Appendix A

Conceptual Framework for Protection and Experimental Determination of Juvenile Chinook Salmon Survival Within the Lower San Joaquin River in Response to River Flow and SWP/CVP Exports

March 20, 1998

Introduction

San Joaquin River flows and State and Central Valley Water Project (SWP/CVP) exports are commonly believed to affect survival of juvenile fall-run Chinook salmon emigrating from the San Joaquin River Basin. Experimental survival studies have provided valuable information and recent analyses have shown a significant relationship between San Joaquin River flow at Stockton and smolt survival through the delta. However, smolt survival studies have been performed at some, but not at all, intermediate flow and export rates specified in the 1995 WQCP, so the exact nature of the response of smolt survival to both export and flow are a subject of contention. Estimated survival rates for coded-wire tagged (CWT) juvenile Chinook salmon smolts have been low in recent years. Those low survival rates as smolts are generally mirrored in low rates of adult returns 2 1/2 years later so that improving survival through the delta is believed by many to be an essential part of restoring San Joaquin salmon runs. Aside from flow and export rate manipulations, installation of a barrier at the head of Old River has been identified by several parties as likely to improve the survival of downstream migrating salmon. Such a barrier is apt to alter the impacts of flow and export rates on smolt survival.

To restore fall-run Chinook salmon, efforts are being evaluated and implemented within the San Joaquin River tributaries to improve spawning and juvenile rearing habitat. However, achieving the doubling goals of the State's WQCP and the federal CVPIA will likely require improvements in tributary spawning reaches and rearing reaches of the tributaries and mainstem and during passage through the delta. This document proposes an adaptive management strategy to use current knowledge to provide a level of protection for smolt passage through the delta while gathering information to allow more efficient protection in the future.

Objectives

The proposed experimental program has been designed to:

> **(1) Implement protective measures for San Joaquin River fall-run chinook salmon within the framework of a carefully designed management and study program which is**

designed to achieve, in conjunction with other non-VAMP measures, a doubling of natural salmon production by improving smolt survival through the Delta.

(2) Gather scientific information on the relative effects of flows in the lower San Joaquin River, CVP and SWP export pumping rates, and operation of a fish barrier at the head of Old River on the survival and passage of salmon smolts through the Delta. (3) Provide environmental benefits on the lower San Joaquin River during the April-May Pulse Flow Period at a level of protection equivalent to the Vernalis flow objectives of the 1995 WQCP and implement the remaining San Joaquin River Portion of the 1995 WQCP.

The design of this investigation has been based, in large part, on experience gained in earlier fisheries investigations and on expected opportunities for providing increased fisheries protection during the spring. Many parties have offered valuable contributions to the improvement of this document since its initial draft and all comments were considered in developing the present design. This investigation is designed to allow clearer interpretation of sampling results regarding specific questions about the impacts of different flow and export regimes on San Joaquin smolt passage through the delta. Additional sampling regimes are described which will provide more data and enable improved statistical analysis of the data. Because a permit for construction of a temporary barrier at the head of Old River has been approved for the next three years, such a barrier is assumed to be in place. A design for evaluating the value of such a barrier is included in this study design.

If smolt survival through the delta is affected by both flow and export rates, then various combinations of flow and export conditions could provide the same level of protection. However, current data do not allow confident quantification of the contribution of each variable to smolt survival. It is likely that flow and export impacts on salmon passage are different, they are probably non-linear, and they may often interact. For instance, reducing export rates by 1000 cfs may have a different impact on smolt passage than increasing river flow by 1000 cfs, the change in export impact of a reduction of 1000 cfs is probably different at high or low exports and at high or low levels of river flow. This proposal uses as wide a range of flows and exports as possible with the head of Old River in place to allow quantification of flow and export impacts while maintaining protection of outmigrant salmon smolts.

Recent studies by USFWS have used ratios of recapture to estimate absolute survival rates rather than the independent indices of survival. This study design will use such ratios to estimate survival rates. Absolute survival rates will allow quantification of the goals of smolt survival designed to help in doubling natural salmon production in the most efficient manner. With such goals, adaptive management will use early experimental results to alter later experimental targets.

By determining the nature of the response to each variable and how each contributes to salmon survival rates through the delta, this proposal aims to allow improved protection when the plan is revisited during future triennial reviews. This proposal has been developed with

close coordination of the USFWS and their efforts to develop an Anadromous Fish Restoration Plan and with interested parties associated with water management on San Joaquin tributaries, with delta export operations, and with salmon restoration.

Test Conditions

Vernalis Adaptive Management Program (VAMP)

The WQCP specifies two different San Joaquin River flow rates within each water year type and holds export rates to no more than the total San Joaquin River flow. Since exports under the WQCP are a function of flow rates it would be impossible to assess their separate impacts on salmon passage. Under the USFWS Biological Opinion for delta smelt, the Bureau of Reclamation has developed an interim operating plan to attempt to meet the specified flow targets at Vernalis through their operations of New Melones reservoir. In its Biological Opinion, USFWS recognizes that there may be years the Vernalis flow targets are unlikely to be achieved through the operations of New Melones alone.

This plan does not use water year type explicitly. Instead, in each year when the existing flow at Vernalis is anticipated to be below 7,000 cfs on April 15, one of the following test conditions is used (Table 1). This matrix of flow and export (when combined with the variety of procedures to estimate smolt survival) is intended to assess impacts of flow at three levels of export and impacts of export at four levels of flow. The intermediate condition (D)permits estimation of the degree of curvature in response.

Choice of maximum flow level of 7000 results from the need to have flow rates in the San Joaquin below 5000 cfs to install and below 7500 cfs to operate the barrier at the head of Old River. A minimum export rate of 1500 cfs is based on the minimum pumping capacity and the likely drawdown rate from the canals during this season. Given the minimum export rate of 1500 cfs the chosen minimum flow rate of 3200 cfs is based on the intent of the USFWS Biological Opinion that exports be less than 50% of the Vernalis flow standard (since the Biological Opinion is based on water year type the numbers in the opinion are not directly comparable). Similarly, the maximum export rate of 3000 cfs is determined by the maximum flow of 7000 cfs and the intent of the BO to limit exports to less than half of the required Vernalis flow standard.

		Vernalis Flow rate			
		7000	5700	4450	3200
Exports	1500	A (4.7:1)		B (3.0:1)	C (2.1:1)
	2250		D (2.5:1)		
	3000	E (2.3:1)			

Table 1. Proposed flow and export rates (in cfs) to achieve the experimental goals.

Under extremely dry conditions, the San Joaquin river flow and associated exports shall be determined per section 6.4 of the San Joaquin River Agreement. USFWS staff in charge of the Anadromous Fish Restoration Program have expressed a desire to use additional water purchases to augment flows in any year when the SJRGA flow contribution is 2000 cfs. In consideration of these factors the 2000 cfs flow target is not considered a required data point within VAMP.

