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and                         )              Project No. 2299  
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2006 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2006-6

Coded-wire Tag Summary Update

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## **EXECUTIVE SUMMARY**

Releases of coded-wire-tagged (CWT) fall-run Chinook salmon originating from the San Joaquin Basin, primarily from the Merced River Hatchery, have been made in the San Joaquin River and tributaries since 1978. Beginning in 1986, CWT hatchery smolt releases have been made in mid-April to early-May of most years to study survival of smolts released at various river flows and in various river reaches.

This report, an update of FERC Reports 1996-13 and 2005-6, summarizes the available recovery data for the 2000-2005 basin release groups. The principal focus of this report is the Tuolumne River CWT smolt survival studies, which began in 1986 and ended in 2002 under the Don Pedro Project FERC fish study program - another CWT smolt survival study was done by DFG in the Tuolumne River in 2005. Relative survival indices for upper and lower Tuolumne release groups are calculated for juvenile and adult recovery locations from various sampling programs. Expanded recoveries at the state and federal export fish salvage facilities were combined for one estimate, as were the recoveries at the Antioch and Chipps Island trawls. Updated adult survival indices for expanded ocean harvest for 2000, 2001 and 2002 releases were 0.55, 0.24 and 1.90, respectively, based on 2006 ocean harvest data. Escapement survival indices for 2000, 2001 and 2002 releases were 0.53, 0.15 and 0.41, respectively, based on returning spawners through the 2005 run. These adult indices indicate moderate survival for the 2000 study, low survival for the 2001 study, and a wide range of values for the 2002 study. Juvenile survival indices for the 2005 releases, initially made at a La Grange flow of 4,000 cfs, ranged from .49 to 1.54 for recoveries made at the delta export fish salvage operations, the Mossdale trawl, and at the Antioch and Chipps Island trawls.

The review of survival estimates from 1986-2005 Tuolumne study releases from various juvenile and adult recovery sources found, in general, that the survival indices are variable, but trend from relatively low survival with low flows (<700 cfs) to relatively high survival with flood flows (>4,000 cfs); results with medium flows (1,300-3,000 cfs) ranged from low to high, but with a majority of indices in an intermediate range of 0.35-0.75. Some recommendations for further data analyses are included.

CWT releases in the Merced, Stanislaus, and San Joaquin rivers that originated from the Merced River Hatchery are summarized in Table 1 for the 2000-2006 period.

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# CODED-WIRE TAG SUMMARY UPDATE

## 1. INTRODUCTION

This report summarizes data on coded-wire tagged (CWT) hatchery salmon reared by the California Department of Fish and Game (CDFG) at the Merced River Hatchery (MRH) or other San Joaquin basin facilities. Specific focus here is on the results of large Tuolumne River smolt survival study releases. Included are updated release and recovery data for all tag codes used in the basin since 2000 as part of the Turlock and Modesto Irrigation Districts (TID/MID) FERC study program.

This report updates Report 1996-13 (TID/MID 1997), which included data available through 1996, and Report 2005-6 (TID/MID 2006), which included data available through 2005. The Stanislaus and Merced data review represents an update of FERC Report 2003-3, Appendix A.

Springtime CWT smolt releases of MRH salmon in the San Joaquin system began in 1986 (brood year 1985) under the Don Pedro Fish Study Program. Since 1998, some CWT salmon were also pan-jet marked and released in smaller groups, often over extended periods and at various locations. Prior to 1999, CDFG conducted the tagging and releases of hatchery Chinook salmon. Starting in 1999, a private contractor has conducted most of the tagging operation at the MRH. For these studies, a CWT is inserted into the snout of each juvenile salmon and the tags are coded by group, usually in lots of about 25,000 tags. The code allows for later determination of the group release date and release location for recovered fish. The tagged fish also have the adipose fin removed to provide an external mark to enable identification of fish containing tags during various sampling efforts. Large CWT releases often include more than one tag code. For most years, an estimate is available of the tag loss, or shed rate and mortality through release, so that an effective release number is provided by CDFG.

