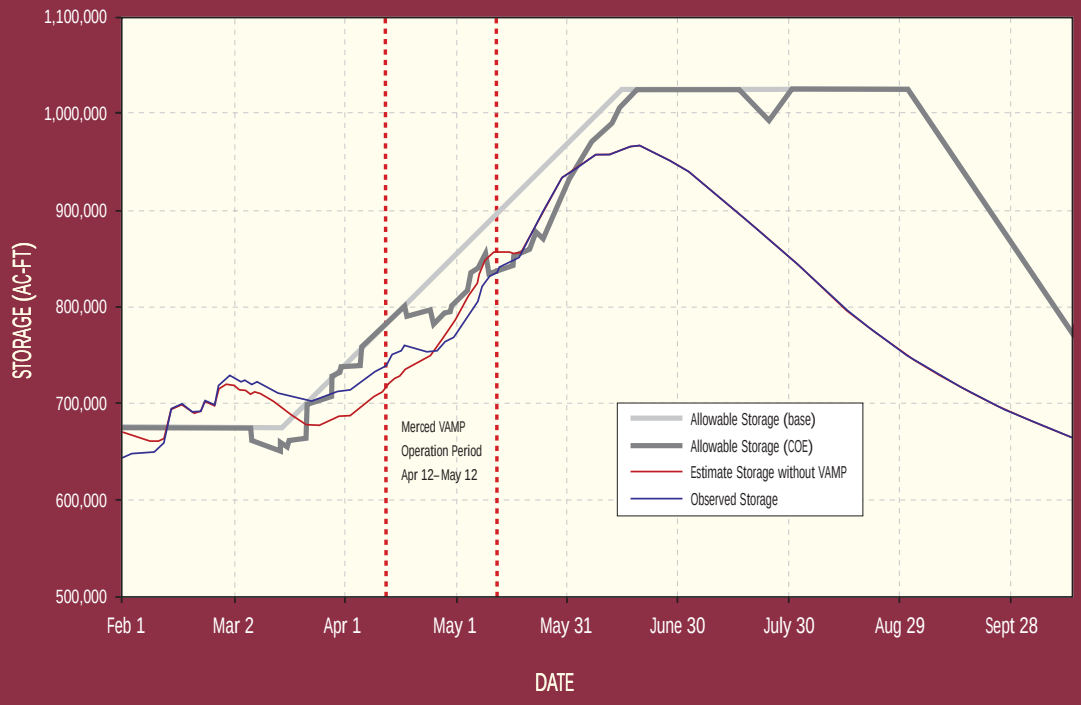


Figure 2.4

STORAGE IMPACTS LAKE McCLURE MERCED RIVER



STORAGE IMPACTS

Supplemental water from the Merced and Tuolumne Rivers was primarily supplied from storage from Lake McClure on the Merced River and from New Don Pedro Reservoir on the Tuolumne River. Therefore, the impacts of VAMP operations can be seen directly as changes in reservoir storage. Due to the extended nature of the VAMP, a 12-year plan, the storage impacts can potentially carry over from year to year. Reservoir storage impacts are reduced or eliminated when the reservoirs make flood control releases.

On the Merced River, flood control releases were required in May, thereby eliminating the storage impacts in Lake McClure that had resulted from the VAMP 2000 operations. Figure 2-4 shows Lake McClure storage with and without the VAMP operation.

On the Tuolumne River, the storage impact of approximately 23,800 acre-feet was reduced to about 7,700 acre-feet due to flood control releases required at the end of September 2000 under the "No VAMP" scenario. This 7,700 acre-feet storage impact will continue until further flood control releases are made. Figure 2-5 shows New Don Pedro Reservoir storage with and without VAMP 2000 operations, assuming the encroachment into the Don Pedro flood control space would have occurred without VAMP releases would have been allowed.

Table 2.5

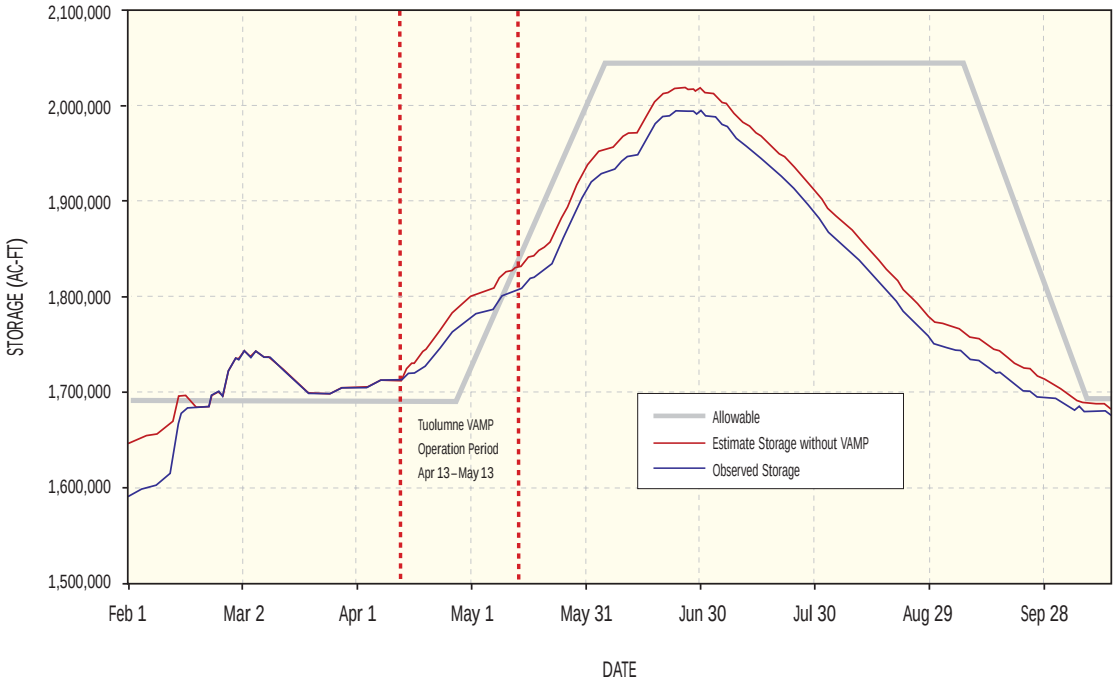
DISTRIBUTION OF 77.68 THOUSANDS ACRE-FEET (TAF) OF SUPPLEMENTAL WATER

AGENCY	DIVISION AGREEMENT DISTRIBUTION (TAF)		SUPPLEMENTAL WATER PROVIDED	DEVIATION FROM DIVISION AGREEMENT
	Base	*Adjusted*		
Merced	41.18	45.16[3]	46.75	+1.59
OID	7.30[1]			
SSJID	7.30[2]			
Exchange Contractors	7.30	7.30	8.28	+0.98
MID	7.30	16.92[4]	15.20	-1.72
TID	7.30	8.30[5]	7.45	-0.85

[1] Provided by MID
[2] Provided by: Merced (54.55%), OID (15.91%), MID (15.91%), TID (13.64%)
[3] Includes 3.98 TAF of SSJID water
[4] Includes 7.30 TAF of OID water and 2.32 TAF of SSJID water
[5] Includes 1.00 TAF of SSJID water

Figure 2.5

STORAGE IMPACTS NEW DON PEDRO RESERVOIR (TUOLUMNE RIVER)



Water Supply

ADDITIONAL WATER SUPPLY ARRANGEMENTS & DELIVERIES

MERCED IRRIGATION DISTRICT (MERCED)

The Agreement includes a provision (Paragraph 8.4) stating, "Merced Irrigation District shall provide, and the USBR shall purchase 12,500 acre-feet of water… during October of all years." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the SJRA Fall Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced.

In addition to providing water in the fall of 2000 pursuant to the Agreement, Merced entered into a contract with USBR to transfer up to 25,000 acre-feet of water to be used to benefit wildlife refuges south of the Delta. This additional water transfer is referred to as the Fall 2000 Transfer. The Fall 2000 Transfer water was to be delivered via the SWP, using available excess pumping capacity at the Banks Pumping Plant. Because the likelihood of available pumping capacity decreases near the end of the year, and due to the benefits to salmon returning to spawn in the Merced River or at the Merced River Hatchery, the decision was made to transfer 16,000 acre-feet in October and 9,000 acre-feet in November.

During October, DWR installed a temporary barrier. As part of the land use agreement allowing for the construction of the Old River Barrier, DWR agreed to remove it if the flow in the San Joaquin River, as measured at the Vernalis gage, exceeded 4,500 cfs. This was an important issue in the scheduling of the Fall Transfer Water.

It became evident in the early stages of planning that in order to meet the desired flow schedule for the Fall 2000 Transfer and not put the Old River Barrier at risk, it would be necessary to schedule some of the Fall SJRA Transfer Water outside of October. Additionally, being able to use the transfer water to bolster flows in November and December would be beneficial to the fisheries. Paragraph 8.4.4 of the Agreement stipulates, "Water purchased pursuant to Paragraph 8.4 may be scheduled for months other than October provided Merced, DFG and USFWS all agree." By letter agreement, Merced, DFG and USFWS agreed to exercise Paragraph 8.4 and allow for the release of Fall SJRA Transfer water in November and December.

The initial daily schedule for the Fall SJRA Transfer called for 7,580 acre-feet to be delivered in October and 4,920 acre-feet to be delivered in December. The initial daily schedule for the Fall 2000 Transfer called for 14,310 acre-feet to be provided in October and 10,690 acre-feet in November (for initial daily schedules, see Appendix B).

Due to a lack of available pumping capacity at the Banks Pumping Plant, the Fall 2000 Transfer was terminated on October 31. As a result, a revised transfer schedule was developed, moving the December Fall SJRA Transfer water to October and November (see Appendix B for the revised schedule). The revised Fall SJRA Transfer water schedule, developed October 31, provided for release of 8,770 acre-feet in October and 3,730 acre-feet in November. At the time of termination of the Fall 2000 Transfer, preliminary data indicated that 13,120 acre-feet had been provided in October.

On November 3, it was announced that excess pumping capacity at Banks Pumping Plant would be available beginning November 6, resulting in another revision to the transfer schedule. This revised Fall SJRA Transfer water schedule (Appendix B) resulted in 8,770 acre-feet provided in October, 750 acre-feet in November and 2,980 acre-feet in December. The revised Fall 2000 Transfer schedule provided 13,120 acre-feet in October and 11,650 acre-feet in November. These values are all preliminary and subject to change.

A preliminary summary of Merced additional water transferred to date is provided in Appendix B.

OAKDALE IRRIGATION DISTRICT (OID)

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement… In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet."

