CHAPTER 5 | SALMON SMOLT SURVIVAL INVESTIGATIONS

One of the primary objectives of the VAMP program is to identify the respective roles of San Joaquin River flow, and SWP and CVP export rates with the HORB in place on the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used in conducting the VAMP 2002 Chinook salmon smolt survival investigations, and presents results of the calculated survival indices and absolute survival estimates for juvenile Chinook salmon during the VAMP 2002 test period. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Hatchery Chinook salmon smolts, released as part of VAMP 2002, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the hatchery for up to 21 days before being released. A sub-sample of the salmon were measured for length and checked for retention of the CWTs a day or two prior to release. The sub-sample was typically comprised of 100 to 300 salmon collected from the top, middle, and bottom of the release group's raceway. Each tag code within a release group was held separately at the hatchery with the exception of the two Durham Ferry releases where each release was made up of four tag codes that were held together in one section of the raceway.

Although tag retention is usually quite high, as a double check on the tag detector, all salmon from the sub-sample that had no tag detected were sacrificed. These sacrificed salmon were dissected to determine whether they contained an un-magnetized tag. A separate sub-sample of 25 salmon was sacrificed from each release group; the tags were removed and read to detect any incorrect tag codes in the raceways. Table 5-1 summarizes results of the CWT retention rate and the estimate of the effective numbers of salmon released to calculate survival indices. Tag retention rates were determined to be similar to last year, with an overall loss rate of 9.5% among all VAMP groups. The tag retention loss rates varied from 0.5% to 15%. It is recommended that this loss rate be reduced for future VAMP studies.

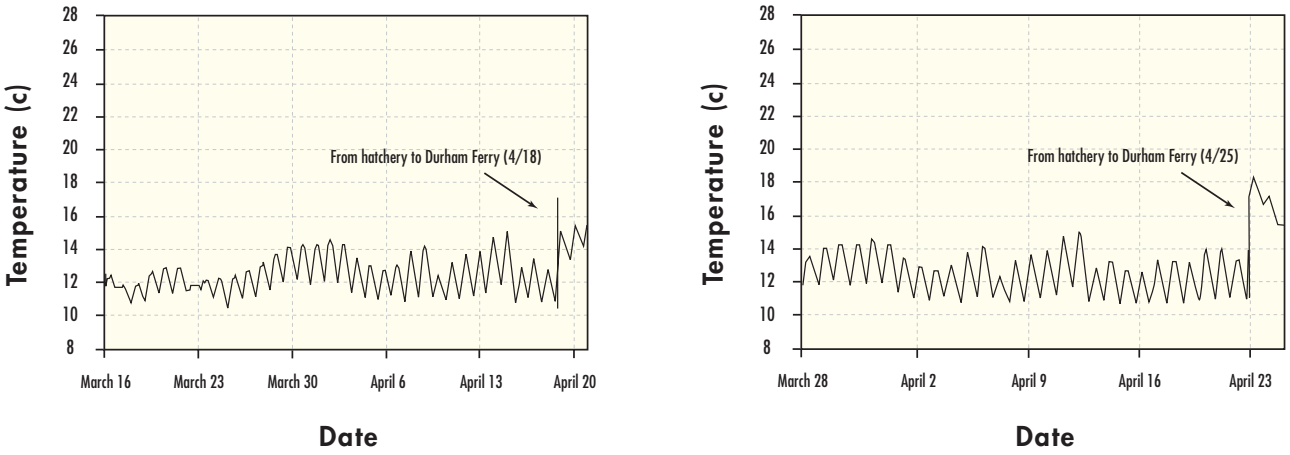
TABLE 5–1

Coded Wire Tag Retention Rates and Effective Release Numbers for Juvenile Salmon Released for VAMP 2002.

RELEASE DATE	TAG CODE	RELEASE SITE	AVERAGE FL (mm)	NUMBER TAGGED	TOTAL LOSS	TAG RETENTION	NUMBER RELEASED	EFFECTIVE RELEASE
April 18	06-44-71	Durham Ferry	83	25,251	123	95.19%	25,128	23,919
April 18	06-44-72	Durham Ferry	83	26,576	129	95.19%	26,447	25,175
April 18	06-44-73	Durham Ferry	83	25,201	123	95.19%	25,078	23,872
April 18	06-44-74	Durham Ferry	83	26,124	127	95.19%	25,997	24,747
April 19	06-44-57	Mossdale	84	25,864	227	99.52%	25,637	25,514
April 19	06-44-58	Mossdale	82	26,301	251	97.01%	26,050	25,271
April 22	06-44-59	Jersey Point	85	25,793	262	97.14%	25,531	24,801
April 22	06-44-60	Jersey Point	83	25,339	269	96.24%	25,070	24,127
April 25	06-44-70	Durham Ferry	80	25,969	138	95.54%	25,831	24,679
April 25	06-44-75	Durham Ferry	80	25,947	138	95.54%	25,809	24,658
April 25	06-44-76	Durham Ferry	80	26,078	139	95.54%	25,939	24,782
April 25	06-44-77	Durham Ferry	80	25,654	136	95.54%	25,518	24,380
April 26	06-44-78	Mossdale	79	26,357	281	94.03%	26,076	24,519
April 26	06-44-79	Mossdale	81	25,977	261	96.52%	25,716	24,821
April 30	06-44-80	Jersey Point	82	25,328	295	96.00%	25,033	24,032
April 30	06-44-81	Jersey Point	82	25,483	289	90.82%	25,194	22,881

FIGURE 5–1

Results of Water Temperature Monitoring at the Merced River Fish Hatchery.



CWT RELEASES

Two sets of CWT salmon releases were made as part of the 2002 VAMP experiment. The first set occurred at 1215 hours on April 18 at Durham Ferry, at 1535 hours on April 19 at Mossdale and at 1010 hours on April 22 at Jersey Point. The second set of releases was made at Durham Ferry at 1050 hours on April 25, Mossdale at 1620 hours on April 26, and Jersey Point at 1535 hours on April 30.

Approximately 100,000 salmon, in four distinct tag lots of about 25,000 fish, were released at Durham Ferry, while approximately 50,000 fish, in two tag lots, were used at each Mossdale and Jersey Point release (Table 5-1). Prior to VAMP 2000, each release was made such that all tag lots were trucked from the hatchery mixed and released as a single group. However, during VAMP 2000, 2001 and 2002, a new transport trailer with three tanks allowed each separate CWT lot to be transported to its release site in a separate tank and distinctly released. As mentioned earlier, the four tag lots comprising each of the groups released at Durham Ferry were already mixed at the hatchery and were therefore transported in a large single tank release truck. This year both Durham Ferry releases were 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.

Releases at Jersey Point were 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.

The water temperature both in the hatchery truck and in the receiving waters was measured at the release site 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 2002 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). The water temperature was measured at locations along the longitudinal gradient of the San Joaquin River and interior delta channels between Durham Ferry and Chipps Island - locations 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 2002 investigations. Water temperature was also recorded within the hatchery raceways at the Merced River Hatchery coincident with the period when juvenile Chinook salmon were being tagged.

Results of water temperature monitoring within the Merced River Hatchery showed that juvenile Chinook salmon were reared in and acclimated to water temperatures of approximately 11-14 C (52- 57F) prior to release into the lower San Joaquin River Figure 5-1. Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the first and second sets of VAMP 2002 releases are compared in Figures 5-2, 5-3, and 5-4. 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 hatchery. Water temperatures measured within the lower San Joaquin River and delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2002 investigations.

TABLE 5–2

Release and Recovery Information for Coded Wire Tag Groups Released for VAMP 2002.

TAG CODE	RELEASE SITE	DATE	TRUCK TEMP F°	RIVER TEMP F°	NUMBER RELEASED	AVG. SIZE (mm)	NUMBER RECOVERED AT ANTIOCH	PERCENT SAMPLED AT ANTIOCH	SURVIVAL INDEX AT ANTIOCH	GROUP INDEX AT ANTIOCH
06-44-71	Durham Ferry		54.5	59	23,919	83	11	0.391	0.085	
06-44-72	Durham Ferry		54.5	59	25,175	83	20	0.391	0.146	
06-44-73	Durham Ferry		54.5	59	23,872	83	12	0.391	0.093	
06-44-74	Durham Ferry		54.5	59	24,747	83	20	0.391	0.149	
Total		April 18			97,713		63	0.391		0.119
06-44-57	Mossdale		55.4	57.2	25,514	84	13	0.388	0.095	
06-44-58	Mossdale		55.4	51.8	25,271	82	29	0.388	0.213	
Total		April 19			50,785		42	0.388		0.153
06-44-59	Jersey Point		59	64.4	24,801	85	101	0.387	0.758	
06-44-60	Jersey Point		59	64.4	24,127	83	89	0.386	0.688	
Total		April 22			48,928		190	0.386		0.724
06-44-70	Durham Ferry		60.8	62.6	24,679	80	6	0.399	0.044	
06-44-75	Durham Ferry		60.8	62.6	24,658	80	2	0.384	0.015	
06-44-76	Durham Ferry		60.8	62.6	24,782	80	4	0.382	0.030	
06-44-77	Durham Ferry		60.8	62.6	24,380	80	6	0.392	0.045	
Total		April 25			98,499		18	0.398		0.033
06-44-78	Mossdale		55.4	63.5	24,519	79	3	0.399	0.022	
06-44-79	Mossdale		55.4	63.5	24,821	81	4	0.400	0.029	
Total		April 26			49,340		7	0.400		0.026
06-44-80	Jersey Point		52.7	63.5	24,032	82	43	0.399	0.323	
06-44-81	Jersey Point		52.7	63.5	22,881	82	32	0.398	0.253	
Total		April 30			46,913		75	0.398		0.289

FIGURE 5–2

Water Temperature Monitoring Results at Durham Ferry.

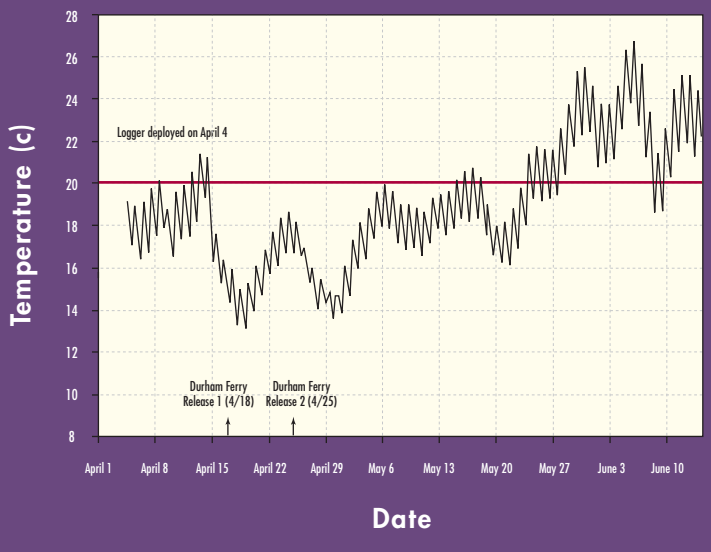


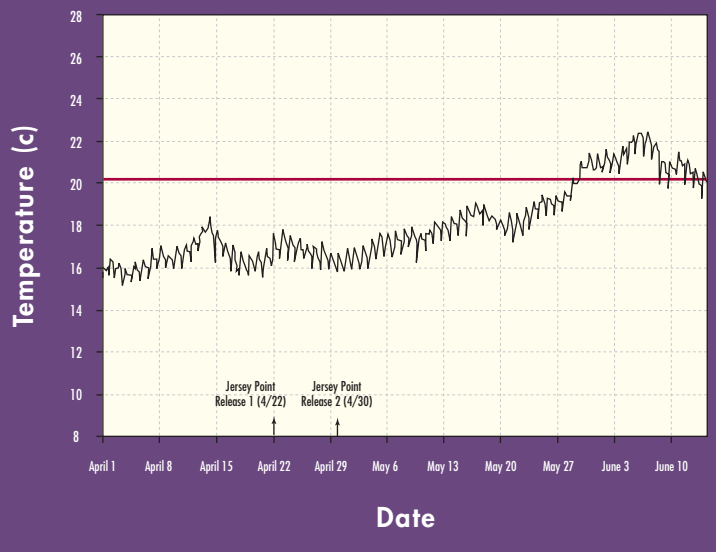
FIGURE 5–3

Water Temperature Monitoring Results at Mossdale.

