CHAPTER 5

Salmon Smolt Survival Investigations

One of the primary objectives of the VAMP program is to identify how San Joaquin River flows and SWP and CVP export rates, with the HORB in place, affect the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used to conduct the Chinook salmon smolt survival investigations, and presents the calculated survival indices, absolute survival estimates and combined differential recovery rates for coded-wire tagged juvenile Chinook salmon released during the VAMP 2004 test period. We also analyzed how survival varied with flow, and flow relative to exports, with and without the HORB. Ocean recovery information on past releases and catches of unmarked juvenile salmon at Mossdale and in salvage are also discussed. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Fish Facility (MRFF) Chinook salmon smolts, released as part of VAMP 2004, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the MRFF for at least 21 days before being released. Sub-samples of these salmon were measured (for fork length) and checked for retention of tags a day or two prior to release. Sub-samples were comprised of approximately 200 salmon collected from the top, middle, and bottom of the release group's raceway. Although tag detection is usually high, all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process. Sacrificed salmon were dissected to determine whether they contained a non-magnetized tag, an undetected tag, or no tag. Each CWT code within a release group was held separately at the MRFF with the exception of the Durham Ferry release. This release was comprised of four CWT codes that were held together at the MRFF. At release, an additional sub-sample of 25 to 75 salmon was taken to verify CWT code. Fifty salmon were taken at Durham Ferry, 75 at Mossdale and 25 at Jersey Point.

Table 5-1 summarizes the release dates, release locations, tag codes, tag retention, and effective release numbers of salmon used to calculate survival indices, estimates, and differential recovery rates. Tag retention rates appeared to be similar to last year, with an overall retention rate of 91% among 2004 VAMP groups compared to 94.5% for 2003. Tag retention rates varied from 82.5% to 96.5%. It is highly desirable that improved retention rates continue to increase for future VAMP studies.

The effective number released (ER) was calculated using the following equation:

$$ER = (T-M)*TR$$

where:

T= *estimated number transported,*

M = *number of mortalities during release and transport (and included those sacrificed as part of the net pen evaluations), and*

TR = *CWT retention rate.*

CODED-WIRE TAG RELEASES

Only one set of CWT salmon releases was made as part of the 2004 VAMP experiment. The releases occurred on April 22 at Durham Ferry, April 23 at Mossdale, and April 26 at Jersey Point. There was not a second set of releases during VAMP 2004, as in past years, due to a lack of fish at MRFF.

TABLE 5–1

2004 CWT Effective Release Data

Release Date	Release Site	Tag Code	Avg FL (mm)	Number Transported	Total Mort (including Net Pen Loss)	Tag Retention %	Number Released	Effective Release
4/22/04	Durham Ferry	06-27-52	83	26,475	138	89.0	26,337	23,440
		06-27-53	82	26,459	139	82.5	26,320	21,714
		06-27-54	82	26,057	138	90.0	25,919	23,327
		06-27-55	83	26,131	139	91.5	25,992	23,783
4/23/04	Mossdale	06-46-70	82	26,439	201	96.5	26,238	25,320
		06-45-82	81	25,950	201	91.6	25,749	23,586
		06-45-83	79	25,904	201	96.5	25,703	24,803
4/26/04	Jersey Point	06-45-80	85	25,708	253	90.0	25,455	22,910

A total of approximately 200,000 CWT fish, with eight distinct tag codes were used during the 2004 VAMP experiments. Each tag code lot consisted of approximately 25,000 fish. A total of approximately 100,000 (4 tag codes) fish were released at Durham Ferry, 75,000 (3 tag codes) at Mossdale and 25,000 (1 tag code) at Jersey Point (Table 5-1). During VAMP 2004, tag codes were mixed and released at each site as one group. As with VAMP 2003, the Durham Ferry release was made from the more desirable location alongside the river, instead of from the top of the levee. The nearby agricultural diversion was turned off from the time of the releases until several hours after the release to allow the tagged salmon time to disperse from the release site.

During the Durham Ferry release, the hose from the tank truck disconnected and approximately 150 salmon escaped out of the hose, spilling onto the ground. These were placed into a net pen, with some proportion later removed and placed back into the river during the counting of individuals for the net pen study.

The release at Jersey Point was made at the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

Water temperatures in the MRFF trucks and at the release sites were measured immediately prior to release. These, as well as additional release and recovery data, are provided in Table 5-2.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2004 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). Water temperatures were measured at locations along the longitudinal gradient of the San Joaquin River and interior Delta channels between Durham Ferry and Chipps Island—locations along the migratory pathway for the juvenile Chinook salmon released as part of these tests (Appendix C-1). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2004 investigations. Water temperatures were also recorded within the hatchery raceways at the MRFF coincident with the period when juvenile Chinook salmon were being tagged and held. These temperature recorders were later transported with the juvenile salmon released at Durham Ferry and Mossdale.

Results of water temperature monitoring within the Merced River Fish Facility showed that juvenile Chinook salmon were reared in, and acclimated to, water temperatures of approximately 10.5–16 C (51–61 F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the VAMP 2004 releases are shown in Figures 5-3, 5-4, and 5-5. Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the MRFF, which is similar to all past years. Water temperatures at the release sites as measured from these temperature recorders indicated temperatures were initially favorable but increased

TABLE 5–2

Release Information for 2004 VAMP Releases

Release Site/Stock	Release Date	Tag Code	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
Durham Ferry (MRFF)	4/22/04	06-27-52	55.4	60	23,440	83
		06-27-53	55.4	60	21,714	82
		06-27-54	55.4	60	23,327	82
		06-27-55	55.4	60	23,783	83
Total					**92,264**	
Mossdale (MRFF)	4/23/04	06-46-70	55.4	63	25,320	82
		06-45-82	55.4	63	23,586	81
		06-45-83	55.4	63	24,803	79
Total					**73,709**	
Jersey Point (MRFF)	4/26/04	06-45-80	57.7	71	22,910	85

quickly over the next few days (Figures 5-3 and 5-4). Water temperatures measured within the lower San Joaquin River and Delta (Figures 5-3, 5-4 and 5-5) reached levels considered to be stressful (20–22 C; 68–72 F) and may have contributed to adverse effects and reduced survival of emigrating juvenile Chinook salmon released as part of the VAMP 2004 investigations.

Water temperatures measured during the 2004 VAMP period in the lower San Joaquin River and Delta were among the highest recorded over the five-year period of VAMP investigations (Appendix D-8). Peak temperatures recorded in 2004 exceeded 20 C (68 F) at all monitoring stations. Average temperatures in the lower San Joaquin River, such as Durham Ferry, Mossdale, Dos Reis the DWR monitoring station, confluence, Channel marker 30, and Channel marker 13 (Appendix C-2) exceeded 18 C (64 F). These temperatures were generally greater than temperatures recorded during the 2000, 2002, and 2003 VAMP tests (Appendix D-8). Water temperatures observed in 2004 were similar to temperatures observed during the 2001 test period (although survival in 2004 was much less than that measured in 2001). Exposure of juvenile Chinook salmon to elevated water temperatures during out migration has been identified as one of the factors contributing to the survival of juvenile salmon. Exposure to elevated water temperatures during out migration may affect the physiology of the smolts, reduce resistance to disease, reduce growth, and increase vulnerability to predation by largemouth bass, striped bass, and other predatory fish within the lower river and delta. The incremental contribution of water temperature exposure during 2004 and previous years to observed salmon smolt survival has not been quantified. Water temperature monitoring within the Merced River Fish Hatchery and within the river and delta is recommended to continue as part of the VAMP investigations.

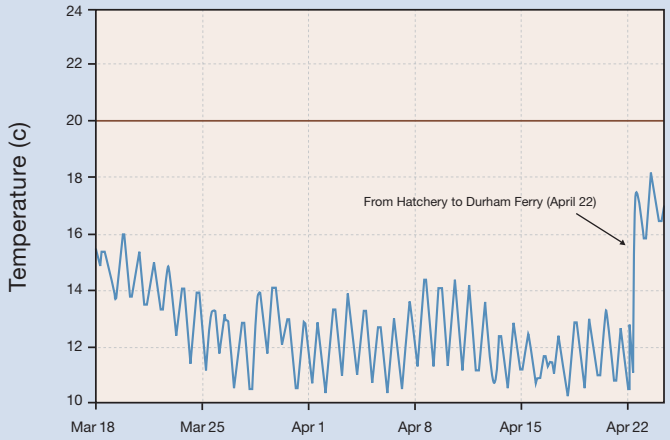
POST-RELEASE NET PEN STUDIES

Survival and Condition

The post-release survival and condition of CWT salmon were evaluated as part of the VAMP program using sub-samples of tagged salmon from each release group. Because tag codes were combined, 50 salmon from Durham Ferry, 75 from Mossdale and 25 from Jersey Point were evaluated for general condition immediately after release. To assess general condition, fork length in millimeters, weight in grams, and six other characteristics were examined (Table 5-3). Other obvious abnormalities or deformities were also noted. To assess short-term effects of handling, transport, and release, an additional sub-sample from each release group of approximately 200 fish per net pen (2 pens at Durham Ferry, 3 at Mossdale and 1 at Jersey Point) were held at the respective release sites for 48 hours. Of these, 25 were measured, weighed, and examined for the six general condition characteristics. The remaining fish were measured for length and weight and evaluated for adipose fin clips and short-term mortality. Due to the mixed tag codes for each of the releases, multiple net pens with approximately 200 fish each were held in order to maintain consistency with the other release groups and previous years. In all, 300 juvenile Chinook salmon were examined for the six general condition characteristics, and

FIGURE 5-1

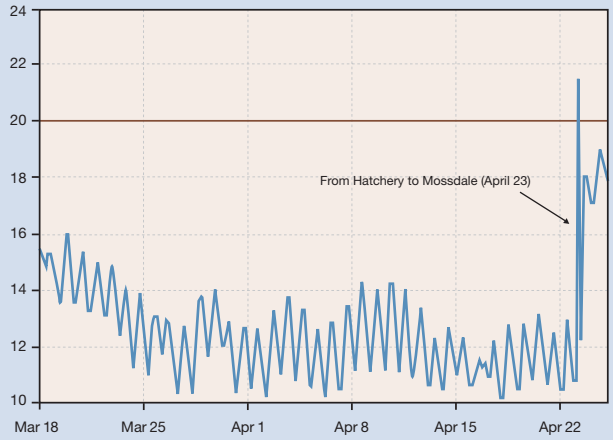
Merced River Fish Hatchery to Durham Ferry



Water temperatures measured in the Merced River Fish Facility and following release at Durham Ferry.

FIGURE 5-2

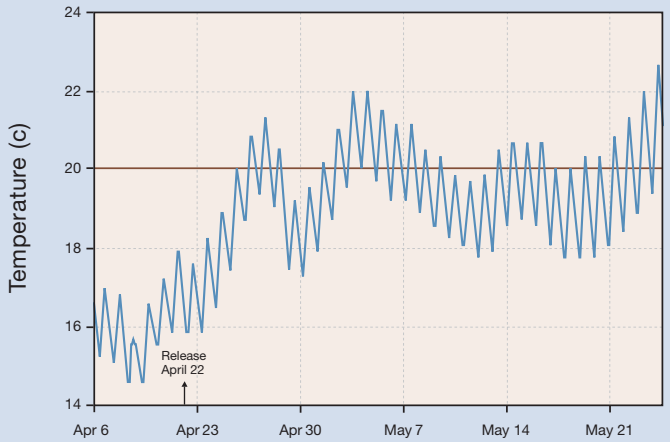
Merced River Fish Hatchery to Mossdale



Water temperatures measured in the Merced River Fish Facility and following release at Mossdale.

FIGURE 5-3

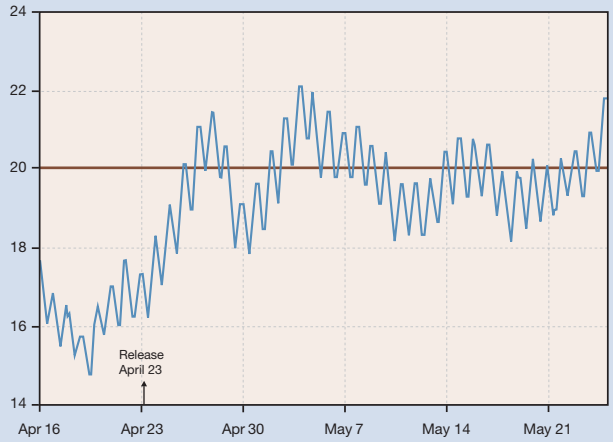
Site 1–Durham Ferry



Water temperatures measured in the San Joaquin River at Durham Ferry.

FIGURE 5-4

Site 2–Mossdale



Water temperatures measured in the San Joaquin River at Mossdale.

FIGURE 5-5

Site 9–USGS Gauging Station at Jersey Point–Top

Water temperatures measured in the San Joaquin River at Jersey Point.

TABLE 5-3

Smolt Condition Characteristics Assessed for Post-release Net Pen Studies

	Normal	Abnormal
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood ore red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0–100% scale loss	Higher relative numbers worse based on 0–100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

1,200 (including the 300 examined for general condition) were measured, weighed and assessed for mortality and presence/absence of adipose fin clip.

Results of the evaluations of the 300 marked salmon examined for the six general condition characteristics, from both immediately after release and 48 hours later, showed few abnormalities (see Appendix C-3). The majority of fish examined had normal coloration (99.94%), and eye characteristics (98.44%) and no fin hemorrhaging (99.97%). Fourteen percent of fish examined showed poor gill color. Scale loss ranged from 0% to 12% and averaged 2.9%. Other abnormalities included: fin rot (0.8%), jaw deformities (< 0.5%) and ragged dorsal fins (1%). In addition, this year 22 (7%) Chinook salmon had a poor or incomplete adipose fin clip, while 2 (0.5%) had no fin clip. Of the 1,200 juvenile Chinook salmon examined, there were 10 mortalities. In comparison, we observed 11 mortalities in 2003.

As mentioned previously, during the release at Durham Ferry, approximately 150 Chinook spilled onto the ground when the hose disconnected from the tank truck. Field crew that were present stated that of the 150 fish, only 4 were directly observed to have died from the incident.

Tag Quality Control

A subset of 25 salmon from each tag group, evaluated for condition as described above, was sacrificed to verify purity of tag codes. Though rare, in the past, salmon from different tag groups have been mixed at some point prior to release. In 2004, no errant tag codes were found in these groups. The remaining fish in each net pen were archived to allow for further evaluation if necessary.