Table 3.1

DAILY TABULATION OF OAKDALE IRRIGATION DISTRICT ADDITIONAL WATER RELEASE

PRELIMINARY
SUBJECT TO CHANGE

[1] CVPIA is the acronym for Central Valley Project Improvement Act.

[2] "Section 3406 b (2) of CVPIA states that 800,000 acre-feet of Central Valley Project yield is dedicated to fish and wildlife."

[3] "Section 3406 b (3) of CVPIA is a program to acquire water for fish and wildlife."

As noted on page 10, OID provided 7,300 acre-feet of supplemental water for the year 2000 VAMP, leaving 3,700 acre-feet of "difference" water. Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 18,700 acre-feet of water to the USBR in 2000.

The OID additional water (3,700 acre-feet) was made available to the USBR on August 16. The 15,000 acre-feet was released by the USBR between October 17 and November 20. Release of the 3,700 acre-feet of "difference" water commenced on November 20 and was completed on December 10. A daily tabulation of the OID additional water release is provided in Table 3-1.

DATE	GOODWIN DAM RELEASE	[1]PRE CVPIA BASE CONDITION RELEASE	[2]B(2) WATER	OAKDALE ID ADDITIONAL WATER RELEASED BY USBR– [3]B(3) WATER		CUMULATIVE OAKDALE ID ADDITIONAL WATER RELEASED
	(cfs)	(cfs)	(cfs)	(cfs)	(acre-feet)	(acre-feet)
Oct 10	311	300	11			
Oct 11	307	300	7			
Oct 12	307	300	7			
Oct 13	313	300	13			
Oct 14	309	300	9			
Oct 15	305	300	5			
Oct 16	304	300	4			
Oct 17	676	300		376	746	746
Oct 18	1,085	300		785	1,557	2,303
Oct 19	1,108	300		808	1,603	3,905
Oct 20	1,109	300		809	1,605	5,510
Oct 21	1,113	300		813	1,613	7,123
Oct 22	1,060	300		760	1,507	8,630
Oct 23	865	300		565	1,121	9,751
Oct 24	659	300		359	712	10,463
Oct 25	478	300		178	353	10,816
Oct 26	382	300		82	163	10,979
Oct 27	379	300		79	157	11,135
Oct 28	383	300		83	165	11,300
Oct 29	384	300		84	167	11,466
Oct 30	376	300		76	151	11,617
Oct 31	376	300		76	151	11,768
Nov 01	386	300		86	171	11,939
Nov 02	388	300		88	175	12,113
Nov 03	386	300		86	171	12,284
Nov 04	384	300		84	167	12,450
Nov 05	382	300		82	163	12,613
Nov 06	380	300		80	159	12,772
Nov 07	382	300		82	163	12,934
Nov 08	383	300		83	165	13,099
Nov 09	382	300		82	163	13,261
Nov 10	378	300		78	155	13,416
Nov 11	379	300		79	157	13,573
Nov 12	377	300		77	153	13,726
Nov 13	376	300		76	151	13,876
Nov 14	378	300		78	155	14,031
Nov 15	385	300		85	169	14,200
Nov 16	385	300		85	169	14,368
Nov 17	384	300		84	167	14,535
Nov 18	383	300		83	165	14,699
Nov 19	380	300		80	159	14,858
Nov 20	377	300		77	153	15,011
Nov 21	383	300		83	165	15,176
Nov 22	378	300		78	155	15,330
Nov 23	380	300		80	159	15,489
Nov 24	381	300		81	161	15,650
Nov 25	382	300		82	163	15,812
Nov 26	385	300		85	169	15,981
Nov 27	378	300		78	155	16,136
Nov 28	378	300		78	155	16,290
Nov 29	380	300		80	159	16,449
Nov 30	380	300		80	159	16,608
Dec 01	386	275		111	220	16,828
Dec 02	385	275		110	218	17,046
Dec 03	383	275		108	214	17,260
Dec 04	383	275		108	214	17,474
Dec 05	386	275		111	220	17,695
Dec 06	386	275		111	220	17,915
Dec 07	387	275		112	222	18,137
Dec 08	384	275		109	216	18,353
Dec 09	382	275		107	212	18,565
Dec 10	386	275		111	220	18,785
Dec 11	384	275	109			
Dec 12	382	275	107			
Dec 13	381	275	106			
Dec 14	382	275	107			
Dec 15	382	275	107			

Old River Barrier

OLD RIVER BARRIER

In 2000, DWR successfully installed and operated the temporary Old River Barrier that included permitting, engineering design, and a short construction schedule. The spring Old River Barrier is a component of the south Delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south Delta and improves water circulation and quality for agricultural purposes.

The spring Old River Barrier was first constructed in 1992 and again in 1994, 1996, 1997 and 2000. The Old River Barrier was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The Old River Barrier was not installed in 1999 due to landowner access problems. The Old River Barrier, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

The Old River Barrier was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of Old River Barrier has been revised on several occasions to accommodate different needs. The most recent design of Old River Barrier provides a wider base to withstand significantly higher flows in the San Joaquin River. The 2000 Old River Barrier was equipped with six 48-inch operable culverts and a weir back-filled with clay.

BARRIER DESIGN AND INSTALLATION

The dimensions of the 2000 Old River Barrier were considerably larger than those constructed in past years Figure 4-1. The base width of the Old River Barrier was increased to 100 feet and the crest elevation was raised to ten feet mean sea level (MSL). The top of Old River Barrier was built with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The larger Old River Barrier was designed to withstand flow stages up to 8.5 feet MSL. A 7,000 cfs VAMP target flow is likely to fluctuate plus or minus 500 cfs under normal circumstances. This fluctuation could result in stages at Old River Barrier within the minimum freeboard zone. A sudden storm event could raise stages enough to cause the Barrier to overtop. Given the experience with Old River Barrier in 2000, and the current flow rating information for Vernalis, DWR does not recommend the 2000 barrier design for study years when VAMP target flows are 7,000 cfs. Also, to safely construct or remove the Barrier, flows at Vernalis must be held below 5,000 cfs.

To help mitigate anticipated low water levels in the south Delta (downstream of the Barrier) caused by the operation of the Old River Barrier, six operable culverts were installed. Operation of the culverts is controlled by a slide gate control structure located on the upstream side of Old River Barrier (Figure 4-1). DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts.

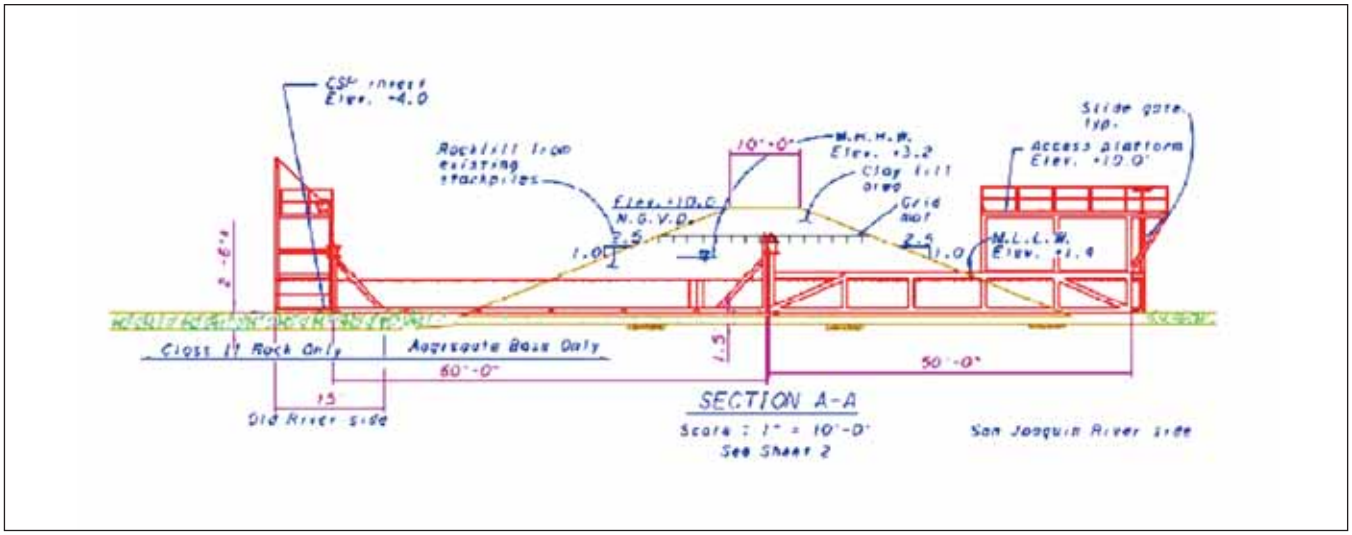
The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2000 Old River Barrier operations (for additional information, see page 18).

Because of the increase in the design flow and the addition of the culverts in the Barrier, DWR protected the existing levees adjacent to Old River Barrier with additional riprap. The riprap extended 300 feet downstream of the Old River Barrier on both banks—protecting the levee from erosion that might occur during the culvert operations or during an emergency breaching.

Head of Old River Barrier

Figure 4.1

HEAD OF OLD RIVER BARRIER CROSS SECTION



BARRIER OPERATIONS AND MONITORING PLAN

DWR obtained permits from the Corps of Engineers and the DFG to install and operate six 48-inch diameter culverts in the Old River Barrier. The culverts permitted flow through the Old River Barrier on an as-needed basis, while ensuring improved flows in the mainstem San Joaquin River.

DWR developed a Barrier operations and monitoring plan. Based on the forecast and monitoring of tidal conditions, DWR would determine the number of culverts to be opened at the Old River Barrier so that water levels at Old River near Tracy Road Bridge, Middle River near Howard Road and Grant Line Canal near Tracy Road Bridge would remain above 0.0 feet MSL. As a result of modeling and/or field monitoring of water levels in the south Delta, culvert slide gates were operated and modified four times between April 16 and May 16. On April 17, two culverts were opened and remained open until the Old River Barrier was removed. On April 27 and 28, the third and the fourth culverts were opened, respectively. The last two culverts were opened on May 11, and all six culverts remained open until the Old River Barrier was breached on May 16.

The daily flows diverted through the culverts varied in response to local tidal conditions and San Joaquin River flow conditions. The characteristics of the flow through the culvert are complicated in that the flow is controlled by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. It is estimated that when the difference in water level across the Old River Barrier is eight feet, the discharge is approximately 150 cfs through each culvert, or a total of about 900 cfs when all six culverts are open.