Tag recoveries are made from (1) sacrificed adipose-clipped juvenile salmon captured at several inland monitoring locations and (2) heads of adult tagged fish retained from port landings, hatcheries, and carcasses found in spawning run surveys. The tags are dissected from the specimens and decoded by CDFG or the U.S. Fish and Wildlife Service (USFWS). Analyses of the decoded data enable estimates of relative and absolute survival indices and the contribution of the tagged fish to the commercial/sport ocean catch and to spawning runs. The CWT smolt survival index studies were primarily intended to examine relative survival rates of hatchery smolts in specific river reaches at various flows within the San Joaquin River (SJR) system and Sacramento-San Joaquin delta.

The Tuolumne River evaluations of 1996-2002 were conducted for the Tuolumne River Technical Advisory Committee (TRTAC) pursuant to the 1995 Don Pedro Project FERC Settlement Agreement. More data details and discussion of study assumptions and implementation are contained in Baker and Speed (1998), Neillands and Loudermilk (1998), the TRTAC peer review process of December 1998 (Centers for Water and Wildland Resources 1998), and TID/MID Report 2004-7 which is a detailed review of the results of large Tuolumne River CWT study releases based on Mossdale trawl recovery data in the 1987-2002 period.

An independent CWT paired smolt release was made by CDFG in the Tuolumne River in 2005 and results comparing daily screw trap and Mossdale trawl captures are presented.

Flow is considered in these tests as a surrogate for all other factors that may affect survival, such as predator populations, predation rates, food availability, temperature, turbidity, pumping or diversion effects, pollution, etc. These factors, which can vary from year to year, and independently from flow, are often unknown (other than temperature or turbidity), further complicating the specific applicability of the study results as they might relate to flow. Major changes in habitat conditions over time resulting from floods, restoration projects, etc. may further lead to differences. Study design also depends on the comparability of the release groups in a number of factors, such as size, smoltification status, disease, and migration timing, which can also vary from year to year.

A key assumption of using CWT hatchery smolts as surrogates for naturally produced salmon has not been well evaluated, such that the results of these tests may not necessarily be applicable to naturally produced salmon. It is also not understood what effects the large number of hatchery salmon may have on naturally produced smolts occupying the same rearing and migratory environment and dependent on the same food resources. Another concern about the use of large numbers of hatchery smolts is that, unlike other monitoring, there are real, and potentially negative, population, genetic, and fitness effects as a direct result because hatchery salmon can return to spawn in the rivers.

Overall, the results have been variable and the method may inherently not be suited to detect major differences over the smaller flow range of “non-flood” releases for the reasons stated above, at least for tributary evaluations.

## 2. METHODS

### 2.1 Data Summary Format

Each CWT release group was catalogued by tag code(s) and recoveries were summarized by code and release group. Inland recoveries of juvenile salmon and ocean and inland adult salmon were made at various locations (Table 1). Data were grouped by year and location for the Merced, Tuolumne, Stanislaus, and the lower San Joaquin Rivers (SJR). Juvenile recovery locations include a trawl near Mossdale on the San Joaquin River, the state (SWP) and federal (CVP) fish salvage operations at the two largest delta water export facilities, the USFWS Chippis Island trawl, and the Jersey Point or Antioch trawl operations by Hanson Environmental, Inc. (1997-2005). In addition to these recovery sites, a pushnet was used one year (1987) in the SJR below the Tuolumne confluence and screw traps has been used at Shiloh Road or Grayson River Ranch in the Tuolumne River from 1995-2006 (Figure 1). Survival indices from pushnet and screw traps are presented, but not used in the survival analyses, as that sampling does not meet study criteria in the few years available. CWT recoveries at screw traps in the Stanislaus and Merced Rivers are not included in this report.

Adult recovery data are from the commercial and sport ocean harvest at various ports. Ocean

harvest data were obtained from Pacific States Marine Fisheries Commission (2007) and includes preliminary 2006 data from CDFG, Oregon Department of Fish and Wildlife (ODFW) and other agencies. Inland recoveries of CWT spawners are from escapement surveys and hatchery return data from CDFG (1986-2005) and are limited to the San Joaquin tributaries and other northern CA hatcheries (2001-2002). Adult recoveries are presented by age group and inland recoveries listed by river. The inland adult recovery data for 2002 is incomplete for that cohort. The juvenile recovery data is from CDFG (Region 4, Fresno) and USFWS (Bay-Delta Office, Stockton).