In this design the data for a given combination of flow and exports are assumed to be derived from a single year. However, if impacts of flow and export are overridden by some other factor that particular combination would need to be achieved in a later year. For example, smolts would be held in net containers (live cars) at release sites along the migration route to assess water toxicity; if significant mortality occurred in these enclosures the data in regard to flow and export rates likely would not be comparable with other years. Similarly, parameters of water quality, size of fish at release, or disease rates in hatchery smolts might invalidate the data from any given year. Evaluation of such uncontrolled variables is discussed under 'logistics' below. This approach reduces the need to replicate all conditions and thereby reduces the length of time needed to perform the experiment. By determining the effects of flows and exports separately it will also be possible to determine whether the ratio of flows to exports or some other (perhaps non-linear) relationship best reflects salmon survival. Several parties suggested that the experimental conditions aim at different ratios of flow to export, but such an approach (like the requirements of the WQCP) would not permit separation of the individual impacts.

These juvenile Chinook salmon VAMP survival studies rely on the consistent installation and operation of the Head of Old River Barrier each year.

Installation and Operation and Evaluation of the Head of Old River Barrier

The California Department of Water Resources currently has a permit allowing installation and operation of a temporary rock barrier at the Head of Old River during the spring period of Chinook salmon smolt emigration. DWR is applying for modifications to the barrier design to include multiple culverts with operable gates. The Head of Old River barrier, installed as a temporary structure each year, requires San Joaquin River flows at Vernalis be less than 5,000 cfs during construction. DWR will be responsible for construction and operation of the barrier. The project team will coordinate with DWR staff regarding anticipated river flows and the installation of the Head of Old River barrier. Consideration is being given to the construction of an operable barrier at the Head of Old River for use during the salmon smolt survival studies. Either an operable or temporary barrier at the Head of Old River is expected, for purposes of development of the experimental design for these smolt survival studies, to be fully functional at San Joaquin River flows less that 7,500 cfs. Salmon smolt survival studies will be conducted as part of VAMP only in those years in which the Head of Old River Barrier is installed and Vernalis flows and exports are in accordance with the experimental design.

A complementary study has been developed as part of the survival investigations to evaluate salmon smolt survival during those years in which San Joaquin River flows are sufficiently high to prohibit either installation or operation of the Head of Old River barrier. These studies will be conducted as part of the Old River barrier evaluation and/or general survival studies on the lower San Joaquin River. Although complementary, salmon survival studies conducted during periods when the Head of Old River Barrier is not installed or not operated in accordance with this study design, will not be included in the survival evaluation outlined under the VAMP experimental design, but will provide useful complementary data on salmon smolt survival.

Evaluation of the effectiveness of the barrier, however, will be enhanced if exports are as similar as possible to conditions in the VAMP. Table 2 describes a set of flow and export conditions similar to Table 1, but with the expectation that flows would be a result of flood control operations rather than water allocations or purchases. To the extent possible, maintenance of steady flow conditions for each release group of fish would lessen variability in the data. Export conditions at these higher flows would likely be influenced by implementation of the WQCP's narrative salmon standard and DOI's Anadromous Fish Restoration Plan.

		Vernalis Flow rate (cfs)		
		up to 10,000	up to 15,000	over 15,000
Exports	1500	F(6.7:1)		
	2250		G(≤6.7:1)	
	3000	H(3.3:1)		I(>5:1)

Table 2. Suggested flow and export rates (in cfs) to assist evaluation of the head of Old River barrier by keeping exports similar in all cases and to allow a similar statistical approach as with the VAMP. Conditions F and H alone would provide much useful information by comparison with Conditions A and E of Table 1. Condition G was omitted from a similar design released as part of the CVPIA, b-2 actions earlier. Coordination with CVPIA would therefore need to be addressed in the particular year when flows on the San Joaquin are likely to fall between 10,000 cfs and 15,000 cfs.

The primary juvenile Chinook salmon survival studies being conducted as part of VAMP rely on

the consistent installation and operation of the Head of Old River Barrier each year. The experimental design assumes that the Head of Old River Barrier will operate with a consistent permeability from one year to the next and that the barrier will be in place throughout the April 15-May 15 (or modified) period of these investigations.

Monitoring will be performed as part of the Old River Barrier evaluation to document juvenile Chinook salmon entrainment through either a temporary barrier with culverts or an operable barrier. In the event that the Head of Old River Barrier is constructed using culverts or other means of diverting flow through the barrier, the experimental design assumes that fisheries monitoring will be performed to document the numbers of coded-wire tagged juvenile Chinook salmon entrained through the barrier throughout the VAMP testing period (100% of the diverted flow monitored) to account for the loss of coded-wire tagged juvenile chinook salmon as a result of permeable Head of Old River Barrier operations. Operation of the barrier during such monitoring will need to be done in a consistent manner, so that it does not confound the results of the VAMP study. A long term monitoring plan will be prepared to reflect this consistent operation during the VAMP text period.

If the Head of Old River Barrier is removed during the VAMP test period (e.g., April 15-May 15) as a result of such factors as incidental take of Delta smelt at the SWP/CVP diversions, results of the mark-recapture study likely would be compromised as a result of the removal of the Head of Old River Barrier.

Criteria for selecting experimental conditions

In each year the choice of target condition would be determined from the Existing Flow conditions as described in Appendix B.

For purposes of planning, the VAMP period has been assumed in this experimental design and study plan to occur during the period from April 15 through May 15. The VAMP program should include sufficient flexibility, however, to accommodate variation in the seasonal timing of Chinook salmon smolt emigration from the San Joaquin River and its tributaries to allow the VAMP testing period to coincide, to the extent possible, with the seasonal period of peak salmon emigration within the April to May time period. The current Biological Opinion (April 26, 1996) for the Temporary Barriers Program precludes installation of the barrier at the Head of Old river prior to April 15. Any changes in timing or configuration will require amending the 404 permit with the Corps of Engineers and the associated biological opinions. Flexibility in the implementation of VAMP would also require developing predictive indicators of natural smolt emigration timing. The timing VAMP also incorporates size of juvenile salmon available for release as part of the survival tests. Coordination for shifting the period of protection will require close coordination between the Hydrology Group and the VAMP Project Work Team described below.

The 31 day period designated for the VAMP testing may be extended, through the Anadromous Fish Restoration Program (AFRP) or other mechanisms to include a 2 week ramping period at the completion of the VAMP test. During this ramping period lower San Joaquin River flows and

SWP/CVP export rates may be adjusted in accordance with biological and environmental conditions. The current biological opinion (April 26, 1996) for the Temporary Barriers Program requires a ramping program if the barrier at the Head of Old River remains in place after the conclusion of the pulse flow.

