Chapter 5

5 Salmon Smolt Survival Investigations

A primary objective of the VAMP study is to determine the effects of San Joaquin River flows, SWP and CVP water exports, and HORB installation on survival of juvenile Chinook salmon smolts emigrating from the San Joaquin River through the Delta. As mentioned in previous chapters, the HORB was not installed in 2005. Therefore the VAMP study was modified to accommodate these differences from past studies. This section describes the methods used to conduct the Chinook salmon smolt survival investigations and estimates survival indices, absolute survival estimates, and combined differential recovery rates for coded-wire tagged (CWT) juvenile Chinook salmon smolts released during the VAMP 2005 test period. The information gathered in 2005 was used in conjunction with past data to assess the relationships between smolt survival, river flow and CVP/SWP exports with and without the HORB. Relationships using escapement (adult salmon returning to the rivers to spawn) are also discussed.

MERCED RIVER FISH FACILITY CODED-WIRE TAGGING

Merced River Fish Facility (MRFF) supplied over 400,000 CWT Chinook salmon smolts for the VAMP 2005 study. Salmon were CWT and marked with an adipose fin clip by MRFF personnel between late March and mid-April 2005 and were generally held for approximately 27 days before release. Salmon were tagged with one of 16 distinct tag codes, depending upon where the fish were to be released. MRFF examined sub-samples of tagged salmon to estimate CWT retention rates. Average tag retention documented by MRFF was 92% and ranged from 86% to 95%. CWT detection is typically high and all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process and to determine if these fish contained an undetected, non-magnetized tag. No sub-sampled fish were found to contain non-magnetized tags.

To better estimate juvenile salmon survival through the Delta, survival estimates incorporate a measure of the VAMP Effective Number (ER) of fish that were tagged and released which accounts for tag retention rate and fish mortalities. The ER was calculated by multiplying the mortalities from the estimated number of fish transported by the tag retention rate which was then subtracted from the Hatchery Effective Number (Table 5-1).

ER = H - (M * TR) where:

H = Hatchery Effective Number of CWT salmon transported. This value incorporates mortalities at the hatchery and during release and the MRFF tag retention rate.

M = number of fish sacrificed for the short-term survival studies. For the Durham Ferry and Dos Reis releases, the total numbers of fish sacrificed were divided among the tag codes based on the proportion of hatchery effective number.

TR = CWT retention rate determined at the MRFF.

VAMP FISH RELEASES

Two sets (Release 1 and Release 2) of CWT salmon were released at three sites on six dates for the 2005 VAMP experiment (Table 5-1). Releases occurred at Durham Ferry, Dos Reis, and Jersey Point. Transport and water temperatures at the time of release are listed in Table 5-2.

Durham Ferry is located on the San Joaquin River upstream of the Head of the Old River (HOR). Due to high water and poor road condition, releases were made at the top of the levee at Durham Ferry. Over 90,000 CWT salmon with four different codes were released on each occasion at Durham Ferry.

Table 5-1
Chinook Salmon Smolt Release Data for VAMP 2005

Release Date	Release Site	Tag Code	Hatchery Effective Number	Fish Sacrificed for Short-Term Survival Exp.	Tag Retention Rate	Effective Number of Fish Sacrificed for Short-Term	VAMP Effective Number Released
Release 1							
2-May-05	Durham Ferry	06-46-72	23,533	127	0.94	119	23,414
2-May-05	Durham Ferry	06-46-73	23,311	126	0.94	118	23,193
2-May-05	Durham Ferry	06-46-74	23,780	128	0.94	120	23,660
2-May-05	Durham Ferry	06-46-75	23,687	128	0.94	120	23,567
Summary			**94,311**	**508**	**0.94**	**478**	**93,833**
3-May-05	Dos Reis	06-45-91	22,823	163	0.91	148	22,675
3-May-05	Dos Reis	06-46-97	22,444	160	0.89	142	22,302
3-May-05	Dos Reis	06-46-98	24,310	173	0.93	161	24,149
Summary			**69,577**	**496**		**452**	**69,125**
6-May-05	Jersey Point	06-45-88	**23,186**	**450**	**0.93**	**419**	**22,767**
Release 2							
9-May-05	Durham Ferry	06-45-84	22,874	107	0.91	97	22,777
9-May-05	Durham Ferry	06-45-85	23,066	108	0.91	98	22,968
9-May-05	Durham Ferry	06-45-86	23,110	108	0.91	98	23,012
9-May-05	Durham Ferry	06-45-87	22,903	107	0.91	97	22,806
Summary			**91,953**	**429**	**0.91**	**390**	**91,563**
10-May-05	Dos Reis	06-45-89	21,574	152	0.86	131	**21,443**
10-May-05	Dos Reis	06-45-90	23,913	169	0.94	158	**23,755**
10-May-05	Dos Reis	06-46-99	23,602	167	0.93	154	**23,448**
Summary			**69,089**	**488**		**443**	**68,646**
13-May-05	Jersey Point	06-47-00	**23,562**	**348**	**0.95**	**331**	**23,231**

Table 5-2
Water Temperature During Transport and Release

Release Site	Release Date	Transport Temperature (F)	River Temperature (F)
Durham Ferry	2-May-05	52	60
Dos Reis	3-May-05	55	63
Jersey Point	6-May-05	52	64
Durham Ferry	9-May-05	52	59
Dos Reis	10-May-05	52	59
Jersey Point	13-May-05	55	66

Dos Reis is located on the San Joaquin River downstream of the HOR, and was used as a release site, in lieu of Mossdale (which is upstream of HOR) in 2005 to assess the mortality of marked salmon diverted in HOR. Additionally, the release at Dos Reis was made on an ebb tide to reduce the likelihood of salmon being pushed upstream into HOR. Just fewer than 70,000 CWT salmon of three tag codes were released on each occasion at Dos Reis.

Jersey Point serves as a "control site" to standardize survival rates since fish released at Jersey Point do not migrate through the Delta and they are released just upstream of the Antioch and Chipps Island revocery locations. CWT salmon were released on a flood tide at Jersey Point to increase fish dispersion throughout the channel before reaching Antioch and Chipps Island (recovery sampling stations). CWT salmon from one tag code were released on each occasion (22,767 and 23,231 CWT salmon, respectively) at Jersey Point.

During the 2005 VAMP study, CWT salmon with different tag codes were held separately at the hatchery except for the fish released at Durham Ferry. During transport it was necessary to combine tag codes from the Dos Reis release, as well. Once the hatchery truck arrived at a release site, approximately 450 salmon were removed for the short-term survival study (see below). The remaining fish were then immediately released.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2005 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 smolts released as part of these tests (Appendix C-1). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2005 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.

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 9.7°- 11.8° C (49.5° - 53.2° F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry and Jersey Point following the VAMP 2005 releases are shown in Figures 5-3 and 5-4. This 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, which is generally the case. Water temperatures measured within the lower San Joaquin River and Delta (Figures 5-3 and 5-4) were within a range considered to be suitable (< 20 C; 68 F) for Chinook salmon smolts and would not be expected to result in adverse effects or reduced survival of emigrating juvenile Chinook salmon released as part of the VAMP 2005 investigations.

SHORT-TERM SURVIVAL STUDY

Two groups of CWT salmon were removed from the MRFF fish transport truck before each release to determine if handling, transport, and release affected short-term, 48-hour survival and general condition. The goal was to place 225 CWT fish into each of 2 net pens (volume ~ $1m^3$; mesh size ~3 mm); however, all numbers were approximated when the fish were removed from the MRFF truck in an attempt to reduce handling stress. As mentioned previously, tag codes were mixed during transport and therefore fish were not kept in separate net pens by distinct tag codes.

Once placed into the pens, sub-samples of 25 fish from each pen were examined for swimming vigor then euthanized for measuring and documenting general condition of transported fish. Each fish was measured for fork length (to nearest 1 mm), weighed (to the nearest 0.1 g) and examined qualitatively for percent scale loss, body color, fin hemorrhaging, eye quality, and gill coloration. For the purposes of the 2005 VAMP study, Table 5-3 defines normal and abnormal conditions for these characteristics. Additionally, quality of adipose fin clip was documented. The sub-sampled fish were taken to the U.S. Fish and Wildlife Service, Stockton office (STFWO), for verification of tag code. After 48-hours, an additional 25 fish from each pen were measured, weighed, and examined for condition, as described above. The remaining fish from each pen were examined for mortalities, euthanized, counted, measured, weighed, and returned to STFWO for later tag code verification, if necessary.

Post transport fish were generally in good condition (Appendix C-3a). All fish were swimming vigorously before being euthanized. Mean scale loss ranged from 2% at the second Jersey Point release up to 12% at the second Durham Ferry release (average of all locations = 5%). Body color and gill color were normal for all fish examined. No fin hemorrhaging was detected in any of the fish. Only one salmon (2%) from the first Jersey Point release had eye

Figure 5-1
Merced River Fish Hatchery to Durham Ferry

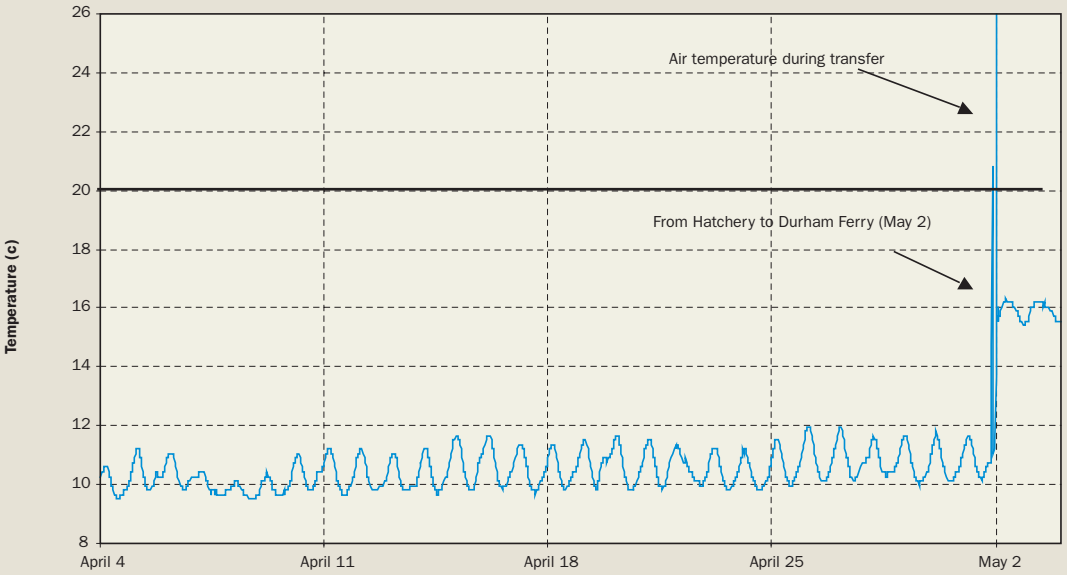


Figure 5-2
Merced River Fish Hatchery to Durham Ferry

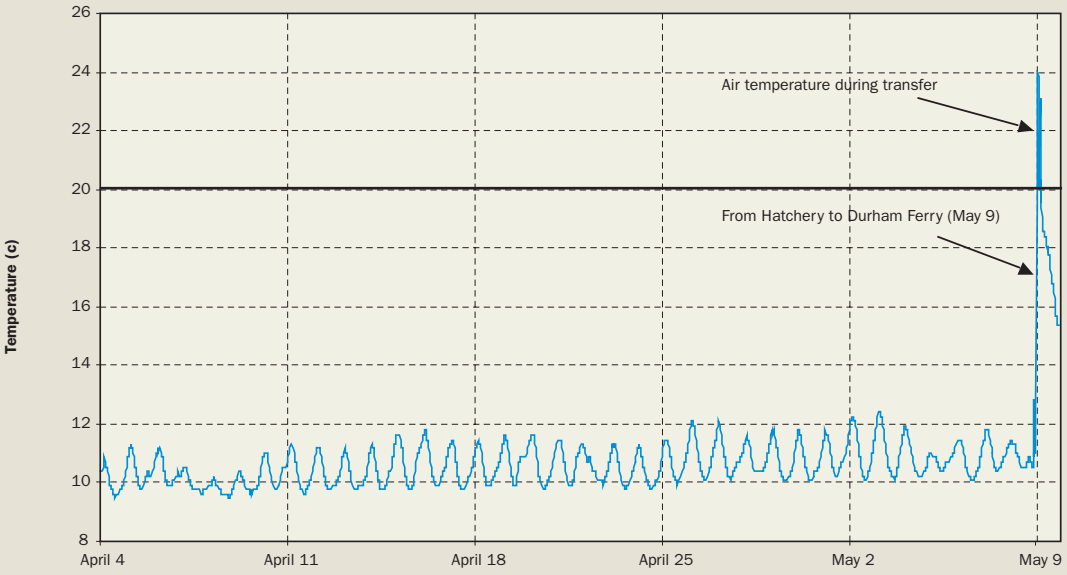
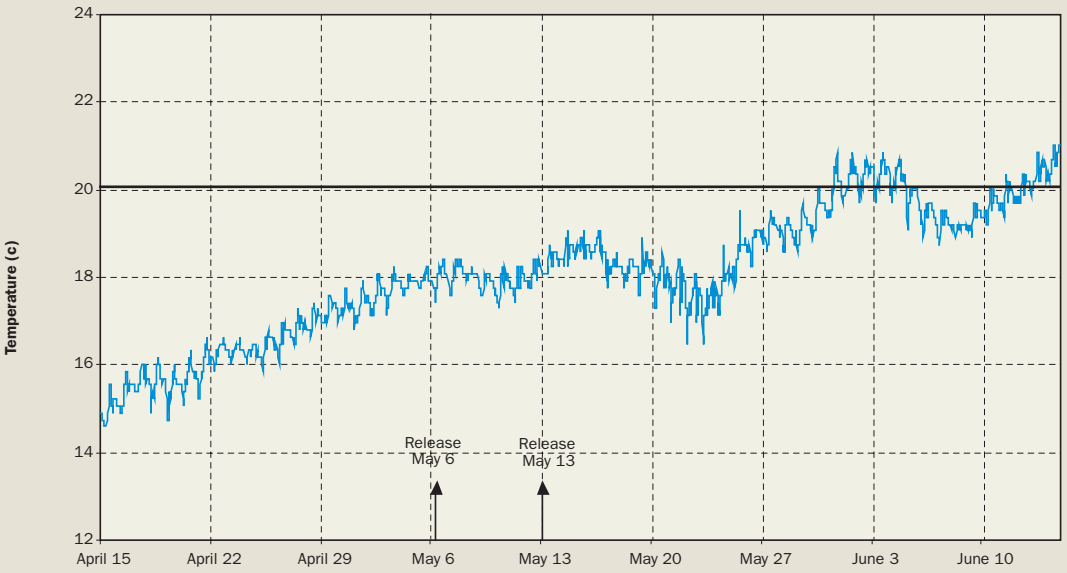


Figure 5-3
Site 1 - Durham Ferry

Figure 5-4
Site 9 - USGS Gauging Station at Jersey Point - Top



hemorrhaging. No errant CWT codes were detected in the 2005 VAMP salmon sub-samples, therefore no additional CWT verification was completed. Adipose fins were completely removed from an average of 85% (range of 74% to 94%) of the CWT salmon.

Short-term survival (48-hours post-transport) was high (99.9%) with only three mortalities (all from the first release at Durham Ferry) within the net pens. Fish retained in the net pens for the 48-hour post release examination were swimming vigorously and generally in good condition (Appendix C-3b). Mean scale loss was (6%) at each site and ranged from 3% to 9% after each of the 48-hour trials. Few fish from the first set of releases had abnormal body color: 4 % from Durham Ferry, 2% from Dos Reis, and 2% from Jersey Point. Abnormal body color was not detected for any of the salmon from the second set of releases. Only 2% of the fish from the first Jersey Point release had fin hemorrhaging. Abnormal eye quality was detected in 4% of the Dos Reis and 2% of the Jersey Point fish from the first release. Abnormal eye quality was detected in 2% of the fish from each of the second releases at Durham Ferry and Dos Reis. Pale gills were detected in 2% of the fish from the second Dos Reis release. No other fish had abnormal gill coloration. These data indicate that the fish used for the 2005 VAMP experiment were in good general condition initially and after 48 hours, and that handling, transport, and release should not have affected their survival.