Health and Physiology

Personnel from the California-Nevada Fish Health Center (FHC) conducted physiological studies on a sub-sample of the juvenile Chinook salmon used in the VAMP study (Harmen, et.al., 2004). Results of this work are summarized below.

Ninety-six Merced River Fish Facililty salmon were examined from the three release groups (32 fish per release group) following transport to release sites at Durham Ferry, Mossdale, and Jersey Point. A general health inspection for viral, *Renibacterium salmoninarum* (Bacterial Kidney Disease agent) and systemic bacterial infection was performed on 12 fish from each release group. Additional assays were conducted on the remaining 60 fish including assessment of : 1) internal and external abnormalities; 2) smolt development (gill tissue of 36 fish, 12 from each release group were analyzed for ATPase activity); and, 3) kidney tissue from 36 fish were examined for presence of *Tetracapsula bryosalmonae* (Tb), the parasite responsible for Proliferative Kidney Disease (PKD). To assess stress recovery, blood plasma levels of chloride, sodium, lactate, glucose, total protein, and cortisol were measured from the remaining 20 fish from each group.

No viral pathogens, systemic bacteria, or *R. salmoninarum* were detected in the 96 fish tested. *Tetracapsula bryosalmonae*

was detected in 37% of the salmon sampled at Durham Ferry, 50% at Mossdale and 64% at Jersey Point. Only 14% or less of the infected kidneys were rated as showing moderate inflammatory changes indicating early stages of PKD.

A large percentage of the groups from Mossdale and Durham Ferry had ATPase activities associated with pre-smolting parr (83% and 42%, respectively). Jersey Point samples were not available due to samples being lost. These data indicate that these fish were not in an advanced state of smoltification at the time of release. It is uncertain how this will effect migration behavior, because, ATPase levels can change rapidly during outmigration and therefore may not have significant effects.

Plasma cortisol tended to increase with each successive release group (i.e. Durham Ferry had the least and Jersey Point had the most). It is likely that longer transport times for each release contributed to the cortisol increase. Plasma protein and chloride levels were normal and similar among all groups.

In summary, the VAMP groups used in 2004 indicated that the incidence of *Tetracapsula bryosalmonae* infection increased with each successive release group, with six of the 66 fish examined for Tb having severe infections and 27 having moderate infection. Despite this infection, fish pathologists at the U.S. Fish and Wildlife California/Nevada Fish Health Center (FHC) concluded that fish were relatively healthy and should have performed adequately for outmigration assessments.

The FHC has provided a health and physiological assessment of VAMP release groups each year from 2000 to 2004. The purpose of these assessments was to rule out survival differences due to differential health between release groups and between years. The FHC looked at health (bacterial, viral, and parasitic infections), smolt development, and stress response to determine if there were significant differences which might affect survival of one group over another. While differences in smolt development and stress response each year were noted, the FHC feels the most significant factor affecting survival was infection with Tetracapsuloides bryosalmonae (the myxosporean which causes Proliferative Kidney Disease, PKD). Incidence of infection with *T. bryosalmonae* ranged from 4% to 100% in annual VAMP study releases between 2000 and 2004 (Table 5-4). This progressive disease can reduce a fish's performance due to associated kidney dysfunction and anemia. Not only does this infection reduce the ability for annual comparisons, but also the severity of infection may increase throughout the study period contributing to higher mortality towards the end of the study.

General Conclusions:

- Severity of PKD infection and impairment due to the disease varied annually
- Severity of PKD progressed, so a group which was healthy at release may become impaired in the weeks following release
- No other infectious diseases (viral or bacterial) have been detected
- Smolt development has been similar among release groups each year (with the exception of the year 2000 first Jersey Point release having higher gill ATPase activity)
- Blood chemistry analysis showed that all release groups were physiologically capable of handling stress in 2000, 2002, 2003 and 2004; several release groups in 2001 (both Durham Ferry and second Mossdale releases) performed poorly likely due to PKD infection or extraneous handling of live boxes.
- Confounding factors in our attempts to assess the health and survival of the VAMP release groups could include differences in transport times, fish handling and site water quality.

TABLE 5-4

Prevalence of Tetracapsula bryosalmonae detected in Merced River Fish Facility Chinook Salmon Smolts, 1996–2004

Year	Sample Date(s)	Prevalence	
1996	May 1	5/8	(63%)
1997	May 1	0/10	(0%)
1998	April 17	0/6	(0%)
1999	April 20	0/6	(0%)
2000	April 18–May 2	2/45	(4%)
2001	May 1–May 12	34/34	(100%)
2002	April 19–May 1	92/201	(46%)
2003	April 21–May 2	30/48	(63%)
2004	April 22–April 26	33/66	(50%)

All samples were taken from VAMP (and precursor project) release groups. Fish were assayed by histopathological examination of posterior kidney by the CA-NV Fish Health Center.

CODED-WIRE TAG RECOVERY EFFORTS

Coded-wire tagged salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities, and during sampling Old River near the barrier (Figure 1-1). Coded-wire tagged salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen for CWT processing. Coded-wire tag processing was done by staff at USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP and CVP salvage facilities. DFG Region IV processed salmon captured in the HORB fyke net sampling.

Coded-wire tag processing consists of dissecting each tagged fish to obtain the 1 millimeter cylindrical tag from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database. All tags were read twice, with any discrepancies resolved by a third reader. All tags are archived for future reference. It should be noted that many tags are recovered at Chipps Island, Antioch, SWP/CVP salvage facilities, and other locations. VAMP releases com-

TABLE 5-5

Recovery Information at Antioch, Chipps Island and the Fish Facility for VAMP releases in 2004

Tag Code	Release Site/ Stock	Release Date	Number Released	Antioch Recoveries							
				First Day Recovered	Last Day Recovered	Number Recovered	Minutes Finished	Percent Sampled	Survival Index	Group Index	
06-27-52	Durham Ferry (MRFF)		23,440	5/04/04	5/04/04	1	584	0.406	0.008		
06-27-53	Durham Ferry (MRFF)		21,714	5/0304	5/03/04	1	620	0.431	0.008		
06-27-54	Durham Ferry (MRFF)		23,327	–	–	0	–	–	–		
06-27-55	Durham Ferry (MRFF)		23,783	–	–	0	–	–	–		
	Total	4/24/04	92,264	5/03/04	5/04/04	2	1,204	0.418		0.004	
06-46-70	Mossdale (MRFF)		25,320	5/02/04	5/02/04	1	590	0.410	0.007		
06-45-82	Mossdale (MRFF)		23,586	–	–	0	–	–	–		
06-45-83	Mossdale (MRFF)		24,803	–	–	0	–	–	–		
	Total	4/23/04	73,709	5/02/04	5/02/04	1	590	0.410		0.002	
06-45-80	Jersey Point (MRFF)	4/26/04	22,910	4/27/04	5/06/04	22	5,812	0.404	0.171		

prise a small portion of the total tagged salmon released in the Sacramento and San Joaquin system. Consequently, many tags recovered at Chipps Island, Antioch, the SWP and CVP salvage facilities, and other locations are from coded wire tag releases not affiliated with VAMP. In order to identify tag recoveries related to VAMP, it is necessary to read all recovered tags.

SWP and 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) was 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 for all time periods. Only CWT salmon recovered in the raw salvage collections were sacrificed for tag processing. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities, as it does not include losses prior to, and associated with, prescreen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2004 studies are shown in Table 5-5. Salvage numbers were low at the CVP and SWP. These results are consistent with earlier studies showing that the HORB reduces the number of CWT salmon entrained at the fish facility.

Antioch Recapture Sampling

Fish sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (Figure 1-1) using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2–inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is 6 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 captured fish were transferred immediately from the Kodiak trawl to buckets filled with river water, where they were held for processing. Data collected during each trawl included: species identification and fork length for each fish captured,

	Chipps Island Recoveries							Expanded Fish Facility		
	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Finished	Percent Sampled	Survival Index	Group Index	CVP	SWP	Recovery Days
	–	–	0	–	–	–		24	6	
	5/03/04	5/03/04	1	400	0.278	0.022		36	0	
	5/02/04	5/02/04	1	400	0.278	0.020		24	0	
	5/01/04	5/01/04	1	400	0.278	0.020		0	6	
	5/01/04	5/03/04	3	1,200	0.278		0.015			4/26 – 5/04
	–	–	0	–	–	–				
	5/06/04	5/06/04	1	390	0.271	0.020		24	0	
	5/02/04	5/06/04	2	1,950	0.271	0.039		0	6	
	5/02/04	5/06/04	3	1,950	0.271		0.020			4/30 – 5/10
	4/28/04	5/03/04	25	2,400	0.278	0.511		12	0	5/4

tow start time and duration, and location in the channel. Any fish mortalities or injuries were documented to comply with the Endangered Species Act permit requirements.

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

Sampling at Antioch began April 24 and continued through May 15. Each day between 5:30 a.m. and 9:00 p.m., anywhere from 11 to 31 tows were conducted. In all, 607 Kodiak trawl samples were collected, for a total of 12,080 tow minutes. During sampling, 6,157 unmarked juvenile Chinook salmon were captured; 127 salmon with an adipose fin clip (and CWT) were collected, 25 from VAMP releases (Table 5-5) and 102 from other MRFF releases. In addition, 1,543 delta smelt, 59 Sacramento splittail, 25 unmarked steelhead, and 8 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

As part of VAMP 2004 recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 24 and May 22. This second shift has been conducted during the spring releases since 1998. The first shift began at sunrise, while the second shift ended at or after sunset, to incorporate the crepuscular periods of the day. Based on analysis of 24-hour sampling at Jersey Point in 1997 (Hanson Environmental, unpublished data), greater numbers of juvenile Chinook salmon appear to be caught around sunrise and sunset. Therefore, targeting this crepuscular period and doubling total trawl effort at Chipps Island should increase the number of CWT salmon recaptured and reduce variability in VAMP survival indices. Sampling continued at one shift per day between May 23 and June 18, five days per week between June 21 and July 2, and three days per week after July 2.

The trawl at Chipps Island was towed at the surface using a net with a mouth opening 10 feet deep by 30 feet wide, with a total length of 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors, along with a weighted lead line, were used on the bottom bridles to keep the mouth of the net open. The net consisted of variable mesh starting with 4-inch mesh at the mouth and ending with a 1/4-inch cod end mesh.

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes; one each in the north, south, and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. The lane sampled four times was chosen at random or selected by the boat operator based on flow conditions.

Coded-wire tagged salmon released for the VAMP 2004 program, were recovered at Chipps Island between April 28 and May 6 (Table 5-5). A total of 31 VAMP CWT salmon were recovered at Chipps Island. During the April 24 through May 22 VAMP recovery period, a total of 12,214 unmarked salmon, 579 CWT salmon from non-VAMP experiments, 37 delta smelt, 82 Sacramento splittail, 7 adipose fin clipped steelhead, and 26 unmarked steelhead were sampled at Chipps Island.

VAMP CHINOOK SALMON CWT SURVIVAL

Survival Indices

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices (SI) were calculated using the formula:

$$SI = (R / (ER*T*W))$$

where:
R is the number recovered, ER is the effective number released, T is the fraction of time sampled, and W is the fraction of channel width sampled.

The fraction of the channel width sampled at Chipps Island (0.00769) was calculated by dividing the net width (30 feet) by the estimated channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was calculated in the same manner, with the net width being 25 feet and the channel width being 1,800 feet. 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 fraction of time sampled for the VAMP 2004 release groups at Chipps Island was about 28%, while at Antioch it was about 41% (Table 5-5).

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group.

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2004 are shown in Table 5-5. Survival indices have been reported to three

significant digits, but we realize indices are not likely that precise. Survival indices were not corrected for the number of CWT fish recovered at the HORB or in sampling at Mossdale conducted by DFG Region IV.

The survival indices of the Durham Ferry and Mossdale groups were very low as measured at Antioch (0.004 and 0.002 respectively) and Chipps Island (0.015 and 0.020 respectively) in 2004. The survival index of the Jersey Point group was higher at 0.171 and 0.511 at Antioch and Chipps Island respectively. While the raw recovery rate at Chipps Island and Antioch was similar, once recoveries were expanded for effort, indices indicated that recoveries were much lower at Antioch, indicating that the greater sampling at Antioch is not translating into additional recoveries. Indices in 2004 were similar to 2003 using the Chipps Island recoveries whereas they were much lower using the Antioch recovery information.

Survival indices for releases made at Durham Ferry and Mossdale were very low relative to releases made at Jersey Point using both sets of recovery numbers (Table 5-5).

Chinook Salmon Survival Estimates and Combined Differential Recovery Rates

The differences in survival indices are further evaluated using absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

where:

SI_u is the survival index of the upstream group (Durham Ferry or Mossdale), SI_d is the survival index of the downstream group (Jersey Point) and i is either Antioch or Chipps Island.

Although referred to throughout this document as absolute survival estimates they are more aptly described as standardized or relative survival estimates. The combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A} / ER$$

where:

R_{C+A} is the combined recoveries at Antioch and Chipps Island of a CWT group, and ER is the effective release number.

The combined differential recovery rate is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

where:

CRR_u is the combined recovery rate for the upstream group (Durham Ferry or Mossdale), and CRR_d is the combined recovery rate for the downstream group (Jersey Point).

The CDRR is another way to estimate survival between the upstream and downstream release locations. It is similar to calculating absolute survival estimates, but does not expand estimates based on the fraction of the time and space sampled. At times the differential recovery rate (DRR) is reported which is similar to the CDRR but only uses recovery numbers from one recovery location—either Chipps Island or the ocean fishery.

The CDRR and the absolute survival estimates should not be very different as 1) the fraction of the time sampled is similar between groups within a recovery location and 2) the fraction of space sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island could result in different survival estimates between the two methods.

Variance and standard errors were calculated for the CDRRs based on the Delta method recommended by Dr. Ken Newman. Plus or minus two standard errors are roughly equivalent to the 95% confidence intervals around the CDRR. Plus or minus one standard error equates to roughly the 68% confidence intervals for normally distributed data (Ken Newman, University of St. Andrews, Scotland, personal communication). In comparing survival between reaches the confidence intervals were used to determine if CDRRs were significantly different from each other. If the 95% confidence intervals overlapped, CDRRs were not considered statistically different from each other. Differences observed using the lower level of confidence (68%) is noted.