BARRIER EMERGENCY RESPONSE PLAN

In addition to the operation and monitoring plan, DWR also developed an "Emergency Operations Plan for the Spring 2000 Head of Old River Barrier". In 2000, the plan provided that if the daily flow at Vernalis was measured or forecasted to exceed 8,500 cfs, the Old River Barrier would be removed.

Operation of the Old River Barrier was uneventful with the exception of the first week, as mentioned on page 6. Flow at Vernalis of approximately 7,100 cfs resulted in about 1.8 feet of freeboard remaining on the upstream side of Old River Barrier. During this period, the DWR Division of Flood Management and Division of Engineering evaluated the situation and recommended that the Old River Barrier not be breached. The barrier remained in place until May 15.

SEEPAGE MONITORING

A seepage-monitoring program was initiated in April to evaluate the effects of the operation of the Old River Barrier on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen on Upper Roberts Island. Each site had two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 to determine vertical gradients.

Hourly groundwater levels in each well were recorded with an in situ datalogger/transducer.

In addition to the groundwater monitoring wells, a temporary gage was installed in April 2000 to record water surface stages in the San Joaquin River, about 1,500 feet downstream from the Old

River Barrier. Installation of a permanent tide gage is scheduled for late 2001. The water surface stages are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the San Joaquin River.

The 2000 data for San Joaquin River elevations and groundwater elevations indicates that a strong relationship exists at Site 1, while weaker relationships exist for Sites 2 and 3. There was an almost immediate response between tidal variation and groundwater level fluctuations, indicating water was moving quickly to the islands upper water bearing zones and to the wells. The data indicated however, that while the Old River Barrier was installed in spring 2000, water levels in the wells did not rise high enough to be a concern for farming operations on Upper Roberts Island near the Old River Barrier.

There was an almost immediate response between tidal variation and groundwater level fluctuations, indicating water was moving quickly to the islands upper water bearing zones and to the wells.

FISHERY MONITORING AT THE OLD RIVER BARRIER

Because the potential existed for juvenile Chinook salmon and other fish species to become entrained into the Old River Barrier culverts, fisheries monitoring was designed and conducted by DFG staff. The objectives of fishery monitoring at the Old River Barrier during the 2000 VAMP program were to:

1. Determine the total number of juvenile Chinook salmon and other fish species diverted through the culverts at the Old River Barrier;

2. Determine the entrainment vulnerability of juvenile Chinook salmon during different tidal stages during day and night; and

3. Assess the entrainment loss of coded-wire tagged (CWT) juvenile Chinook salmon released as a result of entrainment in culverts at the Old River Barrier.

Materials and Methods

Nine fyke nets and six live-boxes were constructed for the purpose of sampling in Old River, into the Old River Barrier. Fyke nets, 30 feet in length, were made of ¼-inch braided mesh. The fyke nets were square in cross-section tapering from approximately 48 inches at the mouth to one square foot at the cod end. Each fyke net was equipped with a live box. Live-boxes (15.5 x 19.5 x 36 inches) were constructed of perforated aluminum sheet metal. An aluminum baffle was placed inside each live-box to reduce the flow of water and improve salmon survival.

The mouth of the fyke net was strapped over a 48-inch diameter opening on tracks and lowered down over the culverts out-fall. Rubber flaps were used to seal the spaces between the culvert and the net opening to prevent fish loss. The culverts were slightly twisted during construction of the Old River Barrier and, as a result, the alignment between the net mouth opening and culvert was not exact. Because the alignment was not exact, some leakage of water past the net mouth opening occurred.

Sampling of the live-boxes was accomplished by boat. Most of the time the hydraulic force moving through the net prevented pulling the live-box completely out of the water or from detaching it from the net. As a result, routine inspection of the nets for holes was not possible during sampling.

Operation of two culverts at the Old River Barrier began April 17. Fyke nets were attached to both culvert outlets. While the culverts were being opened, excess bedding material was washed into the fyke nets, immediately filling both nets with small pebbles and rocks. The rock load in both nets during the first few minutes of culvert operation was such that only one net was able to be emptied and retrieved; the second net had to be detached, set adrift, and replaced with another net.

Fyke nets could not be sampled continuously for the duration that the culverts were open. Continuous clogging of nets and live-boxes, coupled with high water velocities through the culverts, placed additional stress on the nets, which eventually tore beyond salvaging. The nets were removed on April 19 and, to prevent scouring and net damage, a heavy-duty vinyl tarp was tied to the bottom of the nets. The modified nets were subsequently used between April 24 and 28. Scouring of the vinyl tarps and damage to the nets persisted until only two good nets remained. Routine sampling was discontinued to preserve the two remaining nets for use in the pending entrainment studies.

Catch-Per-Unit-Effort (CPUE) for unmarked Chinook salmon was calculated as the number collected per hour. For purposes of these calculations, net efficiency was assumed to be 100 percent, regardless of the number of holes and tears that were found in the nets. In reality however, net efficiencies were probably much lower.

A loss index for CWT salmon released upstream of the Old River Barrier as part of VAMP survival studies was calculated from data collected April 17 through 28. Based on the number of CWT

salmon released as part of VAMP at Durham Ferry and Mossdale, and the total number of CWT salmon collected during sampling at the Old River Barrier, an index of CWT salmon loss downstream of the Old River Barrier was calculated as:

$$I = (TC/TR)(TT/ST)$$

Where:

TC Total number of CWT salmon collected

TR Total number of CWT salmon released

TT Total time (hours) during the test period

ST = Total time sampled at the Old River Barrier during the test period

Entrainment Study

One day and one night release of individually marked groups of juvenile Chinook salmon from the Merced River Hatchery were made at two different locations—directly in front of the Old River Barrier and approximately 500 feet upstream of the Old River Barrier in the San Joaquin River—during the low ebb and high flood tidal cycles. A release scheduled to occur on May 4 during the peak low tide was delayed by a few hours due to difficulties in identifying color-marked salmon.

Merced River Hatchery juvenile Chinook salmon were color-marked at the hatchery with either Meta-Jet dye or photonic fluorescent microspheres. The salmon were then transported from the hatchery to the San Joaquin River and placed in 4x10x4 foot live cages lined with 3/16-inch mesh netting. The test fish were held in the live-cages for ten or more hours to both reduce handling stress and observe any mortality before being released.

Groups of approximately 2,000 juvenile salmon were released immediately upstream of the Old River Barrier. Further upstream, the groups consisted of about 3,000 marked salmon. One particular release group of 2,000 fish experienced 92 percent mortality due largely to being accidentally dropped on the riprap bank before being placed in the live-cages.

Night releases during high and low tidal cycles were made during the evening of May 3 and early morning of May 4. Day releases for both tidal cycles were made during the morning and afternoon of May 11.

Though four culverts were in operation during the May 3 and 4 entrainment tests, only two nets were in suitable condition for sampling. The two nets were removed from the culverts after the first study to avoid damage prior to their use in the second entrainment study. During the second entrainment study, all six culverts were in operation, while again only two nets were available and suitable for sampling.

After both entrainment studies were completed, the nets were inspected and found to have only minor holes in them. The percent of color-marked fish recovered in the nets relative to the number released was used as an index of entrainment vulnerability at the Old River Barrier.

Results and Discussion

Throughout the April 17 to May 16 study period, the number of culverts operated at the Old River Barrier and the number of fyke nets installed varied (Table 4-1). The total hours that the culverts were in operation during the April 17 through May 11 sampling period was approximately 1,800 hours. This was the sum of hours that each culvert was in operation. Total sampling time for all fyke nets combined was 374 hours and ranged from 0.83 to 25.4 hours.

Twenty-six fish species were collected in the fyke nets during Old River Barrier fish monitoring (Table 4-2). Chinook salmon (3,813) and white catfish (1,009) were the two most abundant species collected. Very few delta smelt (1) or splittail (5) were collected (Table 4-2).

A total of 3,813 Chinook salmon were collected in the fyke nets at the Old River Barrier culverts, including:

- 499 CWT Chinook salmon
- 631 Unmarked Chinook salmon (Natural)
- 2,683 Color-marked Chinook salmon (Entrainment study)

The CPUE for unmarked Chinook salmon ranged from 0.0 to 18.8 per net per hour, averaging 1.7 fish per hour. The greatest number of unmarked Chinook salmon (245) was collected on May 4. However, this was during the entrainment study and it is possible that some of the color-marks may not have been identified, and were therefore placed in the unmarked (natural) category. The greatest number of CWT salmon (318) was collected on April 18.

The CPUE for CWT salmon was not calculated because of the variability in release dates and sampling dates. Instead, a period of time (April 17–28) when fyke nets were sampling coincident with CWT Chinook salmon releases upstream of the Old River Barrier at Mossdale and Durham Ferry was selected (see Figure 1-1). During this period, CWT salmon releases upstream as part of VAMP and DFG gear effieciency studies at Mossdale, totaled 133,412 fish. The fyke nets sampled for 265 hours between April 17 and 28, while the culverts were in operation for 566 hours. A total of 471 CWT salmon were collected during that period at the Old River Barrier. Assuming the nets were installed long enough for CWT salmon to move beyond the Old River Barrier and that there was no mortality or predation during transit to the Old River Barrier, using an "overestimated" measure of net efficiency (100 percent), an index of entrainment through the culverts was calculated as approximately 0.75 percent. A more exact percentage by release group can be estimated once the tags from the CWT salmon are read.

In 1997, a similar study was performed when two culverts were constructed within the Old River Barrier. The entrainment index for CWT Chinook salmon in 1997 was 0.6 percent. Release and recapture information for the entrainment study is summarized in Table 4-3.

The percent of color-marked salmon collected was extrapolated to account for the number of nets used and culverts operated. The percent recoveries for color-marked Chinook salmon through the culverts ranged from 68.1 to 138.2 percent (see Table 4-3) for those groups released adjacent to the Old River Barrier, and 0.1 to 17.1 percent for those released upstream of the Barrier. The percent recoveries greater than 100 percent suggest that Chinook salmon smolts are probably more susceptible to entrainment by certain culverts.

The largest range in percent recoveries between tides for color-marked salmon occurred during the day, suggesting that juvenile salmon may congregate more during the day and may disperse in the water column during the evening. The percent recoveries of color-marked Chinook salmon were highest for all release groups during the low tide, except for one color-marked group released upstream of the Old River Barrier three hours after the low tide. This group was released during the flood tide, which could have affected the results.