Experimental Design and Logistic Support

Introduction

The experimental design proposed for evaluating the effects of San Joaquin River flows and SWP/CVP export rates on juvenile Chinook salmon survival during emigration from the lower San Joaquin River represents a long-term commitment to complete these investigations. Implementation of the program will require a substantial commitment of both financial and personnel resources. The proposed salmon survival tests will require hatchery production of juvenile Chinook salmon on the San Joaquin River System, equipment and personnel for coded-wire tagging, holding facilities for tagged fish prior to release, transportation of tagged fish to the release sites, and sampling to recapture marked fish. In addition, logistic coordination is required regarding installation and operation of the barrier at the Head of Old River, and establishing San Joaquin River flow and export levels to be maintained during the period of each year's test. As a result of the long-term nature of the investigation and the importance of developing valid information on juvenile salmon survival each year, the success of the program depends on establishing stable and consistent test conditions for comparisons among years, and reliable implementation of the investigation. These logistic considerations are briefly discussed below.

Project Work Team Coordination and Scientific Direction

Implementation of the VAMP and the associated investigations to determine juvenile Chinook salmon smolt survival as a function of Vernalis flows and SWP/CVP exports will require a multi-disciplinary and multi-agency approach. To facilitate coordination among participants a project work team (PWT) will be formed as a subcommittee of the San Joaquin River Technical Committee (SJRTC). Participation in the project work team would be limited to individuals having scientific and technical expertise relevant to the lower San Joaquin River salmon smolt survival studies. The project work team would be responsible for reviewing the experimental design for the proposed investigations, coordination of sampling activities and data collection, review of proposed investigations submitted as complementary elements to the VAMP, and scientific review and analysis of data collected during each year's investigations, subject to review and approval by the SJRTC and the Management Committee. An explicit liaison with the Hydrological Group (see Appendix B) will be required.

The PWT would work closely with the existing Interagency Ecological Program (IEP) Central Valley Salmon Project Work Team to assure proper coordination between these programs.

The proposed experimental design measures salmon smolt survival rates under at least five different combinations of flow and export rates. The experimental design assumes at least two series of releases of CWT smolts each year during the outmigration period to provide at least two estimates of salmon smolt survival under each set of conditions. Release strategies will be similar in all years of the study with a minimum of 50,000 to 75,000 CWT smolts per release group dependent on location. Further consideration of these smolt numbers may be required if recoveries are either too high or too low due to specific circumstances.

The primary recapture locations would be at Chipps Island, as in previous studies, and at a new, intensively sampled location in the lower San Joaquin (near Jersey Point) and through the ocean fishery recoveries. Additional recapture of coded-wire tagged salmon would occur at the State and Federal Water Project salvage as part of ongoing fisheries monitoring programs within the San Joaquin River and the IEP real-time monitoring program. Recapture of marked salmon in these monitoring programs could be helpful in improving the confidence in survival rate estimates and therefore the budget and resources allocated to these efforts may need to be augmented over the short period of the mark-recapture tests to ensure adequate sampling effort at all key recapture locations.

The experimental design includes both multiple release locations (at Mossdale, Dos Reis, mouth of the Mokelumne River and Jersey Point), and multiple recapture locations, including Jersey Point and Chipps Island and in the ocean fisheries. The use of data from multiple recapture locations and replicated release series provides a stronger basis for evaluating juvenile Chinook salmon smolt survival as part of the VAMP testing program, than reliance on recapture data from only one sampling location and only one series of releases per year. The proposed release and recapture locations (including Jersey Point recapture site) 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 Head of Old River Barrier. In addition, releases at the mouth of the Mokelumne River will serve as a control for recaptures at both Chipps Island and Jersey Point, thereby allowing the calculation of survival indices based on the ratio of marked salmon recaptured from upstream (e.g., Mossdale and Dos Reis) and downstream (mouth of the Mokelumne River) release locations. 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, and substantially strengthens the analytical ability of the experimental design to detect differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

Coded-Wire Tagged Salmon Allocation and Release Strategy

Releases would be made using juvenile Chinook salmon smolts produced from San Joaquin River origin broodstock when available. Releases would be made twice within the period of VAMP each year with the second release series made about one week after the first. The proposed allocation

of juvenile Chinook salmon to the experimental design is summarized below with and without a Head of Old River barrier:

Head of Old River Barrier Operational

Release Location	First Release Series	Second Release Series
Mossdale	75,000[(a)]	75,000[(a)]
Dos Reis	50,000[(b)]	50,000[(b)]
Mokelumne Mouth	50,000[(a)]	50,000[(a)]
Jersey Point	50,000[(a)]	50,000[(a)]
Total number of fish[(a)]	175,000	175,000

[(a)]First priority
[(b)]Second priority release to evaluate the Head of Old River Barrier in a more comprehensive manner

Head of Old River Barrier Non Operational

Release Location	First Release Series	Second Release Series
Mossdale	75,000[(a)]	75,000[(a)]
Dos Reis	50,000[(a)]	50,000[(a)]
Mokelumne Mouth	50,000[(a)]	50,000[(a)]
Jersey Point	50,000[(a)]	50,000[(a)]
Total number of fish[(a)]	225,000	225,000

[(a)]First priority.

Analysis and Interpretation of Results

Biological and physical data to be recorded as part of each test will then be critically reviewed to ensure that the proper smolt survival data are appropriate for subsequent use in statistical analyses. Data from each test will be available to all interested parties for independent review and analysis. The VAMP study will need to continue until valid data from each of the five experimental conditions have been gathered. Weather conditions in each year will determine the experimental conditions in each year until all five conditions have been achieved, thus, there may be a series of dry years when the only flow target that can be achieved is 3200 cfs, or there may be a series of years when flows are too high to allow the experiment to proceed. Therefore, it is impossible to say how long it will be necessary to continue this experiment in order to satisfy the experimental requirements.

The goal of the analyses is to determine the respective roles of flow and exports on smolt survival so that the correct management actions can be taken to improve smolt survival through the San Joaquin Delta.

Plans are to analyze the data in a way similar to that done on the Sacramento Delta (Newman and Rice, 1998), where the log of the recoveries would be modeled using a linear combination of covariates. The model would be fitted using weighted least squares as was done for the Sacramento Delta data. The amount of time and ability to reach a reasonable conclusion from the data will depend on the amount of data and the strength of the effect of the covariates. Replicates within a year, even with a different stock of fish will increase the estimated precision of coefficients and may reduce the number of years needed to conduct the experiment. The present design will allow absolute survival to be estimated between Mossdale and the mouth of the Mokelumne and between Mossdale and Jersey Point using recoveries at Jersey Point and Chipps Island respectively. Recovery data from the ocean fishery will add precision. All the data will be used simultaneously to estimate the model parameters and to determine the respective roles of flows and exports on salmon smolt survival. Attempts also will be made to describe the interaction between flow and export to smolt survival.