	NUMBER RECOVERED AT CHIPPS	PERCENT SAMPLED AT CHIPPS	SURVIVAL INDEX AT CHIPPS	GROUP INDEX AT CHIPPS	EXPANDED SALVAGE CVP	EXPANDED SALVAGE SWP	ABSOLUTE SURVIVAL ANTIOCH	ABSOLUTE SURVIVAL CHIPPS ISLAND	ABSOLUTE DF-MD SURVIVAL ANTIOCH	ABSOLUTE DF-MD SURVIVAL CHIPPS
	4	0.277	0.078		12	12				
	9	0.264	0.176		60	36				
	4	0.273	0.080		0	27				
	4	0.278	0.076		24	36				
	21	0.265		0.105			0.16	0.13	0.77	0.86
	6	0.272	0.112		24	90				
	7	0.273	0.132		72	48				
	13	0.273		0.122			0.21	0.15		
	46	0.273	0.882		0	12				
	37	0.266	0.132		24	12				
	83	0.266		0.830						
	3	0.273	0.058		36	6				
	5	0.259	0.102		0	24				
	3	0.275	0.057		24	25				
	4	0.266	0.080		24	36				
	15	0.257		0.077			0.11	0.16	1.2	1.5
	2	0.273	0.039		12	93				
	3	0.260	0.060		0	24				
	5	0.260		0.051			0.09	0.11		
	18	0.265	0.367		0	0				
	28	0.270	0.589		0	0				
	46	0.265		0.480						

FIGURE 5–4

Water Temperature Monitoring Results at Jersey Point.



POST-RELEASE-LIVE-CAR STUDIES

Survival and Condition

The post-release survival and condition of marked salmon was evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Approximately 200 salmon from each tag code were held at the respective release site in net pens for 48 hours after release and were evaluated for overall short-term mortality which might be associated with the handling, transport and release process. In addition to the 200 salmon held for 48 hours, 25 salmon from each tag code were evaluated for condition immediately after release. Another 25 salmon were held and evaluated using the same condition parameters after the 48-hour holding period. The remaining salmon were measured, weighed and sacrificed for further coded wire tag verification if necessary. Due to the mixed tag codes in the Durham Ferry releases two net pens with approximately 200 fish each were held in order to maintain consistency with the other net pen studies. To assess overall condition, fork length in millimeters, weight in grams, and six other characteristics as described in Table 5-3 were examined. Obvious abnormalities or deformities were also noted.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed few abnormalities in the condition assessed characteristics, and are shown in Appendix C-3. Scale loss ranged from 1-40% and averaged 5.7%. All fish examined were noted to have normal coloration, no fin hemorrhaging, normal eye characteristics and normal gill color. Of the 1,433 salmon assessed, four (0.3%) were found to have a poor or incomplete fin clip. A total of three fish had some type of deformity, two of which had eroded pectoral fins (not uncommon for hatchery raised fish) and one that had a partial operculum. The percentage of salmon deformed within the sample group (0.2%) was within the normal range for hatchery-raised fish.

Out of 2301 fish examined as part of this year' VAMP net pen experiments, no mortalities were observed.

Tag Quality Control

The subset of 25 salmon from each tag group (a total of 25 from each of the Durham Ferry net pens) evaluated for condition as described above were sacrificed to verify purity of tag codes. The additional 200+ fish from each release that were held were archived in a freezer. Though rare, on few occasions in the past, salmon from different release groups have been mixed at some point prior to release. While performing quality control checks on the April 18 Durham Ferry releases, one errant tag code was discovered. A total of 201 tags were read to verify tag code purity. After reading all tags, it was determined that the apparent error was likely the result of tags being lost and found, and not reported as lost, in the lab. All remaining fish will be held for a period to allow tag processing for further evaluation if necessary.

Physiology

Physiological studies were conducted on samples of the juvenile salmon used in the VAMP study by the California-Nevada Fish Health Center (Nichols and Foot 2002). These results are summarized below.

Physiological tests were conducted on a subset of the smolts released at Durham Ferry, Mossdale and Jersey Point at the hatchery before transport to the release site and after they had been

TABLE 5–3

Smolt Condition Characteristics

	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 or 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)

held in the live cars for approximately 24 hours. At the hatchery, 144 fish were examined for virus, systemic bacteria, gill ATPase activity, blood hematocrit value, plasma total protein concentration, plasma chloride concentration, external and internal signs of disease, and other abnormalities. From live cars, a total of 216 fish were assessed for gill ATPase activity, plasma total protein concentration, plasma chloride concentration, internal and external abnormalities, and *Tetracapsula bryosalmonae* (*Tb*) prevalence of infection. No bacterial or viral pathogens were detected in any of the fish examined. Overall 93 of 201 (46%) of fish examined were infected with the kidney parasite *Tb*, the myxosporean causing Proliferative Kidney Disease (PKD). Infection rates ranged from 29% to 70% among individual release groups with 99% of infected fish in the early stage of PKD (Clifton-Hadley et. al. 1987). This stage was characterized by the initial invasion of the kidney blood sinuses by the parasite and minor inflammatory changes. No evidence of anemia was seen in the blood hematocrit values from any of the live car groups but the disease may progress even after the fish enter salt water (Hedrick and Aronstien 1987) and PKD related anemia could arise weeks after release.

Gill Na+/K+-ATPase activity levels were similar among and between hatchery and live car groups. There was no significant change in the 1-6 days between hatchery and 24-hour post-release samples. All sample groups demonstrated elevated gill ATPase activity consistent with salmon in an advanced stage of smoltification.

Plasma total protein concentrations of some individual fish were slightly elevated, although no protein values were outside of normal ranges for juvenile Chinook. Elevated plasma protein values would not necessarily indicate reduced survival for the affected fish. Possible reasons for this site effect include variations in time since last feeding (mild starvation), differences in transport, or site-specific water quality.

Plasma chloride values further supported the "stress event" observed in the hatchery total protein values. All live car groups had depressed plasma chloride values relative to baseline hatchery values ($p<0.001$, t-test) indicating they were under stress probably due to sampling. Hatchery fish were dip-netted directly from the raceway and quickly euthanized, while capture from the live car took longer. Even with this added stress of sampling, plasma chloride values of live car groups remained within the normal range for juvenile salmonids.

In summary, all 6 release groups were in good health and at a similar state of smolt development when sampled at the hatchery and 24-hours post-release. No biologically significant differences were observed in pathogen infections, gill Na+/K+-ATPase activities, or blood chemistry values. Early infections of *Tb* were common, with clinical signs of Proliferative Kidney Disease (PKD) in only 1% of fish examined. Short-term survival of all groups was not likely to be impacted by their health. Health problems resulting from PKD (e.g. anemia) could have arisen several weeks post-release but are not discussed in this part of the report.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed ***FEW*** *abnormalities in the condition assessed characteristics.*

CWT RECOVERY EFFORTS

CWT salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities and during sampling at upper Old River near the barrier (See Figure 1-1) CWT salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this part of the 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 pending CWT processing. Coded-wire tag processing was done by USFWS (Stockton) for fish recovered

at Chipps Island, Antioch, and SWP/CVP salvage facilities. DFG Bay Delta Branch and Region IV assisted in processing the fish captured at the HORB fyke nets.

Coded wire tag processing entails dissecting each tagged fish to obtain the half (0.5 millimeter) or full (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. 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 recovered at Chipps Island, Antioch, SWP/CVP salvage, and other locations are from coded wire tag releases not affiliated with VAMP. Since it is unknown until after reading the tag, which tags are from the VAMP study, all tags recovered are read.

SWP/CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) 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 the CWT salmon recovered in the raw salvage collections were sacrificed for tag decoding. 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, pre-screen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2002 studies are shown in Table 5-2. Salvage numbers at both the CVP and SWP were higher in 2002 than in 2001 but continued to be lower than salvage numbers in years without the HORB installed. It is likely that the smolts migrated to the CVP and SWP via Turner or Columbia Cuts, river junctions off the San Joaquin River downstream of the head of Old River.

Antioch Recapture Sampling

Fishery sampling was conducted in the vicinity of Antioch on the lower San Joaquin River 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 six feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All fish collected were transferred immediately from the Kodiak trawl to buckets filled with river water, where the fish were held during processing. Data collected during each trawl included fish identification, measuring the fork length of fish collected, tow start time, duration and location in the channel. Mortality and damage to fish collected was 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 unmarked salmon, steelhead, delta smelt, splittail, and other fish were released at a location downstream of the sampling site immediately after identification, enumeration and measurement.

Sampling at Antioch was initiated April 4 and continued through May 15. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 8 to 31, 20-minute tows were conducted. All told, 1,088 Kodiak trawl samples were collected, representing a total sampling duration of 21,582 minutes. During the sampling, a total of 6,134 unmarked juvenile Chinook salmon and 1,822 salmon with an adipose fin clip (CWT) were collected. In addition, 963 Delta smelt, 195 splittail, and 50 unmarked steelhead, and 52 adipose-clipped steelhead were caught in the sampling.

Chipps Island Recapture Sampling

As part of VAMP recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 4 and May 28, once daily from May 29 to June 8, and once daily Monday through Friday from June 9 through the end of the month. The first shift was begun just before dawn, while the second shift ended at or after sunset in order to incorporate the crepuscular periods of Chinook movement. It is hypothesized, based on an analysis of salmon smolts caught during twenty-four hour sampling at Jersey Point in 1997, that a greater number of salmon would be caught around dawn and dusk. Both targeting this crepuscular period and doubling the total trawl effort at Chipps Island were intended to increase the numbers of CWT salmon recaptured and reduce the variability in VAMP survival indices. This second shift has been conducted during the spring releases since 1998.

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 net 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 was variable mesh net starting with 4-inch mesh at the mouth and ending with a 1/4 inch cod end.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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. This lane was chosen at random or selected by the boat operator based on flow conditions.

Coded wire tagged salmon released as part of the VAMP program were recovered at Chipps Island between April 24 and May 19. A total of 182 VAMP CWT salmon were recovered at Chipps Island. During the April 24 and May 19 VAMP recovery period, a total of 6,463 unmarked salmon, 1164 CWT salmon from other non-VAMP experiments, 165 delta smelt, 360 Sacramento splittail, 15 clipped steelhead, and 15 non-clipped steelhead, were also collected at Chipps Island.

Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this ***DIFFERENCE****.*

VAMP CHINOOK SALMON CWT 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 were calculated by dividing the number of CWT salmon recovered (R) by the effective number released (E) and multiplying the fraction of time (T) and channel width (W) sampled as shown by the formula (R/E)*T*W. The fraction of the channel width sampled at Chipps Island (0.00769) was the net width (30 feet) divided by an estimate of the channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was also based on the net width (25 feet) and an estimate of the channel width (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 percent of time sampled for the VAMP 2002 release groups at Chipps Island was about 27 percent, while at Antioch it averaged 39 percent.

Survival indices were calculated for each separate tag code to provide a sense of the variability associated with the overall 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. This results in a slightly different index than would be generated by taking the mean of the survival indices of the individual tag codes within a group.

The individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2002 are shown in Table 5-2. As in past years, survival indices from the release locations to Antioch were sometimes lower than to Chipps Island. It is expected that indices to Antioch would be greater than to Chipps Island since Antioch is closer to the release locations and the percent of time sampled is greater and the channel width is narrower at Antioch. It may be the inherent variability associated with catching the marked fish that sometimes causes more to be caught at Chipps Island.

The first and second Durham Ferry releases had survival indices to Antioch of 0.12 and 0.03, respectively. Survival indices to Chipps Island were 0.11 for the first group and 0.08 for the second. While differences between the two groups at Chipps Island did not appear meaningful, those at Antioch did. The individual tag code survival indices at Antioch for the two groups did not overlap and thus there appeared to be a difference in survival between the first and second Durham Ferry groups.

The two Mossdale releases showed similar differences between the first and second releases. The first and second releases had survival indices to Antioch of 0.15 and 0.03 and 0.12 and 0.05 to

Chipps Island, respectively. Again none of the individual tag code survival indices overlapped between groups indicating a real difference between the two groups at both recovery locations.

Similarly, the two Jersey Point groups also appeared to survive at different rates; with the first group surviving at a higher rate than the second. The first group released on April 22 had a survival index to Antioch of 0.72. The second group released on April 30 had an index to Antioch of 0.29. Chipps Island recoveries demonstrated the same apparent difference between groups with the first group having an index of 0.83 and the second group having an index of 0.48.

Why survival was lower for the second groups (releases at Durham Ferry, Mossdale, and Jersey Point), relative to the first groups is unknown. Flow and export conditions were similar for both sets of releases. Water temperatures increased for the releases in the second group, but increases were small and all temperatures at release were below 65 degrees (Table 5-3).

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES AND DIFFERENTIAL COMBINED RECOVERY RATES

More important than the differences in survival indices between sets of releases is the comparison of absolute survival estimates, where the survival indices of the upstream release groups are divided by the survival indices of the downstream groups (recovered at the same location). It is most useful for comparisons between groups, recovery locations and years.