It is evident that color-marked salmon released in front of the Old River Barrier were more vulnerable to entrainment than those released further upstream because they were less able to disperse and avoid the culverts. Therefore, entrainment vulnerability at the 2000 Old River Barrier for natural or CWT salmon migrating downstream in the San Joaquin River is probably better represented by salmon released upstream of the Barrier resulting in greater dispersal and lower percent recoveries (0.1 to 17 percent). This compares to an estimate of 0.75 for the CWT salmon in the monitoring study. Also, the percent recovery for salmon released upstream of the Old River Barrier was not consistent between tidal cycles during day and night releases. This may indicate that there is less influence from tidal cycles on juvenile salmon further upstream of the Old River Barrier, or that there is some degree of loss between upstream releases and the Barrier. The results of this study indicate that tides and the photoperiod may influence Chinook salmon entrainment at the Old River Barrier. A similar study is planned for 2001 with improved net design to increase their longevity and thus, provide for a more continuous sampling downstream of the Old River Barrier. In addition, DFG plans to implement a juvenile Chinook salmon South Delta survival study to monitor migration routes and survival of marked Merced Fish Hatchery juvenile Chinook salmon through South Delta channels downstream of the Old River Barrier.

Table 4.1

CULVERT & NET OPERATION SCHEDULE
AT THE OLD RIVER BARRIER

DATES OF CULVERT OPERATION	NUMBER OF CULVERTS OPERATED	DATES FYKE NETS WERE USED	NUMBER OF FYKE NETS USED
Apr 17– Apr 27	2	Apr 17– Apr 19 & Apr 24– Apr 27	2
Apr 27– Apr 28	3	Apr 27– Apr 28	3
Apr 28– May 11	4	Apr 28 & May 2– May 4	4 2
May 11– May 16	6	May 11	2

Table 4.2

NUMBER OF FISH SPECIES COLLECTED IN FYKE NETS
FROM APRIL 17 THROUGH MAY 11, 2000

American Shad	1
Delta Smelt	**1**
Shimofuri Goby	1
Smallmouth Bass	1
Tule Perch	1
White Crappie	1
Brown Bullhead	2
Black Bullhead	2
Inland Silverside	2
Riffle Sculpin	2
Green Sunfish	3
Largemouth Bass	3
Log Perch	4
Sacramento Blackfish	4
Splittail	**5**
Goldfish	6
Redear Sunfish	8
Striped Bass	9
Black Crappie	10
Bluegill	18
Threadfin Shad	41
Sacramento Sucker	46
Channel Catfish	104
Carp	148
White Catfish	1,009
Total Chinook Salmon	**3,813**
CWT Chinook Salmon	499
Unmarked Chinook Salmon	631
Color-Marked Chinook Salmon	2,683
Total	5,245

Table 4.3

NUMBER OF COLOR-MARKED CHINOOK SALMON RELEASED & PERCENT RECOVERED DURING THE EVENING
(MAY 3 AND 4) & DAY (MAY 11, 2000)

RELEASE LOCATION	NUMBER OF FISH RELEASED	TIDE PHASE AT RELEASE	NUMBER COLLECTED	PERCENT RECOVERED	EXTRAPOLATED PERCENT RECOVERED
Night Releases (May 3 and 4)					
Upstream	3,009	High	93	3.10	6.20
	3,017	Low	16	0.50	1.10
Adjacent	2,014	High	934	46.40	92.80
	157	Low	104	66.20	132.50
Day Releases (May 11)					
Upstream	2,998	High	1	0.03	0.10
	2,999	Low	171	5.69	17.10
Adjacent	2,141	High	486	22.70	68.10
	1,904	Low	877	46.10	138.20

Smolt Survival

VAMP 2000 SALMON SMOLT SURVIVAL INVESTIGATIONS

This section describes the methods used in conducting the VAMP 2000 Chinook salmon survival investigations and presents results of the calculated survival indices and absolute survival rates for juvenile Chinook salmon during the VAMP 2000 test period. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Hatchery Chinook salmon smolts, released as part of VAMP 2000, were coded-wire tagged between March and early April. After the salmon were tagged, they were held in the hatchery for 14 to 21 days before being released. The day before a group of salmon was to be released, a sub-sample of the salmon was measured for length and checked for retention of the coded-wire tags. The sub-sample was typically comprised of 100 to 300 salmon collected from the top, middle, and bottom of the release group's raceway. Each tag code within a release group was held separately at the hatchery with the exception of the three tag codes made up of the second Durham Ferry release that were held together in one section of the raceway. This group was released on April 28.

Though tag retention is usually quite high, as a double check on the tag detector, all salmon from the sub-sample that had no tag detected were sacrificed. These sacrificed salmon were dissected to determine whether they might contain an unmagnetized tag. A separate sub-sample of 25 salmon was sacrificed from each release group; the tags were removed and read to detect any incorrect tag codes in the raceways. The year 2000 tag retention rates were slightly lower than observed in previous years. As a result of the observed tag retention rates, tagging machines will be evaluated prior to VAMP 2001. Old tagging machines require more frequent maintenance and more careful examination to insure the best quality tagging. Table 5-1 summarizes the results of the CWT retention rate and the estimate of the effective numbers of salmon released to calculate survival indices.

CWT RELEASES

CWT salmon from Merced River Hatchery were released at Durham Ferry, Mossdale, and Jersey Point (see Figure 1-1). VAMP 2000 was the first year in which salmon have been released at Durham Ferry, located approximately 11 miles upstream of Mossdale. The release site at Durham Ferry was selected to address the concern that salmon released at Mossdale could disperse into Upper Old River at a higher rate than those originating from the San Joaquin River tributaries during periods when the Old River Barrier was not in place. Releasing the fish at Durham Ferry allowed them to disperse more similarly to juvenile salmon originating from the San Joaquin tributaries. In order to compare the results from one year to the next, the Durham Ferry site will be used in future VAMP survival studies.

CWT salmon were released on April 17 at Durham Ferry, April 18 at Mossdale and April 20 at Jersey Point (see Table 5-1). A second set of releases were made at Durham Ferry on April 28 and at Jersey Point on May 1. Because of the limited number of CWT salmon from the Merced River Hatchery, an additional release was made at Jersey Point on May 1 from the Mokelumne River Hatchery. The use of salmon from the Mokelumne River Hatchery at Jersey Point provided an opportunity to explore the possibility of using further such stock in future years to supplement downstream VAMP releases.

Approximately 75,000 salmon, in three separate tag lots, were released at Durham Ferry, while 50,000, in two tag lots, were released at both Mossdale and Jersey Point (see Table 5-1). While in past years, each release group was trucked from the hatchery and released simultaneously as one large composite group, during VAMP 2000, groups of 25,000 CWT salmon were transported to the sites in separate compartments of the trailer and each tag lot was released five to 15 minutes apart. The group released at Durham Ferry on April 28 had the three tag lots mixed and did not adhere to this protocol.

Merced River Hatchery

Table 5.1

NUMBER OF CODED-WIRE TAGGED JUVENILE CHINOOK SALMON
FROM THE MERCED RIVER HATCHERY RELEASED AS PART OF VAMP 2000.

RELEASE DATE	CWT CODE	RELEASE SITE	AVERAGE FLOW	NUMBER RELEASED	TAG RETENTION RATE	EFFECTIVE NUMBER RELEASED
Apr 17	064563	Durham Ferry	80	26,476	0.924	24,457
Apr 17	060401	Durham Ferry	80	25,980	0.906	23,529
Apr 17	060402	Durham Ferry	80	25,904	0.924	24,177
Apr 18	064401	Mossdale	79	26,391	0.865	23,465
Apr 18	064402	Mossdale	79	25,969	0.858	22,784
Apr 20	064404	Jersey Point	82	26,335	0.981	25,824
Apr 20	064403	Jersey Point	82	26,301	0.971	25,527
Apr 28	0601060915	Durham Ferry	77	28,295	0.947	26,805
Apr 28	0601110814	Durham Ferry	77	25,216	0.947	23,889
Apr 28	0601060914	Durham Ferry	77	25,014	0.947	23,698
May 1	0601061001	Jersey Point	78	26,059	0.981	25,572
May 1	0601061002	Jersey Point	76	26,235	0.940	24,661
April 19–May 3	064405	Mossdale	86	25,798	0.906	23,371

The group released at Jersey Point from the Mokelumne River Hatchery included two 50,000 tag codes, released as a single group of 100,000 salmon.

The water temperature in the hatchery truck and San Joaquin River was measured at the release site immediately prior to release. This information, as well as additional release information, is provided in Table 5-2.

WATER TEMPERATURE MONITORING

The water temperature was monitored during the VAMP 2000 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). The water temperature was measured at locations along the longitudinal gradient of the San Joaquin River and interior Delta channels between Durham Ferry and Chipps Island—locations of the migratory pathways for the juvenile Chinook salmon that were released as part of these tests. The water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2000 investigations.

The water temperature was also recorded within the hatchery raceways at both the Merced and Mokelumne River hatcheries coincident with the period when juvenile Chinook salmon were being tagged. The water temperature was also recorded for one release group from each hatchery in the transport truck, and for a two-day post release observation period. Results of water temperature monitoring during the VAMP 2000 study period are summarized in Appendix C.

POST-RELEASE LIVE-CAR STUDIES

Survival and Condition

The post-release survival of marked salmon was evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Net pen studies were conducted where approximately 200 salmon from each CWT release group were held in live cars for 48 hours after release in order to monitor for any direct and short-term mortality. In addition to the salmon examined in the net pen studies, two groups of 25 salmon from each tag group were evaluated based upon overall condition at release and 48 hours after release. To assess overall condition, fork length in millimeters, weight in grams, eye condition, body color, the presence of fin hemorrhaging, percent scale loss, gill color and vigor were examined. Obvious abnormalities or deformities were also noted.

Table 5.2

VAMP 2000 CODED WIRE TAG RELEASES & RECAPTURES

AT ANTIOCH, CHIPPS ISLAND, & CENTRAL VALLEY PROJECT (CVP), & STATE WATER PROJECT (SWP) FISH FACILITIES

TAG CODE	RELEASE SITE / STOCK	DATE	TRUCK TEMP	RELEASE TEMP (centigrade)	NUMBER RELEASED	AVERAGE SIZE (mm)	NUMBER RECOVERED AT ANTIOCH	PERCENT SAMPLED AT ANTIOCH
06-04-01	Durham Ferry (MRFF)		13.0	14.0	23,529	80	6	0.337
06-04-02	Durham Ferry (MRFF)		13.0	14.0	24,177	80	10	0.337
06-45-63	Durham Ferry (MRFF)		12.5	14.0	24,457	80	11	0.342
	Total	Apr 17			72,163		27	0.342
06-44-01	Mossdale (MRFF)		11.1	13.3	23,465	79	14	0.332
06-44-02	Mossdale (MRFF)		11.1	13.3	22,784	79	16	0.340
	Total	Apr 18			46,249		30	0.340
06-44-03	Jersey Point (MRFF)		12.2	18.0	25,527	82	50	0.325
06-44-04	Jersey Point (MRFF)		11.7	18.0	25,824	82	47	0.327
	Total	Apr 20			51,351		97	0.327
06-01-06-09-14	Durham Ferry (MRFF)		11.1	16.7	23,698	77	8	0.408
06-01-06-09-15	Durham Ferry (MRFF)		11.1	16.7	26,805	77	15	0.313
06-01-11-08-14	Durham Ferry (MRFF)		11.1	16.7	23,889	77	8	0.350
	Total	Apr 28			74,392		31	0.313
06-01-06-10-01	Jersey Point (MRFF)		11.7	17.2	25,572	78	76	0.353
06-01-06-10-02	Jersey Point (MRFF)		11.7	17.2	24,661	76	76	0.315
	Total	May 1			50,233		152	0.315
06-02-53	Jersey Point (MOK)				50,445	87	106	0.355
06-02-54	Jersey Point (MOK)				51,167	85	110	0.353
	Total	May 1			101,612		216	0.355
06-44-05	Mossdale (MRFF)	April 19–May 3	13.0	16.0	23,288	86	9	0.339

NOTE: MRFF denotes Merced River stock.
MOK denotes Mokelumne River stock.