HEALTH AND PHYSIOLOGY

Juvenile Chinook salmon from tagged lots used in the 2005 VAMP study, were brought from the MRFF to the U.S. Fish and Wildlife Service California-Nevada Fish Health Center (CA/NA FHC) six days prior to the first VAMP release and reared for 50 days at water temperatures similar to the San Joaquin River (14.5 to 19.6 C). At the time of transport, a fish health inspection showed that the population was generally healthy but had a low prevalence of an early stage infection by the myxosporean parasite, *Tetracapsula bryosalmonae*. This parasite has been detected in Merced River salmon for several decades (Hederick et al., 1986) and causes Proliferative Kidney Disease (PKD). The level of clinical PKD, as demonstrated by a combined kidney lesion and anemia score, markedly increased starting at 29 days post-exposure (dpe). A total of 76 study salmon (27% cumulative mortality) died due to PKD beginning at 36 dpe through the final sample at 50 dpe. Time post-exposure and disease state correlated with a decline in both hematocrit and plasma magnesium as well as an elevation in circulating white blood cell number and plasma protein concentration. There was no observed PKD effect on time to exhaustion during a 120-minute swim challenge until 50 dpe. Smolt development measurements indicated that the study fish were in an advanced stage of smoltification. Similar to swim performance, saltwater adaptation was not impaired until 50 dpe.

In addition to examining 2005/VAMP salmon maintained at the CA/NV FHC, selected salmon recovered at Chipps Island were also examined for the presence of PKD. While in the field, CWT salmon were dissected to remove the kidney and make kidney imprints on glass slides. *Tetracapsula bryosalmonae* was observed in 40% (17 of 43) of the kidney imprints collected from VAMP salmon recovered in the Chipps Island trawl. From the laboratory experiments, severe disease was not detected until 29 dpe which was chronologically after the last VAMP coded wire tag recovery at Chipps Island on 27 May 2005. These results indicate that while PKD was prevalent in VAMP out-migrating salmon, it may not have reduced VAMP recoveries. However PKD could be a significant mortality factor for VAMP salmon smolts during their early seaward entry phase (past all VAMP recovery stations). A full report is available in Foott et al.,(2005).

Table 5-3
Smolt Condition Characteristics Assessed for Short Term Survival Studies

Character	Normal	Abnormal
Percent Scale Loss	Lower relative numbers based on 0-100%	Higher relative number based on 0-100%
Body Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No bleeding at base of fins	Blood present at base of fins
Eyes	Normally shaped	Bulging or with hemorrhaging
Gill Color	Dark beet red to cherry red colored gill filaments	Gray to light red colored gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

CODED-WIRE TAG RECOVERY EFFORTS

Coded-wire tagged salmon were recaptured at Old River, Mossdale, Antioch, Chipps Island, and the Federal (Central Valley Project (CVP)) and State Water Projects (SWP)(Figure 1-1). CWT salmon recovered in California Department of Fish and Game (DFG) Kodiak trawls at Old River and Mossdale are not discussed in this chapter. Juvenile Chinook salmon with an adipose fin clip caught at all of the sampling locations (except Old River and Mossdale) were sacrificed, labeled, and frozen for CWT processing by staff at STFWO. DFG Region 4 staff processed CWT fish from Old River and Mossdale.

CWT processing consists of dissecting each tagged fish to obtain the 1-mm cylindrical tag from the snout. Tags were then placed under a dissecting microscope and the numbers were read and recorded in a database and archived. All tags were read twice, with any discrepancies resolved by a third reader. All tags were archived for future reference. It should be noted that many CWT Chinook salmon are captured during the VAMP study; however some of these fish may be tagged for other studies and are not affiliated with the VAMP study. VAMP releases comprise a small portion of the total tagged salmon released in the Sacramento and San Joaquin system. In order to identify tags related to VAMP, it is necessary to read all recovered tags.

Table 5-4
Recovery information at Antioch, Chipps Island, and the fish facilities for VAMP releases in 2005.

			Antioch Recoveries							
Tag Code	Release Site	Release Date	Effective Number Released	First Day Recovered	Last Day Recovered	Number Recovered	Recovery Effort (minutes sampled)	Percent of Channel Sampled	Survival Index	Group Index
06-46-72	Durham Ferry		23,414	–	–	0	–	–	–	
06-46-73	Durham Ferry		23,193	5/5/05	5/7/05	2	1,555	0.360	0.016	
06-46-74	Durham Ferry		23,660	5/5/05	5/24/05	3	10,283	0.357	0.024	
06-46-75	Durham Ferry		23,567	5/10/05	5/10/05	1	555	0.385	0.007	
	Total	**5/2/05**	**93,833**	**5/5/05**	**5/24/05**	**6**	**10,283**	**0.357**		**0.013**
06-45-91	Dos Reis		22,675	5/9/05	5/13/05	3	2,423	0.337	0.026	
06-46-97	Dos Reis		22,302	5/17/05	5/17/05	1	580	0.403	0.007	
06-46-98	Dos Reis		24,149	5/10/05	5/11/05	3	953	0.331	0.025	
	Total	**5/3/05**	**69,125**	**5/9/05**	**5/17/05**	**7**	**3,332**	**0.257**		**0.028**
06-45-88	Jersey Point	5/6/05	22,767	5/7/05	5/12/05	31	2,874	0.333	0.263	
06-45-84	Durham Ferry		22,777	5/15/05	5/15/05	1	500	0.347	0.008	
06-45-85	Durham Ferry		22,968	5/17/05	5/17/05	1	580	0.403	0.007	
06-45-86	Durham Ferry		23,012	5/14/05	5/16/05	3	1,420	0.329	0.026	
06-45-87	Durham Ferry		22,806	5/19/05	5/20/05	2	1,154	0.401	0.014	
	Total	**5/9/05**	**91,563**	**5/14/05**	**5/20/05**	**7**	**2,772**	**0.275**		**0.020**
06-45-89	Dos Reis		21,443	5/16/05	5/19/05	5	2,100	0.365	0.039	
06-45-90	Dos Reis		23,755	5/15/05	5/18/05	2	2,020	0.351	0.016	
06-46-99	Dos Reis		23,448	–	–	0	–	–	–	
	Total	**5/10/05**	**68,646**	**5/15/05**	**5/19/05**	**7**	**1,972**	**0.274**		**0.027**
06-47-00	Jersey Point	5/13/05	23,231	5/14/05	5/19/05	27	3,140	0.363	0.212	

* One fish was excluded due to inaccurate data.

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 near the left bank, within the mid-channel, and near the right bank to sample for 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, 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 May 4 and continued through May 31. Each day between 5:30 a.m. and 9:00 p.m., anywhere from 6 to 30 tows were conducted. In all, 633 Kodiak trawl samples were collected, for a total of 12,528

Chipps Island Recoveries							Fish Facilities Recoveries Raw Salvage (Expanded Salvage)		
First Day Recovered	Last Day Recovered	Number Recovered	Recovery Effort (minutes sampled)	Percent of Channel Sampled	Survival Index	Group Index	CVP	SWP	Recovery Days
5/5/05	5/11/05	5	2,608	0.259	0.099		38 (456)	5 (27)	
5/10/05	5/12/05	2	1,152	0.267	0.038		25 (300)	2 (9)	
5/9/05	5/19/05	4	4,132	0.261	0.079		37 (444)	7 (39)	
5/7/05	5/7/05	1	400	0.278	0.018		19 (228)	4 (24)	
5/5/05	**5/19/05**	**12**	**5,732**	**0.265**		**0.058**			**05/3 - 05/24**
5/11/05	5/11/05	1	400	0.278	0.019		0	0	
5/11/05	5/11/05	1	400	0.278	0.018		0*	1 (6)	
5/12/05	5/12/05	1	352	0.244	0.020		0	0	
5/11/05	**5/12/05**	**3**	**752**	**0.261**		**0.019**			**05/15**
5/8/05	5/15/05	32	2,960	0.257	0.634		0	0	–
5/15/05	5/26/05	2	4,772	0.276	0.037		16 (192)	19 (102)	
5/12/05	5/12/05	1	352	0.244	0.021		6 (72)	15 (84)	
5/15/05	5/27/05	3	5,172	0.276	0.056		14 (168)	17 (93)	
–	–	0	–	–	–		7 (84)	9 (48)	
5/12/05	**5/27/05**	**6**	**6,324**	**0.274**		**0.028**			**05/10 - 05/31**
5/14/05	5/16/05	3	1,200	0.278	0.055		0	1 (6)	
5/17/05	5/18/05	2	772	0.268	0.038		0	0	
5/17/05	5/17/05	1	372	0.258	0.020		0	0	
5/14/05	**5/18/05**	**6**	**1,972**	**0.274**		**0.037**			**05/17**
5/14/05	5/20/05	38	2,772	0.275	0.711		0	0	–

tow minutes. During sampling, 5,127 unmarked juvenile Chinook salmon were captured; 248 salmon with a coded wire tag were collected, 97 from VAMP releases (Table 5-4) and 151 from other hatchery releases. In addition, 363 delta smelt, 12 unmarked steelhead, and 6 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

Recovery efforts at Chipps Island were conducted using a mid-water trawl towed at the surface. The trawling net is 82 feet in length and has an opening that is 30 feet wide by 10 feet deep. Mesh size of the net is variable and ranges from 4-inch mesh at the mouth to 5/16-inch mesh at the cod end. To keep the mouth of the net open, the net has floating aluminum hydrofoils on the top bridles and has steel depressors and a weighted lead line attached to the bottom bridles.

For VAMP 2005 trawling was conducted twice per day, seven days per week from May 3, 2005 through June 11, 2005. In past studies, greater recoveries of juvenile Chinook salmon smolts have been reported during sunrise and sunset (Hanson Environmental, unpublished data), therefore, the first shift began during sunrise and the second shift was completed during sunset in an attempt to increase the recovery of juvenile Chinook salmon smolts and reduce the variability in survival indices. Each shift consisted of ten 20-minutes tows conducted in the north, middle, and south sections of the channel parallel to the shore. After six weeks the majority of VAMP juvenile Chinook salmon smolts had migrated past Chipps Island, so sampling was subsequently reduced. Ten morning tows were continued seven days per week between June 12 and June 19; five days per week between June 20 and July 1; and three days per week after July 5.

All fish retained in the cod end of the net are placed in aerated water collected from the sample site. All juvenile Chinook salmon smolts with an adipose fin clip were labeled and retained for later CWT processing. All other fish were identified to species, and enumerated, and released. The fork length of each individual was measured to the nearest mm for most of the catch. As mentioned previously, some salmon were also processed in the field to determine if *T. bryosalmonae* were present. A total of 59 juvenile Chinook salmon with tag codes used in the VAMP 2005 study were recaptured at Chipps Island, with the majority having been released at Jersey Point. During this same time period, the catch included 11,111 unmarked Chinook salmon; 628 CWT Chinook salmon from non-VAMP studies; 101 Delta smelt; 130 Sacramento splittail; 23 marked steelhead; and 21 unmarked steelhead.

CVP and SWP Salvage Recapture Sampling

CVP and SWP fish facilities salvage fish on a continuous basis. To estimate the total number of fish salvaged, sub-samples (raw salvage) are collected approximately every two hours. The number of marked salmon collected during the sub-sampling (raw salvage) is reported in Table 5-4. Expanded salvage is a calculation based on the raw salvage

collected and the time sampled and provides an estimate of the total number of fish salvaged. Expanded salvage does not take into account the indirect loss of juvenile salmon smolts at the facilities as it does not include any loss associated with pre-screening predation, screening, handling, and trucking. Expanded CVP and SWP salvage estimates are also reported in Table 5-4.

During VAMP 2005, expanded salvage was greater than salvage from releases at Durham Ferry in 2004 (CVP = 84; SWP = 12). The increase in salvage for VAMP 2005 was not surprising since the HORB was not installed. The installation of HORB reduces the number of fish observed at the fish facilities. Only a few juvenile salmon smolts that were released at Dos Reis and no smolts released at Jersey Point were observed in the raw salvage. The low salvage of smolts released at Dos Reis was anticipated as these fish are released downstream of the Head of Old River on an outgoing tide and would not be expected to be drawn through Old River into the fish facilities. The Jersey Point releases are downstream of all connections to Old River, but are released on an ebb tide to facilitate disbursement. Though in past years a few salmon released at Jersey Point have been observed, they are generally not expected at the salvage facilities.

TRANSIT TIME

The recoveries of the VAMP smolts collected in 2005 were made at Antioch between May 5 and May 24 and over a similar time period at Chipps Island between May 5 and May 27 (Appendix C-4). Recoveries were made at the CVP and SWP fish facilities between May 3 and May 31 (Table 5-4), a few days earlier and later than at the other recovery locations. All recoveries were made prior to the end of the VAMP period.

VAMP CHINOOK SALMON CWT SURVIVAL

Survival Indices

Survival indices were calculated to estimate survival to Antioch and Chipps Island for marked salmon released at Durham Ferry, Dos Reis and Jersey Point. 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 2005 release groups at Chipps Island was about 28%, while at Antioch it was about 37% (Table 5-4).

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.

Chinook Salmon Survival Estimates, and Differential and Combined Differential Recovery Rates

Survival is further put into context by estimating absolute survival estimates and combined differential recovery rates (CDRR). 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. As in past years, both estimates of absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2005. An additional estimate of survival, differential recovery rates (DRR) was also used for recoveries made in the ocean fishery, two to four years following release, for groups released in past years. DRR are also used when only the Chipps Island recovery location was used, as was the case prior to 2000.

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 Dos Reis), 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 (CDRR) is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

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

The CDRR and DRR are other ways 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.

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 CDRR and DRRs 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 estimate. 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. Confidence intervals using the lower level of confidence (68%) are also included.

Results:

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2005 are shown in Table 5-4. 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 in DFG sampling at Mossdale or in Old River.

The survival indices were low and ranged between 0.013 and 0.063 for the Durham Ferry and Dos Reis groups using either recoveries at Antioch or Chipps Island. We would have expected the Dos Reis survival indices to be greater than those for the Durham Ferry groups, but this was not the case for the first group recovered at Chipps Island (Table 5-4). The group survival index to Chipps Island for the first Durham Ferry group was 0.063 and for the first Dos Reis group was 0.022. This result could be due to the low recovery numbers and inherent variability in the survival indices.

One compounding factor experienced in 2005, was the application of Komeen in Clifton Court Forebay on May 3, a day after our first Durham Ferry release. Komeen is a chemical herbicide containing copper that is known to be toxic to salmon (J. Stuart, NOAA Fisheries, personal communication). During the application period there were no flows into or out of Clifton Court Forebay for 48 hours (DWR, Delta Field Division, personal communication). The SWP exports directly out of Clifton Court Forebay. The first Durham Ferry released fish was observed at the CVP on May 3, indicating that some of the CWT fish released at Durham Ferry may have been diverted into Clifton Court Forebay before the gates were closed on May 3rd which in turn could have reduced their survival. The first Durham Ferry fish was not observed at the SWP until May 8th. Although the first group released at Durham Ferry did not have consistently lower survival indices, than the second Durham Ferry release, to Antioch and Chipps Island, it is uncertain whether this treatment lessened the survival of the first group released at Durham Ferry. We have requested further communication from DWR regarding the timing of when these herbicide applications are scheduled to avoid this potential problem in the future.

The control groups released at Jersey Point had greater survival than those fish released at Durham Ferry or Dos Reis. The survival index of the first Jersey Point group was 0.263 at Antioch and 0.634 at Chipps Island. The second Jersey Point release had survival indices of 0.212 at Antioch and 0.711 at Chipps Island.

In general, higher survival indices were estimated using the Chipps Island recoveries. As in past years, the raw recovery rate at Chipps Island and Antioch was similar, but 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.