It has been recommended that the extremes of conditions within the matrix be tested first and defer testing of the intermediate values until the relationships with the extremes are clear. This may mean repetitious testing of the extremes before the intermediate values are tested. Such a design process would be a sequential adaptive design where conditions tested each year would be determined on which values would provide the most useful information to finding the respective roles of flows and exports on smolts survival.

In addition, past data may be used to estimate the strength of the effects from flows and exports to better determine the amount of time necessary to conduct the experiment. If appropriate, past data may be incorporated in the model fitting process.

Juvenile Chinook Salmon- San Joaquin Basin Origin

Salmon smolt survival studies would be conducted primarily using juvenile fall-run Chinook salmon produced from San Joaquin River brood stock. Factors such as interannual variation in the numbers of adult Chinook salmon returning to the San Joaquin River system to spawn, viability of eggs, disease within the hatchery, and other factors may influence the numbers of San Joaquin River-origin salmon smolts available for testing each year. Currently, the only source for juvenile Chinook salmon to be used in these tests are those fish produced in the Merced River Fish Hatchery. Limited facilities for producing and holding juvenile Chinook salmon at the Merced River Fish Hatchery constrains the number of fish available each year for experimental studies. Options for meeting the demand for juvenile chinook salmon to be used in these tests include re-prioritization of existing fish available each year from the Merced River Hatchery or augmenting the existing facilities and personnel at the Merced River Hatchery. The CWT salmon allocation and release strategy calls for two series of releases each year. Each release series would consist of a minimum of from 175,000 to 225,000 smolts.

As a consequence of competing demands for San Joaquin River origin salmon smolts for use in testing and evaluation programs within the tributaries, in addition to the Delta survival studies, implementation of the long-term survival study program that does not rely on a contingency plan of Feather River CWT hatchery fish will require a commitment of additional resources to ensure

salmon smolts of San Joaquin basin origin are available for use in these tests each year. In addition to providing financial support for hatchery production and rearing facilities, there will be costs associated with incremental increases in labor by hatchery personnel for the care and feeding of juvenile salmon during the holding period, fish health inspections, and loading marked fish from the hatchery holding facilities into the transport truck. As part of development of the long-term plan agreements, financial commitments will need to be established for reliably providing the necessary numbers of juvenile salmon to be used in these survival studies.

In developing the design of the proposed VAMP salmon smolt survival studies, considerable discussion focused on the use of San Joaquin River origin juvenile Chinook salmon, and those produced in the Feather River Fish Hatchery for use in these tests. Many of the previous salmon smolt survival studies conducted in the lower San Joaquin River relied on the use of Feather River Hatchery-origin Chinook salmon. Concern has been expressed regarding the potential genetic implications associated with the release of Feather River-origin salmon into the lower San Joaquin River, and the subsequent return and spawning of these fish within the San Joaquin River basin. In addition, future action by the National Marine Fisheries Service (NMFS) relative to the proposed listing of fall-run chinook in the Central Valley could also influence CWT smolt transfers between river basins. The above also reflects the concern regarding the impact of hatchery fish on the wild stocks. In response to these concerns, the proposed VAMP experimental design outlined above relies on the use of San Joaquin River-origin Chinook salmon smolts.

Coded-Wire Tagging

The experimental design for coded-wire tagging of San Joaquin River origin salmon smolts (six discrete tag groups) includes consideration of logistic constraints imposed by limitations in hatchery holding facilities. Numerous parties have commented on the potential benefits associated with the release of additional coded-wire tag groups. These recommendations have included releasing smaller numbers of marked salmon (e.g., 25,000 fish lots) more frequently throughout the period of the tests, rather than fewer large release groups. Similarly, recommendations have been made for simultaneous release of two or more tag codes to allow for the calculation of independent, replicate survival indices within a release, assuming that a sufficient number of each tag code are recaptured. Given these logistic constraints, multiple tag codes could be applied to groups released at each location (e.g., each 75,000 lot release could be comprised of three discretely tagged groups of 25,000 fish). However, the individual tag groups may not necessarily be held separately within the existing holding facilities prior to release.

Each of the proposed releases of coded wire tagged salmon would be comprised of multiple tag codes of approximately 25,000 fish each. For example, the release of 75,000 coded wire tagged salmon at Mossdale would be comprised of three separate tag codes of 25,000 fish each which would simultaneously be released during each test to provide the opportunity for estimating variance in survival indices within each release group.

Prior to and after coded-wire tagging, juvenile salmon will be inspected for evidence of disease and parasites. Fish health inspections will be performed by a fish pathologist. Any group of marked fish showing unusually high mortality within the hatchery holding facility prior to or after marking,

or evidence of disease or other pathogens which cannot be effectively treated, will not be released as part of these tests. Additional observations of fish health conditions after release will be made for a sub-sample of marked fish held in live cars at release locations (see discussion below).

The coded-wire tagging would be subject to a quality control/quality assurance program to ensure that juvenile salmon have been effectively tagged, and to document tag retention. The quality control/quality assurance program would include a standard magnetic detector to separate tagged and untagged salmon as they are released from the tagging machine. A second quality control check would occur prior to release of the marked fish. A statistically valid sub-sample of marked fish from the hatchery holding facility will be processed using a tag detector to document coded-wire tag retention and tags will be processed to verify appropriate tag codes for each release group. Tag codes will be verified for with a sub-sample of 50 fish per 25,000 marks. A decision will be made about the validity of a release group if one or more erroneous tag codes are detected in the composite sub-sample prior to release. The sub-sample of fish from the hatchery holding facility would also be examined to quantify the percentage of marked fish having a recognizable adipose fin clip. The total number of each coded-wire tag group released would then be calculated based on the actual number of fish marked (actual count) adjusted to account for post-marking mortality within the hatchery holding facilities, a correction factor for coded-wire tag retention, a correction factor for adipose fin clipping, and an adjustment for mortality occurring during loading and transport of marked fish to the release site. Data on length and weight for a sub-sample of each marked group (approximately 200 fish) will be made to document both the length-frequency distribution, and length - weight relationship (condition factor) for each test group. These fish will be held in live cars as part of the quality control program for each release group (see discussion below).

Coded-wire tagging equipment will be required, on a dedicated basis, to ensure that juvenile Chinook salmon can be reliably tagged each year for use in this program. It is recommended that four coded-wire tag machines and support equipment be purchased and dedicated to this project. Replacement parts and maintenance will be part of the annual cost of the program.

Tag codes will be coordinated with other salmon evaluation programs and with the statewide tag coordinator. All juvenile Chinook salmon which are coded-wire tagged will also receive an adipose fin clip.