AND SURVIVAL INDICES

SURVIVAL INDEX AT ANTIOCH	GROUP SURVIVAL AT ANTIOCH	NUMBER RECOVERED AT CHIPPS	PERCENT SAMPLED AT CHIPPS	SURVIVAL INDEX AT CHIPPS	GROUP SURVIVAL AT CHIPPS	EXPANDED SALVAGE CVP	EXPANDED SALVAGE SWP
0.054		7	0.26	0.149		24	144
0.088		10	0.261	0.206		24	132
0.095		11	0.259	0.226		12	185
	0.079	28	0.261		0.193		
0.130		9	0.259	0.192		12	213
0.149		9	0.258	0.199		12	220
	0.137	18	0.259		0.195		
0.433		24	0.264	0.463		0	0
0.401		41	0.264	0.782		0	0
	0.416	65	0.264		0.623		
0.059		7	0.256	0.150		12	75
0.128		5	0.254	0.096		24	96
0.069		10	0.264	0.206		12	60
	0.096	22	0.262		0.147		
0.606		48	0.257	0.949		0	3
0.704		30	0.254	0.623		0	3
	0.692	78	0.258		0.782		
0.427		95	0.252	0.971		0	5
0.439		74	0.256	0.734		0	0
	0.431	169	0.254		0.8512		
0.082		7	0.258	0.151		12	144

The eye condition was assessed based on whether the eyes appeared normally shaped or were bulging while the body color was assessed relative to the darkness of the black spot pigmentation on the dorsal side of the fish and its contrast to the green body color. Fin hemorrhaging was judged based on whether there were spots of blood on or at the base of the fins. Percent scale loss was judged on a scale between 0 to 100 percent and gill color was based on lifting the operculum and ranking the darkness of red of the gills. Normal was considered beet red to dark cherry red and poor was considered light red to grayish/whitish in color. Vigor was considered normal if the fish were active and poor if the salmon were lethargic or motionless.

Results of the evaluations of marked fish in the live cars both immediately after release and 48 hours later showed very few abnormalities in the condition characteristics assessed (Appendix C). Of the 1,283 salmon assessed, 10 had no adipose fin clip while 23 were found to have a poor fin clip. A total of nine had deformation, four of which were caudal and five of which were operculum. In summary, the percentage of salmon deformed within the sample group, 0.7, is within the normal range at a hatchery. (S. Foott, personal communication.)

It appears that overall the salmon used for VAMP 2000 survival experiments were healthy and in good condition, though one was found dead in the live-car and another, in addition to most of those in the net pen at the April 17th Durham Ferry release, appeared to have escaped during the 48-hour post-release holding and observation period.

It appears that overall the salmon used for VAMP 2000 survival experiments were healthy and in good condition …

Physiology

Physiological studies were conducted by the USFWS California-Nevada Fish Health Center on VAMP 2000 salmon as reported by Nichols et al. (2000). Tests were conducted on a sub-sample of the salmon smolts released at Durham Ferry, Mossdale and Jersey Point after they had been held in the live cars for approximately 24 hours. Forty-two salmon were sampled at each site, with the exception of those from the first release at Durham Ferry where only 12 were available because the rest escaped from the net pens. The salmon were euthanized with an overdose of tricain methane sulfonate (MS222), and then measured and evaluated using organosomatic analyses. Tissue samples were collected for pathogen and physiological assays. Organosomatic analysis included length, weight, and observations of any abnormalities. Blood samples were processed to determine hematocrit and leukocrit measurements and to collect plasma.

Conditions factors (K) were calculated for each fish based on fork length and weight based on the formula: $K=Wt/L^3 * 10^5$. Kidney tissue was checked for bacterial pathogens and the internal organs were examined for parasites and abnormalities. Samples of gill tissue were assayed for gill Na+, K+ - ATPase levels as an indicator of saltwater readiness (smolting). Plasma glucose and chloride levels were analyzed to determine the ability of the salmon to adapt to stress. Measurements were made using both stressed and unstressed salmon. The "unstressed" salmon were removed from the net pen as quickly as possible and immediately euthanized while the stressed fish were held out of the water for 30 seconds, and sampled after they were allowed to recover for 45 minutes.

On April 13, 60 salmon were sampled at random from the entire hatchery population in the Merced River Hatchery. These salmon were evaluated in terms of organosomatic analysis, ATPase, histology, bacteriology and virology. Stress physiology evaluations were not conducted on salmon from the Merced River Hatchery.

Results from the physiological tests indicated that all release groups appeared healthy with no significant abnormalities. No viral or bacterial pathogens were detected. Early infections of the PKX parasite (early stage of proliferative kidney disease) were detected in two salmon by histology. Stress treatments demonstrated healthy energy reserves and plasma ion levels in all groups examined.

Based on physiological testing, Nichols et al. (2000) reported that, "Eosinophilic granular cells (EGC's) were quite prominent in the lamina propria layer of the intestine and pyloric caeca from approximately half of each sample group. These immunodefensive cells are found in many organs, particularly those in direct contact with the environment such as gill, skin, and digestive tract. They are often associated with parasitic infections and contain both peroxicdase and lysozyme (Sveinbjornsson et al. 1996, Sire and Vernier, 1995). Earlier assumptions that EGC's acted as mast cells have been found to be incorrect as histamine is not present (Sire and Vernier 1995). While it is not unusual to see in adult Chinook, they have not been observed in such high numbers in the intestines of juvenile Chinook salmon from the Sacramento and Klamath rivers. No lesions or parasites were associated with the EGC's found in the Merced River Hatchery salmon."

Not only were these high EGC levels found in Chinook salmon at the Merced River Hatchery, they were also found in samples from the natural stock in the San Joaquin basin (Scott Foott, personal communication). Although Nichols et al. (2000) suggests that the observed high levels of EGC cells in San Joaquin River salmon stocks may be due to genetic differences (Chinook from the San Joaquin basin are at the farthest southern extent of their range), further evaluation of these results may be warranted.

Tag Quality Control

The subset of 25 salmon from each tag group (25 from the April 28 Durham Ferry release group) held in the net pens (50 to 75 per release group) were sacrificed and used to verify tag codes. Though rare, on few occasions in the past, salmon from different release groups have been mixed. It is not certain why the mixing of salmon from different release groups occurs. Additional CWT salmon from each release group have been archived, if needed, to further evaluate VAMP 2000 tag quality control.

CWT SALMON RECAPTURE SAMPLING

CWT salmon were recaptured at Antioch and Chipps Island and at CVP and SWP Fish Salvage Facilities (See Figure 1-1). Juvenile Chinook salmon with adipose fin clips caught at any of these sampling locations and during the Old River Barrier sampling were sacrificed, labeled, and frozen pending CWT processing. An adipose fin clip identifies juvenile Chinook salmon that are CWT. CWT processing and reading was done in the FWS Stockton laboratory for fish recovered at Chipps Island, Antioch, and SWP/CVP salvage facilities. Both the Stockton FWS office and the DFG Region 4 laboratory in Fresno processed marked salmon recovered in the Old River Barrier sampling. CWT salmon released upstream of Mossdale were also recovered in DFG Kodiak trawls at Mossdale. Any CWT's recovered in the Mossdale trawl sampling were processed by DFG Region 4 in Fresno.

CWT processing entails dissecting each tagged fish to obtain the half (0.5 millimeters) and full (1 millimeter) cylindrical tag from its snout. The tags are then "read" under the microscope by determining the code etched on multiple sides of the tag. Tags were read twice, with any discrepancies resolved by a third reader. All tags were archived for future reference.

SWP/CVP Salvage Recapture Sampling

Sampling at the CVP and SWP Fish Salvage Facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) were "expanded" based on the number of minutes sampled during each two hour time period. The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group estimated for each time period. Only the CWT salmon recovered in the raw salvage collections were sacrificed for tag decoding. Expanded salvage does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2000 studies are shown in Table 5-2. Salvage numbers were low at the CVP and higher at the SWP. The Old River Barrier appears to lessen the number of marked salmon recovered at the CVP as compared to the number recovered at the SWP: in 1999, when the Old River Barrier did not exist, expanded salvage was more similar between the two facilities (Brandes and McLain forthcoming). Results of CWT recaptures for marked salmon released in the San Joaquin River tributary studies are documented in Appendix C.

Antioch Recapture Sampling

Fishery sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (see Figure 1-1) using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to ¼-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is six feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All fish collected were transferred immediately from the Kodiak trawl to buckets filled with river water, where the fish were held during processing. Data collected during each trawl included identification and measuring the fork length of fish collected, tow start time and duration and location in the channel. Mortality and damage to fish collected was documented to comply with the Endangered Species Act permit compliance.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while unmarked salmon, steelhead, delta smelt, splittail, and other fish were released at a location downstream of the sampling site immediately after identification, enumeration and measurement.

Sampling at Antioch was initiated April 19 and continued through May 21. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 12 to 29 20-minute tows were conducted. All told, 751 Kodiak trawl samples were collected, representing a total sampling duration of 14,842 minutes. During the sampling, a total of 4,827 unmarked juvenile Chinook salmon and 1,257 salmon with an adipose fin clip (CWT) were collected.

Chipps Island Recapture Sampling

Sampling at Chipps Island (see Figure 1-1) was conducted daily between April 1 and June 19. One shift of trawling (approximately ten, 20-minute tows per day) was conducted between April 1 and April 17 and again between May 21 and June 19. Between April 17 and May 20, two daily shifts (20, 20 minute tows per day) were conducted. The two shifts included dawn and dusk sampling, similar to the sampling regime used in 1998 and 1999.