Survival indices for releases made at Durham Ferry and Dos Reis were low relative to releases made at Jersey Point

Table 5-5
Absolute survival and Combined Differential Recovery Rates (CDRR) for VAMP releases in 2005

Survival Reach	Release Date	Antioch Absolute Survival	Chipps Island Absolute Survival	CDRR
First release				
Durham Ferry to Jersey Point	2-May-05	0.049	0.099	0.069
Dos Reis to Jersey Point	3-May-05	0.11	0.035	0.052
Second release				
Durham Ferry to Jersey Point	9-May-05	0.094	0.044	0.051
Dos Reis to Jersey Point	10-May-05	0.127	0.058	0.068

using either set of recovery numbers (Table 5-4). This is especially clear when looking at absolute survival rates and CDRR's (Table 5-5).

The CDRR's for the Durham Ferry groups relative to the Jersey Point groups were 0.069 and 0.051 for the first and second releases, respectively. The Dos Reis to Jersey Point CDRR estimates were 0.052 for the first and 0.068 for the second release (Table 5-5). Confidence intervals around each of the estimates suggested estimates were not significantly different for the two groups even though fish released at Durham Ferry are thought to incur additional mortality since it is roughly 15 miles farther upstream than Dos Reis and there was no HORB (Figure 5-5).

The pooled CDRRs of the two Dos Reis groups was 0.060. The pooled CDRR of the Durham Ferry groups was also 0.060. Further pooling of both sets resulted in the CDRR being 0.060. Plus and minus one and two standard errors of the estimates were also calculated and are shown in Figure 5-5.

COMPARISON WITH PAST YEARS

Ocean Recovery Information

Ocean recovery data of CWT salmon groups can provide another independent estimate of the ratio of recovery rate of an upstream release group relative to a downstream release group. Differential recovery rates using ocean recovery information can be compared with absolute survival estimates based on survival indices and the differential **(DRR)** or combined differential recovery rates **(CDRR)** of juvenile salmon recovered at Chipps Island and Chipps Island and Antioch, respectively. The ocean data may be more reliable due to the number of CWT recoveries and the extended recovery period.

Adult ocean 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 2004. 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-class of salmon have been either harvested or spawned by age five. Consequently, these data are essentially complete for releases made through 2000 and partially available for CWT releases made from 2001 to 2003.

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 5-6. 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 (2000-2003). Releases have been made at several locations: Durham Ferry, Mossdale, Dos Reis, and Jersey Point. The Chipps Island and Antioch survival estimates and CDRR (Antioch and Chipps Island recoveries summed) or DRR (Chipps Island recoveries only) are graphed in relation to the differential recovery rate using the ocean recovery information in Figure 5-6.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the MRFF show: (1) there is general agreement between absolute survival estimates based on juvenile CWT salmon recoveries at Chipps Island and the DRR or CDRR using recoveries at Chipps Island or Chipps Island and Antioch and the DRR using adult recoveries from the ocean fishery (r^2=0.71 and r^2 = 0.67), (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.

Figure 5-5
Combined Differential Recovery Rates (CDRR) (+/- 1 and 2 standard errors) of CWT smolts released at Durham Ferry (DF/JP) and Dos Reis (DR/JP) relative to those released at Jersey Point for the first (1), second (2) and combined release groups (1&2) in 2005.

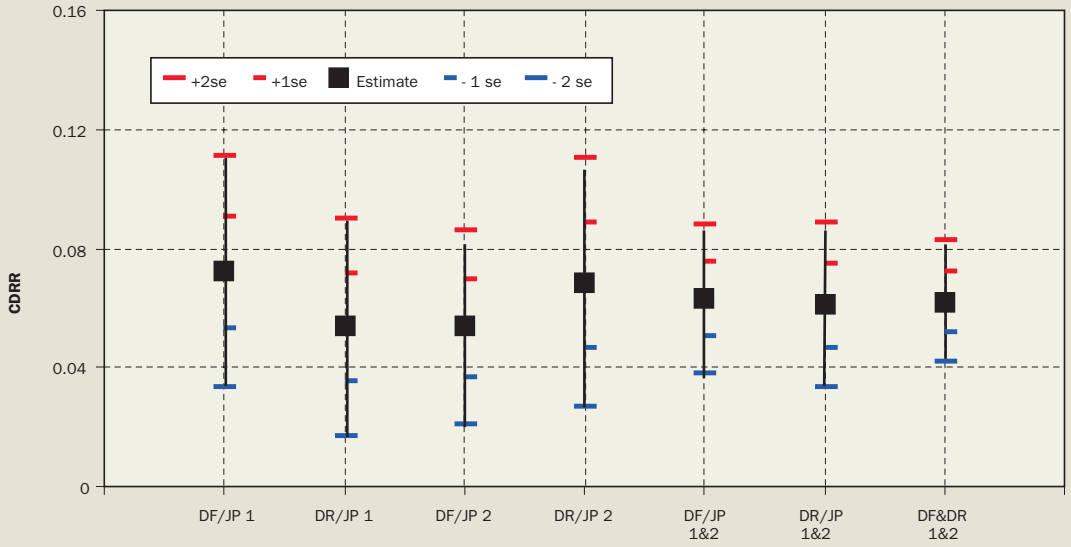


Figure 5-6
Comparison of Antioch and Chipps Island absolute survival estimates and differential or combined differential recovery rates compared to differential ocean recovery rates for 1996-2003.

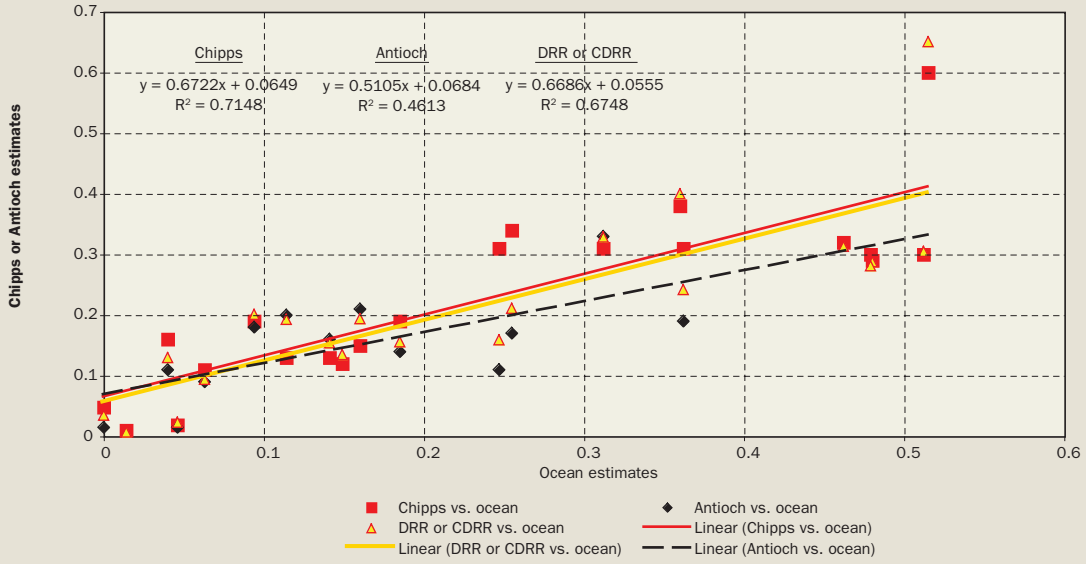


Table 5-6
Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies (1996 - 1999) and VAMP (2000 - 2003).

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	01MAY96	2		3				
	H61110413	28,192	DOS REIS	01MAY96	3		37				
	H61110414	18,533	DOS REIS	01MAY96	1		8				
	H61110415	36,037	DOS REIS	01MAY96	5		10				
	H61110501	53,337	JERSEY PT	03MAY96	39		187				
	Effective Release	107,961	DOS REIS		11		58	0.120		0.135	0.149
	Effective Release	51,737	JERSEY PT		39		187				
1997	H62545	50,695	DOS REIS	29APR97	9		183				
	H62546	55,315	DOS REIS	29APR97	7		167				
	H62547	51,588	JERSEY PT	02MAY97	27		355				
	Effective Release	106,010	DOS REIS		16		350	0.290		0.288	0.480
	Effective Release	51,588	JERSEY PT		27		355				
	H62548	46,728	DOS REIS	08MAY97	5		91	0.300		0.281	0.479
	H62549	47,254	JERSEY PT	12MAY97	18		192				
1998	61110809	26,465	MOSSDALE	16APR98	25		61				
	61110810	25,264	MOSSDALE	16APR98	31		40				
	61110811	25,926	MOSSDALE	16APR98	32		58				
	61110806	26,215	DOS REIS	17APR98	33		47				
	61110807	26,366	DOS REIS	17APR98	23		35				
	61110808	24,792	DOS REIS	17APR98	34		61				
	61110812	24,598	JERSEY PT	20APR98	87		110				
	61110813	25,673	JERSEY PT	20APR98	100		91				
	Effective Release	77,655	MOSSDALE		88		159	0.300		0.305	0.512
	Effective Release	77,373	DOS REIS		90		143	0.320		0.313	0.462
	Effective Release	50,271	JERSEY PT		187		201				
1999	062642	24,715	MOSSDALE	19APR99	8		128				
	062643	24,725	MOSSDALE	19APR99	15		134				
	062644	25,433	MOSSDALE	19APR99	13		132				
	062645	25,014	DOS REIS	19APR99	20		151				
	062646	24,841	DOS REIS	19APR99	19		225				
	0601110815	24,927	JERSEY PT	21APR99	34		338				
	062647	24,193	JERSEY PT	21APR99	25		381				
	Effective Release	74,873	MOSSDALE		36		394	0.380		0.400	0.360
	Effective Release	49,855	DOS REIS		39		376	0.600		0.651	0.515
	Effective Release	49,120	JERSEY PT		59		719				
2000	06-45-63	24,457	DURHAM FERRY	17-Apr-00	11	11	245				
	06-04-01	23,529	DURHAM FERRY	17-Apr-00	7	6	214				
	06-04-02	24,177	DURHAM FERRY	17-Apr-00	10	10	229				
	06-44-01	23,465	MOSSDALE	18-Apr-00	9	14	206				
	06-44-02	22,784	MOSSDALE	18-Apr-00	9	16	174				
	06-44-03	25,527	JERSEY PT	20-Apr-00	24	50	646				
	06-44-04	25,824	JERSEY PT	20-Apr-00	41	47	706				
	Effective Release	72,163	DURHAM FERRY		28	27	688	0.310	0.190	0.242	0.362
	Effective Release	46,249	MOSSDALE		18	30	380	0.310	0.330	0.329	0.312
	Effective Release	51,351	JERSEY PT		65	97	1352				
	601060914	23,698	DURHAM FERRY	28-Apr-00	7	8	46				
	601060915	26,805	DURHAM FERRY	28-Apr-00	5	15	44				
	0601110814	23,889	DURHAM FERRY	28-Apr-00	10	8	70				
	0601061001	25,572	JERSEY PT	1-May-00	48	76	356				
	0601061002	24,661	JERSEY PT	1-May-00	30	76	228				
	Effective Release	74,392	DURHAM FERRY		22	31	160	0.190	0.140	0.156	0.185
	Effective Release	50,233	JERSEY PT		78	152	584				
2001	06-44-29	23,354	DURHAM FERRY	30-Apr-01	14	28	95				
	06-44-30	22,837	DURHAM FERRY	30-Apr-01	22	30	155				
	06-44-31	22,491	DURHAM FERRY	30-Apr-01	17	18	110				
	06-44-32	23,000	MOSSDALE	1-May-01	17	18	123				
	06-44-33	22,177	MOSSDALE	1-May-01	14	15	107				
	06-44-34	24,443	JERSEY PT	4-May-01	50	156	464				
	06-44-35	24,992	JERSEY PT	4-May-01	61	173	553				
	Effective Release	68,682	DURHAM FERRY		53	76	360	0.340	0.170	0.211	0.255
	Effective Release	45,177	MOSSDALE		31	33	230	0.310	0.110	0.159	0.247

Table 5-6
Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies (1996 - 1999) and VAMP (2000 - 2003).

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	
	Effective Release	49,435	JERSEY PT		111	329	1017				
	06-44-36	24,025	DURHAM FERRY	7-May-01	2	8	17				
	06-44-37	24,029	DURHAM FERRY	7-May-01	5	11	47				
	06-44-38	24,177	DURHAM FERRY	7-May-01	2	10	28				
	06-44-39	23,878	MOSSDALE	8-May-01	4	8	25				
	06-44-40	25,308	MOSSDALE	8-May-01	4	11	27				
	06-44-41	25,909	JERSEY PT	11-May-01	17	43	243				
	06-44-42	25,465	JERSEY PT	11-May-01	27	53	332				
	Effective Release	72,231	DURHAM FERRY		9	29	92	0.130	0.200	0.193	0.114
	Effective Release	49,186	MOSSDALE		8	19	52	0.190	0.180	0.201	0.094
	Effective Release	51,374	JERSEY PT		44	96	575				
2002	06-44-71	23,920	DURHAM FERRY	18-Apr-02	4	11	30				
	06-44-72	25,176	DURHAM FERRY	18-Apr-02	9	20	84				
	06-44-73	23,872	DURHAM FERRY	18-Apr-02	4	12	65				
	06-44-74	24,747	DURHAM FERRY	18-Apr-02	4	20	61				
	06-44-57	25,515	MOSSDALE	19-Apr-02	6	13	72				
	06-44-58	25,272	MOSSDALE	19-Apr-02	7	29	70				
	06-44-59	24,802	JERSEY PT	22-Apr-02	46	101	461				
	06-44-60	24,128	JERSEY PT	22-Apr-02	37	89	394				
	Effective Release	97,715	DURHAM FERRY		21	63	240	0.130	0.160	0.154	0.141
	Effective Release	50,787	MOSSDALE		13	42	142	0.150	0.210	0.194	0.160
	Effective Release	48,930	JERSEY PT		83	190	855				
2002	06-44-70	24,680	DURHAM FERRY	25-Apr-02	3	6	18				
	06-44-75	24,659	DURHAM FERRY	25-Apr-02	5	2	17				
	06-44-76	24,783	DURHAM FERRY	25-Apr-02	3	4	8				
	06-44-77	24,381	DURHAM FERRY	25-Apr-02	4	6	4				
	06-44-78	24,519	MOSSDALE	26-Apr-02	2	3	23				
	06-44-79	24,820	MOSSDALE	26-Apr-02	3	4	14				
	06-44-80	24,032	JERSEY PT	30-Apr-02	18	43	282				
	06-44-81	22,880	JERSEY PT	30-Apr-02	28	32	278				
	Effective Release	98,503	DURHAM FERRY		15	18	47	0.160	0.110	0.130	0.040
	Effective Release	49,339	MOSSDALE		5	7	37	0.110	0.090	0.094	0.063
	Effective Release	46,912	JERSEY PT		46	75	560				
2003	06-02-82	24,563	DURHAM FERRY	21-Apr-03	0	1	5				
	06-02-83	26,036	DURHAM FERRY	21-Apr-03	2	4	0				
	06-27-42	24,179	DURHAM FERRY	21-Apr-03	1	1	8				
	06-27-48	24,706	MOSSDALE	22-Apr-03	2	2	0				
	06-27-43	25,480	MOSSDALE	22-Apr-03	3	2	0				
	06-27-44	24,649	JERSEY PT	25-Apr-03	57	71	93				
	Effective Release	74,778	DURHAM FERRY		3	6	13	0.019	0.015	0.023	0.046
	Effective Release	50,186	MOSSDALE		5	4	0	0.048	0.015	0.035	0.000
	Effective Release	24,649	JERSEY PT		57	71	93				
2003	06-27-45	24,815	DURHAM FERRY	28-Apr-03	0	0	0				
	06-27-46	25,319	DURHAM FERRY	28-Apr-03	0	0	0				
	06-27-47	24,758	DURHAM FERRY	28-Apr-03	0	0	0				
	06-27-49	24,219	MOSSDALE	29-Apr-03	0	0	3				
	06-27-50	24,505	MOSSDALE	29-Apr-03	1	0	0				
	06-27-51	25,950	JERSEY PT	2-May-03	39	36	115				
	Effective Release	74,892	DURHAM FERRY		0	0	0			0.000	0.000
	Effective Release	48,724	MOSSDALE		1	0	3	0.010		0.007	0.014
	Effective Release	25,950	JERSEY PT		39	36	115				

Note: Ocean recoveries are based on data through 2004.