## 2.2 Data Analysis

Salmon recovery data were analyzed by comparing recovery numbers of release groups for each recovery location. The release locations were chosen to compare the relative survival of salmon in various reaches of the river system. Upstream and downstream release locations in the San Joaquin tributaries were intended to identify relative survival differences between release sites under certain flow conditions. The San Joaquin River release locations were chosen to provide survival differences of salmon within reaches of that river and in migration routes through the delta.

A survival index of 1.0 indicates no difference in survival of the two groups. Survival index values substantially greater than one may indicate problems of two types: 1) that there is a significant difference between the two release groups, such as disease, stress, behavioral, or physiological factors, and/or 2) the likelihood of recovery from each group differed due to sampling effort, timing, migration rates, or other factors. Survival indices of less than 1.0 may have similar problems that are not readily evident and require careful review to see if study assumptions are met. For example, if fish of either group migrate at different rates or after flows have changed, then data comparability may be compromised. Low recovery numbers also lead to more variable results. The ocean harvest data may represent the most reliable recovery data due to the number of tag recoveries and the extended recovery period, assuming that other study criteria are met. Sampling close to the lower release group can result in greater potential for differential capture probability and spurious data - this problem may occur at Mossdale in some years.

Relative survival index values were calculated for the Tuolumne River releases made in 1986, 1987, 1990, 1994-2002, and 2005 (Table 2). Expanded recoveries that account for sampling effort were used for SWP, CVP, and ocean harvest indices in the analysis. Actual recoveries were used for the Tuolumne River screw trap, and adult inland spawner indices. Mossdale trawl indices are shown for unadjusted and adjusted values (1986 had no trawl at Mossdale). The survival index values were calculated by dividing the number of recoveries from the upper release group by the lower release group, adjusting to account for different numbers in the release groups. Adult recoveries are (1) expanded estimates for fish recovered from the ocean harvest port surveys, and (2) actual carcasses found during basin spawning surveys or hatchery returns; both consist of 1+ to 5- year old salmon. Indices were also calculated for combined recoveries at the delta pump salvage facilities (SWP & CVP) and combined recoveries at the Antioch and Chipp's trawls.

The original analysis of survival indices was plotted against release flow at La Grange at the time of the upper releases. Because there has often been extended migration and recapture periods, the target release flow did not necessarily represent the flow conditions entirely experienced by the study fish. As a result of the TRTAC review, it was decided to also use an adjusted flow at La Grange (accounting for variable rearing/migration time to Mossdale) that was weighted by the daily recaptures at the Mossdale trawl as a better estimate of the flow conditions encountered by the CWT smolts. Another adjustment was made to the Mossdale trawl survival indices to account for varying daily capture effort (time that trawling was in operation) over the recovery period. Indices for recoveries made at pump salvage facilities, Chipps Island and Antioch/Jersey Point trawls, and ocean harvest are also based on expanded values that are weighted for sample effort. The TRTAC review of Mossdale recovery data concluded that 1990, 1994, and 1997 Tuolumne CWT survival studies should be considered invalid due to failure to meet key study assumptions. For 2002, only the first release group at the lower site was used to calculate the Mossdale estimate as the 2 groups were released 3 days apart and the 2<sup>nd</sup> group had anomalous recoveries.

The 2005 study releases made at 4,000 cfs have not yet been reviewed in a similar way, but comparative screw trap and Mossdale recapture data is presented here - the daily catch of CWT's in the Grayson screw traps for the La Grange release and the daily catch of CWT's in the Mossdale trawl for both the upper and lower Tuolumne release groups.