In 2002, we have also used the differential combined recovery rates as an estimate of survival. The combined recovery rate for each release group was obtained by summing the recoveries from Antioch and Chipps Island and dividing by the number released. The differential combined recovery rate was the combined recovery rate of an upstream group relative to the downstream group and is another way to estimate survival between release locations. The differential recovery rate is similar to calculating absolute survival estimates, but does not expand each estimate by the fraction of the time and space sampled. The differential recovery rates and the absolute survival estimates should be similar 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 may result in differences using the two methods in estimating survival.

Variance and standard errors were also calculated for the differential combined recovery rates based on the Delta method provided by Dr. Ken Newman (pers. comm). The differential recovery rates plus or minus two standard errors are roughly equivalent to the 95% confidence intervals. Plus or minus one standard error equates to roughly the 68% confidence intervals. (Ken Newman, personal communication). It is not clear how similar variances, standard errors or confidence intervals could be generated using the absolute survival estimates.

In comparing survival between reaches and replicates the confidence intervals were used to determine if estimates were significantly different. If the 95% confidence intervals overlapped they were not considered statistically different. Differences observed using the lower level of confidence 68% are noted.

The use of absolute survival estimates and differential combined recovery rates are more powerful for use in comparing survival rates, since the use of ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and/or years. Both types of estimates of survival have been calculated for VAMP 2002. An additional estimate of absolute survival will be possible from recoveries in the ocean fishery, 2 to 4 years following release.

Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this difference (Table 5-2). Absolute survival between Durham Ferry and Mossdale and Jersey Point was still somewhat higher for the first releases using the Antioch recovery information. Absolute survival for the two sets of releases was similar using the Chipps Island recovery information, but it is uncertain if these differences are significant.

Results using the differential combined recovery rates also indicated the first groups appeared to survive at a higher rate than the second groups, with the first Durham Ferry and Mossdale groups relative to Jersey Point being higher than the second groups (Table 5-4). Estimates of 95% confidence intervals (plus and minus 2 standard errors) indicated differences were not significant at the $p<0.05$ level. The first Mossdale to Jersey Point estimate was greater than the second using the lower level of confidence (68%) (Table 5-4 and Figure 5-5).

One surprise was that the second group released at Durham Ferry appeared to survive at a higher rate than the second group released at Mossdale. This result was shown using both absolute

TABLE 5–4

2002 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	11	4	23,920	15	0.00062				
	20	9	25,176	29	0.00115				
	12	4	23,872	16	0.00067				
	20	4	24,747	24	0.00096				
Total	63	21	97,715	84	0.00085	0.793			
Mossdale (MD) 1	13	6	25,515	19	0.00074			0.154	
	29	7	25,272	36	0.00142				
Total	42	13	50,787	55	0.00108		0.194		
Jersey Point (JP) 1	101	46	24,802	147	0.00592				
	89	37	24,128	126	0.00522				
Total	190	83	48,930	273	0.00557				
Durham Ferry (DF) 2	6	3	24,680	9	0.00036				
	2	5	24,659	7	0.00028				
	4	3	24,783	7	0.00028				
	6	4	24,381	10	0.00041				
Total	18	15	98,503	33	0.00033	1.377			
Mossdale (MD) 2	3	2	24,519	5	0.00020			0.129	
	4	3	24,820	7	0.00028				
Total	7	5	9,339	12	0.00024		0.094		
Jersey Point (JP) 2	43	18	24,032	61	0.00253				
	32	28	22,880	60	0.00262				
Total	75	46	46,912	121	0.00257				
Combined									
DF (1&2)	81	36	196,218	117	0.00059	0.891			
MD (1&2)	49	18	100,126	67	0.00066		0.162		
JP (1&2)	265	129	95,842	394	0.00411			0.145	
DF/MD (1&2)	130	54	296,344	184	0.00062				0.151

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.518	1.069	0.656	0.931
0.115	0.192	0.134	0.173
0.136	0.251	0.165	0.222
0.448	2.305	0.913	1.841
0.078	0.180	0.104	0.155
0.037	0.151	0.065	0.122
0.618	1.164	0.754	1.027
0.119	0.205	0.141	0.184
0.114	0.175	0.129	0.160
0.124	0.177	0.137	0.164

survival estimates and differential combined recovery rates of the Durham Ferry/Jersey Point groups relative to the Mossdale/Jersey Point groups (Tables 5-2 and 5-4). However, the difference in recovery rates was not significant at either the 68 percent or 95 percent confidence level. Durham Ferry is 11 miles further upstream than Mossdale and is expected to include additional mortality.

Both differential recovery rate estimates of survival between Durham Ferry and Mossdale were not significantly different from each other using either confidence levels (Table 5-4). Thus the differential recovery rates of the two groups were combined and survival between Durham Ferry and Mossdale was estimated at 0.89. These data appear to show that there is substantial variability within recovery rate estimates and that survival was relatively high between the two locations.

In 2000 it did appear that survival was less for groups released at Durham Ferry relative to those released at Mossdale using the absolute survival estimates generated from information at Antioch. This difference led to the recommendation of making releases at both Durham Ferry and Mossdale in future years. When looking at the 2000 data using combined differential recovery rates, the variability was such it was not clear that survival was greater for the Mossdale group. The recovery rate of the first Mossdale group relative to the first Jersey Point group was not significantly different (at the $p<0.05$ level) from the first Durham Ferry group relative to the first Jersey Point group. The same was true for the second set of releases. The first Mossdale/Jersey recovery rate was significantly greater than the second Durham Ferry/Jersey Point group at both levels of significance (Figure 5-6).

In 2001 and 2002 differential recovery rates indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p<0.05$), thus we can infer survival between Durham Ferry and Mossdale was high in these years. Surprisingly, the survival was higher in 2001 for the first Durham Ferry group relative to the Jersey Point group than the first Mossdale group relative to the Jersey Point group using the lower level of significance (Figure 5-7). It is uncertain how the Durham Ferry groups could survive at a higher rate than the Mossdale groups, but it probably is possible. Continuation of releasing groups at both sites, will allow detection of mortality between Durham Ferry and Mossdale if it does occur and become significant in the future. If survival between locations is shown not to be statistically significant then groups can be combined.

FIGURE 5–5

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) Groups in 2002. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.

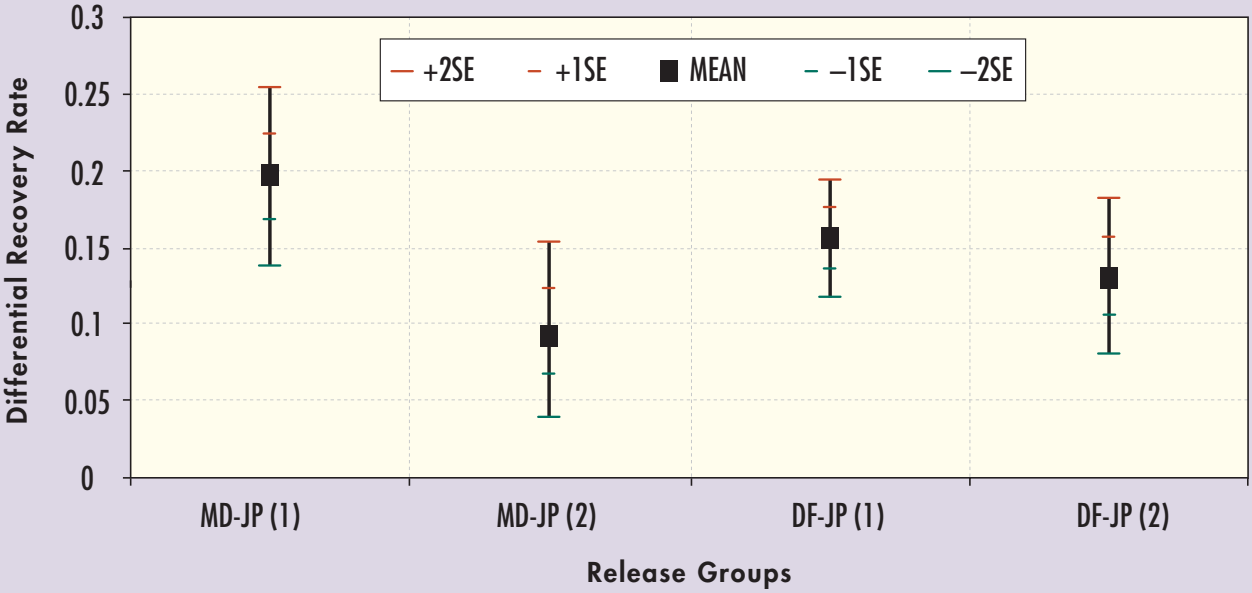
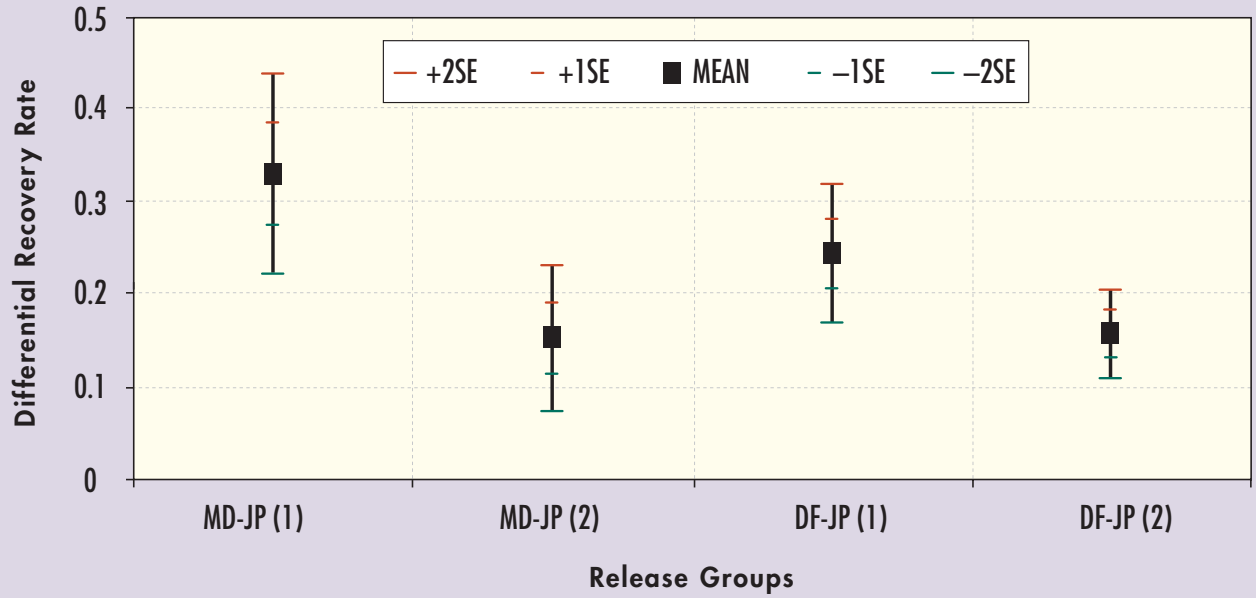


FIGURE 5–6

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) groups in 2000. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.



In 2002, absolute survival for the Durham Ferry and Mossdale groups relative to the Jersey Point groups ranged between 0.09 and 0.21 and averaged 0.14. Differential recovery rates ranged between 0.09 and 0.19. As mentioned earlier, the combined recovery rates relative to the Jersey Point groups was not significantly different between the Durham Ferry and Mossdale groups using the 95% confidence levels. Thus it may be appropriate to combine these recovery rate estimates. Similarly, if replicates are not statistically different, they could be combined. The confidence intervals around each differential recovery rate provide a means to assess whether groups should be combined.

Differential recovery rates of the first and second Durham Ferry groups relative to the Jersey Point releases were not statistically different. Similarly, differential recovery rates for the first and second Mossdale groups relative to the Jersey Point groups were also not significantly different. (Note the two replicates from Mossdale to Jersey Point were significantly different using a 68% confidence interval.) In addition, the differential recovery rates of the Durham Ferry/Jersey Point estimates were not significantly different than the Mossdale/Jersey Point estimates, thus combined estimates were generated (Table 5-4). The combined Durham Ferry/Mossdale to Jersey Point estimate of survival using the combined differential recovery rates was 0.15 - not much different than the average absolute estimate of survival (0.14).