Survival by Reach

In this section, Chinook salmon smolt survival in different reaches of the San Joaquin River will be evaluated between years. These analyses help our understanding of survival through the Delta for VAMP. Initially, survival in the entire reach (Durham Ferry or Mossdale to Jersey Point) will be discussed. Then the entire reach will be broken down by section and discussed further. The second reach discussed will be between Durham Ferry and Mossdale. The third reach is between Durham Ferry (or Mossdale) and Dos Reis. And lastly, the reach between Dos Reis and Jersey Point will be discussed. In this section we will only use CDRR or DRR as our estimate of survival. Data gathered prior to 2000 do not have any Antioch recoveries thus DRR's have been calculated using Chipps Island recoveries alone.

Survival between Durham Ferry or Mossdale and Jersey Point

Smolt survival between Durham Ferry and Jersey Point was low in 2005, as it was in 2003 and 2004. The 2005 survival estimates (0.07 and 0.05) were higher than those obtained in 2003 (0.023, and 0.0) and 2004 (0.026), but still low. The confidence intervals indicate that pooled survival between 2005 and 2004 was not significantly different (Figure 5-7). The pooled estimate in 2003 was the lowest measured to date with a HORB in place. Both the 2003 and 2004 data were much lower than other VAMP years (with the HORB in place) which started in 2000 (Table 5-7). The 2005 data was greater than that gathered in 1994 (0.0) when the HORB was not installed.

Table 5-7
Pooled, Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale, Dos Reis and Durham Ferry in relation to those released at Jersey Point between 2000 and 2005.

Year	CDRR	Standard Error
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
2005	0.060	0.010

The health of the CWT fish in 2005 may account for some of the low survival observed in 2005. While the fish appeared healthy at the hatchery prior to release, they had a low level of PKD infection. The disease progressed in test fish taken back to the CA/NV Fish Health Center, with severe occurrence observed after 29 days. Forty percent of the VAMP fish recovered at Chipps Island had evidence of infection in their kidneys by the parasite that causes PKD. It is not clear whether these levels of low initial infection rates may have affected our survival estimates to Antioch and Chipps Island in 2005. The CA/NV Fish Health Center concluded that while PKD in the VAMP fish may not have affected their survival to Chipps Island it may affect their long-term survival.

In 2003 and 2004, VAMP experimental fish also had PKD. We hypothesized that the PKD alone did not cause the higher mortality since infection and severe infection rates were not as high as they had been in 2001 when survival was greater (SJRG, 2005). However, the high level of PKD infection in combination with the lower flows in 2003 and 2004 may have differentially increased the mortality of upstream released VAMP fish since Jersey Point groups also had PKD but survived at a higher rate. This hypotheses seems supported by the work conducted by the CA/NV FHC in 2005, that indicated that PKD infection and its effects get worse over time and that a longer migration period (due to the lower flows and further distance than those released at Jersey Point) could have resulted in less smolts surviving to Chipps Island in 2003 and 2004.

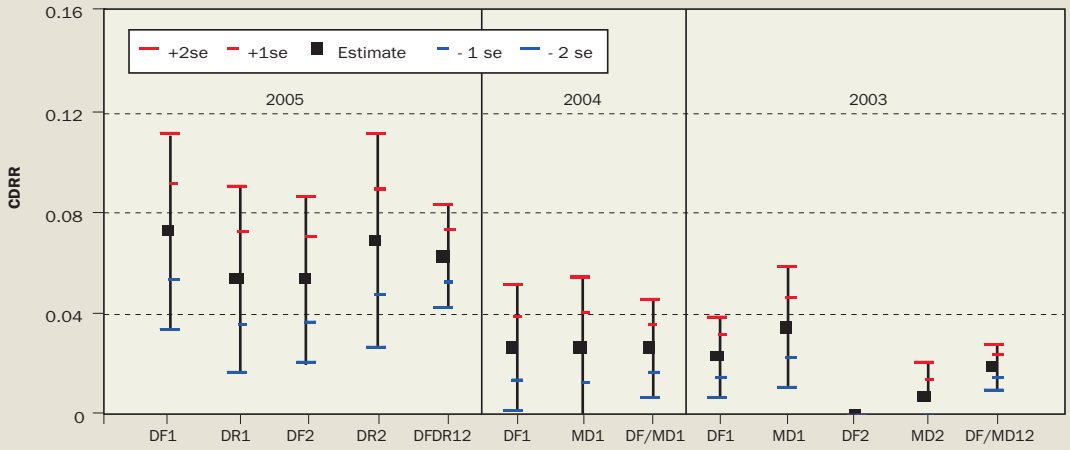
Survival between Durham Ferry and Mossdale

No releases were made at Mossdale in 2005 thus comparisons of survival rates between Durham Ferry and Mossdale cannot be made. However, survival between Durham Ferry and Mossdale between 2000 and 2004 has been generally high using both the Chipps Island and Antioch recoveries as well as the ocean recoveries (Table 5-8). Releases of marked fish at both sites will allow detection of mortality between Durham Ferry and Mossdale if mortality becomes great enough to detect in the future.

Table 5-8
Combined Differential Recovery Rates and Differential Recovery Rates for recoveries at Chipps and Antioch and in the ocean fishery for VAMP fish released at Durham Ferry and Mossdale between 2000 and 2004.

Year	CDRR Chipps and Antioch	DRR Ocean
2000	0.733	1.17
2001	1.325	1.04
2001	0.958	1.19
2002	0.794	0.93
2002	1.377	0.65
2003	0.667	
2003	0	
2004	0.998	

Figure 5-7
Combined Differential Recovery Rates (CDRR) (+ / - 1 and 2 standard errors) of CWT smolts released at Durham Ferry (DF), Mossdale (MD) and Dos Reis (DR) relative to those released at Jersey Point for the first (1), second (2) and combined release groups in 2003, 2004 and 2005. Only one set of releases was made in 2004.



Survival between Durham Ferry (or Mossdale) and Dos Reis

In 2005, releases were made at Durham Ferry and Dos Reis. However, the differences in survival between the two sites and Jersey Point in 2005 were not consistently or significantly different from each other (Figure 5-5). In past years, releases have also been made at Dos Reis and prior to 2005, were paired with comparable releases at Mossdale without the HORB in place. Average survival between Mossdale or Durham Ferry and Dos Reis was 0.71 using the Chipps Island recoveries (and Antioch recoveries in 2005) whereas it was 0.65 using the ocean recoveries (Table 5-9). However, there were two out of the nine instances using the Chipps Island recoveries and one instance using the ocean recoveries where the Mossdale or Durham Ferry groups survived at a higher rate than the Dos Reis groups. Low recovery rates, especially at Chipps Island and Antioch, may hinder our ability to consistently see differences even if they do exist.

Table 5-9
Differential Recovery Rates (and Combined Differential Recovery Rates in 2005) for experimental fish released at Mossdale (or Durham Ferry) and Dos Reis between 1995 and 2005.

MD/DF- DR	Release Date	CI	Ocean
1995	17-Apr	1.26	0.99
1995	5-May	0.31	0.51
1995	17-May	0.44	0.71
1996	30-Apr	0.33	0.38
1998	16-Apr	0.94	1.07
1998	23-Apr	0.4	0.22
1999	19-Apr	0.62	0.7
2005	2-May	1.36	
2005	9-May	0.76	
Average		0.71	0.65

Only once were releases made at Mossdale and Dos Reis with the HORB in place. That was in 1997 and estimates of survival between the two locations were 1.02 using Chipps Island recoveries and 1.29 using ocean recoveries. These data further reinforce that the temporary HORB provides protection to juvenile salmon migrating from the San Joaquin basin by reducing or preventing these fish from being drawn into upper Old River.

Survival between Dos Reis and Jersey Point

Survival in the reach from Dos Reis to Jersey Point in 2005, was much lower than survival from Durham Ferry to Dos Reis. This indicates that most of the juvenile salmon mortality occurs in the lower reach of the Delta. This finding is consistent in all years.

There have been 15 experiments where releases have been made at Dos Reis and Jersey Point, with three of these made in 1997 with the HORB in place. Data was gathered in the spring between 1989 and 1991, 1995 and 1999 and during 2005 without the HORB in place. Survival for the non-HORB years, using CDRR or DRR at Chipps Island (and Antioch recoveries in 2005) ranged between 0.03 and 0.66 and averaged 0.20. For ocean recoveries the DRR ranged between 0.05 and 0.83 and averaged 0.36 (Table 5-10). These data indicate that survival from Dos Reis to Jersey Point is generally low but has been relatively high some years. The highest survival was observed in 1995, 1997, 1998 and 1999.

Table 5-10
CDRR and DRR for survvial between Dos Reis (DR) and Jersey Point (JP) between 1989 and 2005. Stock is either Feather River (FR) or Merced River (MR). The HORB was usually not installed (n) except in 1997 (y).

Year	Release Date	CI DRR or CI and Antioch CDRR	Stock	HORB	DRR Ocean
1989	20-Apr	0.16	FR	n	0.2
1990	16-Apr	0.06	FR	n	0.05
1990	2-May	0.03	FR	n	0.08
1991	15-Apr	0.09	FR	n	0.13
1995	17-Apr	0.31	FR	n	0.83
1996	1-May	0.06	FR	n	0.11
1996	1-May	0.12	MR	n	0.15
1998	17-Apr	0.32	MR	n	0.47
1998	24-Apr	0.28	FR	n	0.77
1999	19-Apr	0.66	MR	n	0.52
1997	29-Apr	0.18	FR	y	0.37
1997	29-Apr	0.3	MR	y	0.492
1997	8-May	0.28	MR	y	0.485
2005	3-May	0.05	MR	n	
2005	10-May	0.07	MR	n	
Average		0.20			0.36

THE ROLE OF FLOW, EXPORTS AND THE HEAD OF OLD RIVER BARRIER ON SMOLT SURVIVAL THROUGH THE DELTA

San Joaquin River flow and flow relative to exports between April 15 and June 15 was correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships were 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 at Vernalis and exports by the CVP and SWP during the spring months when juveniles migrate through the river and Delta to the ocean. These relationships serve as conceptual models of how smolt survival would vary with flows and exports.

VAMP was designed to further define these relationships by testing how San Joaquin River flows (7,000 cfs or less) at Vernalis and exports (1,500 to 3,000 cfs) at SWP and CVP, with the HORB, affect smolt survival through the Delta. The HORB is assumed to improve survival based on studies conducted between 1985 and 1990 (Brandes and McLain, 2001). These studies indicated that smolts released on the San Joaquin River downstream of the HOR 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 HORB barrier cannot be installed when the San Joaquin River flows exceed 5,000 cfs during the scheduled installation period, and would potentially need to be removed if the San Joaquin River flows were to exceed 7,000 cfs.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP since the spring of 2000. The installation of the HORB is assumed as part of the VAMP experimental design. This year was the first year since 2000 that the HORB has not been in place during the VAMP experiment. However, similar survival tests both with and without the HORB were conducted prior to 2000. The results of these earlier tests were also used to help define the relationships between flow and exports on smolt survival with and without the HORB in place.

Role of flow on salmon survival

To assess the relationship between San Joaquin River flows at Vernalis and smolt survival with and without the HORB, CDRRs using recoveries at Chipps Island and Antioch as our estimate of survival between Durham Ferry and Mossdale and Jersey Point data from 1994- 2005 were plotted. In the past 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. To increase our sample size, each separate estimate was used in this year's evaluation. Prior to combining the data from both locations, regression lines comparing the CDRR/DRR's to Vernalis flow were evaluated from both locations independently. The results indicated that the variances and the regression lines from the two locations were not statistically different. Thus the CDRR/DRR data from both Mossdale and Durham Ferry releases were plotted together in the various relationships discussed below.

Flows at Vernalis were 10 day averages for each release starting on the day of the Mossdale release (in previous years) or the day after the Durham Ferry release. Ten day averages were used to represent the flow variable since after 10 days most of the fish are far enough downstream (with some already recovered) that the flow at Vernalis is probably no longer important for that particular group migrating to Chipps Island. Flow data was obtained through DWR's DAYFLOW for past years (updated January 2004). San Joaquin flows downstream of Old River prior to 2005 were obtained from DWR from a model that simulated historical flows using DSM2 (T. Smith, DWR Personal Communication). Flow data for 2005 was obtained from Chapters 2 and 4 of this report. A request has been made to DWR to compare measured flows to those predicted by the model for the spring of 2005.

Role of flow with HORB on Salmon Survival

The CDRR/DRRs using the Chipps Island and Antioch recoveries of the Mossdale and Durham Ferry groups relative to the Jersey Point groups did increase with Vernalis flow with the HORB in place ($p<0.01$; Figure 5-8).

The relationship between Vernalis flow and DRR using the ocean data with the HORB was also positive and statistically significant ($p<0.01$; Figure 5-9). The ocean data has fewer data points because recoveries are not yet available for the 2004 and 2005 releases.

Figure 5-8
CDRR or DRR using Chipps Island and Antioch recoveries between Mossdale or Durham Ferry and Jersey Point with the HORB in place and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release.

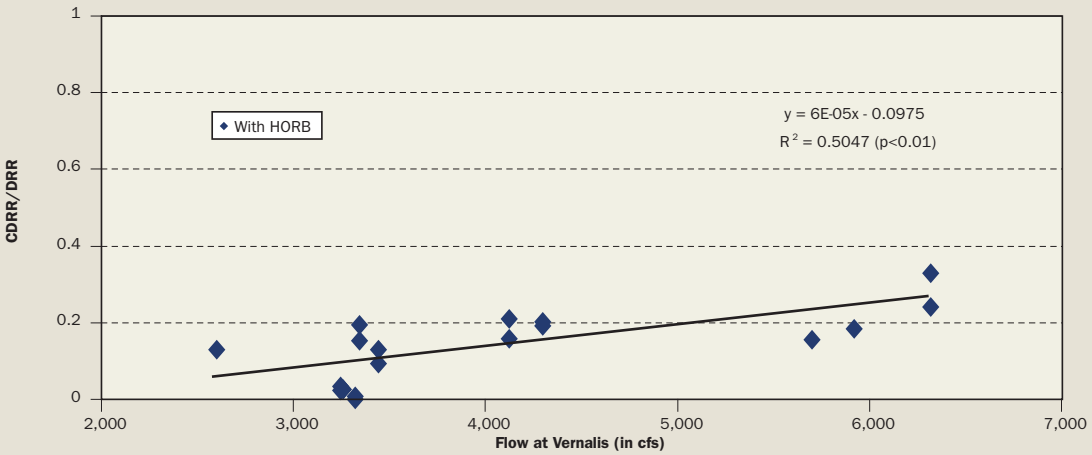


Figure 5-9
DRR using ocean recoveries, between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with the HORB in place.