Absolute survival estimates and CDRRs should be more robust for comparing survival between groups, recovery locations, and years, since using ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Both estimates of absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2004, as in past years. An additional estimate of absolute survival will be possible from recoveries made in the ocean fishery, two to four years following release.

Using the CDRR's the survival estimates from Durham Ferry to Jersey Point and Mossdale to Jersey Point were not different

even though fish released at Durham Ferry are thought to incur additional mortality since it is 11 miles farther upstream than Mossdale (Table 5-6).

The CDRRs of the Mossdale and Durham Ferry groups were the same in 2004 (0.26). Pooling the groups also resulted in the pooled CDRR being the same as each of the individual estimates (0.026). The standard error of the pooled estimate was also calculated and reported (Table 5-7).

TRANSIT TIME

The recoveries of the few VAMP fish collected in 2004 were made at Antioch between April 27 and May 6 (Appendix C-4). Recoveries were made over a similar time period at Chipps Island: April 28 to May 6. Recoveries of upstream groups (Durham Ferry and Mossdale) at Chipps Island were recovered a few days earlier and a few days later than at Antioch. With so few CWT salmon recovered it is uncertain if the broader recovery period at Chipps Island is biologically meaningful. Transit times for marked salmon were estimated from the release day to the first and last day of recovery during VAMP 2004 which is included in Table 5-4.

Recoveries were made at the CVP and SWP fish facilities between April 26 and May 10 (Table 5-5), a longer period than at the other recovery location.

COMPARISON WITH PAST YEARS

Survival between Durham Ferry and Mossdale appeared high in 2004 as in past years. In 2000 through 2003, CDRRs indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p>0.05$) (SJRG, 2003 and 2004), thus we can infer survival between Durham Ferry and Mossdale was generally high in these years. However, low recovery numbers may hinder our ability to detect differences. Continued releases of CWT fish at both sites, will allow detection of mortality between Durham Ferry and Mossdale if it becomes great enough to detect in the future. If survival between locations is shown to be similar (not statistically different) then groups can be combined. When ocean recovery information becomes available it may also provide a means to assess mortality between Durham Ferry and Mossdale.

However, survival was much lower from Durham Ferry and Mossdale to Jersey Point in 2004 than for most of the releases in the past. The 2004 survival estimates were similar to those obtained in 2003. In 2004 the pooled CDRR from Durham Ferry and Mossdale to Jersey Point was 0.026, just slightly higher than that observed in 2003 (0.019). The estimate in 2003 was the lowest measured to date. Both the 2003 and 2004 data is much lower than that measured since VAMP started in 2000 (Table 5-7). Even prior to VAMP, with only Chipps Island recoveries, the lowest differential recovery rate with the HORB in place was 0.133 in 1994.

The health of the CWT fish in of itself did not appear to account for the low survival observed in 2004 or 2003. As we found in 2003, the infection and severe infection rates of *Tetracapsula bryosalmonea* (causative agent of Proliferative Kidney Disease) (PKD) was greater in 2001 than in 2004 (Table 5-8). Survival was greater in 2001 than in either 2003 or 2004 (Table 5-7).

However, as we hypothesized in 2003, the high level of PKD infection in combination with the lower flows could have increased the mortality of VAMP fish in both 2003 and 2004

TABLE 5-6

Survival Indices and Absolute survival estimates using recoveries at Antioch and Chipps Island for CWT fish released as part of VAMP 2004.

Release Site	Date	Antioch Group Index	Antioch Absolute Survival	Chipps Group Index	Chipps Absolute Survival	Combined Differential Recovery Rate
Durham Ferry	4/22/04	0.004	0.02	0.015	0.03	0.026
Mossdale	4/23/04	0.002	0.01	0.020	0.04	0.026
Jersey Point	4/26/04	0.171		0.511		
Durham Ferry and Mossdale						0.026

TABLE 5-7

Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale and Durham Ferry in relation to those released at Jersey Point.

Year	CDRR	Standard Error
1994	0.133	0.099
1997	0.186	0.064
2000	0.187	0.019
2001	0.191	0.014
2002	0.151	0.013
2003	0.019	0.005
2004	0.026	0.010

since Jersey Point groups also had PKD but survived at a higher rate.

The number of days until first recovery of the Mossdale and Durham Ferry groups to Chipps Island appears to be related to San Joaquin River flow. In 2004 the number of days until first recovery was the longest since VAMP started in 2000, with recoveries made 9 days after release with flows at 3,261 cfs. The number of days until first recovery in 2003 and 2002 were similar (6–9) and had similar flow levels. In 2000 and 2001, flows were higher and travel times were faster (4 to 5 days with flows of 6,020 and 4,211 cfs, respectively) (Table 5-9).

In contrast, the number of days until last recovery for the Mossdale and Durham Ferry groups was sooner in 2004 (11 to 13 days) and 2003 (7 to 13 days) than in 2002 (ranged from 15 to 22 days after release) and 2000 (16 to 32 days) when PKD infection rate was lower. The number of days until last recovery in 2003 and 2004 was similar to that observed in 2001 (10 to 13 days) (Table 5-9). Both 2003 and 2001 had the highest percentage of fish with infection and severe infection of PKD (Table 5-8). Differences in the number of days until last recovery may reflect increased mortality over time on the individuals that took longer than the 7 to 13 days to reach the western Delta due to higher incidence of PKD in 2004, 2003 and 2001. It is possible that the combination of the first fish taking longer to reach Chipps Island due to the lower flows and the increased mortality due to the direct or indirect affects of PKD infection for the later migrants may in part explain why survival was so much lower in 2003 and 2004 than in past years.

TABLE 5-8

Severity of PKD infection in VAMP fish between 2000 and 2004. Number positive divided by the sample size is shown in parentheses.

Year	Infected	Severe Infection
2000	4% (2/45)	0%
2001	100% (34/34)	29% (10/34)
2002	46% (92/201)	1% (2/201)
2003	63% (30/48)	21% (10/48)
2004	50% (33/66)	9% (6/66)

Role of Flow and Exports

San Joaquin River flow and flow relative to exports between April and June is correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships are statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$ versus $r^2 = 0.42$; SJRG 2003). These relationships suggest that adult escapement in the San Joaquin basin is affected by flow in the San Joaquin River and exports by the CVP and SWP during the spring months when juveniles migrate through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind these relationships by testing how San Joaquin River flows (7,000 cfs or less) and exports, with the HORB, affect smolt survival through the Delta.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design since the spring of 2000. Similar South Delta studies starting in 1994 were conducted prior to the official implementation of VAMP. Fish from the Feather River Hatchery had been used in south Delta studies conducted prior to 1999 (SJRG, 2002).

To assess the relationship between San Joaquin River flows and survival, pooled CDRRs from 2000 through 2004 were plotted. The CDRRs of all Durham Ferry and Mossdale releases within a year were pooled, as they were not significantly different from each other at the 95% confidence level. These pooled estimates and their 68% and 95% confidence intervals for 2004 and the past four years of VAMP releases (2000–2003) are shown in relation to the averaged San Joaquin River flow at Vernalis

TABLE 5-9

First and Last Day Recovered at Chipps Island of VAMP fish released in 2000–2004.
N/R = No second release was made at Mossdale in 2000, and at any of the release sites in 2004.

Release Location	YEAR (San Joaquin River Flow Target)				
	2000	2001	2002	2003	2004
Durham Ferry (1)	5–32	5–11	8–22	6–11	9–11
Mossdale (1)	5–16	4–11	7–17	8–13	9–13
Durham Ferry (2)	5–23	5–13	7–15	—	N/R
Mossdale (2)	N/R	5–10	9–19	7	N/R

(Figure 5-6). Similar data obtained from releases made at Mossdale in 1994 and 1997 are included but have much wider confidence intervals because fewer recoveries were made since only one recovery location (Chipps Island) was used in these years. In 2004, flows were averaged for the 10-day period after release. In prior years the two, ten-day periods after each release were used. It is obvious that the 2003 and 2004 CDRR's are much lower than would have been predicted based on past data.

The CDRRs with confidence intervals are also shown in comparison to average Vernalis flow relative to combined CVP and SWP exports for the same periods as described above for San Joaquin River flow (Figure 5-7). Prior to 2003, the relationship of relative recovery rate to San Joaquin River flow was significant and improved by incorporating exports. The CDRR obtained in 2003 and 2004 is much lower than what would have been predicted from past data and has lessened the benefit of adding exports into the relationship.

In general, the regression lines do appear to increase as flows and flows relative to exports increase, but the addition of the 2003 and 2004 data has resulted in these relationships no longer being statistically significant. As mentioned in previous years, even when the relationships were statistically significant ($p<0.05$), confidence intervals indicated data points were not significantly different from each other (SJRG, 2003).

It does not appear that flow and exports in 2003 and 2004 accounted for the low survival observed. As mentioned earlier, the VAMP target flows and CVP/SWP exports were similar in 2002, but survival was significantly higher in 2002 as shown using the CDRRs and respective confidence intervals (Figure 5-8).

The Role of HORB on Survival

In 2004, the HORB daily culvert operation was variable during the VAMP period. Initially three culverts were open, but one became blocked on April 23—the day after our Durham Ferry release and the day of our Mossdale release. Most of the fish likely passed the barrier prior to April 28, when two additional culverts were opened and one operating culvert became partially blocked (Table 4-1).

The barrier is assumed to improve survival based on studies conducted between 1985 and 1990 (Brandes and McLain, 2001). These studies indicated that smolts released in the river downstream of the Head of Old River survived at about twice the rate of those released in the Old River. And while those data were not statistically significant, placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin. The barrier can only be operated when San Joaquin River flows are 7000 cfs or less. The highest VAMP target flow/export ratio that can be obtained with the barrier in place is 4.7 (7000 cfs flow and 1500 exports).

In Figure 5-9 the annual pooled CDRR or the DRR's are reported for Vernalis flow/export levels of less than 4.7, with and without the barrier in place. The data with the barrier is generally higher than that without the barrier, with the exception of the 1999 and 2003 and 2004 data. In previous reports, we suggested data obtained in 1999 may have been biased high due to missed sampling for the Jersey Point group that year (Brandes, 2000). However, later reporting indicates that differential recovery rates in the ocean fishery were similar to those obtained with

FIGURE 5-6

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with HORB in place versus San Joaquin River flow at Vernalis in cfs, VAMP years 2000–2004 and non-VAMP years 1994, 1997. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale release were also included.

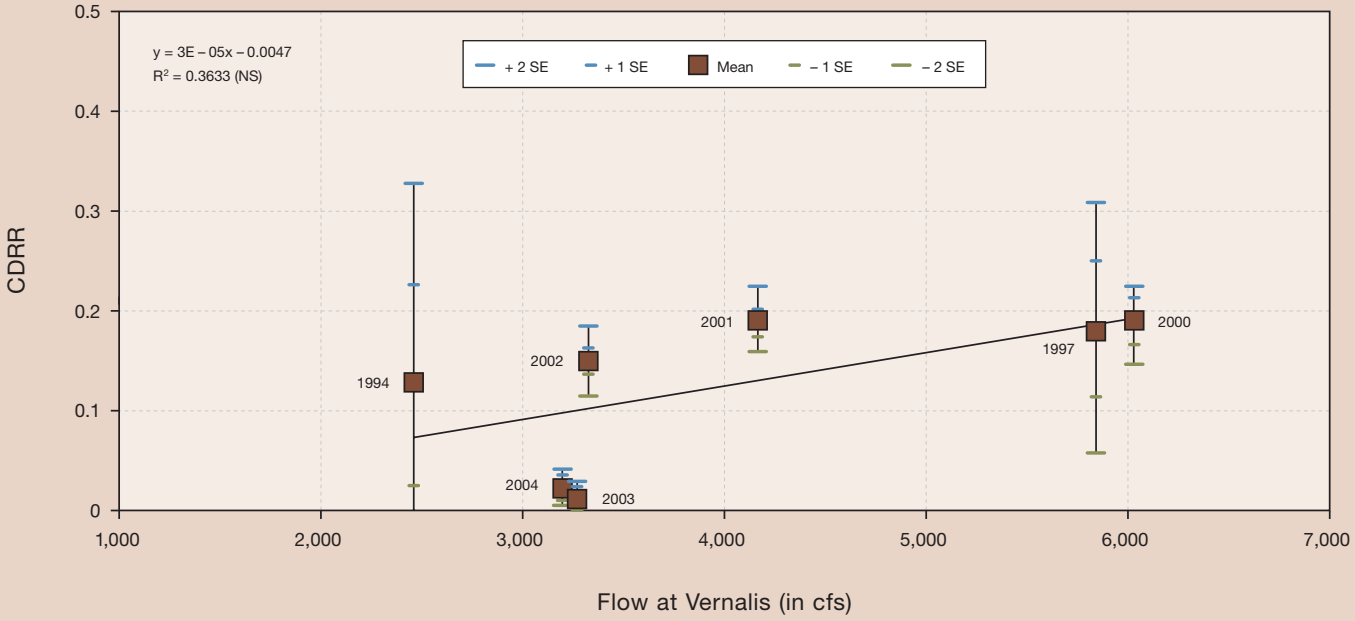


FIGURE 5-7

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis/exports, 1994, 1997, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale release were also included.