Similar estimates of differential recovery rates with the 95% confidence intervals were calculated for past VAMP years (2000 and 2001)(Tables 5-5 and 5-6). (Note there was an error in the 2001 Annual Report in reporting these estimates. - They have been recalculated and included in this report.) Differential recovery rate replicates in those years were also not significantly different from each other at the 95 percent confidence level. Thus they were combined into one estimate of recovery rate for the Durham Ferry/Mossdale groups relative to the Jersey Point groups. Some replicates were significantly different at a lower significance level (~68%). For instance, the Mossdale to Jersey Point and Durham Ferry to Jersey Point replicates in 2000 were significantly different at this lower level of significance. In addition, the combined Durham Ferry/Jersey Point estimates were significantly lower than the Mossdale/Jersey Point estimates in 2001 at this lower level of confidence

TRANSIT TIME

Data on transit times for marked salmon from the release to recapture sites during VAMP 2002 is summarized in graphic form in Appendix C-4. CWT salmon released April 18 at Durham Ferry took between 7 and 19 days to arrive at Antioch and 8 to 22 days to arrive at Chipps Island. The April 19th release at Mossdale release took between 6 and 11 days to arrive at Antioch and 7 and

FIGURE 5–7

Differential Recovery Rates of CWT smolts released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the first (1) and second (2) groups in 2001. The estimate and plus and minus 1 and 2 standard error(s) is provided.

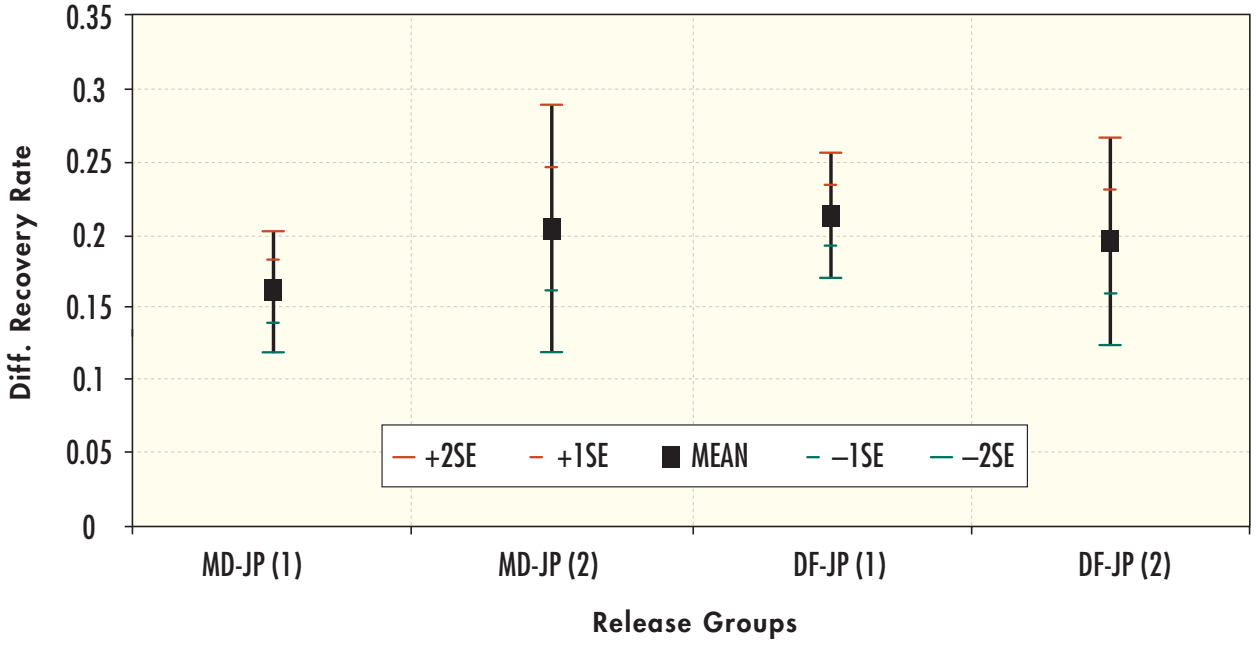


TABLE 5–5

2000 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	6	7	23,629	13	0.00055				
	10	10	24,177	20	0.00082				
	11	11	24,457	22	0.00089				
Total	27	28	72,263	55	0.00076	0.733			
Mossdale (MD) 1	14	9	23,465	23	0.00098				
	16	9	22,784	25	0.00109				
Total	30	18	46,249	48	0.00103		0.328		
Jersey Point (JP) 1	50	24	25,527	74	0.00289				
	47	41	25,824	88	0.00340				
Total	97	65	51,351	162	0.00315			0.241	
Durham Ferry (DF) 2	8	7	23,698	15	0.00063				
	15	5	26,805	20	0.00074				
	8	10	23,889	18	0.00075				
Total	31	22	74,392	53	0.00071	1.036			
Mossdale (MD) 2	9	7	23,288	16	0.00068		0.150		
Jersey Point (JP) 2	76	48	25,572	124	0.00484				
	76	30	24,661	106	0.00429				
Total	152	78	50,233	230	0.00457			0.155	
Combined									
DF (1&2)	58	50	146,655	108	0.00073	1.066			
MD (1&2)	39	25	69,537	48	0.00069		0.178		
JP (1&2)	249	143	101,584	392	0.00385			0.190	
DF/MD (1&2)	97	75	216,192	156	0.00072				0.186

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.443	1.022	0.588	0.878
0.220	0.437	0.274	0.383
0.166	0.316	0.203	0.278
0.445	1.628	0.741	1.332
0.072	0.227	0.111	0.188
0.108	0.202	0.131	0.179
0.814	1.319	0.940	1.193
0.114	0.243	0.146	0.211
0.149	0.232	0.170	0.211
0.149	0.224	0.168	0.205

17 days to reach Chipps Island. Jersey Point release groups were recovered between 2 and 14 days after release at Antioch and between 2 and 21 days at Chipps Island. The April 25 Durham Ferry release group arrived at Antioch between 7 and 18 days and between 7 and 15 days at Chipps Island. The April 26 release group at Mossdale was recovered at Antioch between 7 and 14 days and between 9 and 19 days at Chipps Island. The second Jersey Point release group was recovered between 1 and 14 days after release at Antioch and 1 and 19 days after release at Chipps Island. The transit time from release location to Antioch and Chipps Island of both sets of releases was similar. It is interesting that the Jersey Point groups were recovered over as long or longer period than those released upstream.

Transit times appeared slower in 2002, than in 2001. In 2001, recovery dates were as early as 4 days after releases were made at Durham Ferry and Mossdale. River flows were lower in 2002 than in 2001 (approximately 3,300 cfs versus 4,200 cfs, respectively), which may have increased travel time in 2002. The number of individual recoveries by tag code and the number of minutes towed per day for both Antioch and Chipps Island recoveries are shown in Appendix C-4.

ROLE OF FLOW AND EXPORTS ON ABSOLUTE SURVIVAL AND RECOVERY RATES

Historically, April–June, San Joaquin River flow and flow relative to exports was correlated to adult escapement in the San Joaquin basin 2 1/2 years later (Figures 5-8 and 5-9). Both relationships are statistically significant ($p<0.01$) with the flow/exports variable accounting for slightly more of the variability than the relationship with flow alone ($r^2= 0.44$ vs. $r^2 = 0.58$, respectively). These relationships appeared to indicate that adult escapement in the San Joaquin basin was affected by the amount of flow in the San Joaquin River and exports from the CVP and SWP during the spring months when the juveniles migrated through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind this relationship using smolt survival through the Delta and testing lower San Joaquin River flows with the presence of the HORB.

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 and complementary studies in the south delta were conducted prior to the official implementation of VAMP.

TABLE 5–6

2001 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	28	14	23,354	42	0.00179				
	30	22	22,837	52	0.00227				
	18	17	22,491	35	0.00155				
Total	76	53	68,682	129	0.00187	1.325			
Mossdale (MD) 1	18	17	23,000	35	0.00152				
	15	14	22,177	29	0.00130				
Total	33	31	45,177	64	0.00141		0.159		
Jersey Point (JP) 1	156	50	24,443	206	0.00842				
	173	61	24,992	234	0.00936				
Total	329	111	49,435	440	0.00890			0.211	
Durham Ferry (DF) 2	8	2	24,025	10	0.00041				
	11	5	24,029	16	0.00066				
	10	2	24,177	12	0.00049				
Total	29	9	72,231	38	0.00052	0.958			
Mossdale (MD) 2	8	4	23,878	12	0.00050				
	11	4	25,308	15	0.00059				
Total	19	8	49,186	27	0.00054		0.201		
Jersey Point (JP) 2	43	17	25,909	60	0.00231				
	53	27	25,465	80	0.00314				
Total	96	44	51,374	140	0.00272			0.193	
Combined									
DF (1&2)	105	62	140,913	167	0.00118	1.228			
MD (1&2)	52	39	94,363	91	0.00096		0.167		
JP (1&2)	425	155	100,809	580	0.00575			0.205	
DF/MD (1&2)	157	101	235,276	258	0.00109				0.190

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.920	1.730	1.123	1.528
0.116	0.201	0.137	0.180
0.168	0.253	0.189	0.232
0.476	1.440	0.717	1.199
0.116	0.286	0.159	0.243
0.122	0.263	0.157	0.228
0.908	1.549	1.068	1.388
0.129	0.205	0.148	0.186
0.169	0.242	0.187	0.224
0.162	0.219	0.176	0.204

The differential relative recovery rates of all releases each year were combined as they were not significantly different from each other at the 95 percent confidence level. These combined estimates and their 95 percent confidence intervals for the three years of VAMP releases (2000 - 2002) are shown in relation to the log of the average San Joaquin River flow at Vernalis on Figure 5-10. The average river flow was from the two-10 day periods after release. Data obtained in 1994 and 1997 are added but do not have comparable confidence intervals at this time. The relative recovery rates with the confidence intervals are also shown in comparison to average Vernalis flow/combined exports for the 10 days after release (Figure 5-11). The relationship of relative recovery rate to San Joaquin River flow is improved by incorporating exports. Relationships without the 1994 and 1997 are similar (Figures 5-10 and 5-11). While recovery rates do appear to increase as flows and flows relative to exports increase ($p<0.05$) data points that have confidence intervals around them are not significantly different from each other.

Given the relatively high variability inherent in conducting salmon smolt survival studies within the lower San Joaquin River and Delta, and modeling conducting by Ken Newman (November, 2001) the lack of statistically significant differences between relative recovery rates from similar flow-export conditions was not unexpected. Results of these analysis underscore the importance of collecting salmon smolt survival data under the most extreme flow-export conditions identified as VAMP targets. Flows of 7,000 cfs and exports of 1,500 cfs would provide the highest flow/export ratio (4.7) to test and increase our chances of detecting significant differences in recovery rates between VAMP targets.

THE ROLE OF HORB ON SURVIVAL

The relationship to date between absolute survival between Mossdale and Jersey Point and San Joaquin River flow at Vernalis and exports with and without the barrier in upper Old River is shown in Figure 5-12. Differential recovery rates are not reported since without barrier releases do not have comparable estimates. Replicates of survival estimates within a year measured with the HORB have not been combined as the differential recovery rates were in Figure 5-11. Thus while comparisons can be made between regression lines, variance around each data point is not yet available. Two regression lines have been developed based on survival data with and without the HORB. Statistically neither regression line is significant, although prior to adding the data from 1999, the without barrier relationship was significant. The

FIGURE 5–8

Flow at Vernalis (Mean April 15-June 15) Between 1951-1998 Versus San Joaquin Basin Escapement (2½ Years Later).

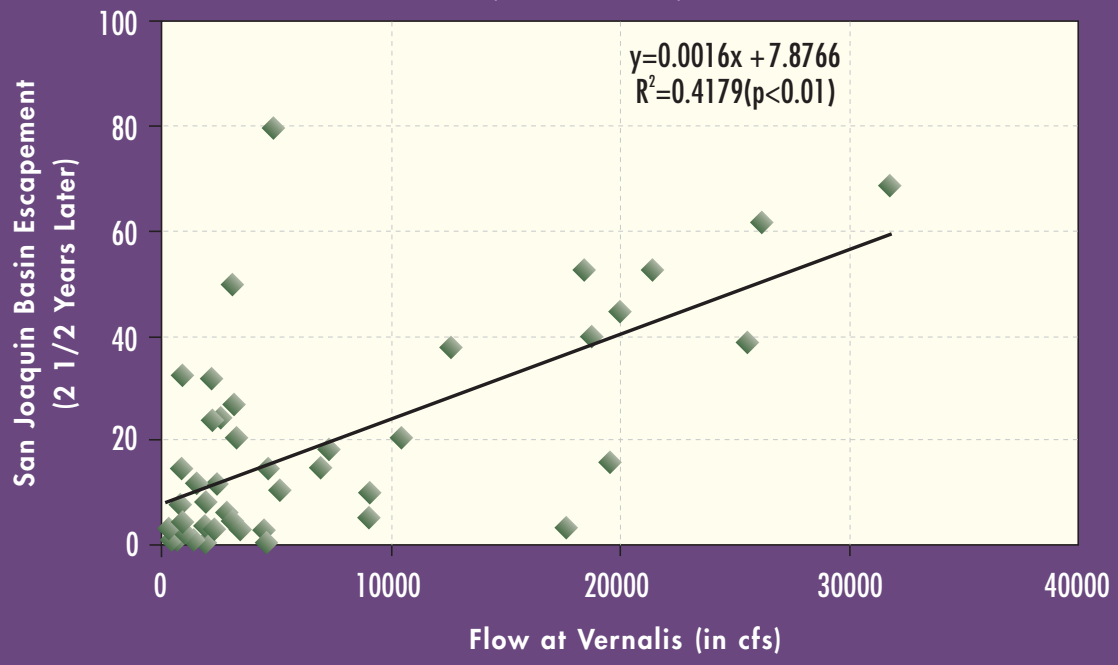


FIGURE 5–9

Mean Spring Flows/Delta Exports (Mean April 15-June 15) Between 1951-1998 and San Joaquin Basin Escapement (2½ Years Later).