### **3. RESULTS AND DISCUSSION**

#### **3.1 Updated Survival Index Results for Tuolumne River CWT Smolt Releases 2000, 2001, 2002 Adult Survival Indices and 2005 Juvenile Survival Indices**

Updated ocean harvest survival indices for 2000, 2001, and 2002 CWT smolt releases were 0.55, 0.24, and 1.90 based on preliminary 2006 expanded ocean harvest data (Table 2). Escapement survival indices for the 2000, 2001, and 2002 releases were 0.53, 0.15, and 0.41 respectively based on data through the 2005 run. Survival indices for adult spawner recoveries of 2002 smolt releases are incomplete at this time.

Juvenile survival indices for recoveries of 2005 CWT smolt releases were .60 for Mossdale recoveries, .60 for combined expanded SWP and CVP recoveries, and 1.25 for combined Antioch and Chipps Island trawl recoveries.

#### **3.2 Survival Indices and Tuolumne Flow Analysis**

There have been a total of 13 paired Tuolumne CWT releases and 10 have been considered valid to date. The release group numbers have ranged from about 50,000-100,000 and all releases were made within mid-APR to early MAY. Figure 2 represents unrefined results that include all years and indices for all recovery sources plotted against unadjusted release flow at La Grange. Figure 3 has the refined results using adjusted Mossdale trawl recoveries, combined recoveries at the

SWP and CVP salvage facilities, combined recoveries at the Antioch and Chipps Island trawls, and adult ocean and spawner recoveries, excluding those years determined to be invalid (1990, 1994, 1997 – FERC Report 2002-4), and plotted with unadjusted release flow at La Grange - the power trendline  $R^2$  value is 0.501. Figure 4 has the same indices, plotted with adjusted La Grange flows (no adjustment for the 1986 and 2005 release flows) -the power trendline  $R^2$  value is similar at 0.478. Tables 3 and 4 have the values used for Figures 3 and 4.

The Figure 4 survival results can be considered in the following general adjusted La Grange flow categories:

#### **Low Flows (500-700 cfs)**

There are two valid years in this category (1990 was excluded). Survival indices for 1987 and 2001 at 560-640 cfs show relatively low survival results. All the results were within 0.15-0.34; the 1987 juvenile survival indices ranged from .28 to .35 and both adult indices were 0.29; the 2001 juvenile survival indices ranged from 0.21 to 0.34 and the adult survival indices were 0.15 and 0.24.

#### **Medium Flows (1,300–3,000 cfs flow)**

There are four valid years in this category (1994 and 1997 were excluded). Juvenile survival indices for 1996, 1999, 2000, and 2002 had highly variable results, ranging from 0.32-1.32. The adult survival indices were relatively higher, ranging from 0.41-1.90.. Interestingly, the higher values were at the lower flows in the range.

#### **High Flows (4,000+ cfs flow)**

There are four years in this category with the CWT releases being made when high flood management flows occurred. Juvenile survival indices for 1986, 1995, 1998, and 2005 ranged from 0.60 to 1.77 and adult indices ranged from 0.70 to 1.90. These indices indicate relatively high survival with flood management flows, but again with variable results.

In general, the survival indices are quite variable, but trend toward higher survival (all indices >0.60) in the four years with high flood release flow conditions (4,000+ cfs as adjusted flow); results at low flows (500-700 cfs) had all values less than 0.35. In some cases the indices exceed 1.0 and/or are based on few recoveries.

### **3.3 Daily CWT catch at the Grayson screw traps and Mossdale trawl in 2005**

Daily CWT recoveries of La Grange releases at the Grayson screw traps and Mossdale trawl were plotted against La Grange flow (Figure 5) for 2005. Both recovery locations had prolonged CWT captures from 20Apr to 31May, typical of previous high flow CWT migration timing. The Grayson traps showed a peak in catch immediately after the upper CWT release date while the Mossdale trawl had two peaks from that group, the first in the initial post-release period and the second around 21May following a La Grange flow increase. Mossdale trawl recoveries of the lower Tuolumne CWT releases, made at Old Fishermen's Club on the San Joaquin River, were

made from 21Apr to 15May (Figure 6). The initial peak of CWT capture was followed by a second peak around 01May and the duration of captures from the lower release group was 2 weeks shorter than the La Grange releases.