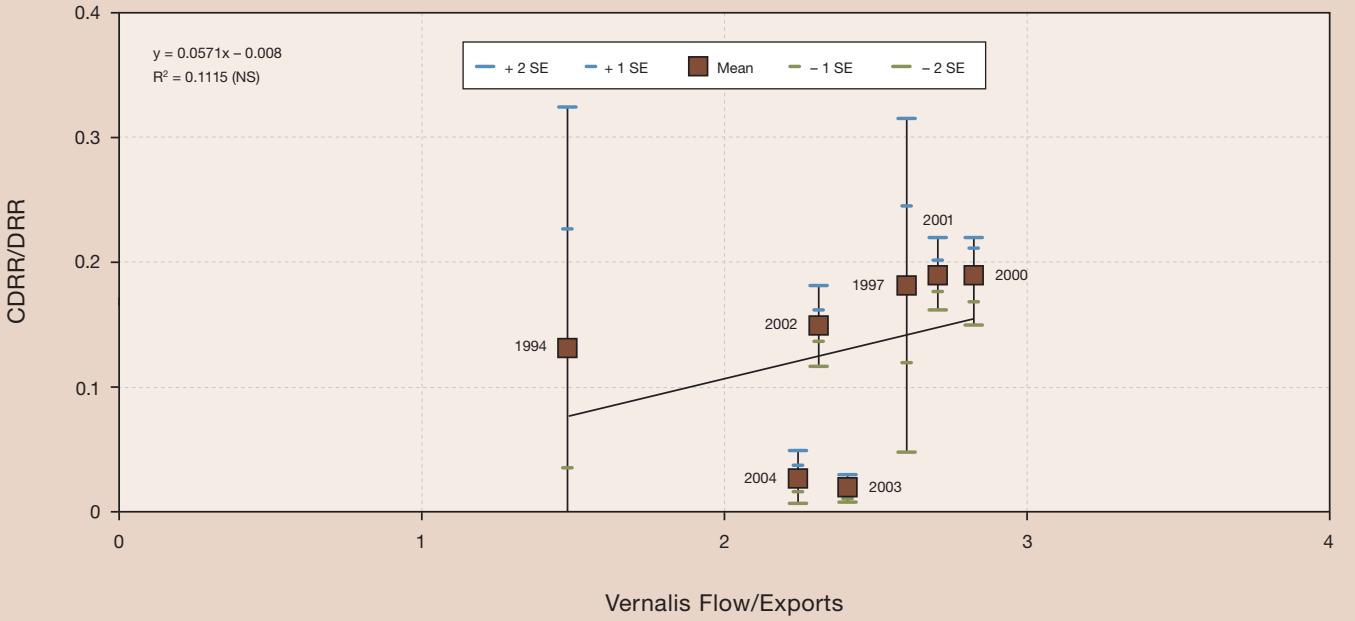


FIGURE 5-8

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) of CWT smolts released at Mossdale and Jersey Point (MD) and Durham Ferry and Jersey Point (DF) for the first release groups (1) in 2002, 2003, and 2004. CDRR were based on the sum of recoveries at Antioch and Chipps Island. Estimates for pooled CDRR's were for the two Durham Ferry and Mossdale releases in 2002 and 2003 and for the only release in 2004.

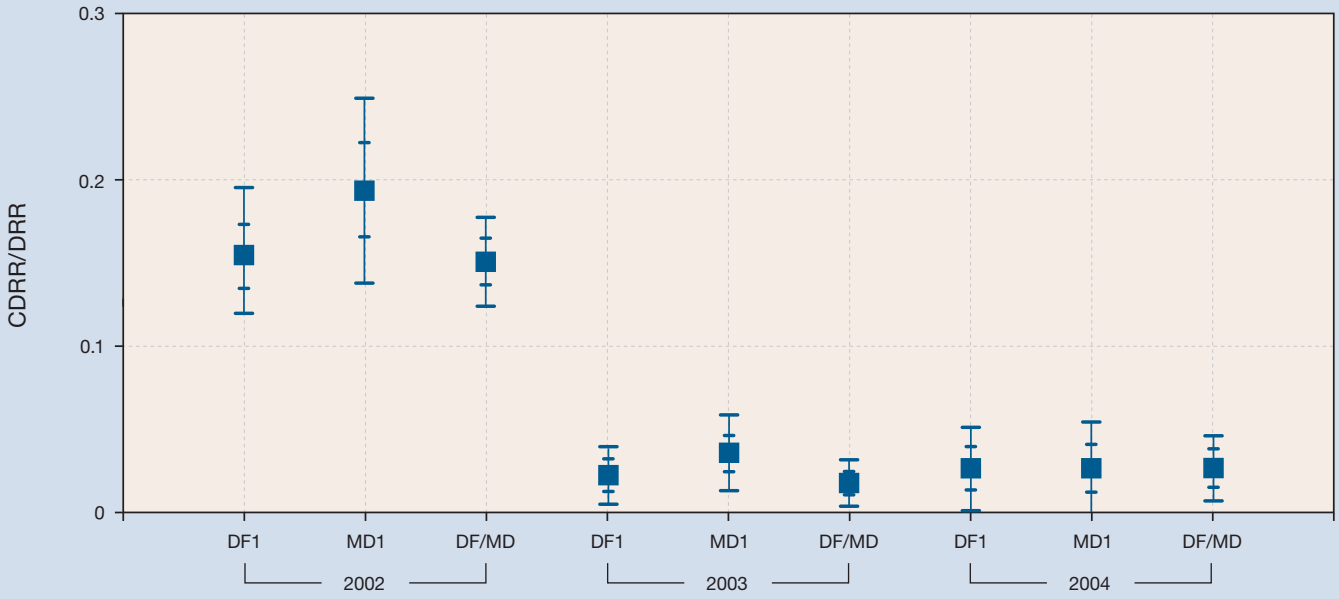


FIGURE 5-9

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis /exports, 1994, 1997, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale releases was also included.

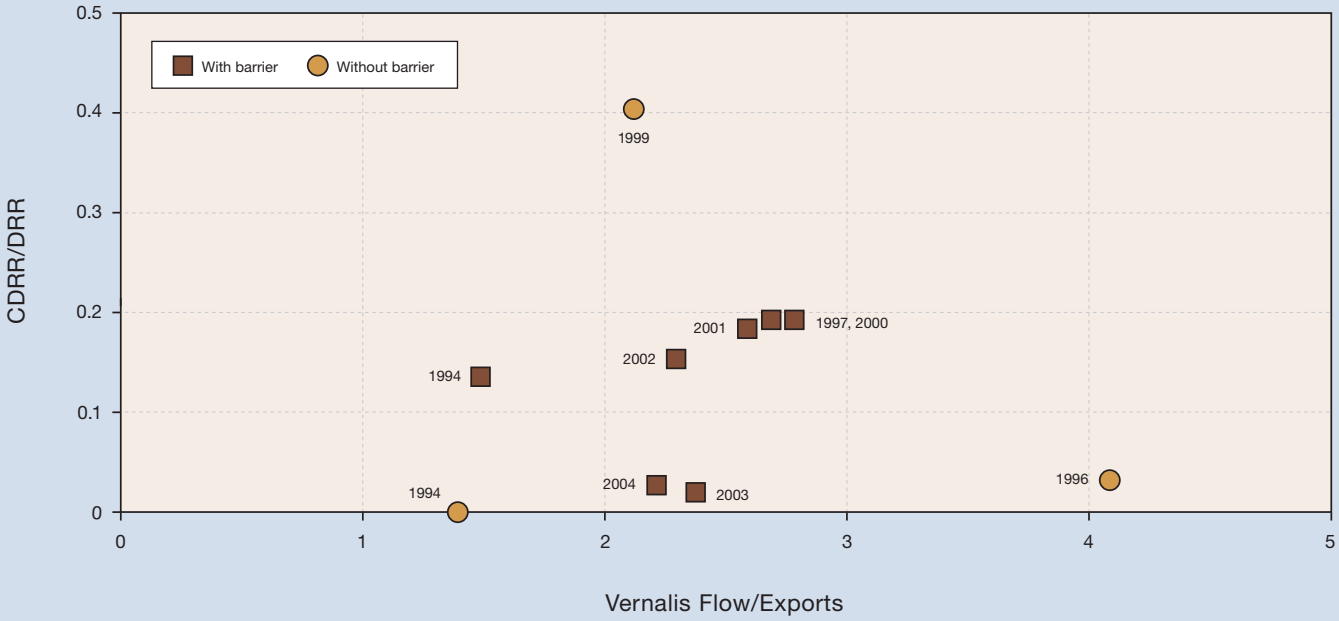
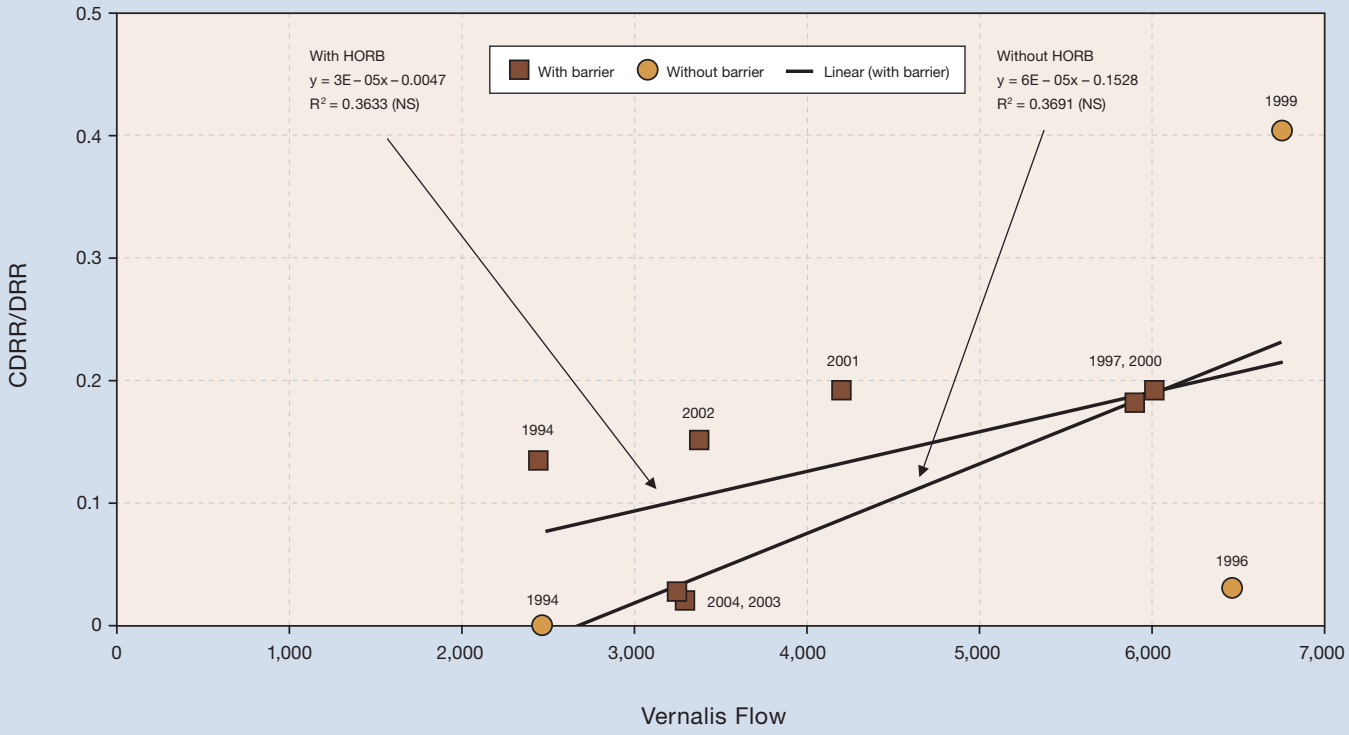


FIGURE 5-10

Combined Differential Recovery Rate (CDRR) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis in cfs, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994,1996,1997 and 1999 from Chipps Island recoveries of Mossdale releases are also included. Comparable DRR's are shown for 1994, 1996, and 1999 when Vernalis flows were below 7000 cfs without the HORB.



the Chipps Island trawl, thus contradicting our suggestion that the data was biased high. The 1999 data is an instance where survival was high at a low flow/export ratio without the barrier in place. In addition, the estimated survival in 2003 and 2004, with the barrier, was low and similar to levels observed in 1994 and 1996 without a barrier in place (Figure 5-9).

The CDRR's or DRR's with and without the barrier, at San Joaquin River flows (at Vernalis) of less than 7000 cfs, are shown in Figure 5-10. These data seem to be better fitted using flow alone to show the differences in survival with and without the barrier. Survival was the highest at the highest flow even without a barrier in 1999. At the lower flows, the barrier appears to generally improve survival at any one flow. Again, the 2003 and 2004 data falls in the range of the non-barrier data at the lower flows— even though the barrier was installed and operated those two years. Measuring survival at 7000 cfs with a barrier would be informative.

The differences in the target conditions tested in VAMP so far have been small, making it difficult to measure differences in survival. In the six years of measuring survival with the HORB in place, the flow to export ratio has only varied from 1.5 (1994) to 2.9 (2000). The maximum flow to export ratio within the VAMP targets is 4.7, but as of yet it has not been tested. The ratios in the relationship between flow/export and adult escapement vary from 0.1 to 1000 (SJRG, 2003) a broader representation of how spring flows relative to exports have varied since 1951.

Varying designs and changes in the culvert operations of the HORB also make it more difficult to detect significant differences in salmon smolt survival at similar flow to export ratios. Even since the adoption of VAMP, permeability (number of culverts open during operation) of the HORB has changed. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry releases and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. In 2003, three culverts were open during the studies. In 2004, between three and five culverts were open during the study.

The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. The amount of water flow moving from the San Joaquin River into Old River would change as flow, stage and the tides

change, even if the number of culverts was consistent between years. These changes in the amount of flow through the culverts and number of culverts operating between years likely affects the entrainment and resulting survival at this point in the river, adding variability in survival from factors other than flow or exports.

The flow through the culverts and seepage through the barrier affects the amount of remaining flow left in the San Joaquin River of which the salmon smolts are exposed. Using flow in the San Joaquin River at Vernalis as the estimate of flow the fish are exposed to instead of flow in the San Joaquin River downstream of the HORB adds additional variation to the relationships we are trying to identify and refine. A better estimate of flow to use in these relationships would be the net flow on the San Joaquin River downstream of upper Old River. An estimate of flow in the San Joaquin River downstream of Old River has been made in the past by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gaged mean daily flow at Vernalis (Chapter 4). To provide more precise estimates an Acoustic Doppler Current Profiler (ADCP) was placed in the San Joaquin River downstream of the HORB in 2003 and 2004 for the purpose of estimating the flow. This method was deemed the best way to estimate flow at this location. Problems with verification and battery malfunction have prevented a full compliment of data to be gathered during these last two VAMP studies. The ADCP data gathered in 2005 will be compared to that estimated using the mean daily flow in Old River to see how they compare and determine if it is possible to estimate San Joaquin flow downstream of Old River in past years. Future analyses will attempt to use these more refined estimates in comparing smolt survival to San Joaquin River flow.