As part of utilizing facilities to support the proposed experimental program, facilities should have adequate capabilities for segregating and holding separate coded-wire tag groups. It is required that juvenile Chinook salmon be held for a period of at least 21 days after tagging when chemical anesthetics are used. Hatchery raceway facilities need to be available which allow for the separation and holding of tagged groups of salmon (tag groups of typically 25,000-75,000 fish each) prior to release. Availability of hatchery facilities for isolating coded-wire tag groups is can be a limiting factor in the types of experimental programs which can be developed for evaluating Chinook salmon survival.

In addition to providing financial support for utilizing holding facilities, there will be costs associated with labor by hatchery personnel for the care and feeding of juvenile salmon during the holding period, fish health inspections, and loading marked fish from the hatchery holding facilities

into the transport truck.

Agreements and financial compensation for the increased costs associated with the mark-recapture program will need to be resolved as part of the logistic support and commitment of resources to the long-term plan.

Tagged Fish Transport

Coded-wire tagged salmon used in previous investigations have been transported from the hatchery to the point of release using transport trucks and personnel provided either by the hatchery or from the State Water Project fish salvage operation. The use of this equipment in the past has resulted in a number of constraints regarding scheduling of fish releases, limited availability of equipment and operators, issues of disease transmission, and limitations on the time of day when releases can be made. To eliminate these constraints, it is recommended that a dedicated fish transport trailer be purchased or rented each year specifically for use in this project. The fish transport trailer should have the capacity to transport up to 125,000 juvenile Chinook salmon smolts, segregated into three or four compartments to allow for separate releases. A truck and operator would be hired privately through the project to accomplish the desired releases at the locations, and in accordance to the schedule established by this experimental design.

Juvenile salmon will be transported from the hatchery to the release location in water of comparable temperature to that occurring within the hatchery. Water temperature will be monitored within the hatchery rearing facilities, transport truck, and release site, to identify and document any potential thermal stress occurring as part of the fish release. Transport of fish from the hatchery to the release location at night will help reduce exposure to elevated water temperatures within the transport truck. Juvenile salmon will not be transported or released as part of this investigation if average daily water temperatures at the release location exceed 20 C (68 F). In the event that water temperatures in the lower San Joaquin River exceed the 20 C threshold, the marked fish will be released downstream at the mouth of the Mokelumne River or at Jersey Point. Water temperature, dissolved oxygen concentrations, and mortality of marked fish within the transport truck will all be documented prior to release.

Tagged Fish Release

Releases of coded-wire tagged juvenile salmon will be made at the Mossdale boat ramp (upstream of the Head of Old River), Dos Reis Park, at the mouth of the Mokelumne River, and Jersey Point. Twelve-inch diameter PVC pipe will be used to facilitate transfer of the marked fish from the transport truck into the river at release locations along the levee. Once established, the release locations would not be modified during the period of these tests to allow comparison of survival indices among years.

Coded-wire tagged salmon will be released, when possible, at an average minimum length of 75 mm or greater. Marked salmon would be released during the late evening/night to reduce the potential effects of predation. To the extent possible, releases at Mossdale or Dos Reis will be made on an ebb tide, while releases at the mouth of the and Mokelumne River and Jersey Point will be made on a flood tide.

Live Car Holding

As part of the mark-recapture studies, juvenile Chinook salmon will be held *in situ* in live cars in the vicinity of each of the release locations. Live cars will be constructed using a PVC frame, non-toxic screen mesh, and supporting floatation. A subsample of juvenile Chinook salmon will be removed from the transport truck for holding in the live cars.

Observations during the post-release holding period will include mortality rates, feeding activity, and swimming behavior. These observations are intended to identify the occurrence of major mortality for a release group which may result from factors such as handling stress during transport and release of a marked group that would influence the validity and interpretation of the corresponding group of marked salmon released into the river as part of these survival studies. Additional parameters to be considered as part of the complementary evaluation of the condition of marked salmon include gill ATPase, thyroxin, lipids, and other physiological parameters. Complementary studies of contaminants and other factors may also be performed to assess the potential effects of other factors on smolt survival.

At the completion of the holding period all marked fish held in the live cars will be sacrificed, and the coded-wire tags will be archived as part of the QC program to ensure the integrity of each mark group. A sub-sample of 50 tags will be processed to verify tag codes for each release group. Additional tags may be processed if tag code errors are identified. Based on results of this QC check a decision will be made regarding the validity of the release for inclusion in subsequent analyses. A preliminary criteria of 95% reliability in tag codes for each composite release group has been selected for evaluating the validity of a test.

Recapture Methods and Locations

Sampling locations for recapture of marked juvenile Chinook salmon include Jersey Point, Chipps Island, and the SWP and CVP salvage facilities. For purposes of the VAMP investigation the primary sampling locations are Jersey Point and Chipps Island. Recaptures will also be documented as part of routine monitoring at the SWP/CVP salvage facilities. Additional recapture data will be obtained from ocean commercial and recreational fisheries.

Sampling for juvenile Chinook salmon at Mossdale by the California Department of Fish and Game (DFG) as part of their routine San Joaquin River fisheries sampling program will determine the seasonal timing of smolt emigration for each year. Sampling by DFG and others in the tributaries will supplement the Mossdale data. Sampling at Turner and Columbia cuts will be performed as part of the IEP real-time monitoring program. Sampling at Chipps Island will be performed by the U.S. Fish and Wildlife Service as part of the routine Chinook salmon abundance and survival investigations (DWR, IEP, AFRP or other program funding). Standard U.S. Fish and Wildlife Service sampling protocols, using a mid-water trawl, will be employed at Chipps Island. Sampling effort at Chipps Island is typically 10 20-minute tows per day. Recovery of coded-wire tagged salmon at the State and Federal Water Project salvage operations would be conducted as part of routine monitoring. Sampling regimes for recapture of CWT smolts will need to be modified as necessary to accommodate limits on the take of delta smelt. Ocean adult recoveries would also be performed as part of ongoing State and Federal fishery resource investigations.

Sampling effort at Jersey Point will be conducted and financed as a direct element of the VAMP.

Fishery sampling as a direct element of the VAMP survival studies will be conducted from April 15 to May 15. Sampling will continue as part of this investigation (potentially at a lower level of intensity) from May 16 to June 1 to evaluate the ramping period. Data collected during each sampling period will be reviewed by the technical team to determine the most appropriate and valid use for evaluating smolt passage and survival under VAMP. Exact dates of sampling will shift in response to any changes in the dates of fish release as recommended by the VAMP PWT.