### **3.4 Other Data in Table 1**

Table 1 includes CWT recovery data from: (1) Merced River smolt releases made between 2000-2006, (2) Stanislaus River smolt releases made in 2000-2006, (3) Lower San Joaquin River/Delta smolt releases made in 2000-2006 which originated from the Merced Hatchery. Data for earlier years were in FERC Reports 1998-5 and 2004-8.

### **3.5 Merced and Stanislaus River smolt survival estimates**

Relative survival indices were calculated for paired CWT releases made in the Merced and Stanislaus Rivers utilizing the same initial analytical methods presented for the Tuolumne releases (Tables 5 & 6). These results have not been subjected to a refinement review similar to that by the TRTAC for the Tuolumne releases.

#### **Merced**

Merced River CWT releases have been made every year since 1994 and were composed of 1 to 3 paired release groups in a given year. There have been 26 study releases during 1994-2006, with 1-3 tests per year and release group numbers have ranged from about 45,000-110,000. The releases have been in a flow range below Crocker-Huffman Dam (as measured at Cressey) of about 200-4,200 cfs, releases have been made in APR through mid-MAY, and release locations have been fairly consistent. The 1994 and early 1997 tests appear to have problems with the lower release groups matching the timing of pulse flows, similar to some Tuolumne releases, so these are excluded, leaving a total of 24 tests.

Figure 7 includes all years and indices for Merced River smolt survival studies (except 1994 and 1997-1) for the Mossdale trawl, combined recoveries at the delta salvage facilities, combined recoveries at the Antioch and Chipps Island trawls, ocean harvest, and spawner recoveries plotted against unadjusted release flow at Cressey (RM 27.7). The overall results again are variable and over about half the Tuolumne flow range. All survival ratios were 0.4-1.4 at flows above 2,300 cfs; results at lower flows (200-1500 cfs) had some values less than 0.1, but tended to also range up to about 0.8, with a few higher results that in some cases exceed 1.0. The polynomial trendline  $R^2$  value is only 0.23.

#### **Stanislaus**

Stanislaus River CWT releases have been made 9 times during 1986-2006. Releases in three years were made after 15MAY (1999, 2000, 2001) and release group numbers have ranged from about 25,000-100,000. These tests have been at a limited flow range below Goodwin Dam of 600-1500 cfs, with the exception of 5,260 cfs in 2006.

Figure 8 includes all years and indices for Stanislaus River smolt survival studies similar to the

Merced analysis. Survival indices to date appear unrelated to flow and also have a wide range of values.

### **3.6 Recommendations**

Complete adult recovery data through the run of 2010 from releases in 2006 will conclude the data resulting from basin study releases made through 2006. Continuing tributary CWT survival tests is questionable unless further insights are developed; a more complete assessment is needed of existing data for the Merced, Stanislaus, and San Joaquin Rivers.

Recommendations for further Tuolumne analyses are:

- Daily recovery data from delta sampling sites other than Mossdale could be reviewed to examine the timing pattern of recoveries
- Review absolute (not relative) survival to examine between year differences for survival to various recovery locations, accounting for sampling effort
- Consider if adjustment for the difference in distance between release groups is warranted, since the downstream release locations have varied over 15.5 river miles.
- Consider use of multivariate methods to analyze the indices and determine confidence intervals as has been done for VAMP releases. Further grouping of recovery data or other data treatment could be considered.
- Link existing within-Tuolumne indices to other CWT data in the San Joaquin River and Delta for those years to examine potential combined downstream survival in the inland reach down to Jersey Point in the western Delta.
- Continue comparison of Tuolumne results to those of other San Joaquin tributaries, the San Joaquin River, and the delta.