Prior to 1998, ten 20-minute tows were made per day with sampling beginning at approximately 7:00 a.m. and ending around 12:00 (noon). With the addition of a second shift, the first shift began at daybreak. The second shift began in the late afternoon and concluded just after dark. It was hypothesized, based on an analysis of salmon smolts caught at Jersey Point throughout a 24-hour sampling period in 1997, that the greatest number of salmon would be caught during dawn and dusk. Changing the starting time of the first shift and doubling the effort at Chipps Island was intended to increase the numbers of CWT salmon recaptured and reduce the variability in VAMP survival indices.

The mid-water trawl net, towed at the surface near Chipps Island, had a mouth opening of ten by 30 feet. The net tapered from the mouth to the cod end with its length totaling 82 feet. Net mesh varied from four inches to ¼ inch at the cod end. Lead weights were attached to the bottom rib line of the net and floats attached to the top rib line. A metal depressor door was fastened to each bottom bridle line and an aluminum hydrofoil was fastened to each top bridle line to keep the net orientated and fishing properly.

Sampling at Chipps Island was conducted in three trawl lanes: north, south and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled four times. This was an attempt to sample evenly across the channel to provide the best estimate of the number of marked salmon surviving to Chipps Island.

CWT salmon released as part of the VAMP program were recovered at Chipps Island between April 22 and May 21. During this period, a total of 12,843 unmarked salmon, 1,999 CWT salmon, 97 delta smelt, 1,125 splittail, 11 adipose-clipped steelhead and 20 wild steelhead were recovered. Of the 1,999 CWT salmon recovered, only 211 were from Merced River Hatchery origin released as part of the VAMP study (see Table 5-2). A total of 169 CWT salmon were recovered as part of the Jersey Point release using Mokelumne River fish.

VAMP 2000 CHINOOK SALMON CWT SURVIVAL INDICES

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Chipps Island and Antioch. Survival indices were calculated by dividing the number of CWT salmon recovered by the effective number released and the fraction of time and channel width sampled. The fraction of the channel width sampled at Chipps Island (0.00769) was the net width (30 feet) divided by an estimate of the channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was based on the net width (25 feet) used at Antioch divided by an estimate of the channel width (1,800 feet) at Antioch. The fraction of time sampled, at both locations, was calculated based on the number of minutes sampled, between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period. The percent of time sampled for the VAMP 2000 release groups at Chipps Island was roughly 26 percent, while at Antioch it ranged between 31 and 41percent.

The survival indices of the separate tag codes are calculated to provide a sense of the variability associated with the index. To generate the survival index for each group, the recovery numbers and release numbers are combined within the group to estimate a composite survival index for the combined tag codes within a release group. This results in a slightly different index than would be generated by taking the mean of the survival indices of the individual tag codes within a group. Although it has not been done, it may now be more appropriate to calculate a mean survival from the two or three independent tag groups released within a group for the 2000 VAMP releases when they were held and released as independent groups.

The survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2000 are shown in Table 5-2. Survival indices for the composite release groups are summarized in Table 5-3.

Survival indices from the release locations to Antioch were generally lower than those at Chipps Island. This is contrary to what would be expected since Antioch is closer to the release locations than Chipps Island. This may be a result of the marked salmon not being equally distributed or vulnerable to the trawls throughout the 24-hour period and the expansions for effort may be biasing the Chipps Island estimates high. Further evaluation of these differences is warranted.

More important than the raw survival indices between locations are the comparisons of the survival indices within the same recovery location and the trends between the groups using the two recovery locations. The use of absolute survival estimates, where the survival index of the upstream release group is divided by the survival index of the downstream group (recovered at the same location), is most useful for between year comparisons.

The first and second Durham Ferry releases had survival indices at Antioch of 0.08 and 0.10, respectively. Survival indices at Chipps Island were 0.19 and 0.15. The individual tag code survival indices at Antioch and Chipps Island showed overlap within each of the groups and similar values between the two Durham Ferry groups, such that there may be no true difference between the two groups (see Table 5-2). Based on this information, it appears that the two Durham Ferry groups survived at similar rates.

The survival indices of the first and second releases at Jersey Point ranged from 0.42 to 0.69 at Antioch and 0.62 and 0.78 at Chipps Island. The second group released at Jersey Point on May 1 appeared to survive at a higher rate than the first group, based on results from both recovery locations. However, the overlap in individual tag code survival indices at Chipps Island between the two Jersey Point groups suggest that there may not be a true difference between these two releases (see Table 5-2). Recoveries at Antioch suggest that the second Jersey Point release group (May 1) did survive at a higher rate than the first release group (April 18). As part of the VAMP 2000 experimental design, releases were made at both Mossdale and Durham Ferry to determine how survival differed between these two locations. Results of the release at

Table 5.3

SURVIVAL INDICES
CALCULATED FOR VAMP 2000

RELEASE SITE & RELEASE DATE	RECAPTURE SITE	
	Antioch	*Chipps Island*
Durham Ferry: April 17	0.08	0.19
Mossdale: April 18	0.14	0.20
Jersey Point: April 20	0.42	0.62
Durham Ferry: April 28	0.10	0.15
Jersey Point: May 1[1]	0.69	0.78
Jersey Point: May 1[2]	0.43	0.85
Mossdale: April 19–May 3	0.08	0.15

[1] Merced River Hatchery stock [2] Mokelumne River Hatchery stock

Mossdale on April 18 and at Durham Ferry on April 19, using Antioch recoveries, indicated that the survival index was higher from the release at Mossdale (0.14) than for the Durham Ferry release (0.08). This result was expected considering that migration for marked salmon released at Durham Ferry is approximately 11 miles longer than salmon released at Mossdale. In contrast, survival indices calculated based on the recoveries at Chipps Island indicate that there was no substantial or detectable mortality between Durham Ferry (0.19) and Mossdale (0.20). Individual survival indices in the Durham Ferry and Mossdale groups did not overlap between groups using the Antioch recovery indices, but did overlap for Chipps Island recoveries (see Table 5-2). Further exploration to define true differences in survival for Mossdale and Durham Ferry releases would be helpful.

Two sets of releases were made at Mossdale that provide an additional comparison between the two recovery locations. The first group, released on April 18, was released as part of the VAMP 2000 studies. The second group was released between April 19 and May 3 to provide efficiency estimates of the DFG Kodiak trawl used at Mossdale to estimate survival for upstream tributary releases made by the DFG, Region 4. The survival index, for the DFG group released at Mossdale for the trawl effieciency evaluation between April 19 and May 3, would normally be calculated by first subtracting those recovered in the Mossdale trawl. But because so few were actually caught (6), subtracting prior to calculating survival indices was not done. The Antioch survival indices were 0.14 and 0.08, while the survival indices at Chipps Island were 0.20 and 0.15, respectively

for the April 18 and April 19–May 3 Mossdale releases. Both sets of indices support the conclusion that the second release made over the course of 15 days survived at a lower rate than the group released on April 18. No overlap in the individual tag code survival indices between groups for either the Antioch or Chipps Island recoveries existed (see Table 5-2), giving more credence to the conclusion that survival rates were different between the two release groups.

Potential differences between the survival indices for the paired groups of Merced and Mokelumne hatchery salmon released at Jersey Point on May 1 are not as clear. The recoveries at Antioch appeared to show that the Mokelumne River Hatchery stock had a lower survival than the Merced River Hatchery stock. In contrast, recoveries at Chipps Island indicated that survival was higher for the Mokelumne group than for the Merced group. Again, there seemed to be greater overlap within the group survival indices using the Chipps Island recovery information than the Antioch recovery information, giving less confidence in the true differences in the Chipps Island recovery data (see Table 5-2). It is recommended that further investigations and analyses be performed to compare survival for Mokelumne River and Merced River stocks released at Jersey Point, and to further understand why the trends between groups are not consistent between the survival indices generated using Antioch and Chipps Island recoveries.

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES FOR VAMP 2000

Absolute survival rates (or standardized survival) were estimated using the ratio of the survival indices of smolts released at Durham Ferry and Mossdale in relation to those released at Jersey Point. These absolute survival estimates are more powerful for use in comparing survival rates as a function of flow and export rates among years, since the use of ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Thus, two independent estimates of absolute survival have been calculated for VAMP 2000 using recoveries at both Chipps Island and Antioch. An additional estimate of absolute survival will be possible from recoveries from the ocean fishery in 2 ½ years following release.

Absolute survival estimates for VAMP 2000 are summarized in Table 5-4, using data from Table 5-2.

These absolute estimates of survival and both sets of recovery information indicate that the April 17 Durham Ferry group survived at a slightly higher rate than the April 28 group. The variability around each estimate is likely such that there is no true difference in survival between the two Durham Ferry releases.

Absolute estimates of survival between Mossdale and Jersey Point were 0.33 based on the Antioch indices versus 0.31 based on the Chipps Island indices indicating a good agreement between survival estimates based on the two separate recovery locations.

Table 5.4

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES FOR VAMP 2000

REACH	RECOVERY SITE	
	Antioch	*Chipps Island*
Durham Ferry to Jersey Point [1]	0.19	0.31
Durham Ferry to Jersey Point [2]	0.14	0.19
Mossdale to Jersey Point [3]	0.33	0.31

[1] April 17 Durham Ferry Release [2] April 28 Durham Ferry Release
[3] April 18 Mossdale Release

Comparison of absolute survival estimates between Mossdale (April 18) and Durham Ferry (April 17) release groups indicated that survival was lower for the Durham Ferry release based on Antioch survival indices, whereas absolute survival indices were similar using the Chipps Island recovery data. This apparent discrepancy in absolute survival between the two recovery locations requires further analysis and investigation. It was hoped that with absolute survival estimates and multiple recovery locations, similar trends in salmon survival would be detected and provide additional support for evaluating the effects of river flow and exports on salmon smolt survival. Inconsistent trends and survival estimates between the two recovery sites may be the result of high variability in one or both sets of recovery data. Further investigation of the variability in survival between the two recovery locations is needed.

TRANSIT TIME

Data on transit times for marked salmon from the release to recapture sites during VAMP 2000 is summarized in tabular and graphic form in Appendix C. CWT salmon released April 17 at Durham Ferry took between five and 18 days to arrive at Antioch and between five and 32 days to arrive at Chipps Island. The April 28 Durham Ferry release arrived at Antioch between six and 21 days and between five and 23 days at Chipps Island. The April 18 Mossdale release took between four and 26 days to arrive at Antioch and between five and 16 days to arrive at Chipps Island. Significant variability was observed between last days of recovery for the April 17 Durham Ferry release group and the Mossdale release group at the Antioch and Chipps Island recovery locations. These differences may reflect variability associated with recovering individual fish when numbers are low toward the end of the group's migration

period. The number of individual recoveries by tag code and the number of minutes towed per day for both Antioch and Chipps Island recoveries are shown in Appendix C.