The salmon smolt survival study includes intensive fisheries monitoring in the general vicinity of Jersey Point. This intensive sampling location will be directly related to the salmon smolt survival studies, and therefore labor and equipment costs will be a specific component of the proposed project budget. The addition of the Jersey Point sampling site, and the increase in sampling effort proposed for this location, have been designed to increase the recapture of marked salmon released as part of these investigations and provide an opportunity for developing an independent salmon smolt survival estimates between upstream releases (Mossdale and Dos Reis) and Jersey Point (releases at the mouth of the Mokelumne River will serve as a control location for estimating survival using a ratio recapture method). Sampling will be conducted 18 hours per day throughout the recapture period (approximately 2 hours before dawn to 2 hours after sunset).

Sampling at Jersey Point will be conducted 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 6 feet deep and 25 feet wide. A flow meter will be used to determine the volume of water sampled during each collection, for use in calculating catch-per-unit-of-effort (CPUE). Trawl duration will be 20-minutes, sampling in an up-current direction. Trawling will be performed in a consistent reach of the lower San Joaquin River, which has been selected based on results of the 1997 reconnaissance survey. Trawling within a consistent reach each year will facilitate comparisons in recoveries among years and the development of appropriate expansion factors for calculating survival indices. The identified Jersey Point sampling area is in the general vicinity of a USGS flow monitoring station that will also provide useful data on hydraulics in the sampling area for use in evaluating results within and between years.

The Kodiak trawl will be towed between two skiffs. A third skiff will be available on-site to provide reliability of sampling effort over the intensive monitoring period in the event of boat breakdown or equipment failure. A duplicate Kodiak trawl will also be available on-site to help ensure reliable and consistent sampling throughout the April 15-June 1 period of these collections.

Fisheries Collection and Tag Processing

Data collected during each trawl sample will include species identification, enumeration and forklength measurements of juvenile Chinook salmon and other fish species collected, and water volume sampled. Juvenile Chinook salmon having an adipose fin clip, indicating the presence of a coded-wire tag, will be sacrificed, placed in individual, labeled, plastic bags and held on ice until they can be frozen.

The frozen samples will be provided to the U.S. Fish and Wildlife Service, California Department of Fish and Game, or other qualified organization, for coded-wire tag removal and processing as part of the existing coded-wire tag processing program. A result of the San Joaquin River salmon smolt survival studies, there will be an incremental labor cost associated with coded-wire tag processing. An agreement for financial compensation for the incremental cost of tag processing will need to be established as part of the long-term program to ensure that tags are processed promptly and data made available for use in estimating smolt survival each year.

Operational and Hydrologic Monitoring

USGS, USBR, and DWR will perform hydrologic monitoring within the lower San Joaquin River and Delta during the period of these tests. During 1997 problems in flow monitoring at the Vernalis gauge were encountered as a consequence of changes in rating curves during the period of these tests. As a part of VAMP additional gauging and monitoring will be performed to document flows occurring within the lower San Joaquin River. Hourly information on water surface elevation and flow measurements at established monitoring locations throughout the lower San Joaquin River and Delta will be used to document conditions during each test period. Based on experiences in 1997, recalibration of the gauging stations at Vernalis by USGS near the start of the VAMP flow period would be an important adjunct.

Detailed operational records of SWP and CVP operations (e.g., Clifton Court gate operations, hourly export rate and volume) will also be maintained to document operational conditions during each test. Data on daily exports from other relatively large diversions located on the lower San Joaquin River and Delta emigration route will also be documented. The Hydrology Group would likely carry out all these activities.

Concern has been expressed regarding the effects of the operation of the Clifton Court Forebay on hydraulic conditions occurring within the Delta during the period of VAMP. To minimize daily variation associated with Clifton Court Forebay operation, Clifton Court Forebay should be opened once per day during the VAMP study period with subsequent export rates, as determined by diversions at the Banks Pumping Plant, in accordance with the experimental design.

Water Quality Monitoring

Routine water quality monitoring will be performed from April 1 through June 1 each year. Water quality monitoring will include, but not be limited to, water temperature, dissolved oxygen, and electrical conductivity. Water quality monitoring performed specifically as part of this test will complement routine baseline water quality monitoring performed by the Department of Water Resources.

Water temperature will be monitored using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). Ten temperature monitoring locations will include fish release sites within the San Joaquin River, fisheries sampling locations (Mossdale, Columbia Cut, Chipps Island), and locations downstream along the longitudinal gradient of the San Joaquin River and interior Delta channels used as migratory pathways for juvenile Chinook salmon released as part of these tests. Temperature monitoring will also be performed at the SWP and CVP diversions.

Water temperature will be recorded at 20-minute intervals throughout the period of the investigations. Temperature recorders will be located near the surface and near the bottom at selected stations to determine potential vertical stratification in temperature. Temperature loggers will be retrieved and the data downloaded at approximately two week intervals to reduce the risk of instrument failure and loss of monitoring data.

Dissolved oxygen will be monitored using a portable DO meter (e.g., YSI Instruments) near the surface and near the bottom at each of the fisheries sampling locations twice per day (morning and afternoon). In addition, dissolved oxygen will be measured coincident with the retrieval of temperature monitoring data at the surface and bottom at each of the 10 temperature monitoring locations described above.

Electrical conductivity will be monitored using a portable meter (e.g., YSI Instruments) at the same locations and frequency as described for dissolved oxygen monitoring.

Water quality monitoring data such as electrical conductivity, water temperature, and water surface elevations will also be obtained for use in documenting conditions occurring during each salmon smolt survival test as part of routine monitoring performed by DWR, USBR, USGS, and other agencies.

In addition to routine water quality monitoring, interest has been expressed in complementing these survival investigations with measurement of water quality constituents (contaminants) which may affect the health, condition, or survival of juvenile salmon migrating through the lower San Joaquin River and Delta. Although not a direct element of the VAMP survival studies, the experimental design provides a scientific framework for accommodating complementary investigations.

VAMP Documentation Reports

Results of coded-wire tag processing, documenting the numbers of juvenile salmon from each tag group released, in association with data on the operating and environmental conditions occurring during the period of each study, will be documented and made available as part of annual reports. Draft annual reports will be completed and made available for peer review by December of each year, with a final annual report completed no later than March 1 each year. All data collected will be made available in electronic format for independent review and analysis by any interested party.

Funding

The proposed San Joaquin River Chinook salmon smolt survival studies (VAMP) outlined in this proposal represent an increased level of effort above the survival studies routinely performed as part of IEP investigations. Incremental costs associated with the proposed investigations discussed above will occur as a direct result of conducting the VAMP investigations. These incremental costs would include, but not be limited to, intensive sampling efforts in the vicinity of

Jersey Point, increased labor costs associated with tagging, transport and release, coded-wire tag processing, and any additional sampling effort requested at existing agency or IEP-sponsored sampling sites (Chipps Island). Additional capital investment will be required for developing facilities to ensure the adequate production of a sufficient number of San Joaquin origin Chinook salmon for use in these tests and for purchase of the coded-wire tagging machines, coded-wire tags, and the transport trailer.