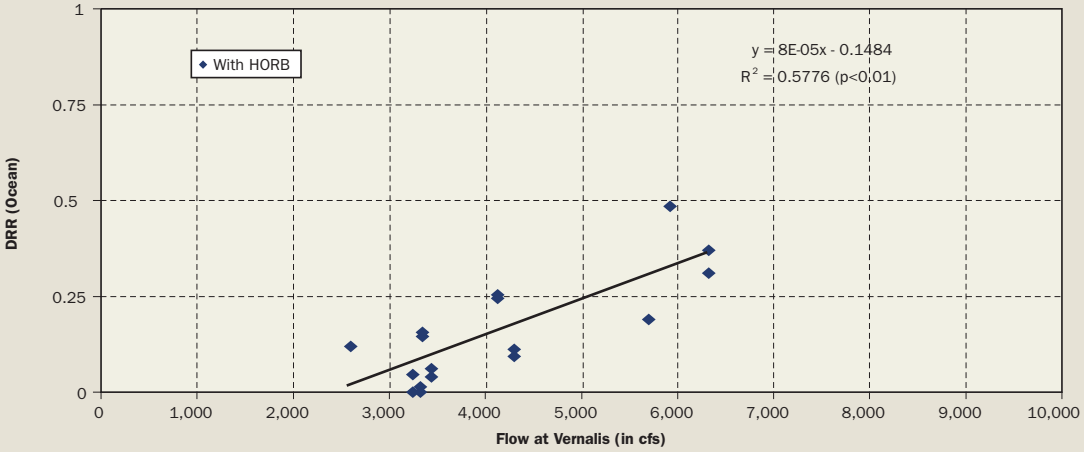
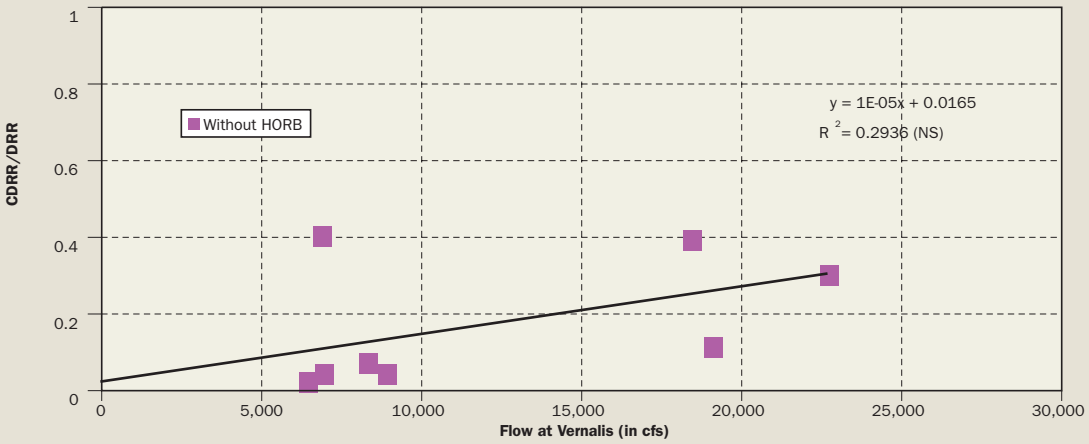


Figure 5-10
CDRR or DRR using Chipps Island and Antioch recoveries between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release without the HORB in place.



Role of flow without HORB on Salmon Survival

Without the HORB in place, the regression line of the DRR/CDRR's using the Chipps Island and Antioch recoveries of the Mossdale and Durham Ferry to Jersey Point survival increased with flow, but the relationship was not statistically significant (Figure 5-10).

The relationship using the ocean data without the HORB had a higher r^2 value than the one obtained using the Chipps Island and Antioch data, but was still not statistically significant (Figure 5-11). The two relationships were similar indicating that increasing flow may improve survival of the Mossdale and Durham Ferry groups relative to the Jersey Point groups without the HORB in place.

It is not surprising that there is more variability associated with smolt survival at any given flow at Vernalis without the HORB since the flow and proportion of marked fish moving into HOR varies more without the HORB.

To explore this issue further, we evaluated a group of test fish that "stayed" on the mainstem San Joaquin River and were not diverted into upper Old River. The CDRR/DRR's of smolts released at Dos Reis relative to those released at Jersey Point were compared to modeled San Joaquin flow downstream of the HOR. Three data points were gathered when the HORB was installed in 1997. The Chipps Island/Antioch data indicated a possible relationship between survival and flow, but one year (1999) was an obvious outlier (Figure 5-12). The relationship using the ocean recovery data showed that survival from Dos Reis to Jersey Point did increase with San Joaquin flows downstream of the HOR and it was statistically significant at the $p<0.01$ level (Figure 5-13). The 1999 data was no longer an outlier indicating that perhaps the Jersey Point group was biased low due to some missed sampling at Chipps Island that spring, as hypothesized in an earlier report (Brandes, 2000). This relationship indicated that survival is increased as flow increases on the mainstem San Joaquin River downstream of Old River, for the fish staying on the mainstem San Joaquin River when there is no HORB in place.

The Role of Exports on Survival

Another goal of the VAMP program is to identify the role of exports on juvenile salmon survival through the Delta. VAMP limits CVP+SWP exports to between 1,500 and 3,000 cfs depending on the flow target, because of its dual protective purpose. Historically, exports were generally much greater during this period. The VAMP design was intended to identify the role of exports with the HORB at flows of 7,000 cfs by experimenting at exports of 1,500 and 3,000 cfs. Conditions have not provided a 7,000 cfs flow with a HORB to test either export level. These limitations have made assessing the role of exports using the VAMP data difficult at this time.

In years when the HORB could not be installed it was recommended in the VAMP framework agreement to limit exports to either 1,500 or 3,000 cfs to make better comparisons with and without the HORB. In 2005, an agreement to have combined SWP/CVP pumping at 1,500 cfs for two weeks and then 3,000 cfs for the following two weeks was established and fish releases were to be made at each export level. However this agreement was not implemented as one of the parties did not initially adjust pumping as proposed. The failure to adjust pumping rates resulted in a combined pumping of approximately 2,250 cfs when marked fish were first released. A resolution was then implemented to maintain pumping at this rate for the full VAMP period. Pumping was approximately 2,250 cfs for the first 26 days of the 31 day VAMP period. Starting on May 26, exports increased gradually because the continued implementation of the reduced export level was increasing the costs (Environmental Water Account debt) to levels unacceptable to the implementing agencies.

Role of exports with HORB

Exports do not appear to explain additional variability in smolt survival over that using flow alone, in data obtained with the HORB in 1994, 1997 and between 2000 and 2004. This is counter to our conceptual model based on the better relationship of flow/exports and San Joaquin basin escapement 2 1/2 years later between 1951 and 2002 than that when using flow alone. In the recovery data from Chipps Island and Antioch (CDRR and DRR) with the HORB installed, regression analyses did show a relationship between the Durham Ferry and Mossdale data and flow/export ratios (Figure 5-14). However, the p value (0.02) indicated lower significance than the regression using flow alone ($p <0.01$) (Figure 5-8).

The ocean recovery data, while only available for releases prior to 2002, does show a trend of increasing survival with higher flow/export ratios but the relationship is not as statistically significant ($p<0.10$; Figure 5-15). Again, the relationship using flow alone was stronger (Figure 5-9).

One limitation in these experiments is the extremely narrow range of exports (1,450 to 2,350 cfs) during these smolt survival experiments with the HORB – a narrower range than in the VAMP design and much more narrow than the range of export levels observed since 1951 used in the adult escapement relationships. This narrow range may be why we can not detect a better smolt survival relationship using the flow/export ratio variable than when using flow alone with the HORB in place.

Figure 5-11
DRR using ocean recoveries, between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with and without the HORB in place.

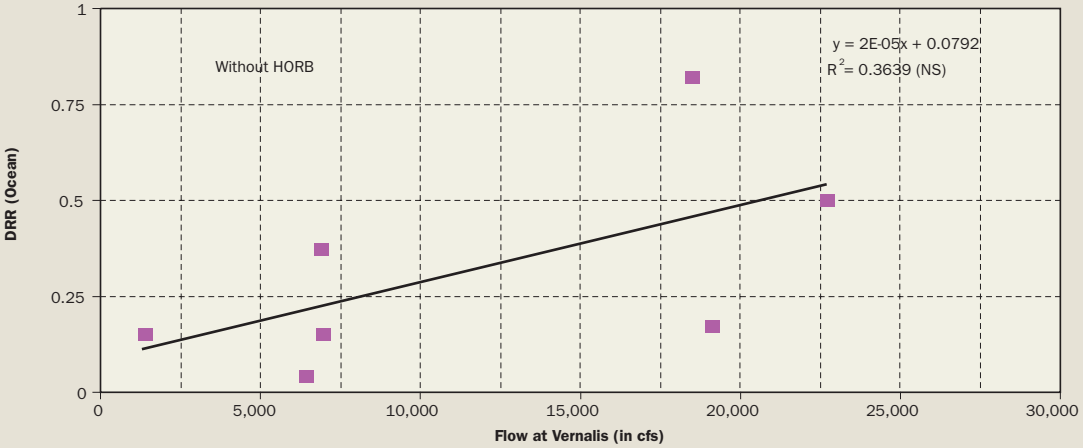


Figure 5-12
Survival between Dos Reis and Jersey Point (using recoveries at Chipps or Chipps and Antioch) with and without the HORB and modeled San Joaquin flows downstream of Old River. 1997 data was gathered with the HORB in place.

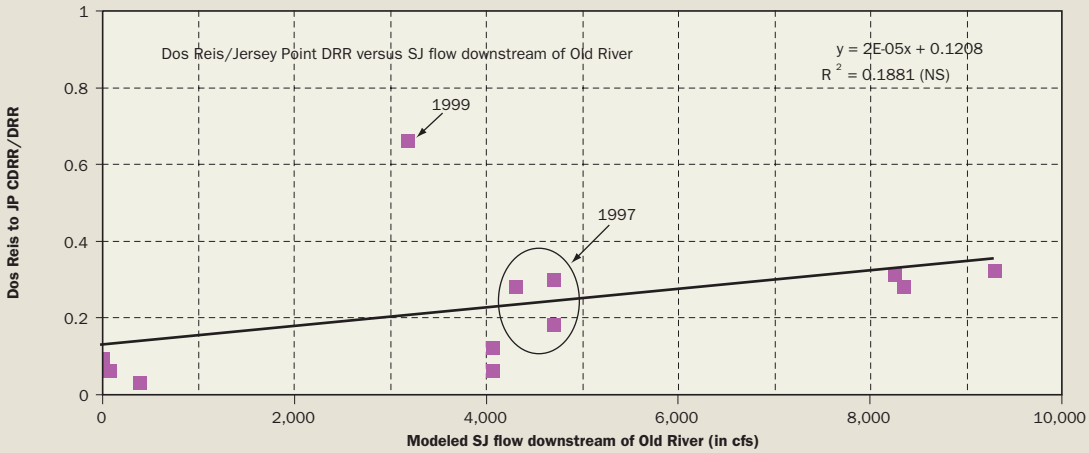


Figure 5-13
Ocean DRR of survival between Dos Reis and Jersey Point with and without a HORB and San Joaquin flows downstream of Old River. 1997 data was gathered with the HORB in place.

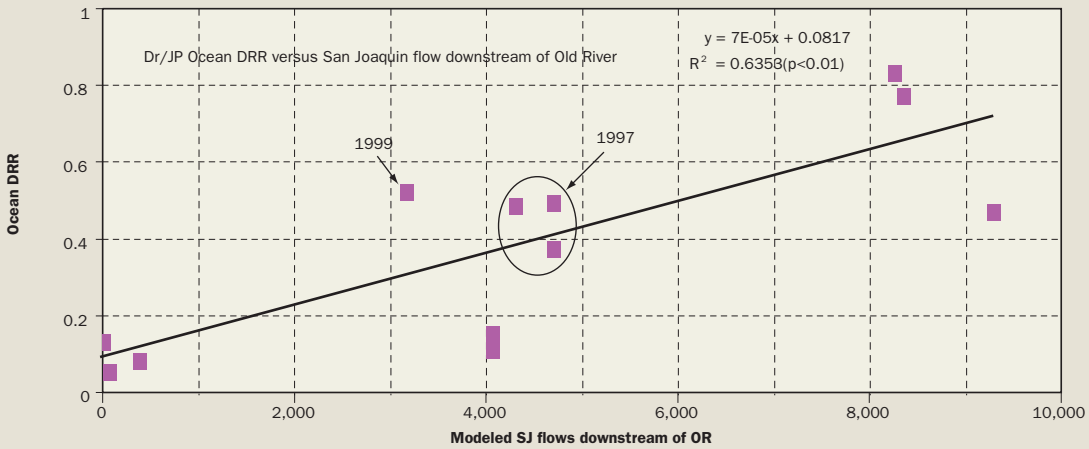


Figure 5-14
The survival between Durham Ferry or Mossdale and Jersey Point (CDRR/DRR) using Antioch and or Chipps Island recoveries and the Vernalis flow/export ratio for the 10 days after the Mossdale release. The data is gathered in years when there was a HORB in place.

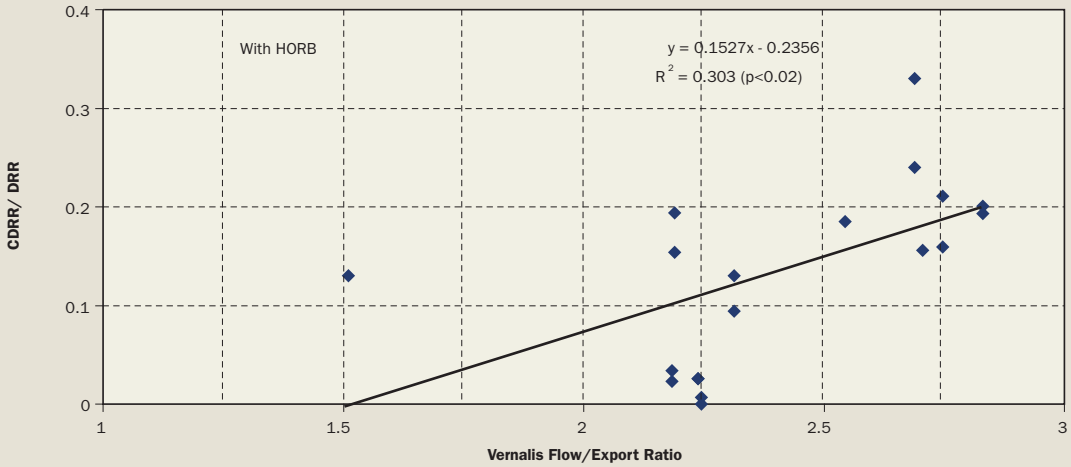


Figure 5-15
Ocean DRR of fish released at Durham Ferry or Mossdale and Jersey Point versus mean Vernalis flow/export ratio 10 days after release with the HORB in place.

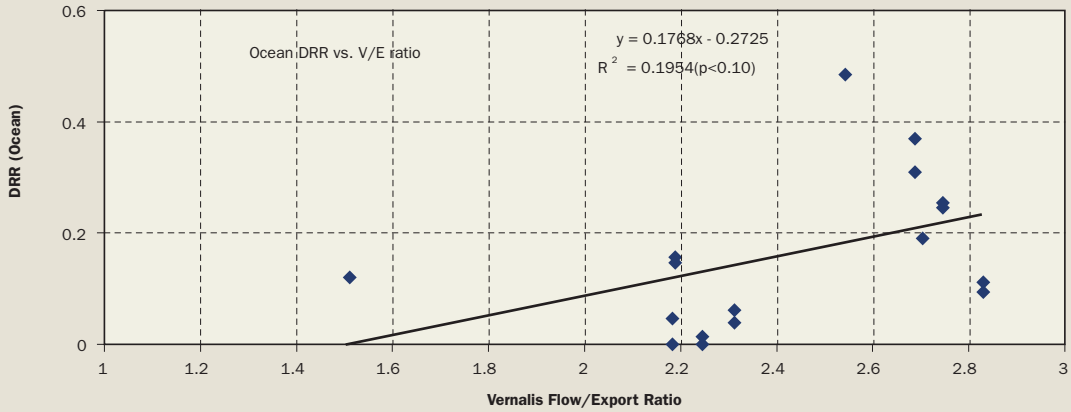
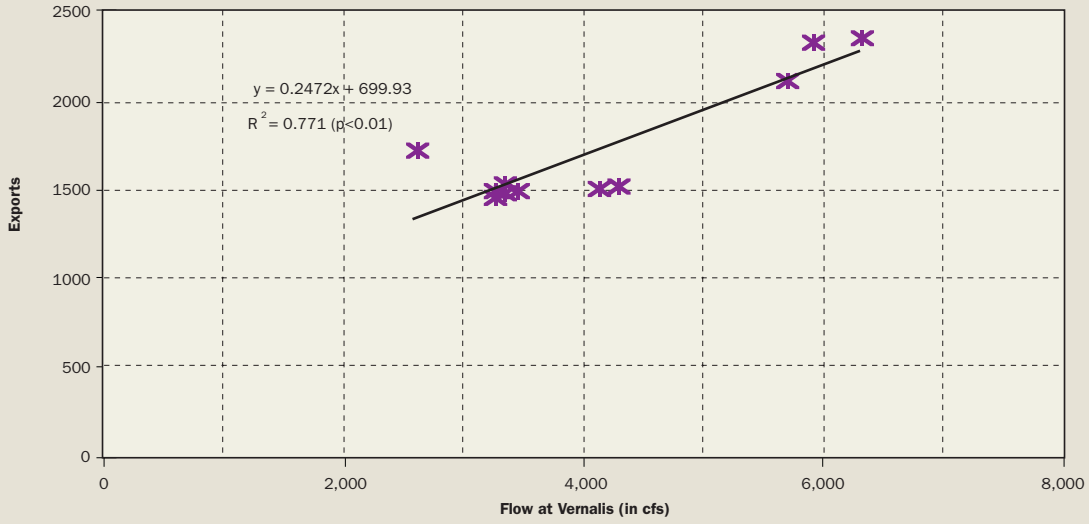


Figure 5-16
The relationship between San Joaquin River flows at Vernalis and CVP+SWP Exports during VAMP smolt survival tests conducted with the HORB in years between 1994 and 2004.