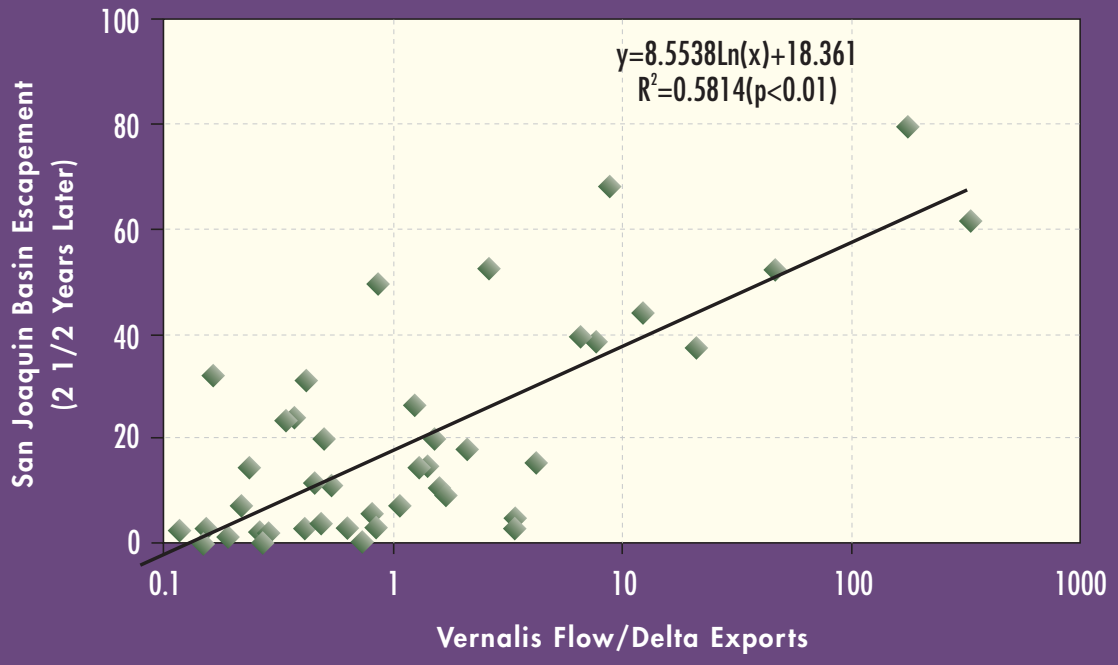


FIGURE 5–10

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place Versus Flow at Vernalis, 2000-2002. 2000-2002 Vernalis Flows Were Averaged for Both 10 day Periods After Release. 1994 and 1997 Data are Added but do not Have SE. The Equation Without the 1994 and 1997 Data Added is Similar at y=0.0621Ln(x) – 0.3445 (R^2=0.6371).

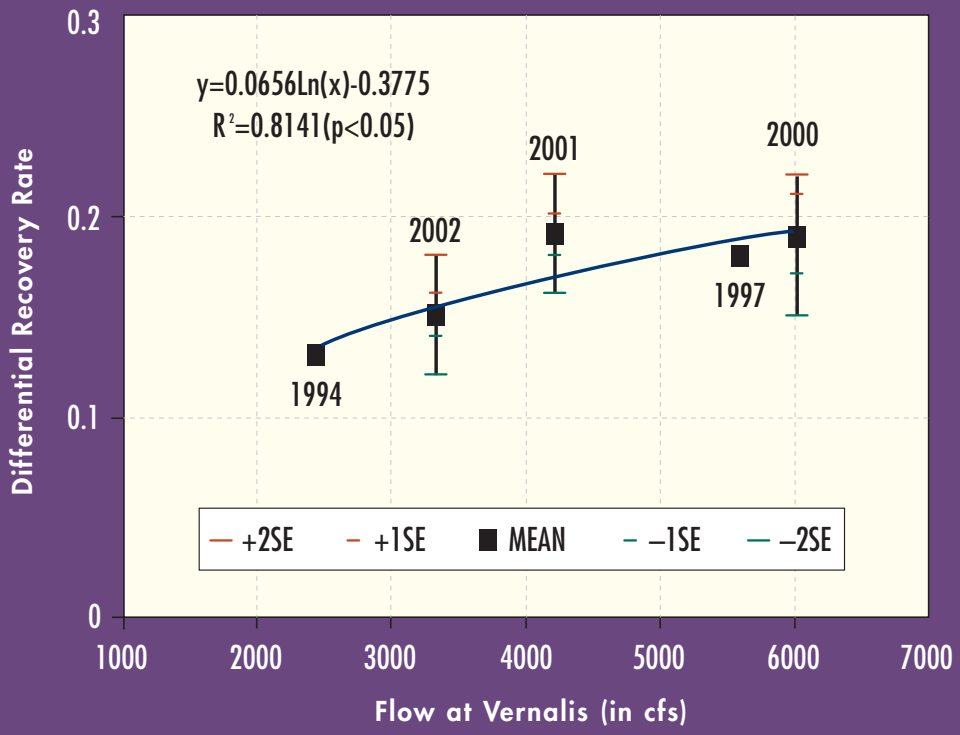
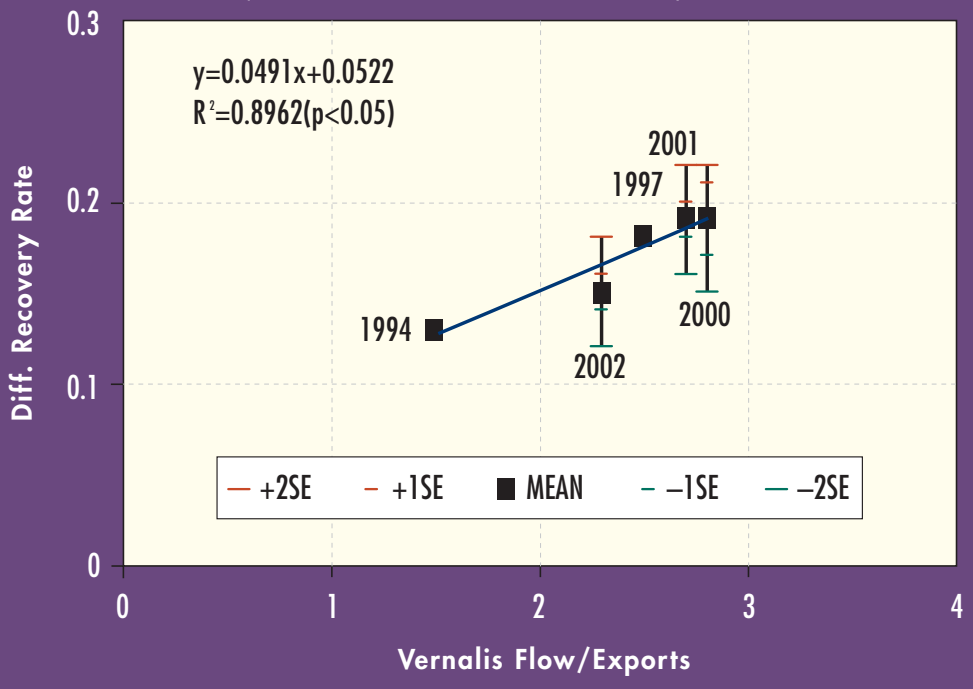


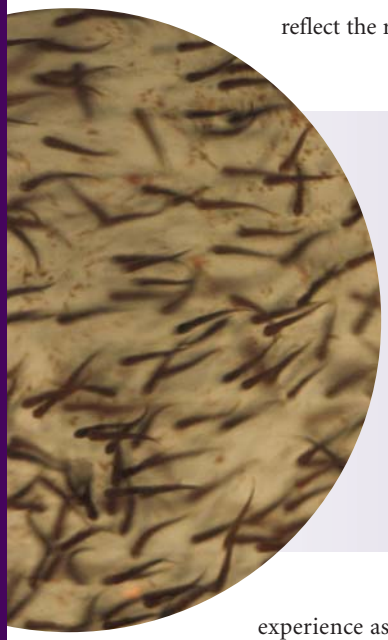
FIGURE 5–11

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place, Versus Inflow at Vernalis/exports, Average of Both 10 day Periods After Release, 2000-2002. 1994 and 1997 Data are Added but do not Have SE. The Equation Without 1994 and 1997 is y=0.0857x – 0.0462, R^2=0.9643.



barrier appears to generally increase survival at any one flow/export level, although the survival was high in 1999 without a barrier. We have hypothesized that data collected in 1999, could be biased high as sampling was interrupted during collection of the downstream control group (Brandes, 2000).

Figure 5-12 shows the relationship between absolute salmon smolt survival and San Joaquin River flow at Vernalis relative to exports with the HORB. A better estimate of flow would be the net flow on the San Joaquin River downstream of upper Old River because of the different permeability of the HORB (culvert operations) over the years. The estimated flow in the San Joaquin River downstream of upper Old River would better reflect the river flow the juvenile salmon experience as they migrate down the San Joaquin River. This estimate has been calculated in past years 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.



It appears as exports increase relative to flow, survival (differential recovery rates) decreases. Although the relationship is significant the individual recovery rates are not significantly different from one another. One source of variability that could be reduced is the variable permeability of the HORB within and among years. During the five years the barrier has been installed (and comparable survival studies conducted) the design and permeability has changed. In 1994, the HORB was installed without culverts, while in 1997 the barrier had two open culverts that diverted approximately 300 cfs into upper Old River. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry release and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. It is estimated that approximately 400 cfs of San Joaquin River flow moved through the culverts in 2001 and 2002 (Simon Kwan, personal communication). The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. This changes as flow/stage on the river changes and as the tide changes, even if all 6 culverts remain open for the remaining 9 years of the study. The varying designs and changes in the culvert operations of the barrier add variability to the survival measurements, making it more difficult to detect significant differences between closely related flow/export ratios.

In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in target conditions of which to measure survival. The ratios in the relationship between flow/export and adult escapement vary from 0.1 to 1000.

