

Summary

EXECUTIVE SUMMARY

The San Joaquin River Agreement (SJRA) and Vernalis Adaptive Management Plan (VAMP) are the cornerstone of a history-making commitment to implement the State Water Resources Control Board (SWRCB) 1995 Water Quality Control Plan (WQCP)

program represents the fifth year of formal compliance with SWRCB 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



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for the lower San Joaquin River and the San Francisco Bay-Delta Estuary (Bay-Delta). [VAMP](#), officially initiated in 2000 as part of SWRCB Decision 1641, is a large-scale, long-term (12-year), experimental/management program 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 with the installation of the Head of Old River Barrier (HORB). VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolts, while gathering information to allow more efficient protection in the future. Specific experimental objectives of VAMP include quantification of juvenile salmon smolt survival under a set of six San Joaquin River flow rates (3,200 to 7,000 cfs) and SWP/CVP export rates (1,500 to 3,000 cfs).

The 2004 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2004

the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier; results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations.

The VAMP experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured. Absolute survival estimates are calculated and used to evaluate relationships between salmon survival and San Joaquin River flow and CVP and SWP exports. The experimental design includes both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chippis Island, SWP and CVP salvage operations, and in the ocean fisheries). The use of data from multiple release and recapture locations allows for more thorough

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evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP release and recapture locations are consistent from one year to the next, providing a greater opportunity to assess salmon survival over a range of Vernalis flows, SWP/CVP exports, with and without the presence of the Head of Old River Barrier. Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. Use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

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 2004 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 3,200 cfs, with an installed HORB, and SWP/CVP export rates of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2004 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.

VAMP provides for a 31-day pulse flow (target flow) in the San Joaquin River at the Vernalis gage along with a corresponding reduction in SWP/CVP exports. The magnitude of the pulse flow is based on an estimated flow that would occur during the pulse period absent the VAMP. As part of the development of the VAMP experimental design, the VAMP hydrology and biology groups meet regularly throughout the year to review current and projected information on hydrologic conditions occurring within the San Joaquin River watershed to refine the experimental design. This facilitates communications and coordination both as part of the VAMP experimental survival program and scheduling streamflow releases on the Tuolumne, Merced, and Stanislaus rivers to facilitate experimental investigations and provide protection for juvenile salmon within the tributaries, as well as the mainstem San Joaquin River. VAMP experimental test

conditions that have occurred over the past five years are summarized below:

VAMP Period	Vernalis Flow (cfs)	SWP/CVP Exports (cfs)
April 15–May 15, 2000	5,869	2,155
April 20–May 20, 2001	4,224	1,420
April 15–May 15, 2002	3,301	1,430
April 15–May 15, 2003	3,235	1,446
April 15–May 15, 2004	3,155	1,331

A total of 476,503 acre-feet has been contributed over the five years by the SJRGA. At the end of the five years reservoir deficits in New Don Pedro and Lake McClure are 11,151 acre-feet and 215,197 acre-feet respectively as of October 14, 2004 (Appendix D). These values may be offset by SJRGA water conservation activities implemented by the irrigation districts. Water deficits of the other SJRGA members that contribute water have been replenished at the beginning of each year. A total of 1,508,809 fall-run Chinook salmon smolts were produced at the Merced River Fish Facility over the five years in support of the VAMP. The annual allotment of test fish ranged from a high of 392,186 in 2002 to a low of 188,884 in 2004, with an average of about 309,000 provided in each of the other VAMP years. As a result of the relatively low return of adult salmon to the Merced River in the fall of 2003, the availability of test fish for 2004 was limited to less than 200,000 fish. This allowed for a single release of CWT salmon at Durham Ferry, Mossdale, and Jersey Point.

Temperature data were collected through the use of a series of computerized recorders at the Merced River Fish Facility, in the transport trucks, and located throughout the lower San Joaquin River and Delta. Overall the average temperature at all sites ranged from 19 to 22 C.

Of the 21,845 juvenile Chinook salmon entrained at the HORB during the first five years of VAMP, approximately 8,300 were VAMP CWT released salmon. Most of the VAMP salmon (97%) were entrained within two days of their release. A high proportion of the entrainment at the culverts occurred at night. The yearly entrainment loss index for VAMP salmon at the HORB averaged $0.8\% \pm 0.4\%$ and ranged from a high of 1.5% in 2002 to a low of 0.4% in 2004. For unknown reasons the 2003 VAMP test measured the lowest survival since the VAMP was initiated, with 2004 showing only a slight improvement. The Combined Differential Recovery Rates ranged from a high in 2001 of 0.191 to a low in 2003 of 0.019. Results of the salmon survival studies suggest a general trend in which survival improves as San Joaquin River



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flows increase and as the ratio of San Joaquin River flow to SWP/CVP exports increases. These relationships, based on data between 2000 and 2004 (including similar data obtained in 1994 and 1997), however, are not statistically significant ($p < 0.05$). Hydrologic conditions occurring within the San Joaquin River watershed between 2000 and 2004 have limited the experimental flow conditions to a relatively narrow range. Further tests, over a wider range of flow and export conditions (e.g., San Joaquin River flow of 7,000 cfs and SWP/CVP export rates of 1,500 cfs), are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports, on juvenile Chinook salmon smolts survival. Various historical data are summarized in Appendix D.

Results of salmon migration monitoring at Mossdale between March 15 and June 30 have shown that approximately 31–76% of the juvenile Chinook salmon smolts migrate downstream from the San Joaquin River tributaries during the VAMP period and were, therefore protected by increased San Joaquin River flows, installation of the Head of Old River Barrier, and decreased export rates. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions.