Additional analyses by Dean Marston of California Deparment of Fish and Game found that the CDRR and DRR's increased as exports increased in simple linear regressions (r^2 = 0.47 – Chipps and Anitoch recoveries, and r^2 = 0.69 – ocean recoveries) of the Mossdale groups relative to the Jersey Point groups, using both Antioch and Chipps Island and ocean recoveries. But when the exports and flow values used in these regressions were regressed against each other, there was a strong relationship between flow and exports (r^2 = 0.77) indicating that in general the experiments conducted with the HORB at the lower flows had lower exports and experiments at the higher flows had higher exports (Figure 5-16). It is problematic to identify the respective roles of each variable when the two variables tested are linked in this way.

Our next step is to experiment at flows of 7,000 cfs with the HORB and vary exports (1,500 and 3,000 cfs) to better define the export affect, independent of flow, on smolt survival.

Role of exports without HORB

The role of exports on smolt survival without the HORB in place is even more difficult to identify at this time. As mentioned earlier, relationships of smolt survival without the HORB with flow alone were not statistically significant (Figures 5-10 and 5-11). Regressions of exports to smolt survival without the HORB were weakly or not statistically significant (Figure 5-17) using both the Chipps Island and Antioch and ocean recoveries, but both relationships indicated survival increased as exports increased. The best relationship is a weakly significant multiple regression that includes flow and exports, with survival (using ocean recoveries) increasing as both flow and exports increase ($p<0.68$, $p<0.10$). In these data flows and exports were not correlated to each other (r^2 =0.0142), but the export range was limited to between 1400 and 3700 cfs. It is possible that increasing exports in this range decreases residence time in Old river such that survival for those smolts moving into Old River have higher survival. These findings are counter to our hypothesis that survival decreases as exports increase relative to flow.

Regressions between the DRR from Mossdale and Durham Ferry using Chipps Island and Antioch and ocean recoveries did not show a relationship with flow/export ratios (Figure 5-18) – but again these data are limited in the range of export values tested. The adult escapement data which incorporates a larger range in export values indicates a positive and strongly statistically significant relationship ($p<0.01$) with flow/exports without the HORB but we are not able to detect this same relationship with the smolt survival data we have gathered to date. As in the with HORB data, it will be important to continue these experiments in the future and to measure survival at different export levels at the same flows without the HORB.

The Role of the HORB on survival through the Delta

One obvious result of the HORB on survival through the Delta is the lower salvage (and direct loss) for fish released at Durham Ferry and Mossdale when the HORB is installed. In 2005, several hundred of the Durham Ferry group, were salvaged indicating a higher loss compared to previous years because the HORB was not in place.

Comparing the with and without HORB data, using the Chipps Island and Antioch data, appears to indicate that there is value in installing the HORB at flows between about 3,000 and 6,000 cfs (Figure 5-19a). The benefit, using the ocean data, seems less apparent but may improve survival between flows of 4,000 and 6,000 cfs (Figure 5-19b).

Relationship of flow and exports to adult escapement 2 1/2 years later

The relationships between flow and flow/exports to escapement (all year classes) 2 1/2 years later have been shown in previous reports (SJRGA, 2003). In this section of the report, we will present revised escapement data (includes all age classes) which only includes escapement from the Stanislaus, Tuolumne and Merced rivers. Previous estimates included escapement in the Mokelumne, Calaveras and Consumnes rivers as well. In addition, the data has been updated to include the most recent escapement (to 2004) and flow (to 2002) data. These revised and updated escapement data were obtained from the USFWS Anadromous Fish Restoration Program's website at http://www.delta.dfg.ca.gov/afrp/index/asp.

These updated escapement data for the years of 1953 to 2004 was divided into two groups: the first group includes data gathered in those years when the HORB was in place for at least 2 weeks during the smolt out-migration period (April 15 to June 15) 2 1/2 years earlier and the second group includes escapement data for those years when there was no HORB. These relationships using both sets of data continue to show that escapement is significantly ($p<0.01$) correlated to Vernalis flows (Figure 5-20) and Vernalis flows/CVP+SWP exports continues to explain more of the variability in adult escapement than when using flow alone when there was no HORB in place (Figure 5-21). In addition, escapement was significantly correlated to Vernalis flows minus exports (Figure 5-22). The highest r^2 value for the years when there was a HORB in place was for the relationship between adult escapement and flow. This may reflect the relatively low exports in the years the HORB has

Figure 5-17
Chipps Island DRR or Chipps Island and Antioch DRR and ocean DRR for CWT smolts released at Mossdale or Durham Ferry relative to those released at Jersey Point versus combined SWP+CVP mean exports for the 10 days after release in years between 1994 and 2005 when there was no HORB in place.

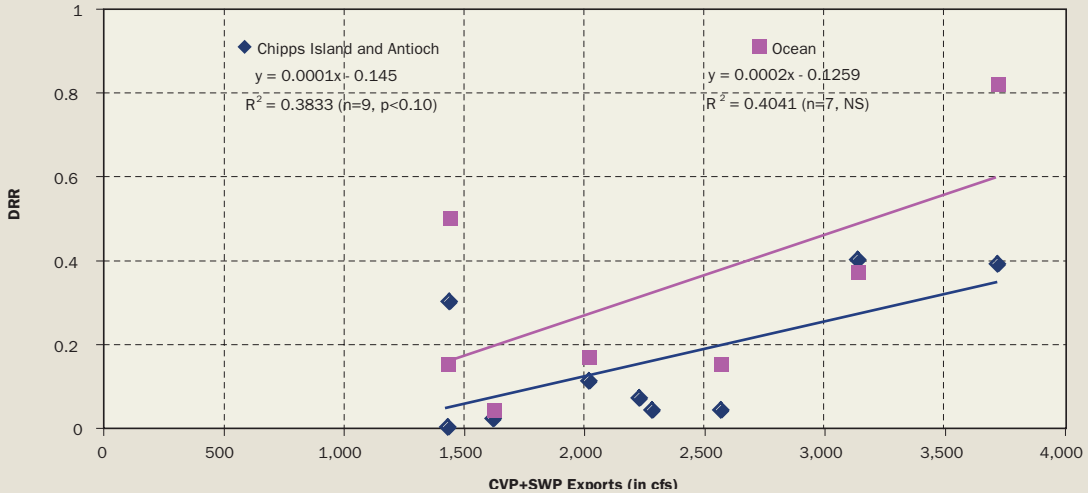


Figure 5-18
Ocean DRR's and Antioch and/or Chipps Island CDRR's or DRR's for fish released at Mossdale and Jersey Point versus the mean Flow/Export ratio for the 10 days after release without the HOR barrier.

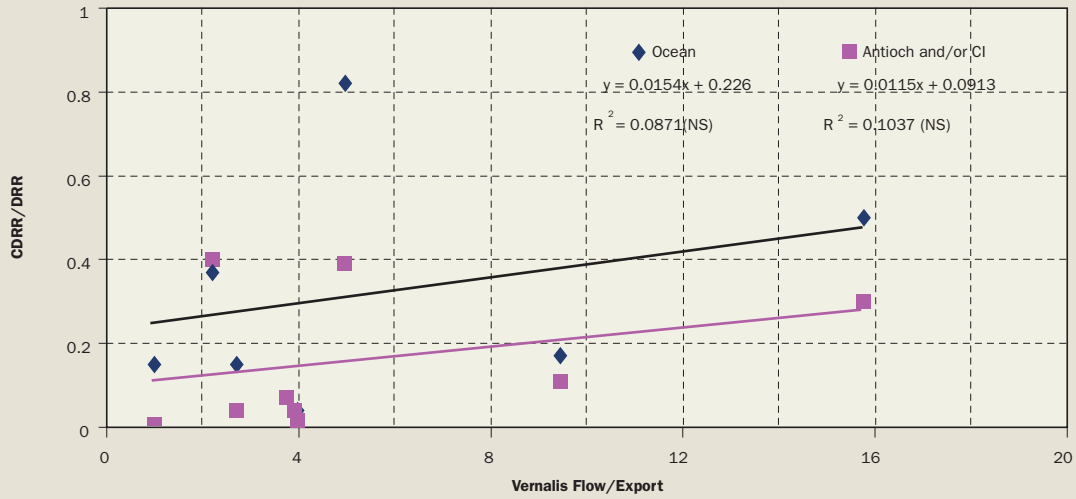


Figure 5-19
CDRR or DRR using Chipps Island and Antioch recoveries between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs.

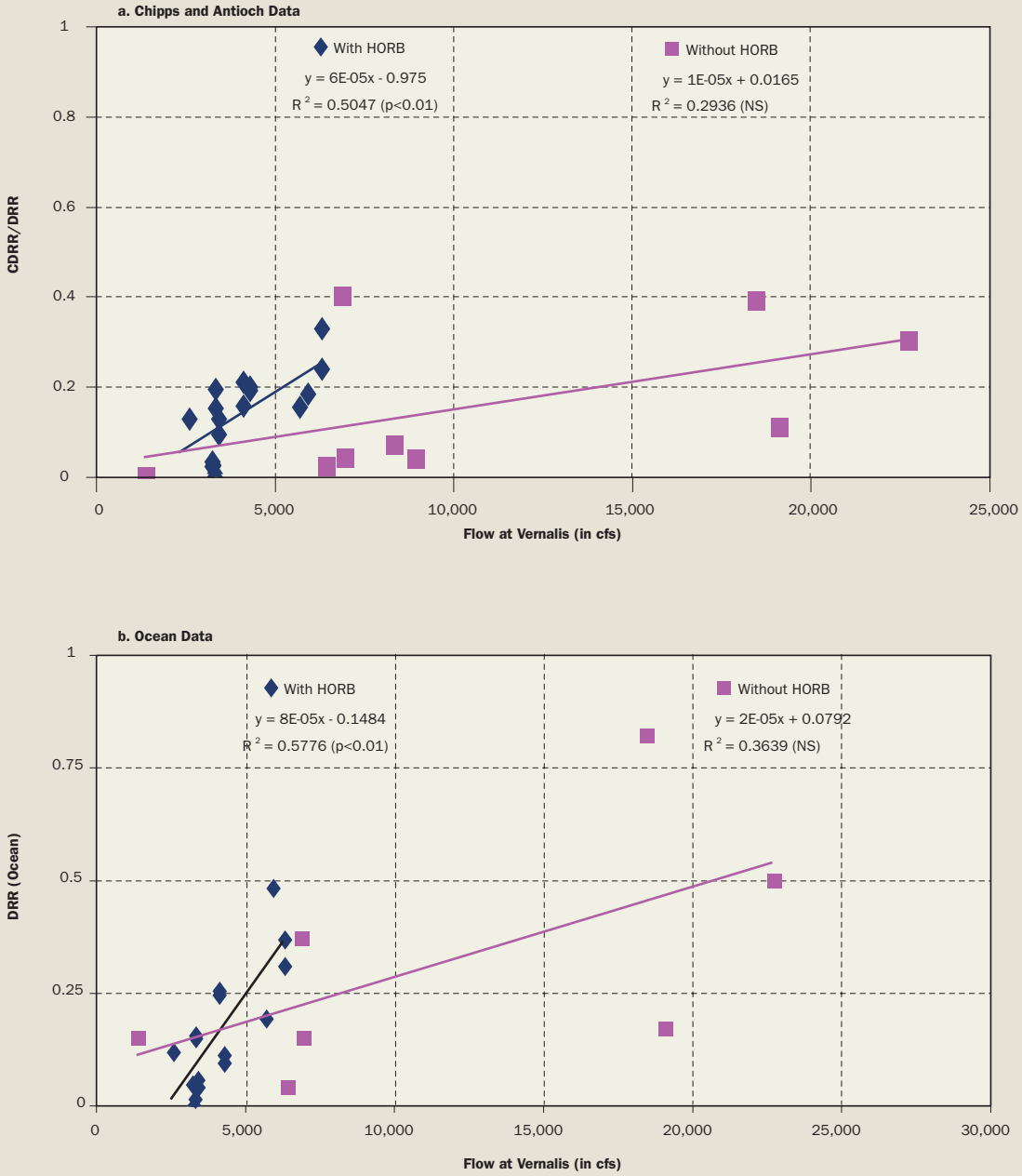


Figure 5-20
Vernalis flows versus escapement 2 1/2 years later in years with and without the HORB.

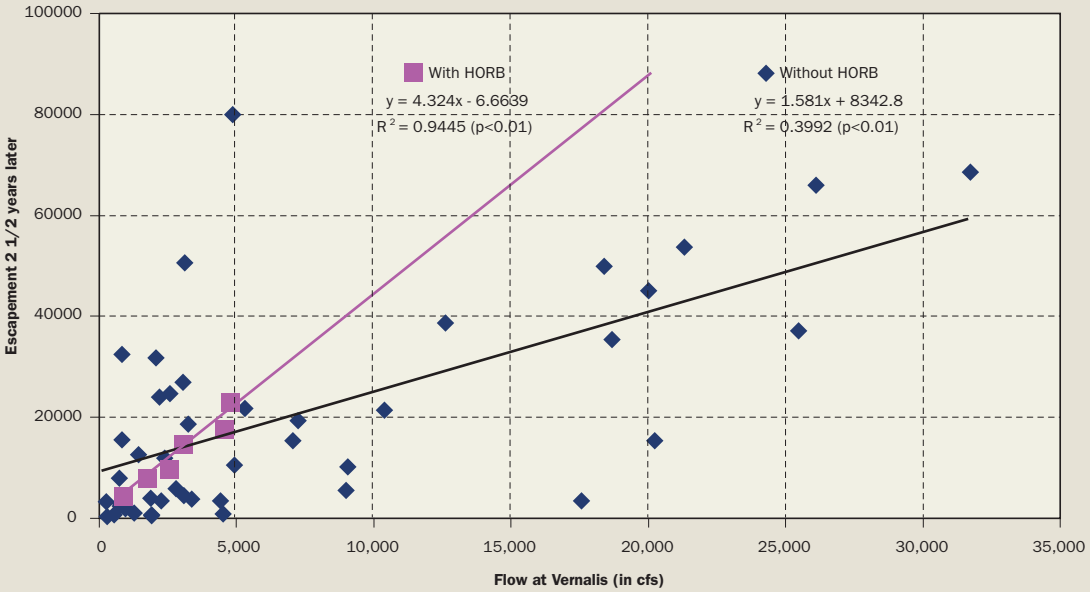
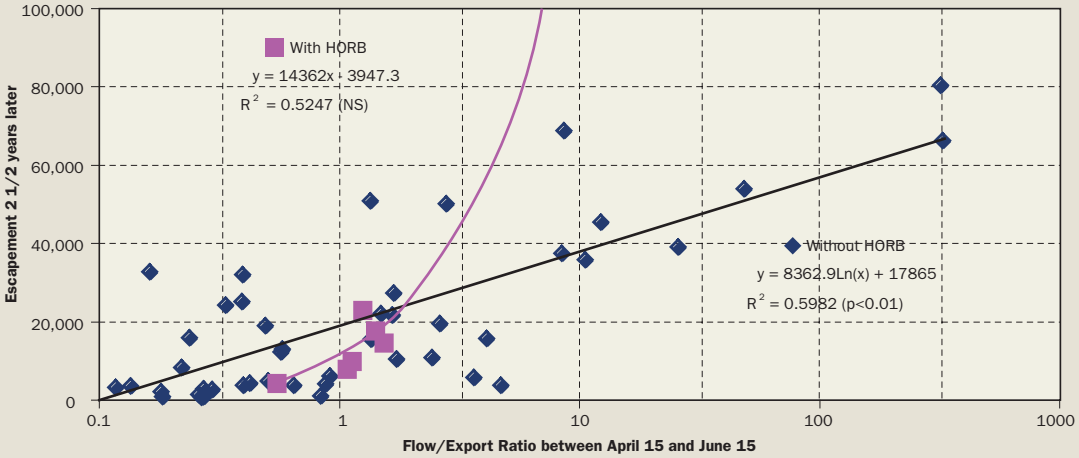


Figure 5-21
Vernalis flow/export ratio versus adult escapement 2 1/2 years later in years with and without the HORB in place.



been in place and the greater effect over a broader range of flow relative to exports on escapement when there wasn't a HORB.