TABLE 5–10

Release and Recovery Information for CWT Smolts Released in San Joaquin Tributaries in Spring of 2004

Tag Code	Release Site/Stock	Release Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)	ANTIOCH RECOVERIES			
							First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished
06-45-92	Shaffer Bridge (MRFF)	4/19/04	N/P	N/P	23,628	85	—	—	0	—
06-45-93	Shaffer Bridge (MRFF)	4/19/04	N/P	N/P	22,440	85	05/04/04	05/04/04	1	584
	Total				**46,068**		05/04/04	05/04/04	1	584
06-45-94	Hatfield State Park (MRFF)	4/20/04	52.9	59.9	23,489	84	—	—	0	—
06-45-95	Hatfield State Park (MRFF)	4/20/04	52.9	59.9	23,037	84	—	—	0	—
	Total				**46,526**					
06-46-64	Shaffer Bridge (MRFF)	4/27/04	55.9	59	25,501	84	—	—	0	—
06-46-65	Shaffer Bridge (MRFF)	4/27/04	55.9	59	25,489	84	—	—	0	—
	Total				50,990					
06-46-66	Hatfield State Park (MRFF)	4/28/04	55.9	63.9	24,511	82	—	—	0	—
06-46-67	Hatfield State Park (MRFF)	4/28/04	55.9	63.9	25,307	82	—	—	0	—
	Total				**49,818**					
06-45-96	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,028	86	—	—	0	—
06-45-97	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,358	86	—	—	0	—
06-46-68	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,340	86	—	—	0	—
06-46-69	Upper Merced @ MRFF	5/09/04	N/P	55.9	24,417	86	—	—	0	—
	Total				**100,143**					
06-45-81**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,274	89	—	—	0	—
06-45-98**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,897	89	—	—	0	—
06-45-99**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,769	89	—	—	0	—
	Total				**73,940**					

** Tag codes released on two days, 5/12 and 5/13; Drafted 9/30/04 Preliminary data

Comparison With Other Marked Fish Released From Merced River Fish Facility

Coded wire tagged salmon from the Merced River Fish Facility were released in the San Joaquin River tributaries between April 19 and May 12 as part of independent (complimentary) fishery investigations. Releases were made in the upper and lower reaches of the Merced River. These studies are reported in more detail in Chapter 6, but are discussed here as they relate to VAMP releases.

Survival indices of the downstream Merced releases (Hatfield State Park) would include mortality down the mainstem San Joaquin River as well as through the Delta. While the survival indices to Antioch and Chipps Island of these lower Merced River release groups would include some additional river mortality, if mainstem mortality was low then the indices would be comparable to survival indices of fish released at Durham Ferry and Mossdale as part of VAMP.

Survival indices of the lower Merced River groups were comparable to indices from the upstream VAMP releases. No recoveries were made at Antioch. Survival indices using Chipps Island recoveries were similar to the VAMP releases with indices ranging between 0.006–0.020 (Table 5-10). Survival indices to Chipps Island of VAMP released fish at Mossdale and Durham Ferry ranged from 0.015 to 0.020 (Table 5-5).

These data would indicate that whatever variables affected the survival of upstream released VAMP fish in 2004 also affected survival of the lower Merced groups. The mortality factor was limited to upstream groups and did not seem to affect the Jersey Point group similarly. We also found this to be true for the 2003 groups (SJRG, 2004).

ANTIOCH RECOVERIES			CHIPPS ISLAND RECOVERIES							FISH FACILITIES	
										Expanded Recoveries	
Percent Sampled	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	CVP	SWP
—	—		—	—	0	—	—	—			
0.406	0.008		—	—	0	—	—	—			
0.406		0.004	—	—	0	—	—		—		
—	—		4/30/04	4/30/04	1	400	0.278	0.020			
—	—		5/1/04	5/1/04	1	400	0.278	0.020		12	6
			4/30/04	5/1/04	2	800	0.278		0.020		
—	—		—	—	0	—	—	—			
—	—		5/16/04	5/16/04	1	400	0.278	0.018			
			5/16/04	5/16/04	1	400	0.278		0.009		
—	—		5/6/04	5/11/04	2	2388	0.276	0.038		12	
—	—		—	—	0	—	—	—		12	6
			5/6/04	5/11/04	2	2388	0.276		0.019		
—	—		—	—	0	—	—	—		24	
—	—		—	—	0	—	—	—			
—	—		—	—	0	—	—	—		12	0
—	—		—	—	0	—	—	—			
			—	—	0	—	—		—		
—	—		5/20/04	5/20/04	1	400	0.278	0.019		12	12
—	—		—	—	0	—	—	—			
—	—		—	—	0	—	—	—		36	6
			—	—	1	400	0.278		0.006		

Comparison with Sacramento River Delta Releases

As in 2003, we reviewed survival indices for juvenile salmon released at Sacramento to see how they compared to VAMP releases in 2004. The average survival index in 2004 for the three separate groups of Feather River Hatchery smolts released on April 15, April 30 and May 14 was 0.19—much lower than that measured in 2003 (0.51). This would indicate that from a relative scale survival was lower through the Sacramento River delta in 2004 than in 2003, whereas with the VAMP fish survival was low for both years. This indicates that perhaps different variables were responsible for the low VAMP survival estimates in 2003 and 2004.

OCEAN RECOVERY INFORMATION FROM PAST YEARS

Ocean recovery data of CWT salmon groups can contribute to a more thorough understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of recovery rate of a test release group relative to a control release group. Differential recovery rates using ocean recovery information can be compared with absolute survival estimates based on survival indices and the differential or combined differential recovery rates of juvenile salmon recovered at Chipps Island and/or Antioch, respectively. The ocean harvest data may be particularly reliable due to the number of CWT recoveries and the extended recovery period.

Adult recovery data are gathered from commercial and sport ocean harvest checked at various ports by DFG. The Pacific States Marine Fisheries Commission database of ocean harvest CWT data was the source of recoveries through 2003. The ocean CWT recovery data accumulate over a one to four year period after the year a study release is made as nearly all of a given year-classes of salmon have been either harvested or spawned by age five. Consequently, these data are essentially complete for releases made through 1999 and partially available for CWT releases made from 2000 to 2002.

Differential recovery rates based on ocean recoveries, Chipps Island recoveries or combined Antioch and Chipps Island recoveries for salmon produced at the MRFF are shown in Table 5-11. Absolute survival estimates based on Chipps Island and Antioch survival indices are also included. The earlier releases were made as part of south Delta survival evaluations (1996–1999) with the later releases associated with VAMP (2000–2002). Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point. The Chipps Island and Antioch survival estimates and combined differential (Antioch and Chipps Island recoveries summed) or differential recovery rates (Chipps Island recoveries only) are graphed in relation to the differential recovery rate using the ocean recovery information in Figure 5-11.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the MRFF show: (1) to date, there is general, but variable, agreement between survival estimates and differential recovery rates based on juvenile CWT salmon recoveries in Chipps Island and adult recoveries from the ocean fishery, (2) there is less agreement with Antioch trawling which has fewer years of data, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch, Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be essential to evaluate the biological benefits of changes in flow and export rates under VAMP.

SAN JOAQUIN RIVER SALMON PROTECTION

One of the VAMP objectives is to provide improved conditions to increase the survival of juvenile Chinook salmon smolts produced in the San Joaquin River tributaries during their downstream migration through the lower river and Delta. It is assumed that these actions to improve conditions for the juveniles will translate into greater adult abundance and escapement in future years, especially during low flows, when corresponding adult escapement (2 1/2 years later) has been extremely low (SJRG, 2003).

To determine if VAMP has been successful in targeting the migration period of naturally produced juvenile salmon, catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

The time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. The average catch per minute per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2004 is shown in Figure 5-12. Unmarked salmon do not have an adipose clip and could be unmarked fish from the Merced River

FIGURE 5-11

Comparison of Antioch and Chipps Island survival estimates and differentials of combined differential recovery rates compared to differential ocean recovery rates for 1996-2002.

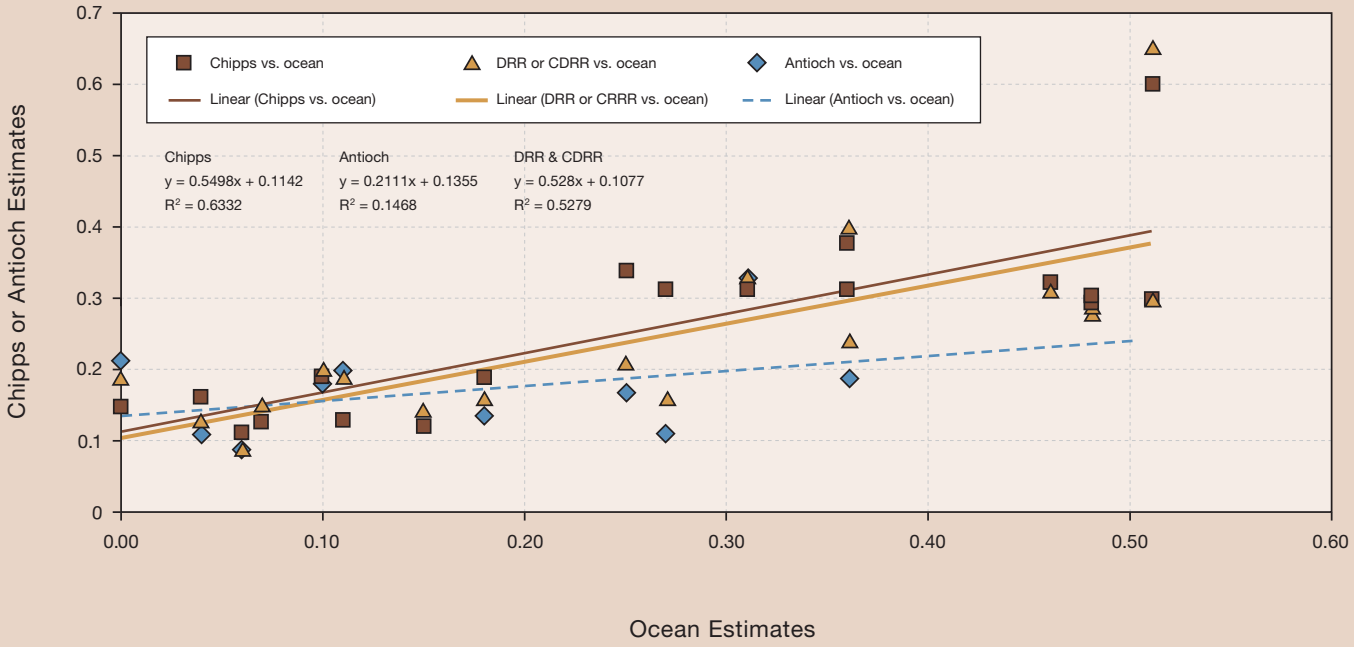


TABLE 5-11

Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced River Fish Facility Salmon Released as Part of South Delta Studies Between 1996 and 2002

Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) TOTAL	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
1996	H61110412	25,633	Dos Reis	5/01/96	2		3				
	H61110413	28,192	Dos Reis	5/01/96	3		37				
	H61110414	18,533	Dos Reis	5/01/96	1		8				
	H61110415	36,037	Dos Reis	5/01/96	5		10				
	H61110501	53,337	Jersey Pt	5/03/96	39		187				
	Effective Release	107,961	Dos Reis		11		58	0.12		0.14	0.15
	Effective Release	51,737	Jersey Pt		39		187				
1997	H62545	50,695	Dos Reis	4/29/97	9		183				
	H62546	55,315	Dos Reis	4/29/97	7		167				
	H62547	51,588	Jersey Pt	5/02/97	27		355				
	Effective Release	106,010	Dos Reis		16		350	0.29		0.29	0.48
	Effective Release	51,588	Jersey Pt		27		355				
	H62548	46,728	Dos Reis	5/08/97	5		91	0.30		0.28	0.48
	H62549	47,254	Jersey Pt	5/12/97	18		192				
1998	61110809	26,465	Mossdale	4/16/98	25		61				
	61110810	25,264	Mossdale	4/16/98	31		40				
	61110811	25,926	Mossdale	4/16/98	32		58				
	61110806	26,215	Dos Reis	4/17/98	33		47				
	61110807	26,366	Dos Reis	4/17/98	23		35				
	61110808	24,792	Dos Reis	4/17/98	34		61				
	61110812	24,598	Jersey Pt	4/20/98	87		110				
	61110813	25,673	Jersey Pt	4/20/98	100		91				
	Effective Release	77,655	Mossdale		88		159	0.30		0.30	0.51
	Effective Release	77,373	Dos Reis		90		143	0.32		0.31	0.46
	Effective Release	50,271	Jersey Pt		187		201				
1999	062642	24,715	Mossdale	4/19/99	8		128				
	062643	24,725	Mossdale	4/19/99	15		134				
	062644	25,433	Mossdale	4/19/99	13		132				
	062645	25,014	Dos Reis	4/19/99	20		151				
	062646	24,841	Dos Reis	4/19/99	19		219				
	0601110815	24,927	Jersey Pt	4/21/99	34		338				
	062647	24,193	Jersey Pt	4/21/99	25		381				
	Effective Release	74,873	Mossdale		36		394	0.38		0.40	0.36
	Effective Release	49,855	Dos Reis		39		370	0.60		0.65	0.51
	Effective Release	49,120	Jersey Pt		59		719				
2000	06-45-63	24,457	Durham Ferry	4/17/00	11	11	239				
	06-04-01	23,529	Durham Ferry	4/17/00	7	6	208				
	06-04-02	24,177	Durham Ferry	4/17/00	10	10	226				
	06-44-01	23,465	Mossdale	4/18/00	9	14	206				
	06-44-02	22,784	Mossdale	4/18/00	9	16	170				
	06-44-03	25,527	Jersey Pt	4/20/00	24	50	643				
	06-44-04	25,824	Jersey Pt	4/20/00	41	47	690				
	Effective Release	72,163	Durham Ferry		28	27	673	0.31	0.19	0.24	0.36
	Effective Release	46,249	Mossdale		18	30	376	0.31	0.33	0.33	0.31
	Effective Release	51,351	Jersey Pt		65	97	1333				
	601060914	23,698	Durham Ferry	4/28/00	7	8	46				
	601060915	26,805	Durham Ferry	4/28/00	5	15	42				
	0601110814	23,889	Durham Ferry	4/28/00	10	8	70				
	0601061001	25,572	Jersey Pt	5/01/00	48	76	356				
	0601061002	24,661	Jersey Pt	5/01/00	30	76	228				
	Effective Release	74,392	Durham Ferry		22	31	158	0.19	0.14	0.16	0.18
	Effective Release	50,233	Jersey Pt		78	152	584				

TABLE 5–11 (continued)