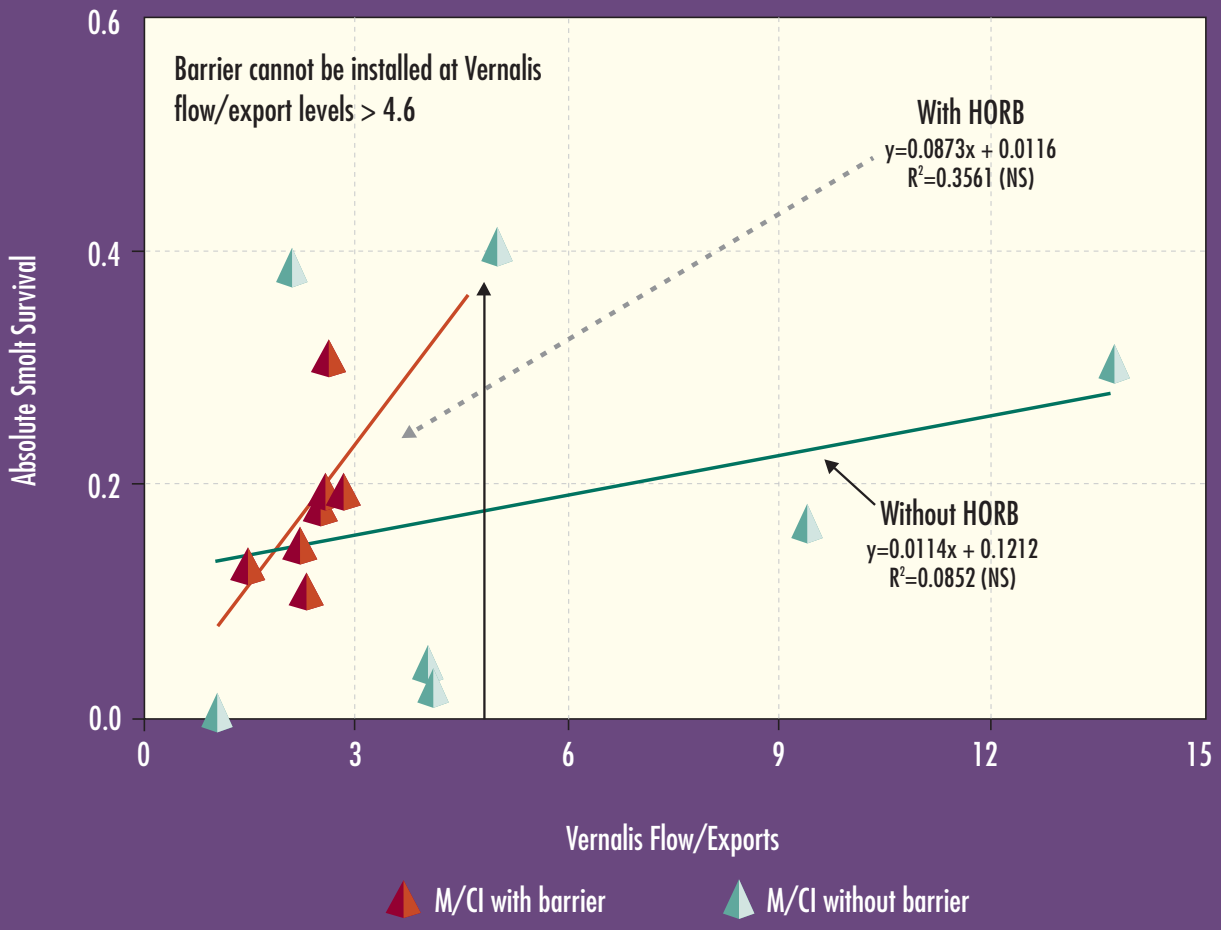
In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in TARGET CONDITIONS of which to measure survival.

OCEAN RECOVERY INFORMATION FROM RECENT YEARS

Ocean recovery data of CWT salmon groups can contribute to a more complete understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of survival of a test release group relative to a control release group, or "absolute survival", and can be compared with estimates based on juvenile salmon recoveries at Chipps Island and Antioch. Past recoveries at Jersey Point (1997-1999) can not be compared since the Jersey Point trawling site was located upstream of the Jersey Point release site and a ratio between the upstream and downstream sites can not be generated. Recovery from trawling at Antioch began in 2000. The ocean harvest data may be particularly reliable due to the number of tag recoveries and the extended recovery period.

FIGURE 5–12

Estimates of Survival Versus Vernalis Flow/Exports With and Without a HORB.



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 2001. The ocean CWT recovery data accumulate over a 1-4 year period following the year a study release is made as nearly all of a given year class of salmon have either been harvested or spawned by age 5. Consequently, these data are essentially complete for releases made through 1996 and 1997 and partially available for CWT releases made from 1998-2000. Once the data for these and later releases are available they will be used to compare the three independent estimates of survival (using Antioch, Chipps Island, and ocean recoveries): based on VAMP releases starting in 2000.

Survival estimates based on ocean recoveries for salmon produced at the Merced River Hatchery, and released as part of south delta survival evaluations from 1996-2000 were compared to survival estimates based on Chipps Island and Antioch recoveries (Table 5-7). Releases over that period were made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point. Ocean absolute survival ratios were very similar to those at Chipps Island for the releases made in 1996, and 1999, and 2000 and at Antioch for the Mossdale and second Durham Ferry releases in 2000. Although ocean absolute survival ratios were higher than those to Chipps Island for releases in 1997 and 1998 and to Antioch for the first Durham Ferry release in 2000, they were generally similar (in the mid-range of survival).

Results of this comparative analysis of survival estimates for Chinook salmon produced in the Merced River Hatchery show (1) there is generally good agreement between survival estimates based on juvenile CWT salmon recoveries in Chipps Island and Antioch trawling and adult recoveries from the ocean fishery, (2) survival estimates using Chipps Island or Antioch recoveries were lower in some years than estimates based on ocean recoveries, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch,

TABLE 5–7

Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced Hatchery Salmon Released as Part of South Delta Studies Between 1996 and 2000.

RELEASE YEAR	SAN JOAQUIN RIVER *(Merced River Origin)* TAG NO.	RELEASE NUMBER	RELEASE SITE	RELEASE DATE	CHIPPS IS. RECOVS.	ANTIOCH RECOVS.
			Juvenile Salmon CWT Releases			
1996	H61110412	25,633	DOS REIS	MAY 01 '96	2	
	H61110413	28,192	DOS REIS	MAY 01 '96	3	
	H61110414	18,533	DOS REIS	MAY 01 '96	1	
	H61110415	36,037	DOS REIS	MAY 01 '96	5	
	H61110501	53,337	JERSEY PT	MAY 03 '96	39	
	Effective Release	107,961	DOS REIS		11	
	Effective Release	51,737	JERSEY PT		39	
1997	H62545	50,695	DOS REIS	APR 29 '97	9	
	H62546	55,315	DOS REIS	APR 29 '97	7	
	H62547	51,588	JERSEY PT	MAY 02 '97	27	
	Effective Release	106,010	DOS REIS		16	
	Effective Release	51,588	JERSEY PT		27	
	H62548	46,728	DOS REIS	MAY 08 '97	5	
	H62549	47,254	JERSEY PT	MAY 12 '97	18	
1998	61110809	26,465	MOSSDALE	APR 16 '98	25	
	61110810	25,264	MOSSDALE	APR 16 '98	31	
	61110811	25,926	MOSSDALE	APR 16 '98	32	
	61110806	26,215	DOS REIS	APR 17 '98	33	
	61110807	26,366	DOS REIS	APR 17 '98	23	
	61110808	24,792	DOS REIS	APR 17 '98	34	
	61110812	24,598	JERSEY PT	APR 20 '98	87	
	61110813	25,673	JERSEY PT	APR 20 '98	100	
	Effective Release	77,655	MOSSDALE		88	
	Effective Release	77,373	DOS REIS		90	
	Effective Release	50,271	JERSEY PT		187	
1999	064606	25,005	MOSSDALE	APR 20 '99	2	
	062642	24,715	MOSSDALE	APR 19 '99	8	
	062643	24,725	MOSSDALE	APR 19 '99	15	
	062644	25,433	MOSSDALE	APR 19 '99	13	
	062645	25,014	DOS REIS	APR 19 '99	20	
	062646	24,841	DOS REIS	APR 19 '99	19	
	0601110815	24,927	JERSEY PT	APR 21 '99	34	
	062647	24,193	JERSEY PT	APR 21 '99	25	
	Effective Release	99,878	MOSSDALE		38	
	Effective Release	49,855	DOS REIS		39	
	Effective Release	49,120	JERSEY PT		59	
2000	06-45-63	24,457	DURHAM FERRY	APR 17 '00	11	11
	06-04-01	23,529	DURHAM FERRY	APR 17 '00	7	6
	06-04-02	24,177	DURHAM FERRY	APR 17 '00	10	10
	06-44-01	23,465	MOSSDALE	APR 18 '00	9	14
	06-04-02	22,784	MOSSDALE	APR 18 '00	9	16
	06-44-03	25,527	JERSEY PT	APR 20 '00	24	50
	06-04-04	25,824	JERSEY PT	APR 20 '00	41	47
	Effective Release	72,163	DURHAM FERRY		28	27
	Effective Release	46,249	MOSSDALE		18	30
	Effective Release	51,351	JERSEY PT		65	97
	601060914	23,698	DURHAM FERRY	APR 28 '00	7	8
	601060915	26,805	DURHAM FERRY	APR 28 '00	5	15
	0601110814	23,889	DURHAM FERRY	APR 28 '00	10	8
	0601061001	25,572	JERSEY PT	May 1 '00	48	76
	0601061002	24,661	JERSEY PT	May 1 '00	30	76
	Effective Release	74,392	DURHAM FERRY		22	31
	Effective Release	50,233	JERSEY PT		78	152

NOTE: Ocean recoveries are based on data through 2001

	EXPANDED ADULT OCEAN RECOVS. (AGE 1+ TO 4+) TOTAL	CHIPPS ISLAND	ANTIOCH	OCEAN CATCH
		Juvenile Salmon CWT Survival Estimates		
	3 37 8 10 187			
	58 187	0.14		0.15
	183 167 351			
	350 351	0.29		0.49
	91 191	0.28		0.48
	61 40 58 47 35 61 110 90			
	159 143 200	0.30 0.31		0.51 0.46
	57 101 119 112 138 191 244 302			
	389 329 546	0.32 0.65		0.35 0.59
	10 10 20 10 9 50 24			
	40 19 74	0.31 0.31	0.20 0.34	0.38 0.29
	4 4 0 14 32			
	8 46	0.19	0.14	0.12

Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be valuable in evaluating 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 and increased 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 hoped that these actions to improve conditions for the juveniles would translate to greater adult escapement in future years, especially during low flows, when escapement 2 1/2 years later has been extremely low in the San Joaquin basin (Figure 5-13).

To determine if VAMP in 2002 was successful in protecting juvenile salmon emigrating from the San Joaquin River tributaries, estimates of survival were compared with VAMP and in the absence of VAMP. Catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were also compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

In assessing VAMP's objective to provide increased protection for the natural production of juvenile salmon migrating from the San Joaquin River tributaries, an estimate of survival was calculated with VAMP and in the absence of VAMP. The equation of survival to flow/exports was used to estimate survival under both conditions (Figure 5-11). With VAMP the flow/export ratio during the VAMP period was 2.3. This flow/export ratio generated a survival of 0.15. Without the export curtailments and flow augmentation due to VAMP the flow/export rate was estimated to be 0.35 (given the barrier was still in without the VAMP flow and exports). At this level of flow/export rate survival was estimated to have been 0.08. The export curtailments and increase in flows from VAMP essentially doubled survival from 0.08 to 0.15.

The original 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 was passing into the delta at Mossdale during that time period. The average catch per minute per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2002 is shown in Figure 5-14. Unmarked salmon do not have an adipose clip and could be fish from the Merced River Hatchery or juveniles from natural spawning. An assessment of the percent of catch per unit effort over time indicated that the

FIGURE 5–13

Natural and Hatchery Escapement Returning to the San Joaquin Basin Between 1953 and 2001.

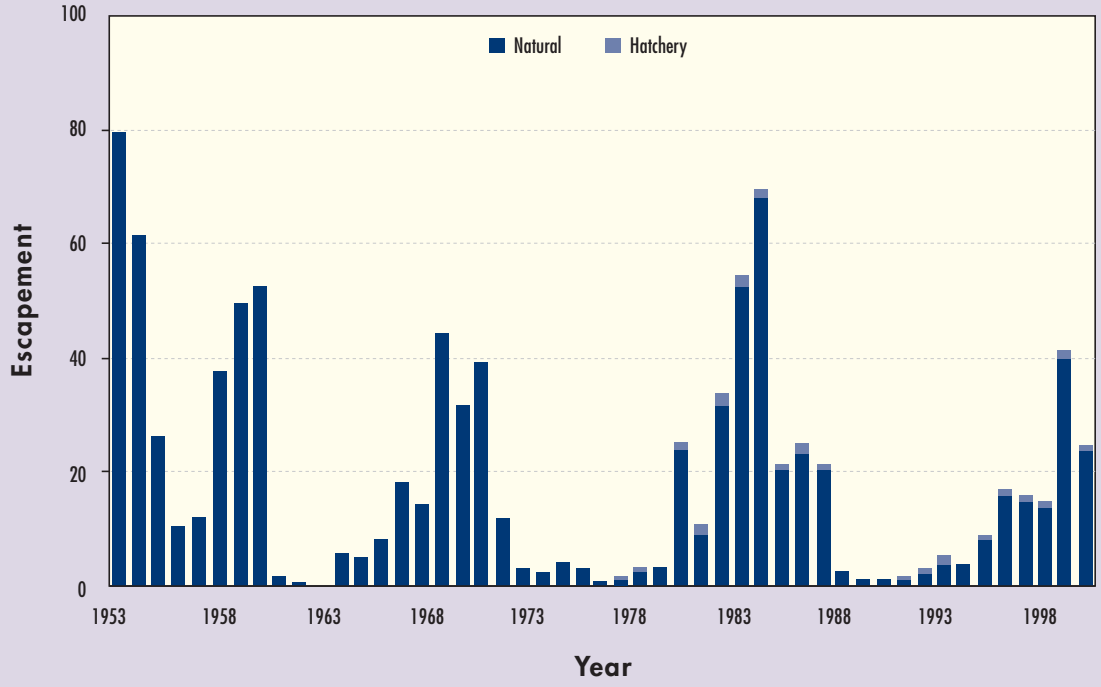


FIGURE 5–14

Catch Per Cubic Meter of all Unmarked Juvenile Chinook Salmon in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.