Prior technical reports presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2003 recommendations were used, in part, as the basis for developing the 2004 VAMP test program. For example, the 2003 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. The 2003 report also recommends modifications to the HORB and entrainment monitoring program including a delay in salmon releases at Durham Ferry and Mossdale for approximately five days after barrier closure to allow time for gravel and rock to flush from the culverts and improve fishery sampling, measuring flows within the culverts, continue monitoring to evaluate potential impacts of seepage, monitoring fish entrainment at the culverts, and improve the experimental design of Head of Old River Barrier investigations. These and other recommendations were addressed as part of the 2004 VAMP program.

During 2004, as since 2002, the local landowner provided a short-term curtailment of agricultural diversion pumping during the release of test fish at Durham Ferry. In addition, the 2004 VAMP program continued use of the net pen studies and a fish health assessment to determine the health and survival of test fish released as part of VAMP. Efforts also continued to improve the procedure used to statistically analyze VAMP survival and recovery information, however additional improvements remain to be made in the ability to measure flow passing through the Head of Old River Barrier culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River. Measurements in the future of San Joaquin River flow downstream of the Old River Barrier will be used in evaluating the relationship between San Joaquin River flow and juvenile Chinook salmon survival. An additional complimentary study on survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries was incorporated into the 2004 VAMP investigations.

The estimated survival of CWT salmon released from Durham Ferry and Mossdale in 2004 was the second lowest measured since initiation of the VAMP. Results of health and physiological examinations indicated that the test fish were relatively healthy and should have performed adequately for outmigration assessment. Water temperatures measured within the lower San Joaquin River and Delta were within a range that may have been stressful and may have contributed to adverse effects and reduced survival of juvenile Chinook salmon released as part of the 2004 VAMP investigations.

Prior reports recommended that, to the extent possible, VAMP survival testing be conducted at high flow and low export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival between target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed did not provide conditions suitable for testing a high flow/low export relationship as part of the VAMP 2004 program. Recommendations from the 2003 VAMP program were used to improve the overall experimental design and implementation of the 2004 VAMP investigations. Recommendations made based upon analyses of the VAMP 2004 program will also be used, in a similar way, by the hydrology and fisheries technical committees in developing and implementing the experimental design for the 2005 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2004, a set of conclusions and recommendations has been developed. These conclusions and recommendations pro-

vide guidance and a foundation for design and implementation of future VAMP studies. Key conclusions and recommendations derived from VAMP 2004 include:

- Differential recovery rates of the Durham Ferry and Mossdale groups relative to the Jersey Point group using recaptures at Antioch and Chipps Island indicated that there was no statistical ($p < 0.05$) difference in survival between the Durham Ferry and Mossdale releases conducted in 2004.
- The proportion of CWT salmon released and recaptured from the combined Durham Ferry and Mossdale groups relative to the proportion of CWT salmon released and recaptured from the Jersey Point (control) showed that the relative proportions during 2004 were similar to 2003 but significantly lower than survival results from the 2002 VAMP, although flow and export conditions (target flow 3200 cfs and exports of 1500 cfs in all three years) were comparable. The factors contributing to the significantly lower survival in 2003 and 2004 are unknown.
- The relationships between salmon survival, Vernalis flow, and SWP/CVP exports were not statistically significant based on results of VAMP tests over the past five years and similar pre-VAMP data gathered in 1994 and 1997.
- Real-time streamflow data at Vernalis were improved by weekly flow measurements, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows.
- DWR installed a stage recorder and fixed acoustic Doppler velocity meters in the San Joaquin River downstream of the confluence with Old River and in the Old River downstream of the HORB for use in measuring 2004 river flows.
- The design, construction, and operation of the HORB were successful in 2004. Salmon releases at Durham Ferry and Mossdale were delayed approximately five days after HORB closure to allow time for gravel and rock to flush from the culverts and to improve fisheries sampling at the site. Operation of the HORB with three to five culverts open was successful in maintaining South delta water levels. Mechanical malfunctions required varying culvert operations throughout the period.
- The index of salmon entrainment at the HORB from the single release in 2004 was substantially lower in comparison to the first releases made in 2002 and 2003 but similar to the 2001 loss. The comparisons may be limited due to the single release of test fish in 2004 and the varying culvert operations.
- The variability inherent in conducting salmon smolt survival studies in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon



survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, when possible, high target flow and low export conditions be selected to conduct survival tests at VAMP flow and export extremes, or equivalent, to improve the ability to detect potential differences in salmon smolt survival among test conditions.

- Approximately 72 percent of the unmarked salmon smolts migrating past Mossdale in 2004 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- Individual agency program and funding constraints limited the implementation of complementary studies in 2004. Complementary studies provide additional information on factors and mechanisms affecting salmon survival during migration from the lower San Joaquin River and through the Delta.
- The relationships between salmon survival rates and Vernalis flow and SWP/CVP export conditions tested in the first five years have not been found to be statistically significant. Survival tests at extreme target levels (e.g., 7,000 cfs flow and 1,500 cfs exports), or equivalent, are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and

SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.

- It is recommended that further effort be given to identifying and evaluating opportunities to adaptively refine and modify the VAMP experimental design to improve the level of protection provided to juvenile Chinook salmon migrating downstream in the San Joaquin River, improve the ability to detect statistically significant relationships between flow and export rates and juvenile salmon survival if they exist, reduce potential adverse impacts to aquatic resources and their habitat within the upstream tributaries, and maximize the efficient use of available water resources within the San Joaquin River watershed during VAMP implementation.
- The VAMP program has demonstrated the value of large-scale, long-duration, interdisciplinary experimental investigations that provide both protection to fishery resources while also providing important information that can be used to evaluate the performance and biological benefits of various management actions. The VAMP program has also demonstrated the value of an interdisciplinary approach, integrating fisheries and hydrology adaptively in response to current environmental conditions, in the design and successful implementation of management programs.