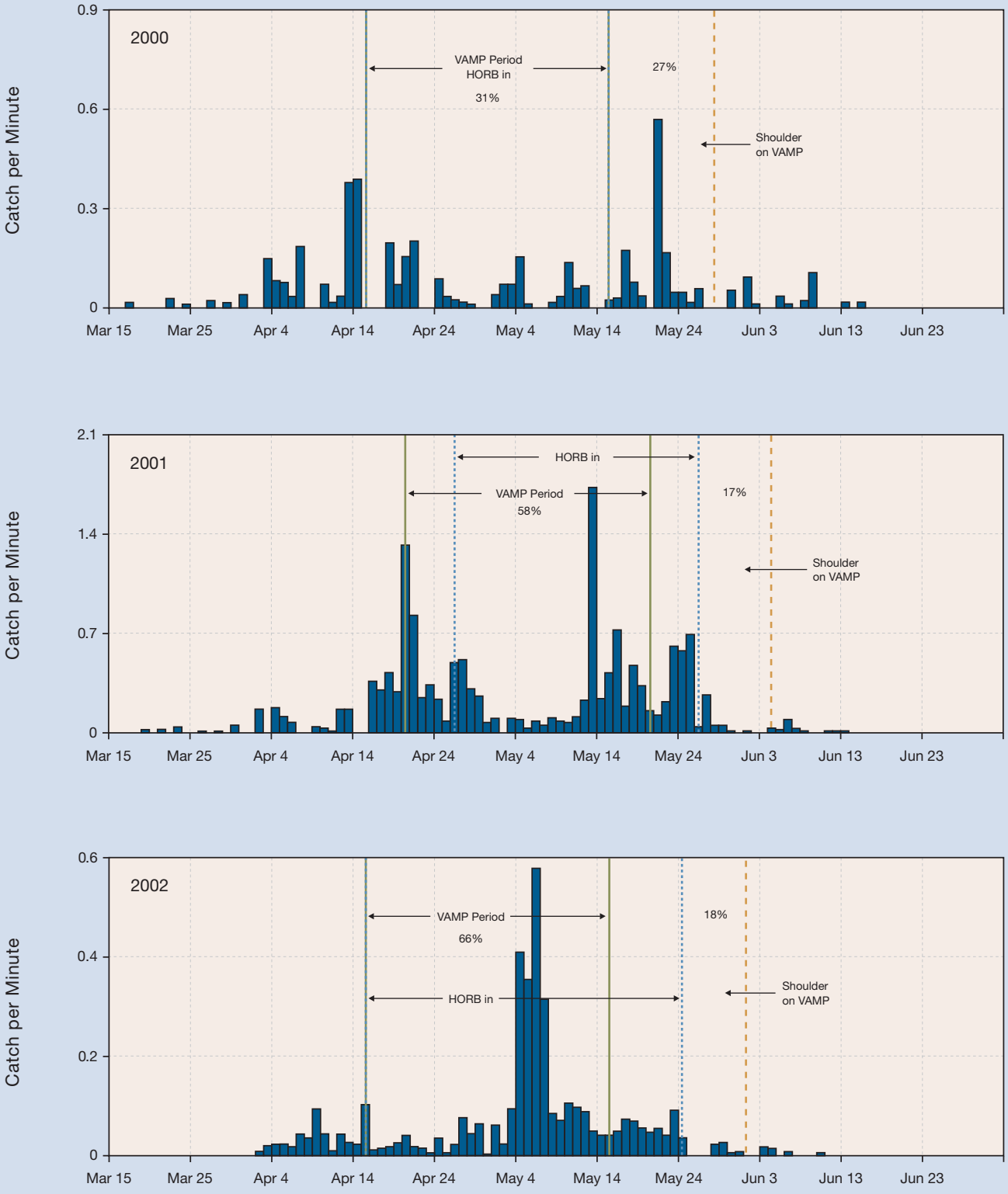
Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced River Fish Facility Salmon Released as Part of South Delta Studies Between 1996 and 2002

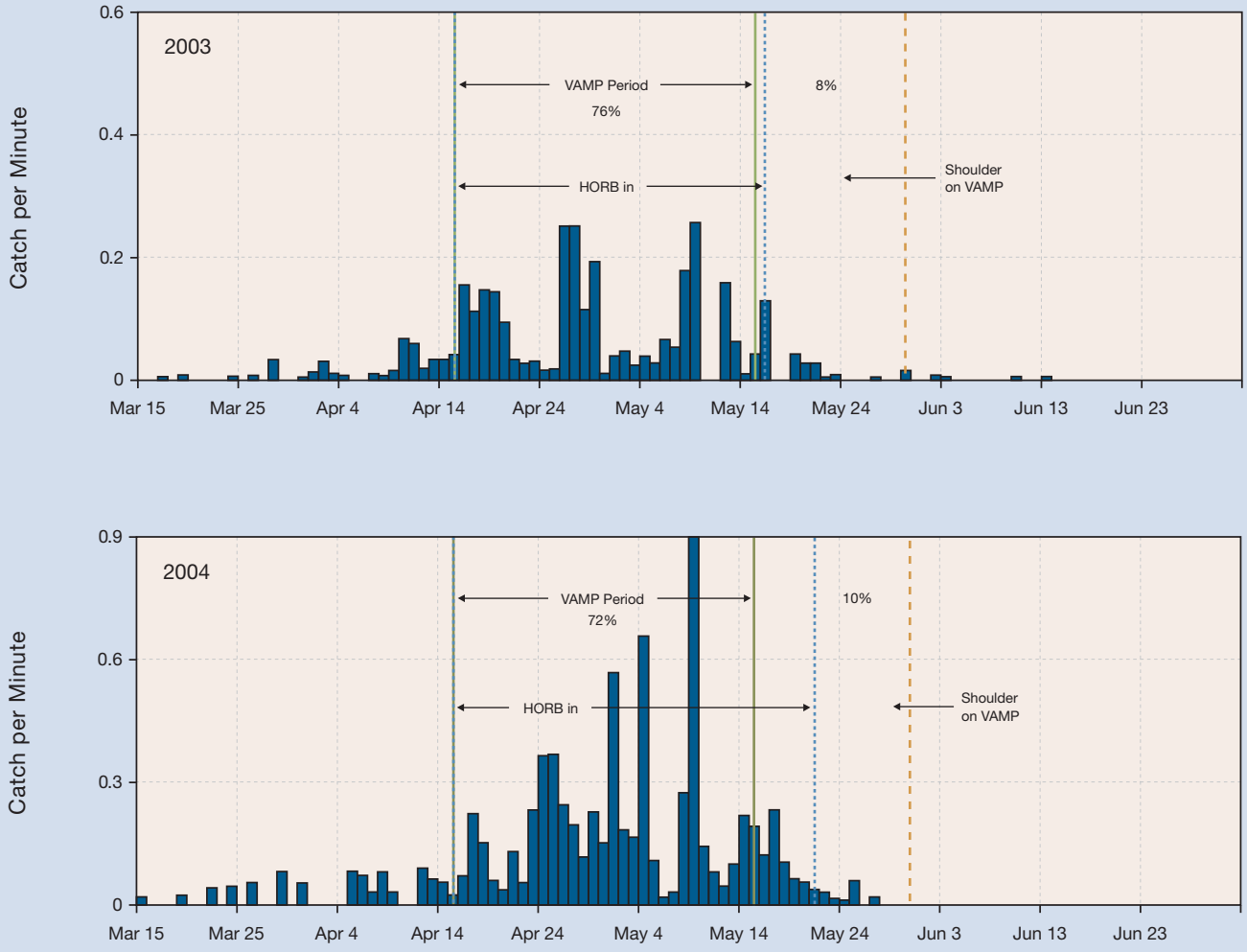
Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) TOTAL	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
2001	06-44-29	23,354	Durham Ferry	4/30/01	14	28	70				
	06-44-30	22,837	Durham Ferry	4/30/01	22	30	141				
	06-44-31	22,491	Durham Ferry	4/30/01	17	18	94				
	06-44-32	23,000	Mossdale	5/01/01	17	18	116				
	06-44-33	22,177	Mossdale	5/01/01	14	15	101				
	06-44-34	24,443	Jersey Pt	5/04/01	50	156	416				
	06-44-35	24,992	Jersey Pt	5/04/01	61	173	467				
	Effective Release	68,682	Durham Ferry		53	76	305	0.34	0.17	0.21	0.25
	Effective Release	45,177	Mossdale		31	33	217	0.31	0.11	0.16	0.27
	Effective Release	49,435	Jersey Pt		111	329	883				
	06-44-36	24,025	Durham Ferry	5/07/01	2	8	14				
	06-44-37	24,029	Durham Ferry	5/07/01	5	11	35				
	06-44-38	24,177	Durham Ferry	5/07/01	2	10	25				
	06-44-39	23,878	Mossdale	5/08/01	4	8	19				
	06-44-40	25,308	Mossdale	5/08/01	4	11	27				
	06-44-41	25,909	Jersey Pt	5/11/01	17	43	191				
	06-44-42	25,465	Jersey Pt	5/11/01	27	53	270				
	Effective Release	72,231	Durham Ferry		9	29	74	0.13	0.20	0.19	0.11
	Effective Release	49,186	Mossdale		8	19	46	0.19	0.18	0.20	0.10
	Effective Release	51,374	Jersey Pt		44	96	461				
2002	06-44-71	23,920	Durham Ferry	4/18/02	4	11	0				
	06-44-72	25,176	Durham Ferry	4/18/02	9	20	12				
	06-44-73	23,872	Durham Ferry	4/18/02	4	12	0				
	06-44-74	24,747	Durham Ferry	4/18/02	4	20	0				
	06-44-57	25,515	Mossdale	4/19/02	6	13	0				
	06-44-58	25,272	Mossdale	4/19/02	7	29	0				
	06-44-59	24,802	Jersey Pt	4/22/02	46	101	41				
	06-44-60	24,128	Jersey Pt	4/22/02	37	89	40				
	Effective Release	97,715	Durham Ferry		21	63	12	0.13	0.13	0.15	0.07
	Effective Release	50,787	Mossdale		13	42	0	0.15	0.21	0.19	0.00
	Effective Release	48,930	Jersey Pt		83	190	81				
	06-44-70	24,680	Durham Ferry	4/25/02	3	6	0				
	06-44-75	24,659	Durham Ferry	4/25/02	5	2	3				
	06-44-76	24,783	Durham Ferry	4/25/02	3	4	0				
	06-44-77	24,381	Durham Ferry	4/25/02	4	6	0				
	06-44-78	24,519	Mossdale	4/26/02	2	3	2				
	06-44-79	24,820	Mossdale	4/26/02	3	4	0				
	06-44-80	24,032	Jersey Pt	4/30/02	18	43	14				
	06-44-81	22,880	Jersey Pt	4/30/02	28	32	19				
	Effective Release	98,503	Durham Ferry		15	18	3	0.16	0.11	0.13	0.04
	Effective Release	49,339	Mossdale		5	7	2	0.11	0.09	0.09	0.06
	Effective Release	46,912	Jersey Pt		46	75	33				

Note: Ocean recoveries are based on data through 2003.

FIGURE 5-12

Catch per minute of unmarked juvenile Chinook caught in the Mossdale Kodiak trawl between March 15 and June 30 of 2000 through 2004. Percentages equate to share of Chinook caught during the VAMP period or Shoulder period of the total catch between March 15 and June 30.




2003
Catch per Minute
0.6
0.4
0.2
0
VAMP Period
76%
8%
HORB in
Shoulder
on VAMP
Mar 15
Mar 25
Apr 4
Apr 14
Apr 24
May 4
May 14
May 24
Jun 3
Jun 13
Jun 23

2004
Catch per Minute
0.9
0.6
0.3
0
VAMP Period
72%
10%
HORB in
Shoulder
on VAMP
Mar 15
Mar 25
Apr 4
Apr 14
Apr 24
May 4
May 14
May 24
Jun 3
Jun 13
Jun 23