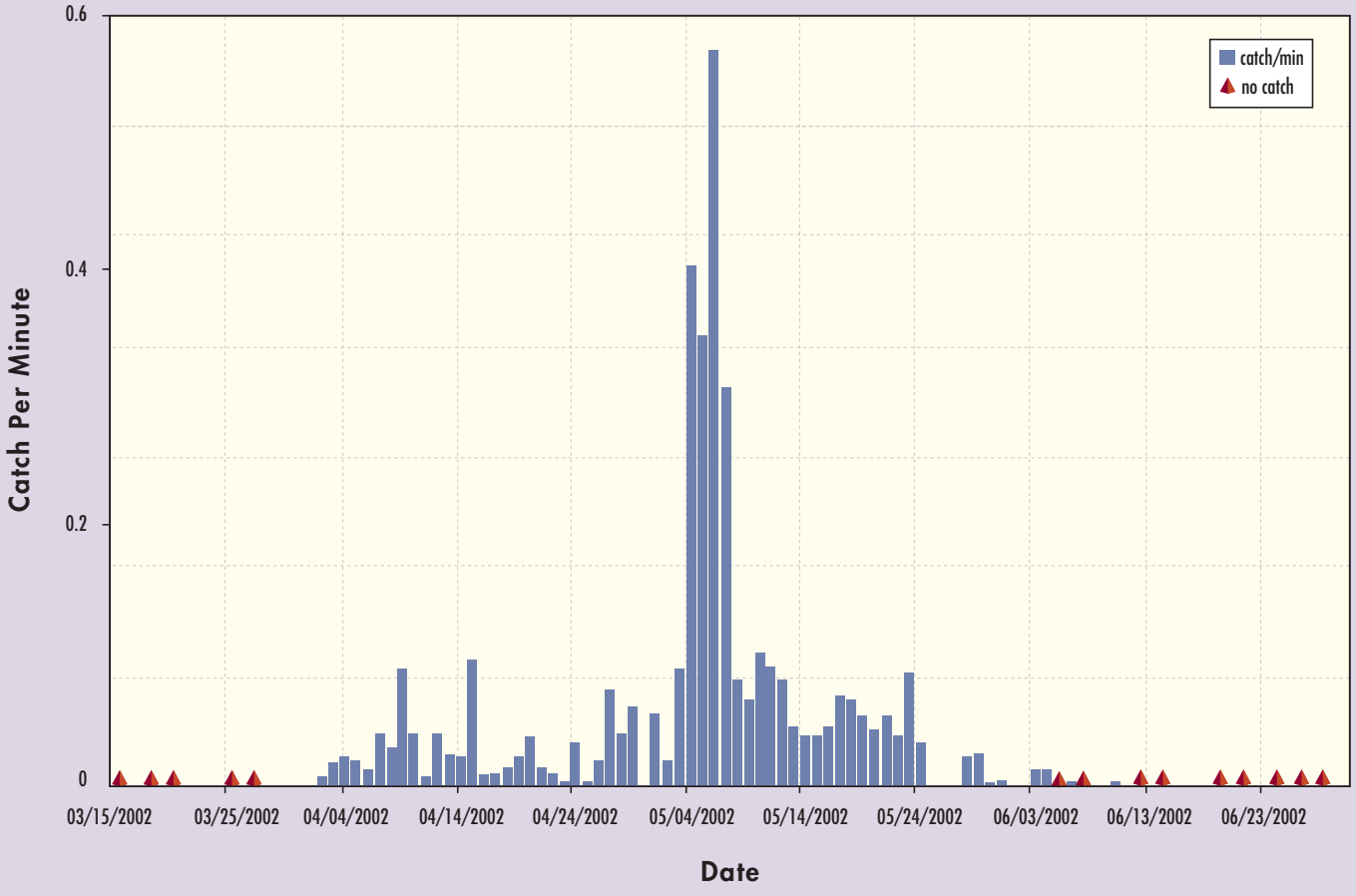
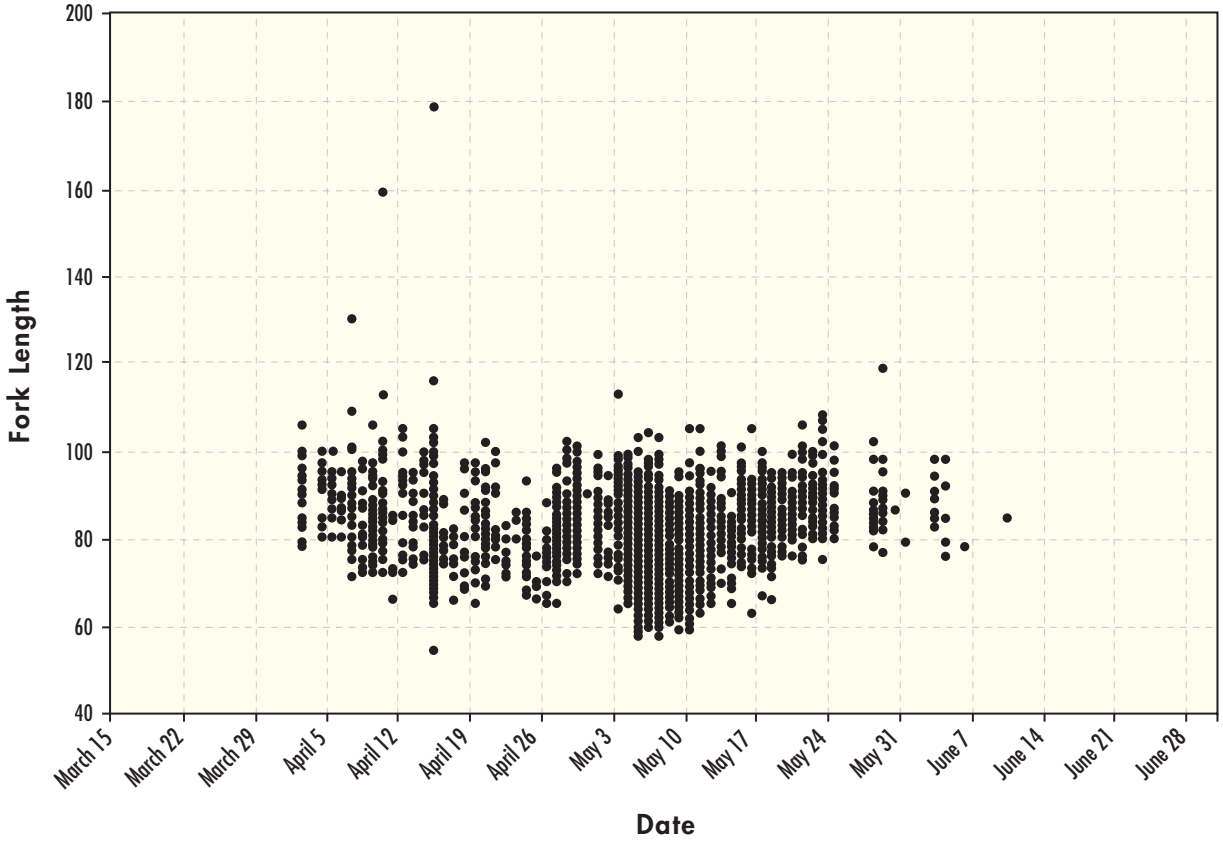


FIGURE 5–15

Individual Fork Lengths for Unmarked Juvenille Chinook in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.



majority of juvenile salmon (77%) migrated past Mossdale during the VAMP period. Delaying removal of the HORB until May 24, continuing export curtailments and ramping exports into early June protected an even greater percent of the population (91%). Reducing flows may stimulate movement of the juvenile salmon out of the system. Continuing the export curtailments and keeping the barrier in place for a week after the VAMP period provided some protection to these later out-migrants. These additional protection measures after VAMP appear to have been beneficial to protecting a greater proportion of the population of unmarked juvenile salmon emigrating from the San Joaquin basin.

Each unique size in millimeters of the juvenile salmon caught in the trawl at Mossdale between March 15 and June 30 is shown in Figure 5-15. In early April there were large juvenile salmon observed in the catch. These may be yearlings that have over-summered in the San Joaquin tributaries. Additional protection in early April may be warranted for this component of the population.

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 downstream in the western Sacramento-San Joaquin delta. The untagged salmon are either naturally produced or hatchery 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 at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from subsamples taken throughout the day. Approximately 4-5 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 50-80% of the number salvaged, or about 6- 8 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 or additional mortality associated with trucking and handling. Salvage density of salmon is the number of salvaged fish per acre-foot of water pumped.

The number 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 and density of juvenile salmon salvaged and lost. Density may be the best indicator of when the most juvenile salmon were moving through the salvage system.