In a multiple regression correlating escapement to flows and exports, exports did not provide any additional predictive power to the model than using flow alone. It is not clear why escapement without the HORB is better predicted using the flow/export ratio than flow alone in simple linear regressions, but in a multiple regression, exports do not explain any additional variability in escapement in all years between 1953 and 2004 over that of flow alone. The with and without HORB data was not partitioned in the multiple regression analyses and may explain some of these differences.

In addition, the ratio of exports to flow (opposite of the flow to export ratio) has been used in the past to estimate the amount of flow diverted into HOR when there is no HORB installed (Jim Snow, DWR, personal communication). It is likely the amount of flow diverted affects the proportion of smolts diverted into HOR. The smolts diverted into HOR would likely be more affected by project exports which in turn would affect their overall smolt survival through the Delta and sequential adult returns 2 1/2 years later. This relationship between the ratio of exports/flow and the proportion of flow diverted into Old River may help explain why we see relationships with the flow/export ratio to adult escapement but do not find that exports account for any additional variability in a multiple regression analyses with flow.

The benefit of examining these adult relationships is that there is more data gathered over a broader range than for smolt survival under the VAMP framework. These adult relationships would indicate that as you increase flows and decrease exports relative to flows there should be corresponding increases in smolt survival and adult escapement 2 1/2 years later. So while we cannot yet see a significant relationship of flow/exports to smolt survival with the limited data gathered to date, these data would suggest there is a relationship and it predicts adult escapement better than flow alone when there is no HORB. The relationship of flow alone to data gathered with the HORB may reflect the lack of variability in exports with the HORB in place during these experiments as mentioned previously.

When comparing the relationships of escapement and flow with and without the HORB we find that the HORB may have increased escapement between average flows of about 3,000 to 5,000 cfs (Figures 5-20). However, it is not clear that the with and without HORB regression lines are different from one another. Using the relationships of escapement, to evaluate the benefits of the HORB, are imprecise because the HORB wasn't in place for the entire migration period of the juvenile salmon that returned to spawn 2 1/2 years later. This is only one of the sources of noise in the escapement data. Additional data are needed to confirm this apparent benefit. Returns based on cohort estimates (specific year classes) would provide an important refinement to this assessment, as the assumption that the majority of spawners are 3-year old fish is known to be inaccurate.

Summary

With the HORB in place we have established statistically significant relationships between smolt survival and flow at Vernalis. These relationships are found using the Chipps Island and Antioch smolt recovery data and the ocean recovery data. The smolt survival data obtained without the HORB show a trend of increasing survival as flows increase but relationships are weaker and not statistically significant. The relationship between ocean recovery rates of the Dos Reis groups relative to the Jersey Point groups indicate that survival improves as flows increase for smolts that remain within the mainstem San Joaquin River when there is no HORB. The role of exports on smolt survival within the VAMP (with HORB) and without a HORB is more difficult to define based on the limited data. It is imperative that we measure the two export rate conditions (1,500 and 3,000 cfs) at flows of 7,000 cfs with a HORB in place so that the uncertainty can be resolved. Additional data should also be gathered without the HORB. Finally, the relationships with adult escapement infer that survival through the Delta can be improved with 1) increased flow when there is a HORB, 2) increased flow/export ratios when HORB is not installed, and 3) with a HORB at flows between 3,000 and 5,000 cfs.

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 hypothesized that these actions to improve conditions for the juveniles will translate into greater adult abundance and escapement in future years.

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

Figure 5-22
Relationship between San Joaquin flow minus exports between April 15 and June 15 and adult escapement 2 1/2 years later with and without the HORB in place.

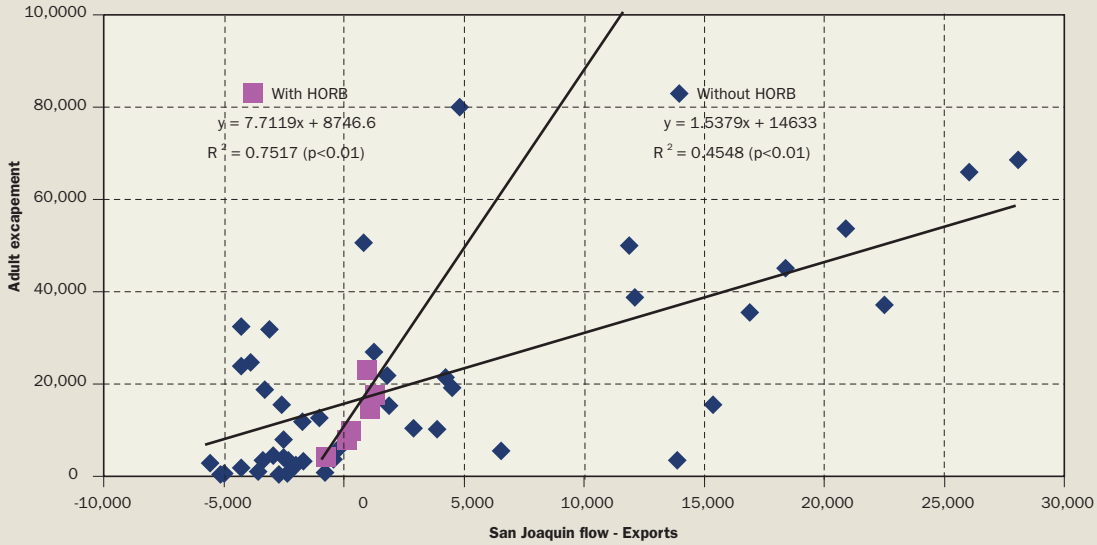


Figure 5-23
The average daily densities of unmarked salmon caught in the Mossdale Kodiak trawl on the San Joaquin River and the percent of smolts protected during the pre-VAMP and VAMP periods.

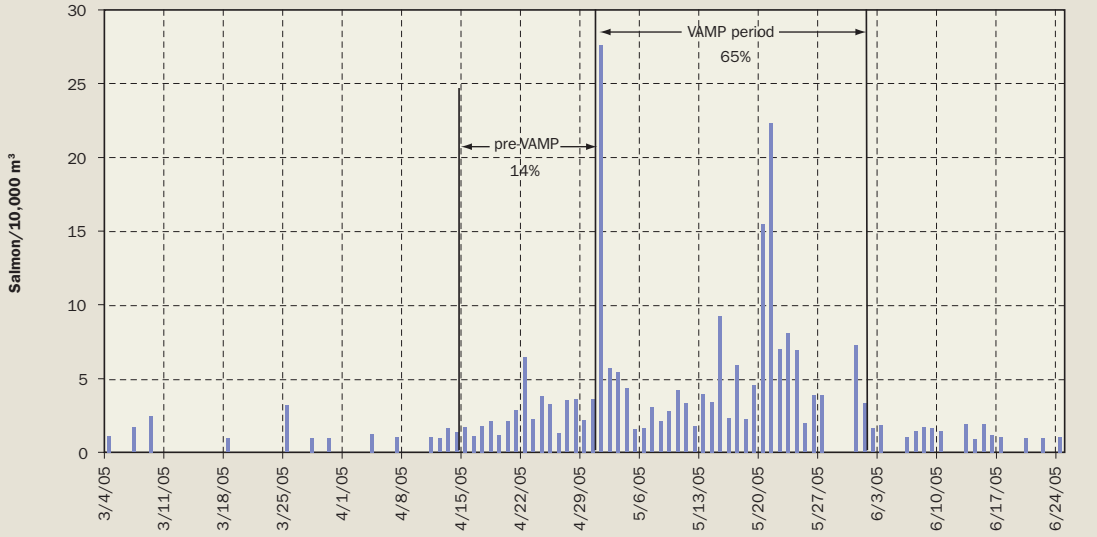


Figure 5-24
Mossdale Kodiak trawl individual daily forklengths of all unmarked juvenile Chinook salmon, March 15 through June 30, 2005.

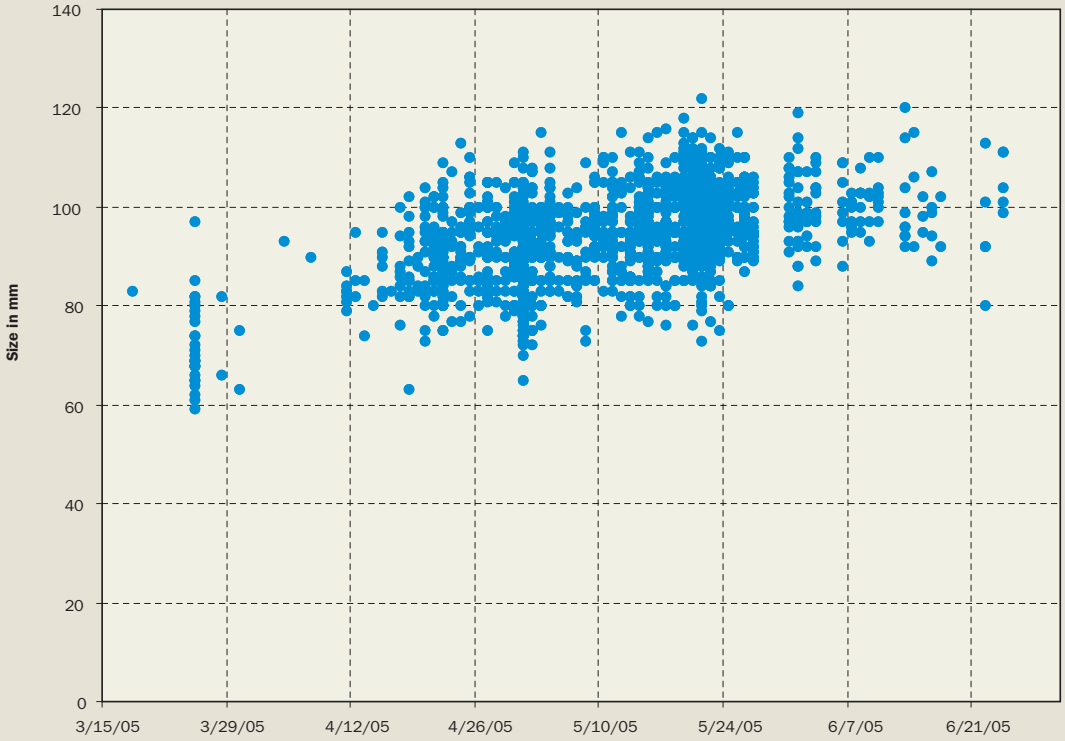
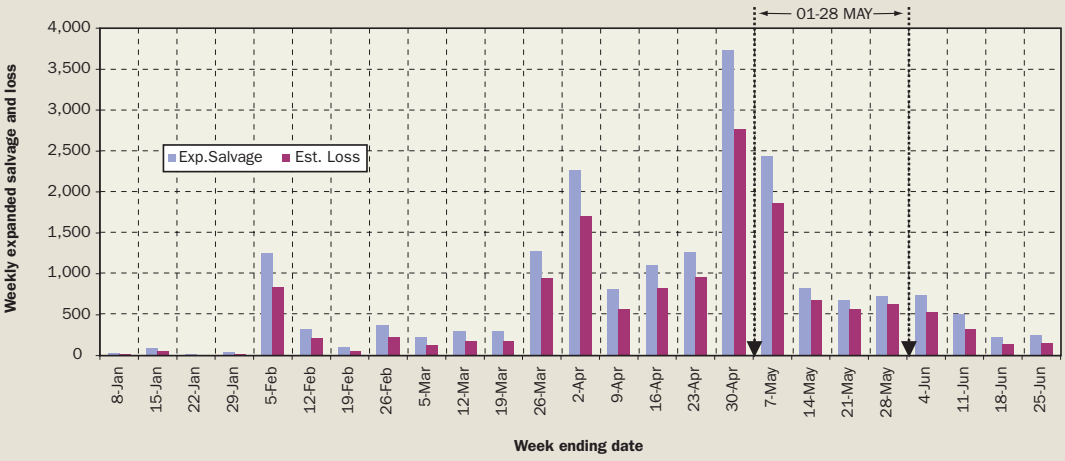


Figure 5-25
2005 CVP Estimated Salmon Salvage and Loss



Unmarked Salmon Recovered at Mossdale

The typical time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon smolts emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. In 2005, the VAMP period was delayed until May 1 with the intent of providing more stability in the river flows at Vernalis. The average catch per 10,000 cubic meters per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2005 is shown in Figure 4-6. Unmarked salmon do not have an adipose clip and could be juveniles from natural spawning or unmarked fish released from the MRFF.

Approximately 65% of the unmarked catch that passed Mossdale between March 15 and June 30 passed during this years VAMP period (May 1 – June 1) (Figure 5-23). The range has varied between 31 and 76% in the pervious VAMP years since 2000 (SJRG, 2005). The pre- VAMP shoulder on VAMP that restricted exports between April 18 and May 1 provided protection to an additional 14% of the population in 2005 (Figure 5- 23). The size of the juvenile salmon migrating past Mossdale between March 15 and June 30, 2005 is shown in Figure 5-24.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon and transport them by tanker truck for release in the western Sacramento-San Joaquin Delta. The untagged salmon are 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 MRFF smolts at the salvage facilities to provide some general indications as to the origin of the unmarked fish.

The losses at the CVP and SWP are based on expanded salvage and an estimate of screen efficiency and survival through the facility and salvage process. The CVP pumps divert directly from the Old River channel and direct losses are estimated to range from about 50 to 80% of the number salvaged. Four to five salmon are estimated to be lost per salvaged salmon at the SWP because of high predation rates in Clifton Court Forebay. The CVP losses are 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, or any additional mortality associated with trucking and handling, or post-release predation.

Density of salmon at the fish facilities is represented by the combined number of salvage and losses estimated per acre-foot of water pumped. This approach provides more comparable densities at each facility than density values based only on salvage estimates that were used previously, due to the different calculation of associated losses at each location. 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 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 May 1 to May 28 approximated the 2005 VAMP period. A review of weekly data for January through June indicates that the highest CVP salvage and loss occurred from late April to early May. Lesser peaks occurred between late March and early April and in early February (Figure 5-25). Highest SWP salvage and loss were in late April with a sustained broad peak from mid-May to mid-June (Figure 5-26). The primary CVP and SWP peaks occurred during an extended period of late March to mid-June when combined CVP and SWP weekly export rates were equal to, or exceeded by Vernalis flow (Figure 5-27).