SURVIVAL ESTIMATES FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

CWT salmon releases were made in the San Joaquin River tributaries between April 12 and May 19 as part of the independent fishery investigations. Releases were made in the upper and lower Merced (Hatfield State Park) River, upper Tuolumne River (La Grange) and on the main-stem San Joaquin River just downstream of the confluence with the Tuolumne River (Old Fisherman's Club). Releases were also made on the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River. As mentioned earlier, one additional group was released at Mossdale between April 19 and May 3 to evaluate the efficiency of the DFG trawl at Mossdale used to estimate survival for upstream release groups.

Survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.02 and 0.12 (Appendix C). No survival indices to Antioch were available for tagged fish released after May 18. Survival indices ranged between 0.02 and 0.13 to Chipps Island and include most of the San Joaquin River tributary releases (Appendix C). Unfortunately, in most cases, the variability in survival indices within a group at each recovery location was large enough that the detection of real differences between upstream and downstream locations may be limited (see Appendix C). The ability to detect differences is a function of the precision and magnitude of the survival measurement. Both factors influence the ability to detect differences between treatment groups.

Inconsistent trends and survival estimates between the two recovery sites may be the result of high variability in one or both sets of recovery data.

Information on the transit time between release and recovery of the CWT groups released in the San Joaquin River mainstem and tributaries at both Antioch and Chipps Island is summarized in Appendix C. As observed for VAMP releases, there was substantial variability in the last days of recovery for the various groups released upstream in the tributaries. Though it was anticipated that it would take longer for the marked salmon to reach Chipps Island because it is further downstream than Antioch, as described throughout this section, based on the last day that salmon were recovered this was not always the case. This may reflect the lower probability of catching the marked salmon at the end of the group's migration period since fewer salmon are available for capture.

DISCUSSION

The data obtained using Chipps Island recovery information gathered in 2000 is shown in relationship to past years data using the same recovery location in Appendix C. The survival ratios obtained in 2000 were relatively high in comparison to other survival ratios measured since survival ratios were compared starting in 1994. Only 1999 and 1995 had higher survival ratio estimates between Mossdale and Jersey Point than that obtained in 2000. Past absolute survival estimates and survival indices between Mossdale and Jersey Point from VAMP 2000 are shown in relationship to Vernalis flow and the presence of an Old River Barrier in Figure 5-1. Simple regression analyses were used to compare absolute survival estimates to river flow at Vernalis. Two regression lines have been developed based on historical survival data with and without the Old River Barrier. Statistically, neither regression is significant.

Evaluating the role of SWP and CVP exports on salmon smolt survival through the South Delta and the affect of the Old River Barrier are key elements of VAMP. Presence of the Old River Barrier affects both the emigration route of salmon smolts and hydraulic conditions in the lower San Joaquin River and Delta that are thought to alter the vulnerability of juvenile salmon to export-related effects.

The role of SWP and CVP exports with the Old River Barrier in place is difficult to determine at this time, in part, because of the few releases made with the Barrier in place and the different permeability of the Barrier when it has been in place. Releases at both Mossdale and Jersey Point have only been made in the three years when the Old River Barrier was in place. In 1994, the Old River Barrier was installed without culverts, while in 1997 the Old River Barrier had two open culverts that passed approximately 300 cfs into Upper Old River. And in 2000, the Old River Barrier had six gated culverts, with two open during the Mossdale and first Durham Ferry release and four open during the second Durham Ferry release. The varying designs and changes to the permeability of the Barrier add noise to the resulting data, making it more difficult to detect the effects of flow and export on salmon survival.

Additional noise is added to the data from changing the upstream release location from Mossdale to Durham Ferry. Future investigations, using releases at both Durham Ferry and Mossdale are needed to assure that releases made at Mossdale and Durham Ferry result in similar survivals so that past data can be used in

evaluating the effects of SWP and CVP exports on salmon survival. If the survivals between the two release locations are not similar, then using only Durham Ferry data will increase the number of years needed to complete the VAMP study. Variation in survival results and trends between the two recovery locations (Antioch and Chipps Island) also adds a level of uncertainty but the benefit of having two rather than only one survival estimate per year is of major value.

However, given this noise, the data to data appears to show that smolt survival between Mossdale/Durham Ferry and Jersey Point increases as exports increase from 1,600 to 2,300 cfs with the Old River Barrier in place (Figure 5-2). This relationship is statistically significant, likely because of small sample size. Figure 5-3 shows salmon survival, river flow (at Stockton) and exports with the Old River Barrier in place. Flow at Stockton was selected for use in these analyses to account for flow diverted from the lower San Joaquin River through the operable culverts at the Old River Barrier. Water diverted through the Old River Barrier directly affects flows downstream within the lower San Joaquin River that need to be taken into account when evaluating the flow—survival relationship for juvenile Chinook salmon emigrating from the San Joaquin River and Delta. Further analysis of San Joaquin River flow measurements and the effects of water diversions through the Old River Barrier need to be taken into account in the analysis and interpretation of VAMP 2000 and subsequent Chinook salmon survival investigations.

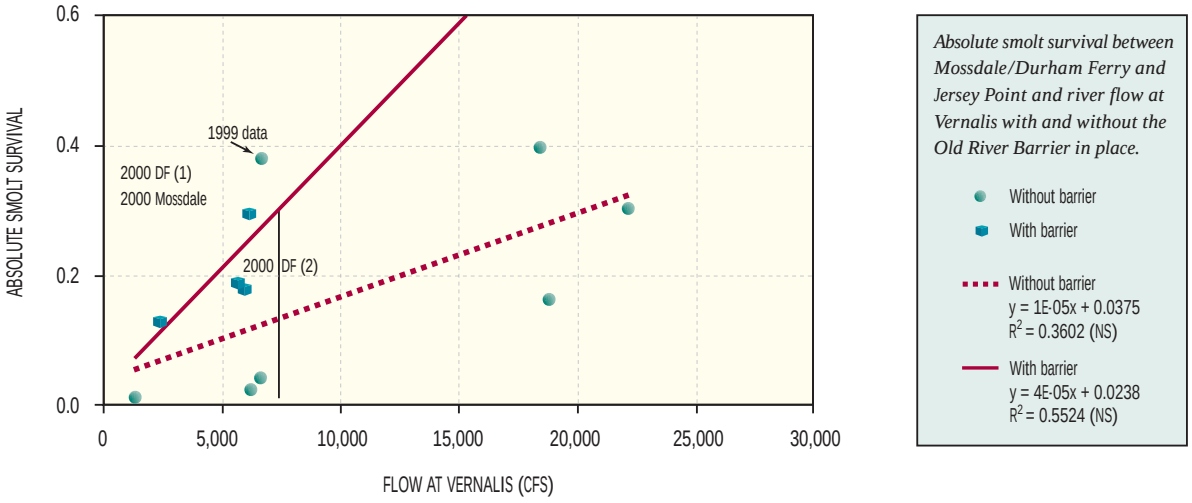
Although the multiple regression is not statistically significant (Figure 5-3), as San Joaquin River flow at Stockton and exports increase, in the narrow range measured, survival between Mossdale and Jersey Point increases. It is difficult to separate the respective roles of the two factors since they are both increasing as survival increases. Typical river flow and exports have a much wider range of variability than those used in the VAMP experiment period.

There have been a number of recent fishery studies conducted to determine the effects of flow, export, and migration route on smolt survival. These studies serve as a foundation for the VAMP studies. The results of these past studies shed some light on the roles of flow, exports, and the barrier in Upper Old River, but are clouded by confounding aspects of the data, which we hope to overcome with more replicates, that should improve our accuracy and precision and allow future conclusions to be better justified. There have been several past studies focused on providing an indirect evaluation of the effect of flows and exports to smolt survival with a barrier for determining absolute survival between Dos Reis and Jersey Point. Paired experiments with salmon from the Merced and Feather River hatcheries have shown that absolute survival is higher for salmon originating from the Merced River Hatchery (Brandes and Pearce, 1998). Studies in 1998, 1999, and 2000 were conducted to determine smolt survival at Chipps Island. Studies of smolt survival through Upper Old River relative to Jersey Point produced low survival indices (Brandes and McLain, 2000). The mixed results of the historical studies support the continuance of additional VAMP studies to support scientific conclusions concerning the role of flow, exports, and the Old River Barrier in smolt survival.

Definitive conclusions about the respective roles of flow and exports on salmon smolt survival are not possible from the VAMP data at this time. It is recommended that further evaluation of VAMP 2000 results occur prior to determining the study plan for VAMP 2001. It is also recommended that VAMP experiments continue. Results of these studies will hopefully provide the information needed to make appropriate management decisions to protect salmon smolts emigrating from the San Joaquin basin.

Figure 5-1

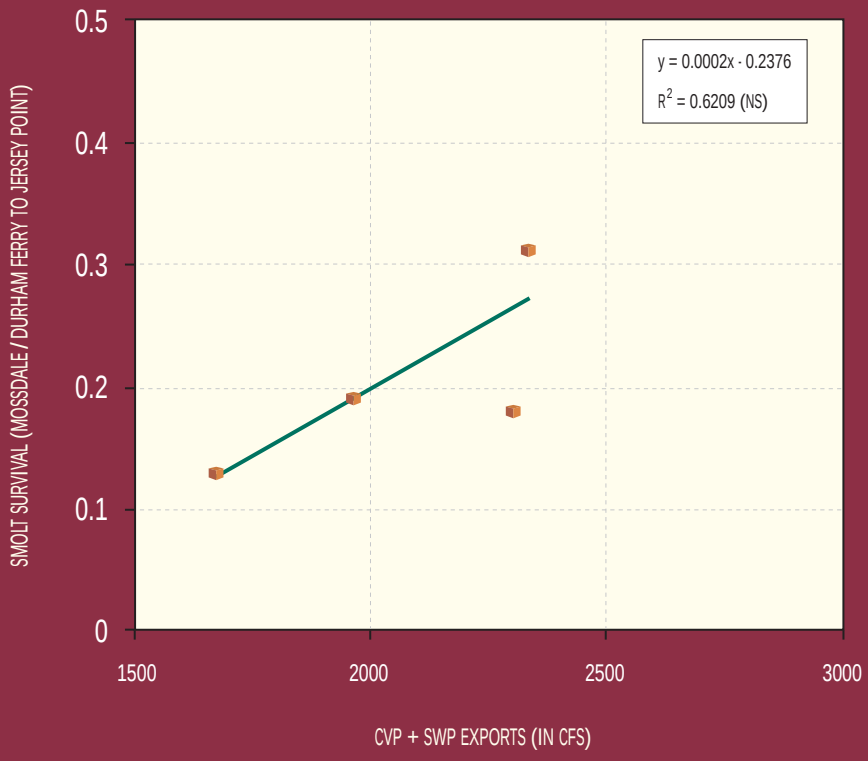
ABSOLUTE SMOLT SURVIVAL



Absolute smolt survival between Mossdale/Durham Ferry and Jersey Point and river flow at Vernalis with and without the Old River Barrier in place.