Scientific Collection Permits

The sampling program, as outlined in this proposal, includes intensive fisheries monitoring during the spring at several locations, including Chipps Island and Jersey Point, where Delta smelt may be collected. Sampling with a Kodiak trawl has been shown in previous investigations to be an effective method of collecting not only juvenile chinook salmon, but also juvenile and adult Delta smelt. Scientific collection and incidental take (ESA) permits will be required as part of the proposed investigations. Contingency plans will be developed and implemented as part of the proposed sampling in the event that Delta smelt or other protected species (e.g., juvenile winter-run salmon, Sacramento splittail) are collected as an incidental component of fisheries sampling targeting on juvenile fall-run Chinook salmon. Permits have been established for IEP sampling, including conditions of sampling as part of the real-time monitoring program and Chipps Island sampling programs, which would apply to sampling as part of either this proposal or the high flow contingency salon smolt survival investigations. Intensive sampling in the vicinity of Jersey Point will be covered under a separate permit unless an arrangement is made to include it under the IEP permit by regulatory agencies and the IEP.

Products

Results of the proposed experimental investigations will provide detailed scientific information regarding the relationship between San Joaquin River Chinook salmon smolt survival and lower San Joaquin River flows and SWP/CVP exports. The study finding will provide a technical foundation for assessing and refining management recommendations.

Results of each year's sampling will be documented in annual technical reports presenting detailed information regarding the experimental design, results of data collection activities. The final report will present results of statistical analyses and hypothesis testing as established a priori within the framework of these tests.

The proposed experimental design will also provide interim levels of protection for Chinook salmon smolts targeted on the maximum biological benefit coincident with the peak period of smolt outmigration. Interim levels of fisheries protection established in concert with this proposed investigation will directly benefit the San Joaquin River Chinook salmon population.

Complementary Investigations

Various parties have expressed interest in developing complementary monitoring elements to further evaluate the potential factors influencing Chinook salmon mortality within the lower San

Joaquin River (river reach) and Delta. Interest has been expressed in evaluating the potential effects of hydraulic conditions, predation, entrainment mortality, and exposure to toxic contaminants. Although these studies would not be a direct element of VAMP, the basic experimental design developed for this program can be complemented by additional studies to evaluate the specific factors contributing to salmon mortality. We encourage the development of these complementary study elements and their integration into the overall San Joaquin River Chinook salmon survival program and a timely report of all results to interested parties. Detailed proposals identifying the objectives and general approach for evaluating Chinook salmon emigration patterns (e.g., radio tracking and hydroacoustic studies), contaminant toxicity, and predation are being developed. Direct entrainment losses of marked salmon under the various experimental conditions proposed as part of this investigation will also be evaluated, using data from SWP/CVP salvage operations. Examples of several of the potential complementary studies are briefly described below.

Hydraulic Measurements and Studies

As a complementary element to VAMP, additional measurements of hydraulic conditions, such as the direction and velocity of flows within various channels and the influence of tidal interactions on Delta hydraulic conditions, should be performed. During the 1997 pilot studies, dye injection studies were conducted coincident with the release of marked juvenile Chinook salmon into the lower San Joaquin River. Additional dye release studies can be performed as a complementary element of VAMP to provide further information on the pattern and distribution of water flows under different conditions of Vernalis flow and exports for use in documenting changes in environmental conditions occurring among years. Results of dye injection studies can also be used to help calibrate particle tracking model studies, in addition to other hydrodynamic modeling of South Delta flows. As a complementary element to VAMP, these studies offer the opportunity to integrate better information on hydraulic conditions and the corresponding biological information developed through the VAMP salmon mark-recapture program.

Furthermore, efforts should be made to improve the flow measurements being used within the lower San Joaquin River to manage upstream releases in accordance with the Vernalis flows established by the experimental design. Additional measurements can also be made to evaluate the influence of Clifton Court gate operations on velocity conditions occurring within the South Delta and other hydrodynamic effects that may be directly or indirectly influencing salmon smolt survival.

Index of Predation Losses

Predation within the lower San Joaquin River, primarily by striped bass and largemouth bass, has been identified as a potentially significant factor reducing the survival of juvenile Chinook salmon during these investigations. To develop an indicator of the relative abundance of predatory fish within the area each year, the salmon survival studies could be expanded to include a creel survey of recreational anglers. An example of a creel survey program is briefly outlined below.

The creel survey would be conducted within the area from Mossdale downstream on the lower San Joaquin River to Pittsburg (adjacent to Chipps Island). The creel surveys would be performed during the period from April 1 through May 15. The creel survey program would include surveys

of angler catch (by species) and effort by boat and by interviews at marinas and boat launching facilities. Based upon the results of the creel survey an index of predator abundance for both largemouth bass and striped bass, in addition to other species, can be developed. The predator abundance index would not be a quantitative estimate of the absolute numbers of predatory fish inhabiting the lower San Joaquin River each year. The relative index would provide a measure of predation for comparison with juvenile Chinook salmon survival indices among years and account, potentially, for variability in smolt survival indices in addition to Vernalis flow, SWP/CVP exports, and SWP/CVP salvage.

Predator surveys could also be designed using other sampling methods, analyses of stomach contents, radio tracking of predators to determine geographic distribution and movement patterns, etc.

Wild Chinook Salmon Live Car Holding

As a complementary investigation, live cars would also be available for holding wild juvenile Chinook salmon collected within the San Joaquin River and tributaries for comparison with survival of hatchery-reared salmon used in these tests. Wild Chinook salmon may be collected from rotary screw traps (or beach seines) located within the San Joaquin River tributaries. Wild salmon would be transported downstream to live car observation sites located in the San Joaquin River at the release location upstream of Mossdale, and at the recapture location in the vicinity of Jersey Point. Approximately 50 wild Chinook salmon would be held in live cars at each of the two locations. Coordination in obtaining wild Chinook salmon for use in these observations would be established between the Delta survival program and upstream tributary monitoring efforts. Capture and observation of wild salmon would coincide, to the extent possible, with the release schedule of San Joaquin River origin hatchery-reared smolts.

Contaminant Toxicity

Considerable interest has been focused on evaluating the potential effects of contaminant toxicity on juvenile Chinook salmon survival within the lower San Joaquin River. Pesticides, herbicides, and other water quality contaminants have been documented within the lower San Joaquin River which may contribute to chronic and sub-lethal stress or acute mortality. Complementary studies to VAMP which could be developed to evaluate the effects of contaminant toxicity on juvenile Chinook salmon survival may include an expansion of the live car holding to observe juvenile Chinook salmon survival over longer periods of time (e.g., 5 - 20 days) at various locations along the longitudinal gradient to the lower San Joaquin River. In addition to live car holding tests, juvenile Chinook salmon collected from the lower San Joaquin River may be sacrificed for pathological examination (e.g., liver necrosis) and/or chemical analyses of body burden concentrations of various chemical constituents.