Salmon densities at the CVP facilities were highest in late April to early May, with an earlier peak in late March (Figure 5-28). Densities at the SWP facilities were highest in the second half of May and were elevated from mid-April through early June (Figure 5-28).

The size distribution of unmarked salmon during mid-March through May in the Mossdale trawl (Figure 5-24) was a subset of the size distribution of those salvaged at the fish facilities (Figure 5-29, Source E. Chappell, DWR). Based on comparisons with Mossdale data (Table 4-2), it appears that some salmon salvaged prior to VAMP could have been from the San Joaquin basin.

Results of these analyses showed that the 2005 VAMP test period and the pre-VAMP curtailment in exports for Delta smelt 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 through the Delta.

SUMMARY AND RECOMMENDATIONS

The survival estimates and CDRRs measured in 2005 were low and similar to those estimated in 2003 and 2004. One of the reasons 2005 survival was low was due to the fact that there was no HORB installed. We would have predicted higher survival if the HORB had been installed.

The health of the fish used in 2005 was again somewhat suspect and improving their condition should be discussed with those responsible for fish production in the basin. Specifically, factors that could reduce the incidence of the parasite that causes PKD should be identified. The CA/NV FHC has shown PKD is also in the wild population in the San Joaquin basin. The survival indices were consistently low for all of the marked fish released from MRFF, with the exception of those released at Jersey Point. However, the survival of fish released at Jersey Point may have been reduced after they passed Chipps Island because they also had PKD but in general were recovered sooner then those released upstream.

There are statistically significant relationships of smolt survival and flow with the HORB. These relationships are found using the Chipps Island and Antioch recoveries of the Durham Ferry and Mossdale groups relative to the Jersey Point groups and when using ocean recoveries. Escapement 2 1/2 years later was also significantly ($p<0.01$) correlated to San Joaquin River flow at Vernalis with a HORB.

There is also a trend of increasing smolt survival with San Joaquin River flow without the HORB but the relationships are not statistically significant. There is however, a statistically significant relationship between spring flows without a HORB and adult escapement 2 1/2 years later. Without a HORB the best predictor of escapement is the flow/export ratio.

To better determine relationships of smolt survival to exports and flow, certain conditions should be targeted during the remaining years of VAMP and in years when the HORB cannot be installed. Two of the conditions that need to be tested are at exports at 1,500 and 3,000 cfs with San Joaquin River flows at 7,000 cfs with the HORB in place. In addition, the 7,000 cfs flow and the 1,500 export condition would achieve the highest inflow to export ratio (4.7) within the VAMP design and provide a larger ratio to test. Unless these extremes are tested soon, the length of the study may need to be extended. Furthermore, more data should be obtained when the HORB cannot be installed to further refine and define the survival relationships to flow and exports without the HORB in place.

Figure 5-26
2005 SWP Estimated Salmon Salvage and Loss

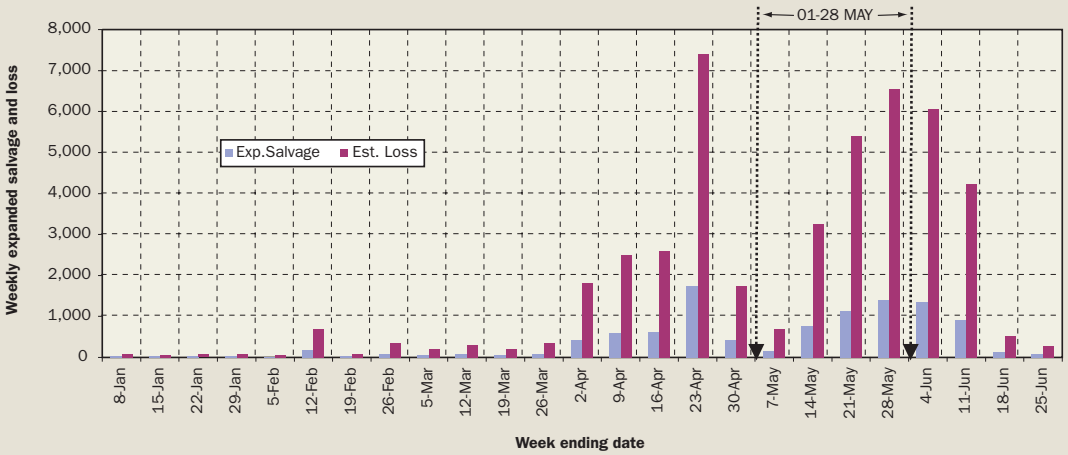


Figure 5-27
2005 Weekly Export Rates and Vernalis Flow

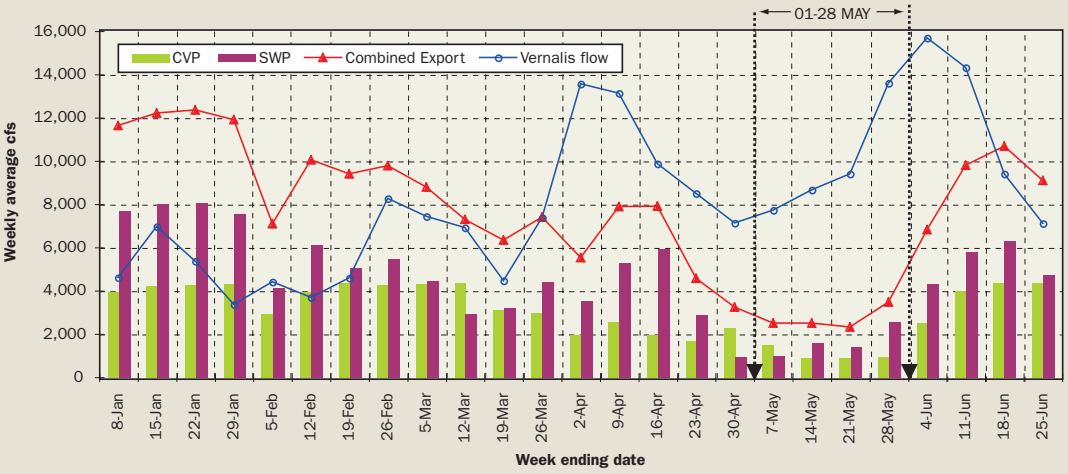


Figure 5-28
2005 CVP & SWP Combined Salvage and Loss Density

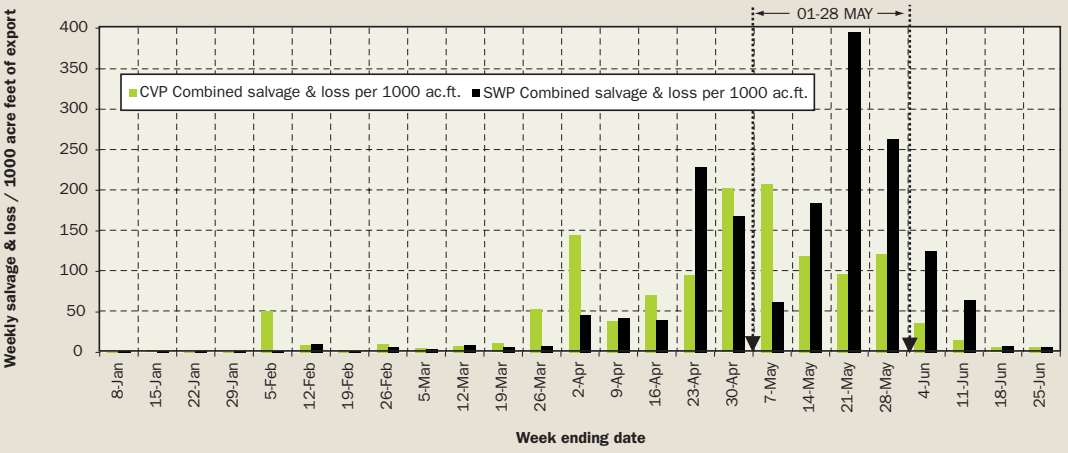
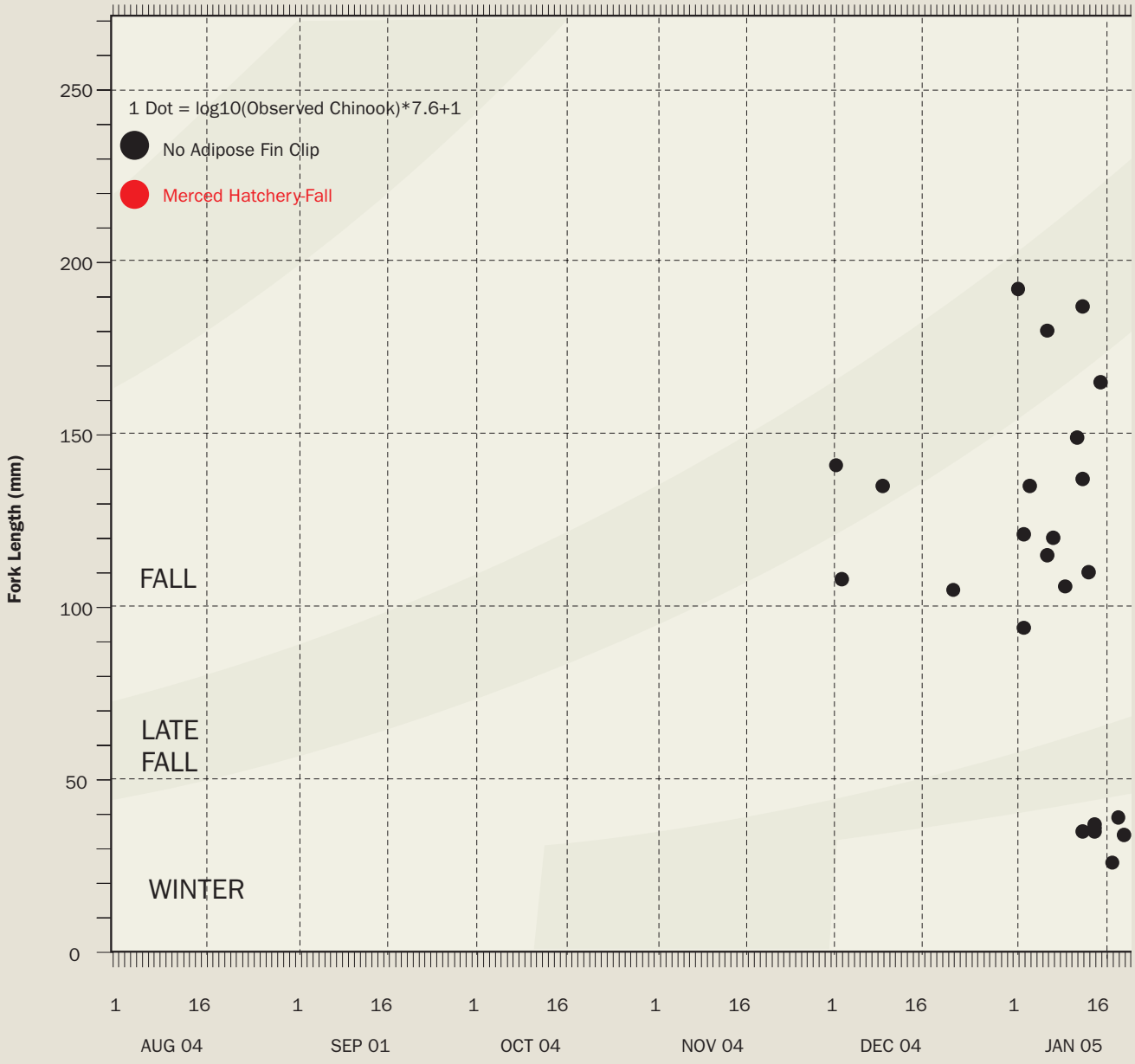
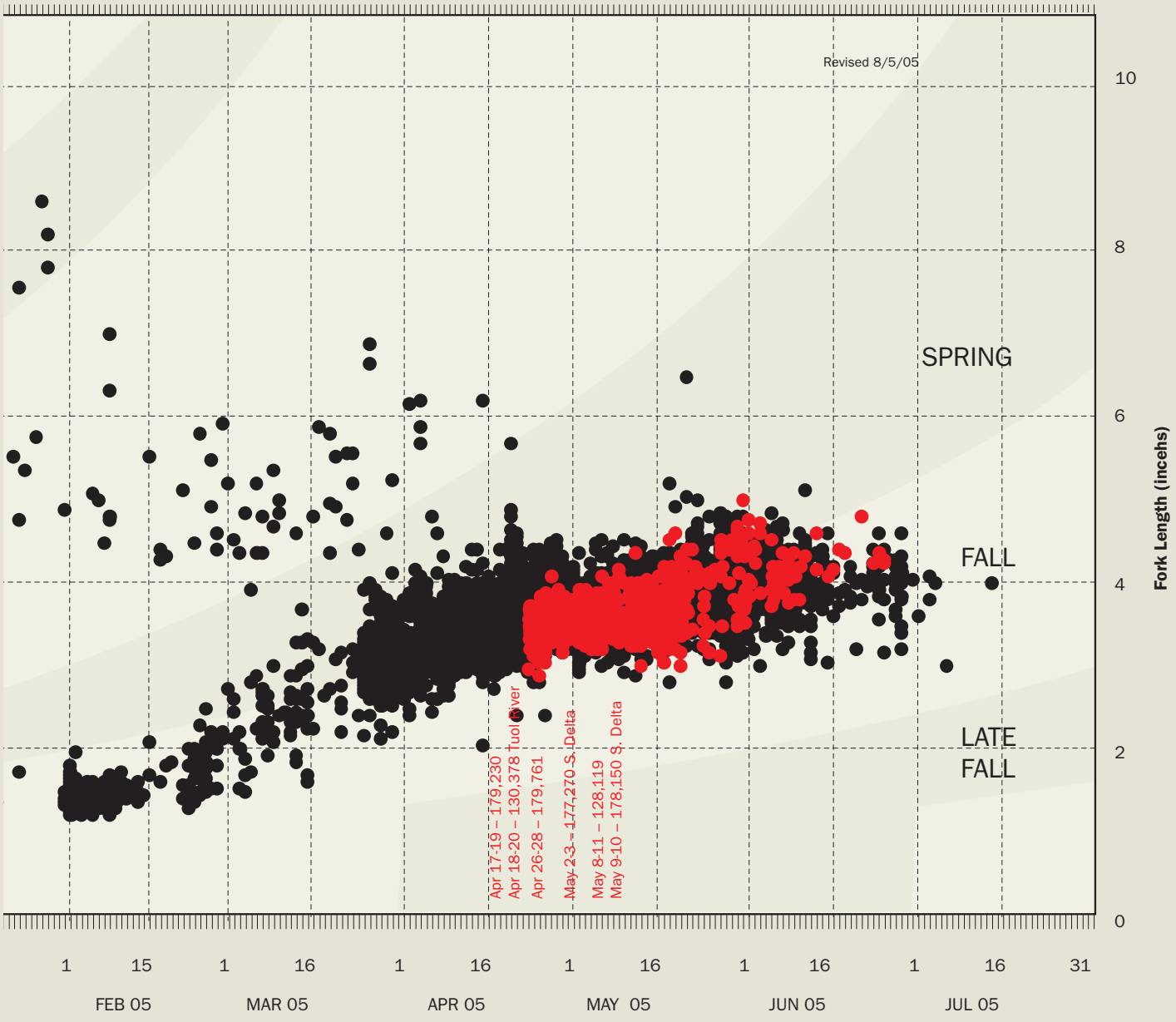


Figure 5-29
Observed Chinoook Salvate at SWP & CVP
Delta Fish Facilities 8/1/04 Through 7/31/05




Revised 8/5/05
SPRING
FALL
LATE
FALL
Apr 17-19 – 179,230
Apr 18-20 – 130,378 Tuolumne River
Apr 26-28 – 179,761
May 2-3 – 177,270 S. Delta
May 8-11 – 128,119
May 9-10 – 178,150 S. Delta
Fork Length (inches)
0
2
4
6
8
10
1
15
1
16
1
16
1
16
1
16
1
16
31
FEB 05
MAR 05
APR 05
MAY 05
JUN 05
JUL 05