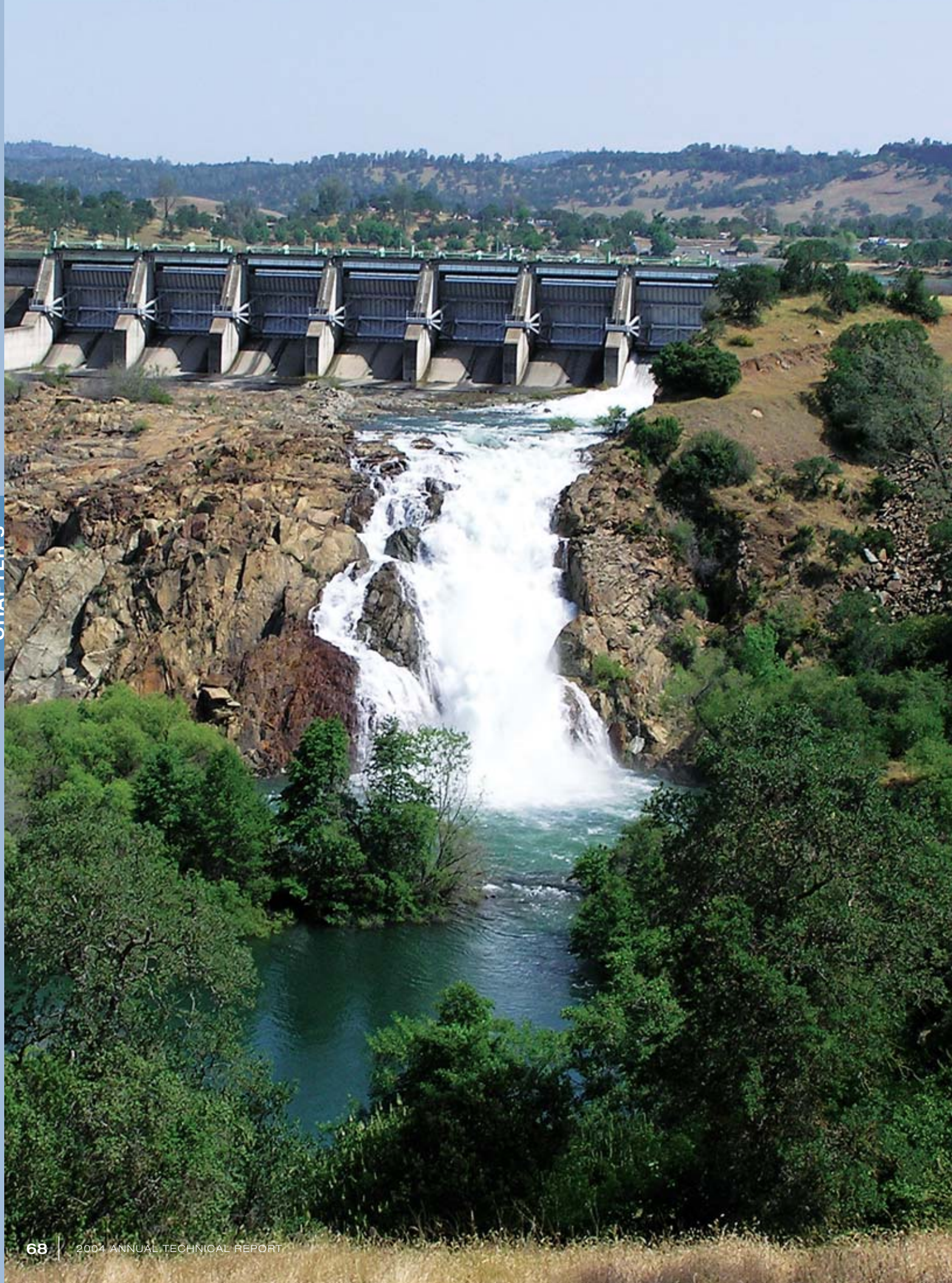
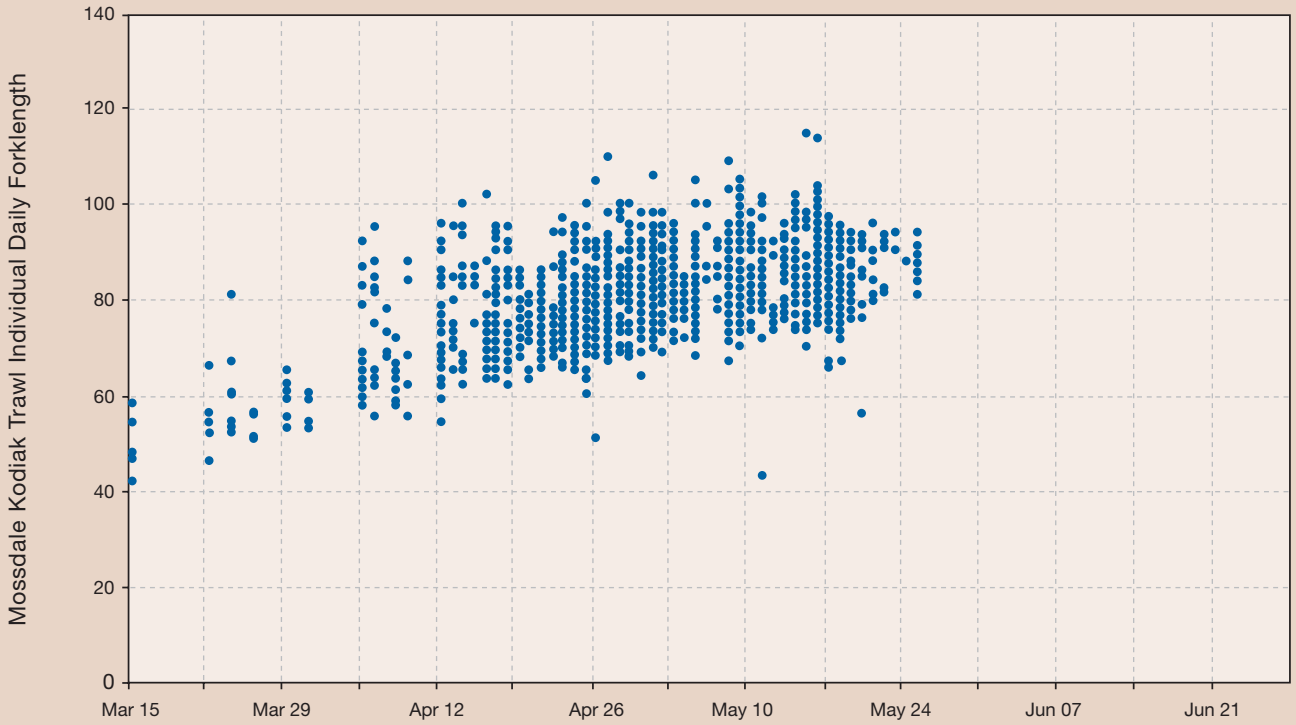


FIGURE 5-13

Mossdale Kodiak trawl individual daily forklengths of all unmarked juvenile Chinook salmon, March 15, 2004 through June 30, 2004.



Fish Facility or juveniles from natural spawning. Approximately 72% of the unmarked catch that passed Mossdale between March 15 and June 30 passed during the VAMP period: April 15 to May 15—which is similar or higher than in past years since the VAMP has been implemented. The shoulder on VAMP that restricts exports until later in May or early June also provided protection to an additional 8 to 27% of the population over the years (Figure 5-12). The percentage of juvenile salmon migrating during the shoulder on the VAMP period in 2004 was 10%. The size of the juvenile salmon migrating past Mossdale between March 15 and June 30, 2004 is shown in Figure 5-13.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release them downstream in the western Sacramento-San Joaquin Delta. The untagged salmon are either naturally produced or untagged MRFF salmon, potentially from any source in the Central Valley. It is not certain which unmarked salmon recovered are of San Joaquin basin origin, although the timing of salvage and fish size can be compared with Mossdale trawl data and CWT recovery data for Merced River Fish Facility smolts at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from sub-samples taken throughout the day. Four to five salmon are estimated to be lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50 to 80% of the number salvaged, or about six to eight times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the Delta due to water export operations, additional mortality associated with trucking and handling, or post-release predation. Salvage density of salmon is the number of salvaged salmon per acre-foot of water pumped. The DFG and DWR maintain a database of daily, weekly, and monthly salvage data.

The number and density of juvenile salmon that migrated through the system, the placement of the HORB, and the amount of water pumped by each facility are some of the factors that influence the number of juvenile salmon salvaged and lost. Density

Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point.

is an indicator of when concentrations of juvenile salmon may be more susceptible to the export facilities and salvage system.

The weekly data covering the period of April 18 to May 15 approximated the 2004 VAMP period. A review of weekly data for late February through May indicates that the highest salvage and losses occurred during early to mid-March (Figures 5-14 and 5-15). Combined CVP and SWP weekly export rates at that time averaged 11,500–12,000 cfs and Vernalis flow averaged 3,400–3,600 cfs (Figure 5-16). Salmon density at the CVP facilities were very elevated in March as well, but their density was highest in the first week of May (Figure 5-17). Densities at the SWP facilities were generally lower than at the CVP, but were at their highest levels the week prior to and during most of the VAMP period (Figure 5-17). The size distribution of unmarked salmon during mid-March through May in the Mossdale trawl (Figure 5-13) was a subset of the size distribution of those salvaged at the fish facilities (Figure 5-18: Source E. Chappell, DWR). Based on comparisons with Mossdale data, it appears that some salmon salvaged prior to VAMP could have been of San Joaquin basin origin. The high salvage and density observed in early to mid March was also preceded by peak capture of fry and juvenile (pre-smolt) outmigrants in screw traps at Caswell State Park on the Stanislaus River upstream of Vernalis and at Mossdale (Figure 6-1) (Cramer 2004).

Results of these analyses showed that the 2004 VAMP test period coincided with much of the peak period of San Joaquin River salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow likely provided improved conditions for salmon survival, although starting the VAMP period two to three weeks earlier may have had benefits for San Joaquin salmon smolts and smolts of other salmon races and stocks.

SUMMARY AND RECOMMENDATIONS

The survival estimates and CDRRs measured in 2003 and 2004 were low compared to past years. It is unclear why survival in 2003 and 2004 were so low but it does not seem to be directly related to San Joaquin River flow or CVP and SWP exports. It is also possible the low survival observed in the past two years is due to different factors. The MRFF fish were infected with the