FIGURE 5–16

2002 SWP Salmon Salvage and Loss.

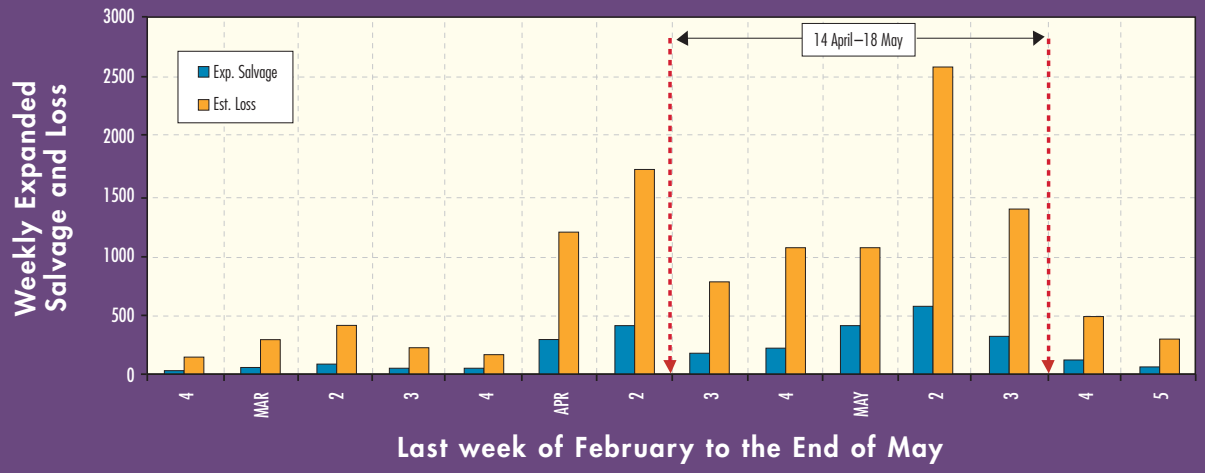


FIGURE 5–17

2002 CVP Salmon Salvage and Loss.

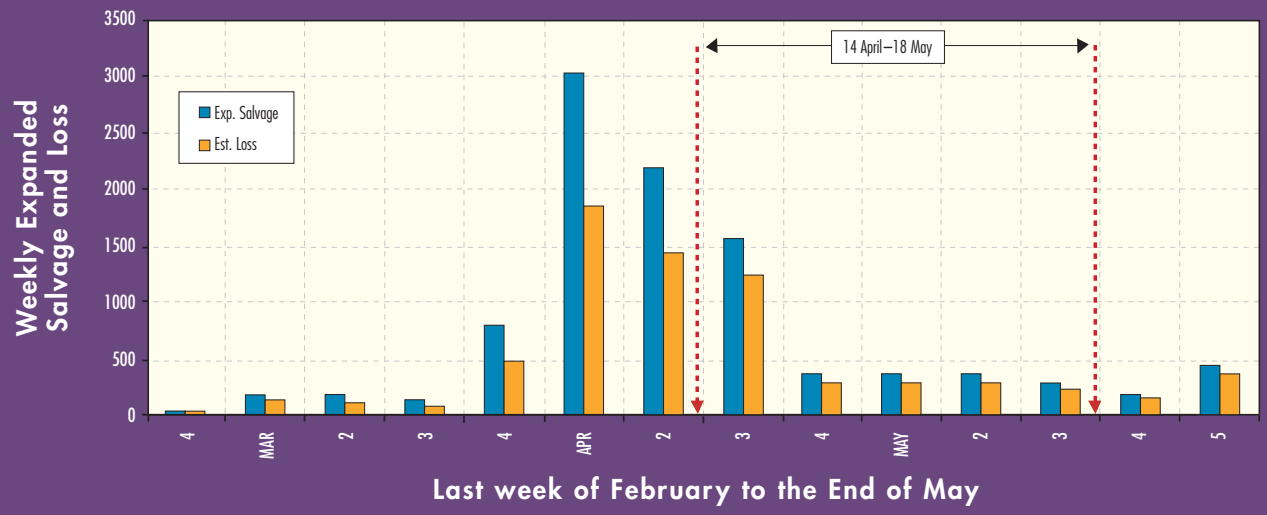
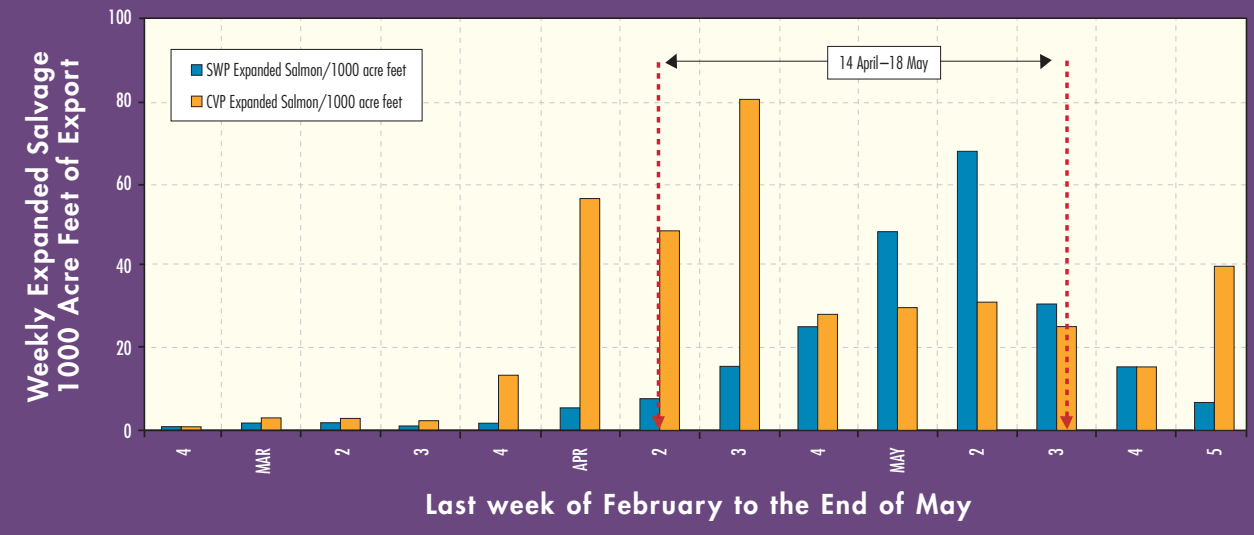


FIGURE 5–18

2002 SWP & CVP Expanded Salmon Salvage Density.



A review of the weekly salvage data around the 2002 VAMP period indicates that the highest salvage and losses occurred during the second week of May at the SWP and in the second week prior to the VAMP period at the CVP (Figures 5-16 and 5-17). Salmon density was highest in the first week of the VAMP period at the CVP facility, which also had high densities in the two preceding weeks, and in the fourth week of the VAMP period at the SWP facility (Figure 5-18). The salvage, loss and density information indicates that the salmon protection measures of VAMP may have been beneficial if they were implemented in the first half of April, similar to 2000 and 2001. Reducing exports during this earlier period of time would not only provide better conditions for juvenile salmon emigrating from the San Joaquin River basin, but from the Sacramento River basin as well.

It is recommended that these ***CONDITIONS*** *be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed.*

Juvenile spring-, winter-, and fall- run Chinook salmon migrate through the Delta in early April from the Sacramento River basin. Compared to the previous two years, salvage, losses, and density were several times lower in 2002, indicating that overall juvenile abundance was much less this year at the fish facilities.

The size distribution of unmarked salmon during April and May in the Mossdale trawl (Figure 5-15) and at the salvage facilities (Figure 5-19): Source E. Chappell, DWR) were generally similar in 2002, as was observed in 2001.

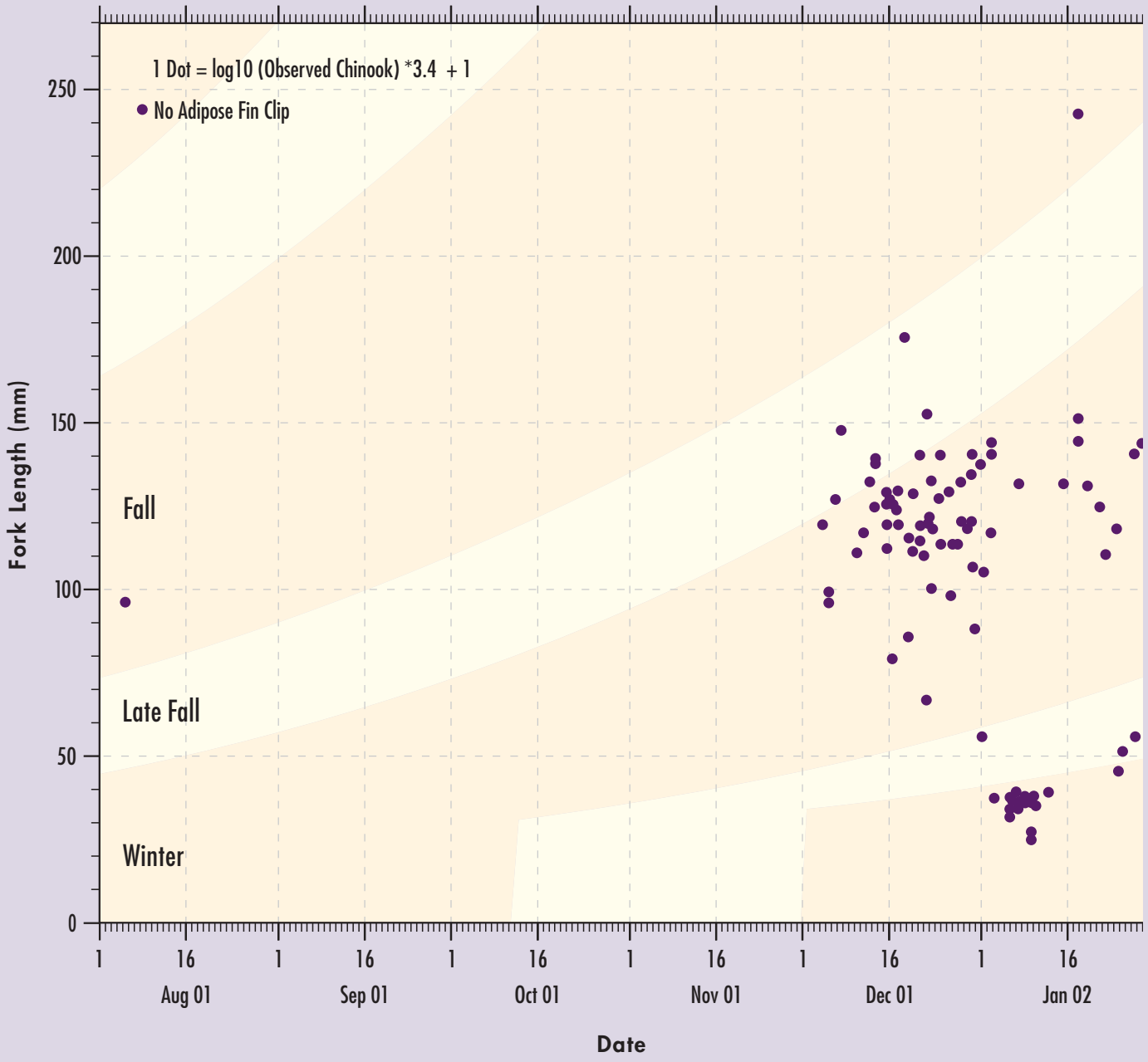
Results of these analysis showed that the VAMP 2002 test period coincided with much of the peak period of salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow provided improved conditions for salmon survival, although starting the VAMP period two weeks earlier may have had substantial benefits. Additional VAMP studies are required, however, to improve quantification of biological benefits over a broader range of environmental conditions.

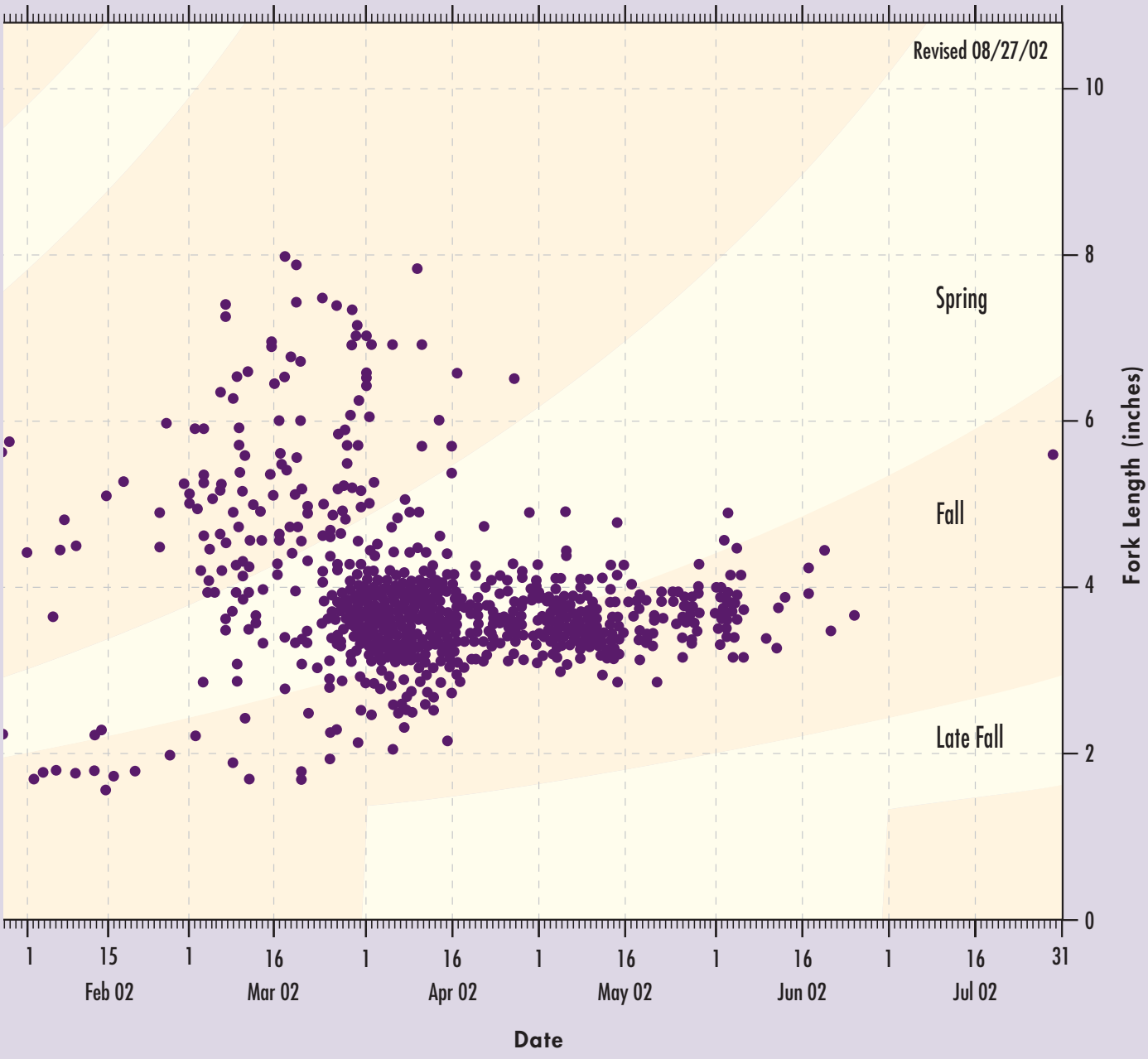
Summary and Recommendations

The variability in survival (recovery rates) at any one flow or flow/export with the HORB makes any preliminary conclusions uncertain based on VAMP results to date. Measuring survival within the narrow ranges of flow and export targets within the VAMP design further limits our ability to detect significant differences between targets. Future studies should prioritize, to the extent possible, flows of 7000 cfs and exports of 1500 cfs to achieve the highest target ratio (4.7) within the VAMP design to better enable us to determine the role of flow and export on salmon smolt survival. It is recommended that these conditions be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed. It is uncertain how such a condition can be prescribed independently of the hydrology within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team. Also continued assessment of past data is recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

FIGURE 5–19

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/01/01 through 7/31/02.




Revised 08/27/02
Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
1
15
1
16
1
16
1
16
1
16
31
Feb 02
Mar 02
Apr 02
May 02
Jun 02
Jul 02
Date