More sophisticated studies may involve evaluation of juvenile Chinook salmon growth, feeding activity, predator avoidance, or other behavioral and physiological measurements of chronic sub-lethal stress that may result from exposure to chemical constituents and would ultimately affect juvenile Chinook salmon survival.

The design of the contaminant toxicity investigations proposed as a complementary element to

VAMP should be coordinated and reviewed by the IEP contaminant project work team.

Entrainment Losses

There are a large number of water diversions located on the lower San Joaquin River and Delta that may contribute to direct entrainment losses of juvenile Chinook salmon. Complementary studies could be developed and implemented to assess the potential significance of entrainment mortality on the overall survival of juvenile Chinook salmon emigrating from the lower San Joaquin River. Additional investigations of salmon losses attributable to direct entrainment at the SWP/CVP diversions can also be developed using data from the mark-recapture tests being performed as part of VAMP

Juvenile Salmon Behavior and Movement Patterns

It has been hypothesized that changes in Vernalis flow and SWP/CVP export rates will affect Delta hydraulic conditions and the rate of emigration and movement patterns of juvenile Chinook salmon within the lower San Joaquin River and Delta. Crude estimates of the rate of emigration can be developed based upon analyses of the timing of coded-wire tag recaptures performed as part of VAMP. More sophisticated observations of juvenile salmon behavior may be made through such techniques as radio or acoustic tag tracking. Juvenile Chinook salmon could be equipped with radio transmitters and their movement patterns through the lower San Joaquin River and Delta determined under various flow and export conditions implemented through VAMP.

Although radio tracking has proven to be a valuable technique in many investigations, the size of the transmitter at this time prohibits the use of this technique on salmon smolts particularly those emigrating during the spring in the lower San Joaquin River (typically less than 100 mm). Larger juvenile salmon, however, could be used for radio and acoustic tracking as part of these complementary study elements to VAMP.

Seasonal Timing of Salmon Fry and Smolt Outmigration

The VAMP program has been targeted on a 31 day period from April 15 - May 15. Complementary studies on the seasonal timing and abundance of salmon fry and smolt emigration in the lower San Joaquin River will provide valuable input into the design of VAMP and, ultimately, development of management actions designed to improve protection for juvenile Chinook salmon. Studies are currently being conducted using Kodiak trawl collections on the lower San Joaquin River at Mossdale in addition to screw trap collections and seining within San Joaquin River tributaries and/or mainstem San Joaquin River. Results of these complementary studies will provide the necessary information to determine the seasonal period of peak salmon outmigration and potential biological and environmental triggering indicators which will allow flexible implementation of VAMP to coincide with the peak salmon smolt outmigration each year.

Juvenile Salmon Emigration and Survival from the Tributaries

Mark-recapture survival studies are being conducted to evaluate Chinook salmon smolt

emigration and survival from the tributaries. Results of such investigations can provide additional complementary information to further assess the relative significance of mortality within the tributaries and river section of the lower San Joaquin River, and be used to compare it to survival estimates developed through VAMP for the Delta reach. Mark-recapture survival studies with San Joaquin origin Chinook salmon smolts will benefit from the increased sampling effort and recapture of marked salmon as part of the VAMP sampling program. The expansion of sampling at Jersey Point as part of VAMP will provide an opportunity to calculate indices of salmon smolt survival from the tributaries for comparison each year with survival indices from Mossdale and Dos Reis releases. Coordination will be required, however, to ensure that the seasonal timing of tributary and Delta releases coincides with the period of intensive sampling and flow and export conditions developed as part of VAMP.

Additional survival estimates can be derived using results of marked juvenile Chinook salmon released at various locations within the upstream tributaries, in combination with downstream recaptures. Additional survival indices can also be developed for marked salmon using recapture data from ocean adult recoveries. These survival indices offer the opportunity for evaluating survival between the river segment of the lower San Joaquin River, and within the Delta. The experimental design and methods used in CWT releases will be reviewed by the technical work group to determine valid comparisons among survival indices from these complementary tests. These data will provide an opportunity to examine trends in Chinook salmon survival within these various reaches, and potential changes in survival in response to variation in San Joaquin River flows and SWP/CVP exports.

<u>Comparison of Wild versus Hatchery Chinook Salmon Smolt Survival</u>

A number of questions have arisen regarding the use of hatchery produced Chinook salmon smolts for assessing survival of wild salmon emigrating from the lower San Joaquin River and tributaries. The combination of increased sampling within the tributaries, opportunities for additional marking of wild Chinook salmon, and the increased level of sampling and recaptures occurring as part of VAMP provide an opportunity to evaluate and compare survival of juvenile Chinook salmon produced in the Feather River Hatchery, Merced River Hatchery, other production facilities, and wild salmon smolts produced in the tributaries. Comparisons can be made of the relative size and abundance of marked and unmarked salmon collected as part of these tests, in addition to other indicators of smolt condition. Provisions have been made within the experimental design for VAMP, for example, for complementary studies of physiological indicators such as ATPase levels, length frequencies, condition indices, and other measurements among stocks used as part of these tests. Further consideration would need to be given to methods in which the experimental design for VAMP can be used as a framework for evaluating the comparative survival of the hatchery produced and in-river produced salmon smolts. Coordination of these investigations should be made with the San Joaquin River project work team.

<u>Jersey Point Trawl Efficiency Calibration</u>

VAMP includes a major expansion of sampling effort at Jersey Point in an effort to increase the numbers of marked juvenile Chinook salmon recaptured and improve the corresponding indices on salmon smolt survival. Fisheries sampling has been found to vary based on instream flows with generally greater sampling efficiency occurring under lower flow conditions. The influence of flow

on sampling efficiency of the Kodiak trawl at Jersey Point is unknown. The inclusion of releases of marked salmon at the mouth of the Mokelumne as part of the VAMP experimental design provides the necessary paired control to allow comparison of relative survival indices across a range of flow conditions.

As part of these investigations data from the USGS flow and velocity monitoring station at Jersey Point, and other available data, would be reviewed to determine the magnitude of variation in flow expected at the sampling location as influenced by variation in flow at Vernalis, SWP/CVP export rates, and tidal dynamics. If flow at Jersey Point is found to be relatively stable among years within the range of flow and export conditions being considered as part of VAMP, variation in collection efficiency may be small. If flow is found to vary substantially among years, variation in collection efficiency may contribute to variation of survival indices developed as part of VAMP.