FIGURE 5-14

2004 SWP Salmon Salvage & Loss

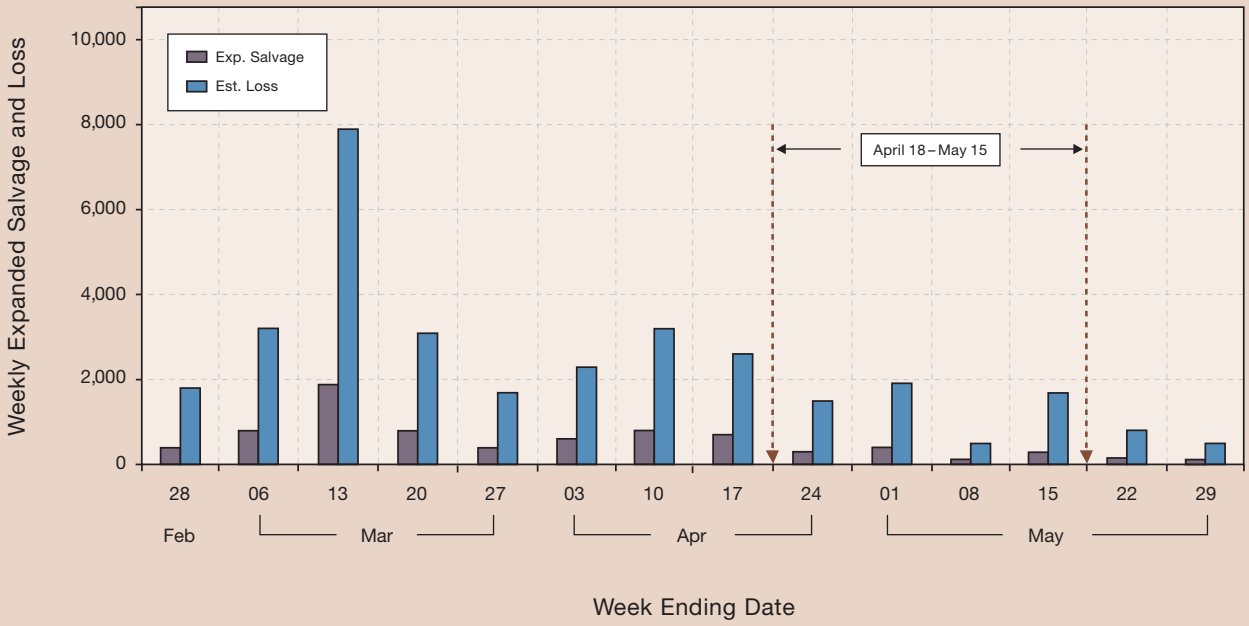


FIGURE 5-15

2004 CVP Salmon Salvage & Loss

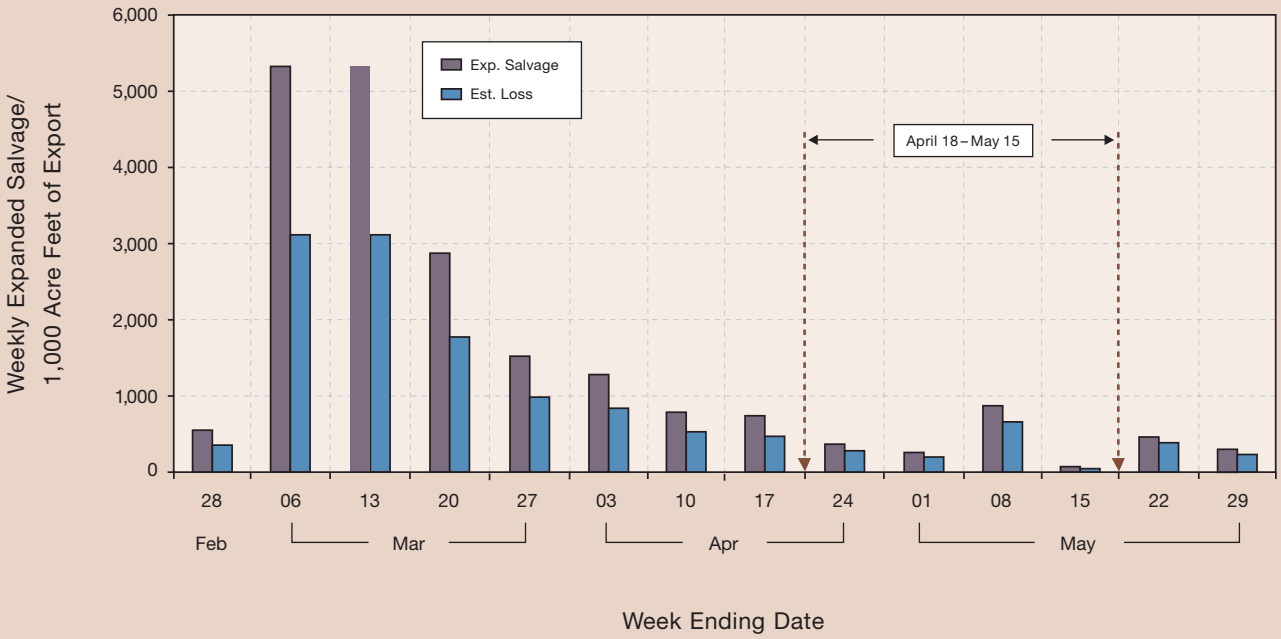


FIGURE 5-16

2004 Weekly Export Rates and Vernalis Flow

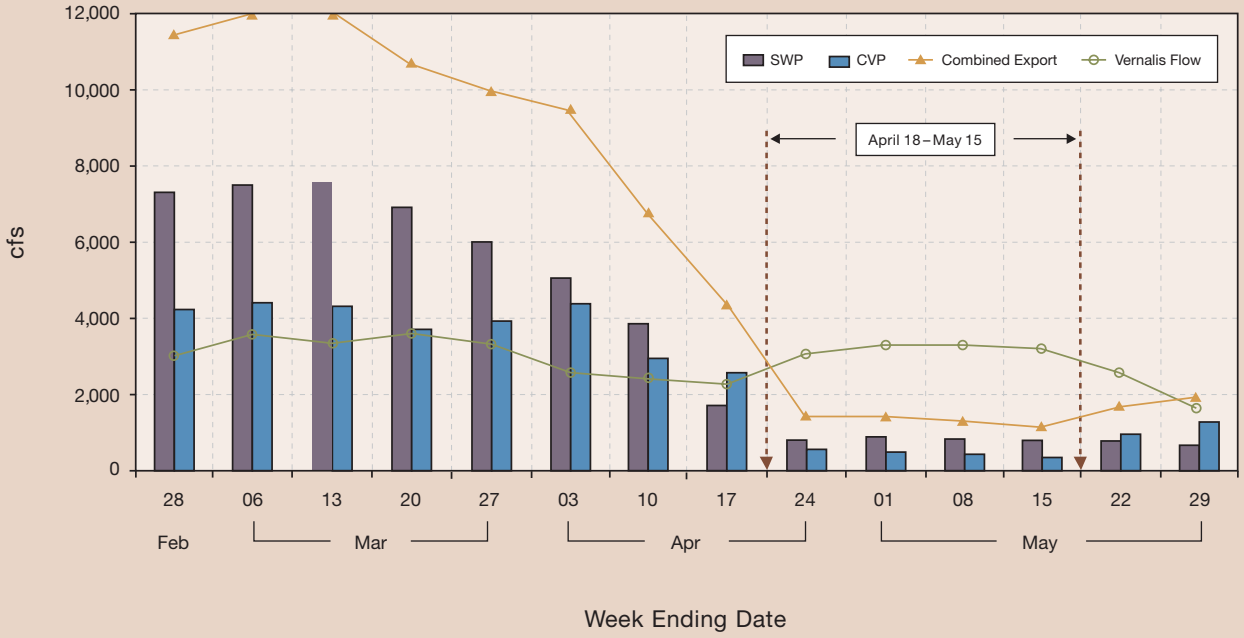
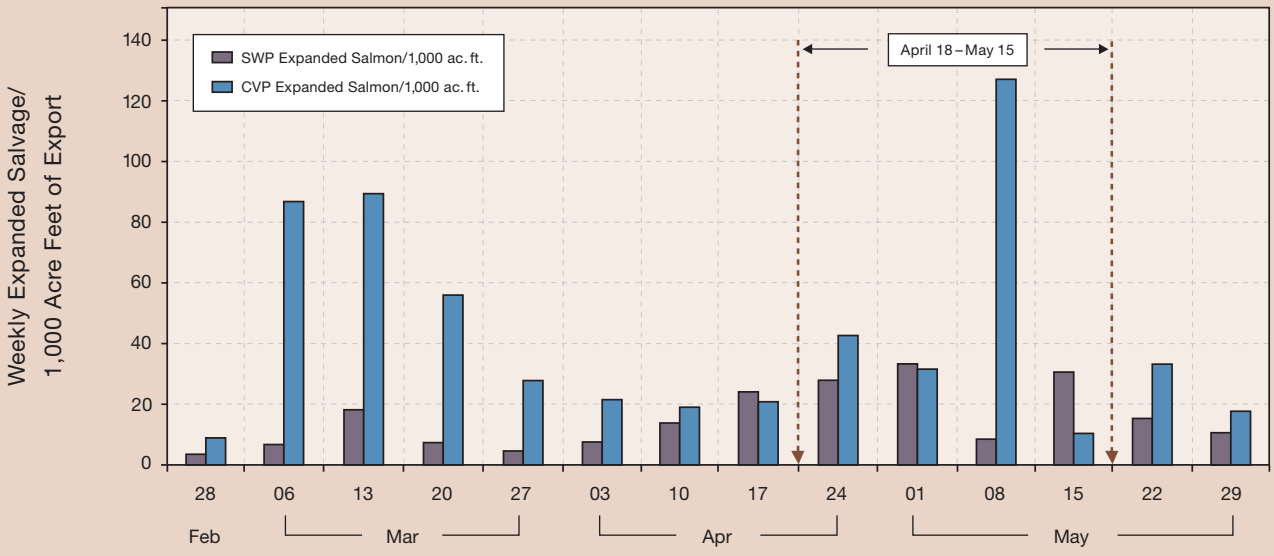


FIGURE 5-17

2004 SWP / CVP Expanded Salmon Salvage Density



parasite that causes PKD. Fish have been infected in past VAMP study years and it does not appear that the incidence of PKD was actually higher in 2003 or 2004. However, the combination of the lower flows and PKD infection may have affected the mortality of the VAMP fish in 2003 and 2004 resulting in shorter transit duration and higher mortality relative to past VAMP releases.

The high and similar mortality of the CWT groups released on the Merced River indicates that whatever increased the mortality of the VAMP fish was some condition that was common to the other marked fish released into the Merced River and lasted for several weeks. This condition also appeared to be restricted to the lower San Joaquin River and Delta or differences in the survival indices for the upstream and downstream Merced River releases would have been greater. While the causes are unclear, it would appear the condition continued into or reappeared in 2004. Repeating the study in future years will determine if this is to be continuous change in the survival rates or limited to lower flow years or just 2003 and 2004.

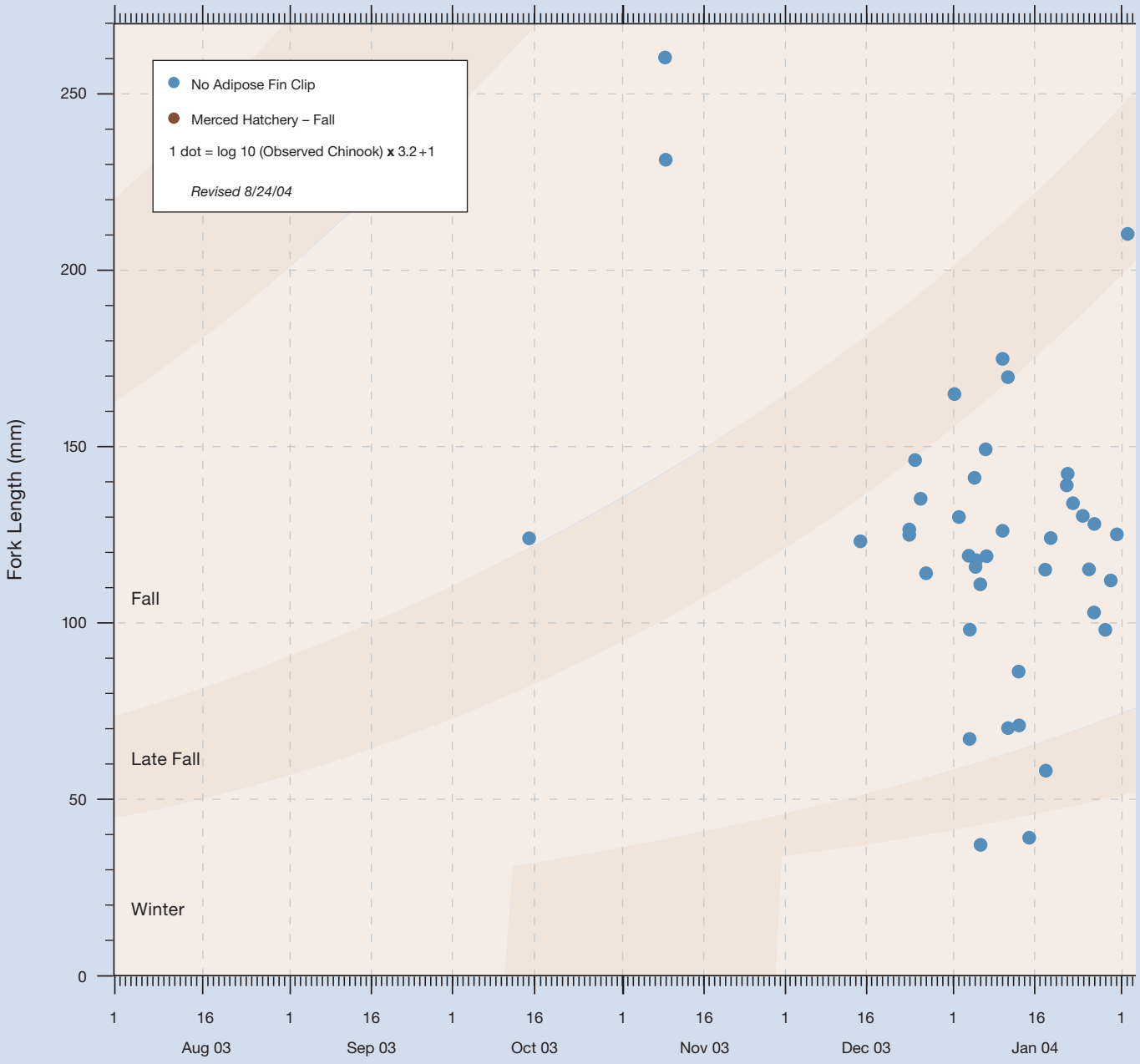
Even without the change since 2003, there have been several impediments to defining and refining the relationships between smolt survival and San Joaquin River flow and CVP and SWP exports. These impediments have been discussed in this and previous VAMP reports. The different permeability of the HORB and not having estimates of flow in the San Joaquin River downstream of the barrier add noise to our estimates of flow. In addition, using diseased MRFF fish in VAMP experiments adds a potential bias to our estimates of survival, even-though PKD is also present in wild stocks (Ken Nichols, USFWS internal memo, 12/6/02). Measuring survival within the narrowly defined flow and export VAMP targets further exacerbates the problem of noise in the variables of interest. The level of precision of our survival estimates and the noise in flow measurements limits our ability to precisely define the relationship of survival to flow and exports. Yearly, pooled estimates are now based on releases of 300,000 to 400,000 fish with two recovery locations, sampling roughly seven to ten hours per day, yet recoveries have not been great enough to statistically differentiate between survival estimates measured at VAMP target flow and exports levels obtained to date. Differences in survival may be occurring but our ability to detect them is limited.

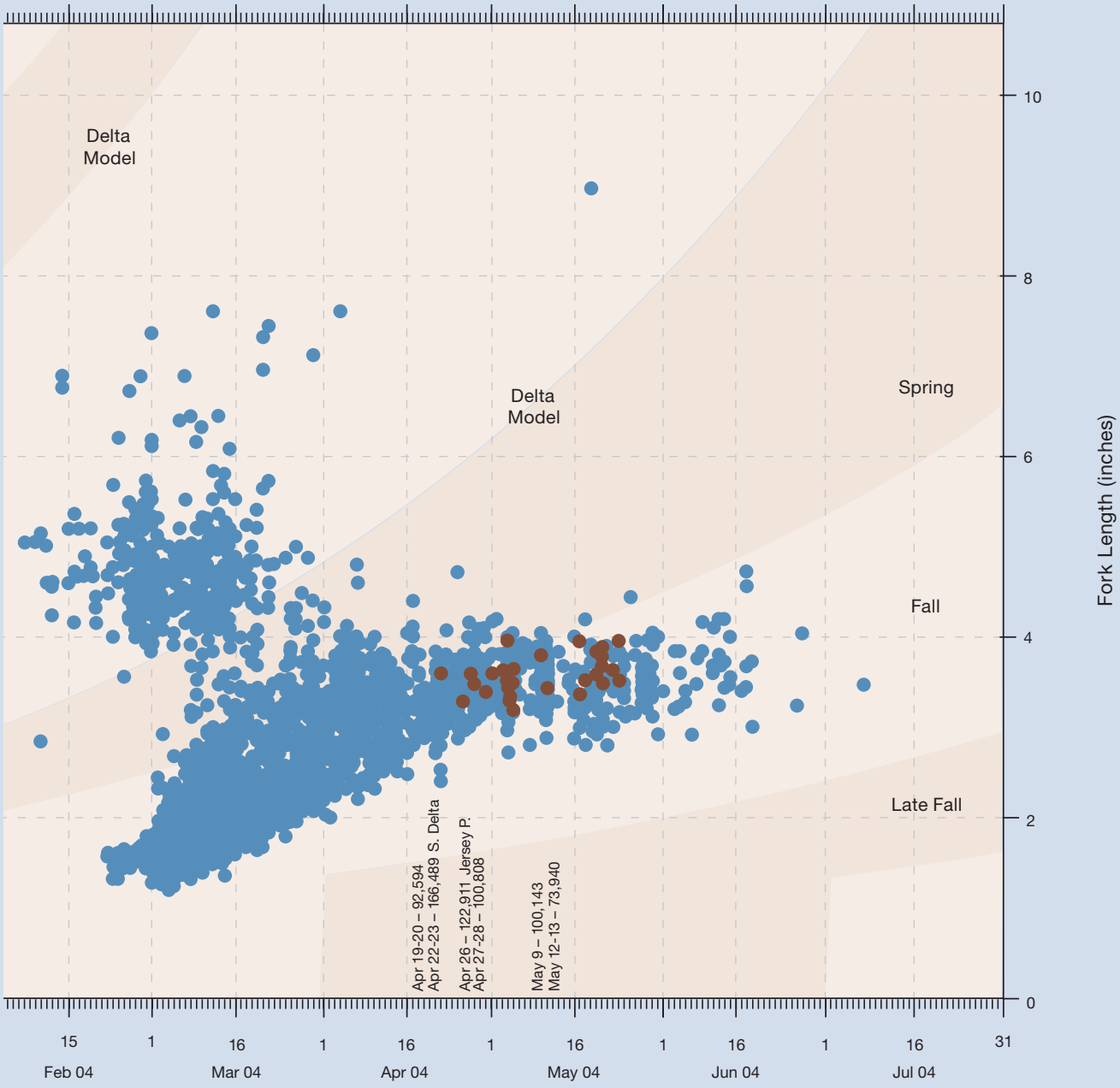
To address this dilemma, future studies should prioritize measuring survival at the highest VAMP target flow and lowest export levels. Flows of 7,000 cfs and exports of 1,500 cfs would achieve the highest inflow to export ratio (4.7) within the VAMP design and provide a new target to test. Based on information to date, the higher flow would probably increase survival and may lessen any effects or infection rate of PKD. This should increase recovery numbers such that confidence intervals may be statistically different from previously obtained CDRRs. It is uncertain how such a condition can be prescribed, independent of the hydrology, within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team.

Further confidence in defining and refining the relationship of smolt survival to flow and exports could be obtained by increasing the length of the study. The fifth year of VAMP was completed in 2004 with seven years remaining in the study. Additional replication can resolve uncertainty when variation is high. Continued assessment of past data is also recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

FIGURE 5-18

Observed Chinook Salvage at the SWP & CVP Delta Fish facilities August 1, 2003 through July 31, 2004.




Delta Model
Delta Model
Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
Apr 19-20 – 92,594
Apr 22-23 – 166,489 S. Delta
Apr 26 – 122,911 Jersey P.
Apr 27-28 – 100,808
May 9 – 100,143
May 12-13 – 73,940
15
1
16
1
16
1
16
1
16
1
16
31
Feb 04
Mar 04
Apr 04
May 04
Jun 04
Jul 04