Figure 5-2

SURVIVAL VS. EXPORTS WITH BARRIER

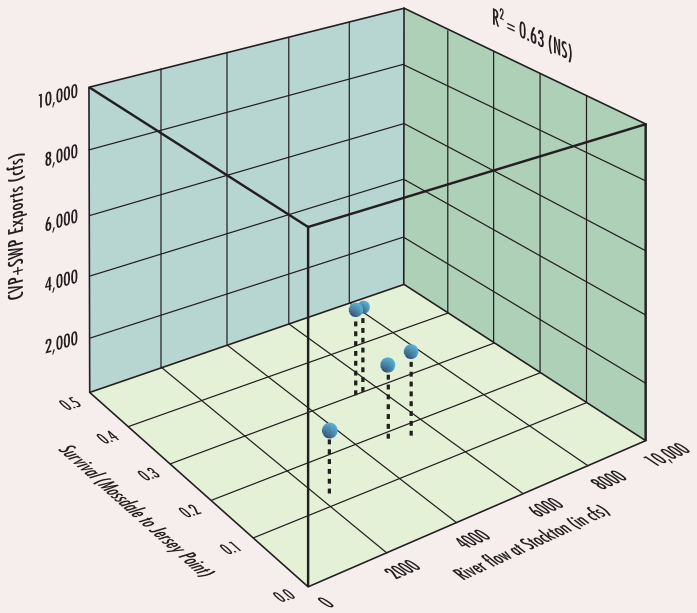


Absolute smolt survival versus CVP+SWP Exports (in cfs) in years with a Barrier in Upper Old River

Figure 5-3

SURVIVAL VS. RIVER FLOW AND EXPORTS

The relationship between the absolute estimate of survival between Mossdale (Durham Ferry) and Jersey Point and San Joaquin River flow at Stockton and CVP+SWP Exports with barrier at Upper Old River.



Conclusions

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

The VAMP pulse flow and experimental investigation of juvenile Chinook salmon survival was implemented during spring 2000. The Vernalis target flow was 5,700 cfs, with SWP and CVP export flow of 2,250 cfs. The Old River Barrier was successfully installed and maintained throughout the VAMP test period, but was characterized by variable culvert operations. Estimates of juvenile Chinook salmon smolt survival were calculated based upon releases of CWT juvenile salmon produced in the Merced River Fish Hatchery and released at Durham Ferry, Mossdale, and Jersey Point. Marked salmon were subsequently recaptured in sampling at the Old River Barrier, SWP and CVP export facility salvage, and through intensive fisheries sampling conducted at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2000 investigations, conclusions and recommendations have been developed, as summarized in Table 6-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2001 operations and investigations.

Table 6.1

SUMMARY OF VAMP 2000 CONCLUSIONS AND RECOMMENDATIONS.

CONCLUSIONS	RECOMMENDATIONS
Technical Elements	
Durham Ferry appears to be an appropriate site for upstream treatment releases.	Use Durham Ferry as the upstream release site in subsequent VAMP studies.
There appeared to be significant mortality between Durham Ferry and Mossdale using Antioch recoveries while survival was similar for the two groups using Chipps Island recoveries.	Do more releases at Mossdale to compare survival differences between Durham Ferry and Mossdale.
Jersey Point appears to be an appropriate downstream release location.	Continue to use Jersey Point as the downstream control group.
Antioch and Chipps Island appear to be suitable as recovery locations. Trends between release groups however, sometimes varied between the two recovery locations.	Use both recapture sites next year. Further evaluations are necessary to determine why trends sometimes differ between locations and to potentially modify methodology/design for 2001 study. Pilot sampling at Benicia may help address these differences between recovery locations.
Releases of 50,000 salmon are adequate at Jersey Point (control release).	Use release groups of 50,000 fish again. Evaluate individual tag codes to determine if smaller releases sizes are appropriate.
Variation was high between the two recapture sites for fish released from Jersey Point.	Paired upstream (treatment) and downstream (control) releases are justified.
Survival indices for Mokelumne and Merced River salmon released at Jersey Point were different, with results differing by recovery locations.	No recommendation is made regarding the use of Mokelumne River fish as a Jersey Point control for VAMP at this time. Redo study and pursue additional analysis.
Further evaluation of the high variance in survival indices and variation of indices between recovery locations may result in changes in techniques and experimental design of the salmon survival investigations to lessen variability.	Solicit peer review from statisticians and CALFED science program. Evaluate bias and ways to lessen variance. Redo power analyses to determine true potential to achieve VAMP goals.
Quantifying salmon movement through the Old River Barrier culverts is difficult and results are unclear.	Refine sampling technique. Explore other study design options. Develop flow measures in Old River. Develop a sound culvert design including effective net attachments to quantify potential impacts.
Policy/Management Elements	
Coordination of project operations was adequate but timing of field measurement at Vernalis needs refinement.	Measure flows at Vernalis site earlier and more frequently. Explore other gaging station sites and flow descriptors.
Design of Old River Barrier in 2000 was inadequate at 7,000 cfs.	High priority for resolution of conflicts between flows and Barrier – develop issue paper.
Old River Barrier seems to have limited impacts on seepage and related issues.	Continue present monitoring.
Budgeting and planning should be expanded beyond one year.	Begin three-year planning. Reevaluate budget to determine if cost savings are possible.
No complementary studies, such as water quality and radio tagging, have been integrated to date into the VAMP framework.	Seek out and support linked studies. Encourage proposal development through CALFED, AFRP, and other funding opportunities. Achieve peer review and set up coordination plan.
Conclusions are not yet possible on the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival.	Continue VAMP test program.

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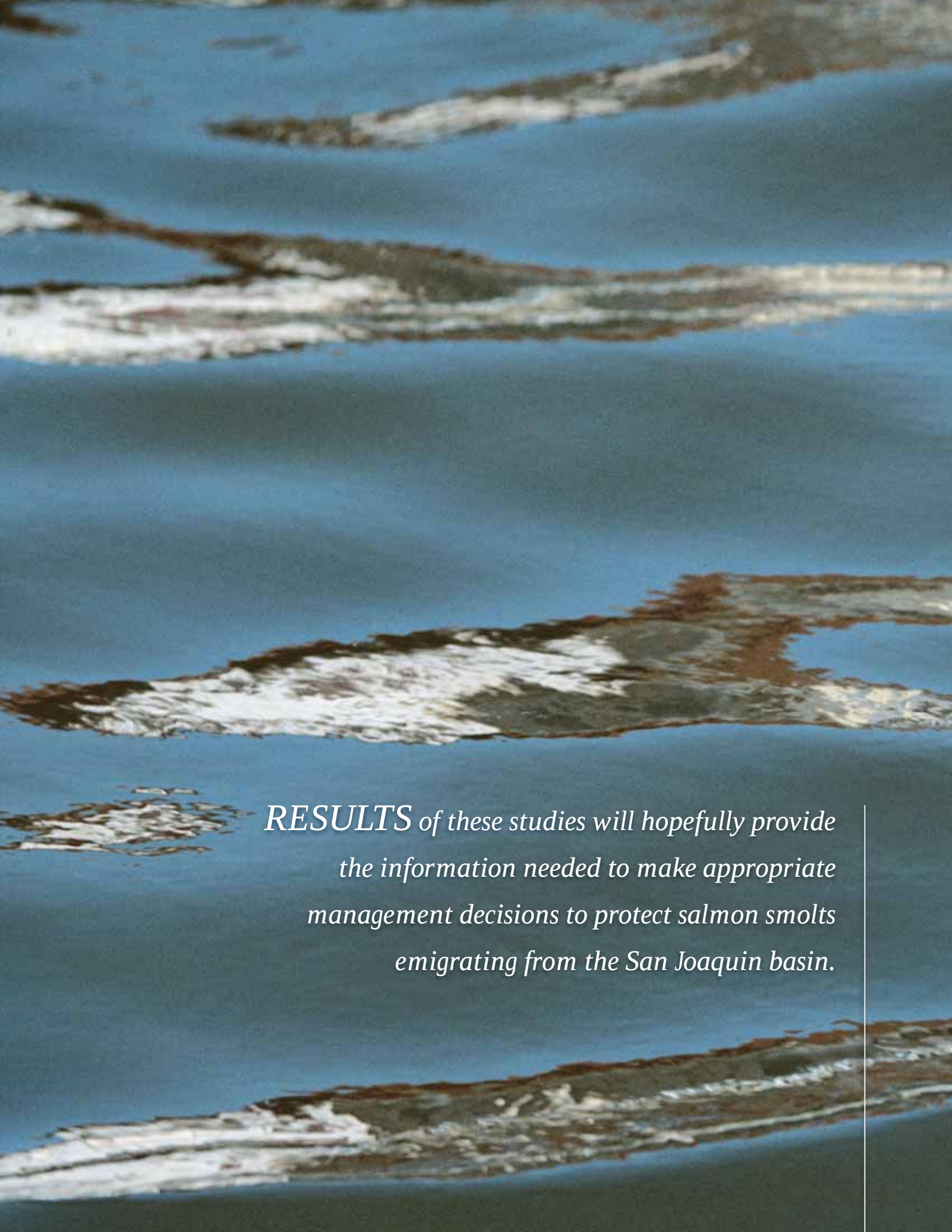

RESULTS of these studies will hopefully provide the information needed to make appropriate management decisions to protect salmon smolts emigrating from the San Joaquin basin.

Signatories

SIGNATORIES TO THE SAN JOAQUIN RIVER AGREEMENT

U.S. BUREAU OF RECLAMATION

U.S. FISH AND WILDLFE SERVICE

CALIFORNIA DEPARTMENT OF WATER RESOURCES

CALIFORNIA DEPARTMENT OF FISH AND GAME

OAKDALE IRRIGATION DISTRICT*

SOUTH SAN JOAQUIN IRRIGATION DISTRICT*

MODESTO IRRIGATION DISTRICT*

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