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Table 1. Tuolumne River CWT (2000-2005)

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Table 1. Merced River CWT (2000-2006)

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Table 1. Stanislaus River CWT (2000-2006)

Table 1. Stanislaus River CWT (2000-2006)

STANISLAUS RIVER		INLAND TOTAL BY RIVER Age 2 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.						INLAND TOTAL BY RIVER Age 3 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.						INLAND TOTAL BY RIVER Age 4 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.						INLAND TOTAL BY RIVER Age 5 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.					
BY 99	06-44-07													1											
	06-44-08																								
	06-44-09													1											
	06-44-10													2						1					
	06-44-11													2						1					
TOTAL	UPPER																								
	LOWER																								
BY00	0601110804																			0					
	0601110805																			0					
	0601110715																			1					
TOTAL	UPPER																								
	LOWER																								
BY01	06-44-46													1						0					
	06-44-47													1						0					
	06-44-48							1						1						0					
														0						0					
TOTAL	UPPER													1											
	LOWER							1																	
BY 02	06-45-67							1						0											
	06-45-68							1						0											
	06-45-69							1						0						2					
	06-45-70							0						0						1					
	06-45-71							0						0						0					
TOTAL	UPPER																								
	LOWER							1																	
BY05	06-47-17																								
	06-47-18																								
	06-47-19																								
	06-47-20																								
TOTAL	UPPER																								
	LOWER							1																	





Table 1. San Joaquin River CWT (2000-2006)

Table 1. San Joaquin River CWT (2000-2006)

SAN JOAQUIN RIVER	INLAND TOTAL BY RIVER Age 2 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.	INLAND TOTAL BY RIVER Age 3 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.	INLAND TOTAL BY RIVER Age 4 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.	INLAND TOTAL BY RIVER Age 5 SAC. BATT. FEATH. AMER. MOK. STAN. TUOL. MER.
BY02	06-02-82 06-02-83 06-27-42 06-27-48 06-27-43 06-27-44	1 1 2 1 1 4 19	1 1 2 1 2 7	1 1 1 11
TOTAL				
TOTAL				
TOTAL				
BY02	06-27-45 06-27-46 06-27-47 06-27-49 06-27-50 06-27-51	1 1 1 1 2 15	1 1 1 1 1 1	1 1 1 13
TOTAL				
TOTAL				
TOTAL				
BY03	06-27-52 06-27-53 06-27-54 06-27-55 06-46-70 06-45-82 06-45-83 06-45-80	1 2		
TOTAL				
TOTAL				
TOTAL				
BY04	06-46-72 06-46-73 06-46-74 06-46-75 06-46-97 06-46-98 06-45-91 06-45-88			
TOTAL				
TOTAL				
TOTAL				
BY04	06-45-84 06-45-85 06-45-86 06-45-87 06-45-89 06-45-90 06-46-99 06-47-00			
TOTAL				
TOTAL				
TOTAL				
BY05	06-47-13 06-47-14 06-47-16 06-47-15			
TOTAL				
TOTAL				
TOTAL				
BY05	06-47-21 06-47-22 06-47-24			
TOTAL				
TOTAL				
TOTAL				

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

Tuolumne River		RELEASE YEAR	EFFECT. TAG NO.	RELEASE DATE	AVG. FL (mm)	RIVER SITE	RELEASE DATE	SMOLT RECOVERIES										OCEAN		
								PUSHNET/ RS TRAP	MOSS- DALE	SWP PUMPS	EXPAND. SWP	CVP PUMPS	EXPAND. CVP	JERSEY PT. (ANTIOCH)	JERSEY(ANT) SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	CATCH	SPAWN EXPD.
1986	06-46-54	49,630	OLGB	14APR86	-	-	131		183		-	-	-	16		226	976	60		
	06-46-55	49,518		14APR86	-	-	135		205		-	-	-	18		210	929	58		
	6600 cfs	51,300	MAPES	14APR86	-	-	159		255		-	-	-	10		219	969	54		
	w/o HORB	52,174		14APR86	-	-	155		238		-	-	-	10		231	1037	50		
	TOTAL	UPPER	99,148	81	51	OLGB	RM diff. = 50	-	266	6573	388	3312	-	-	34	0.40	436	1905	118	
	TOTAL	LOWER	103,474	80	51	MAPES		-	314	7351	493	3465	-	-	20	0.27	450	2006	104	
1987	06-46-60	29,953	OLGB	16APR87	97	47	20		44		-	-	-	2		10	32	2		
	06-46-61	30,609		16APR87	137	47	23		48		-	-	-	0		6	37	1		
	LG FLOW:	29,037	OLGB	16APR87	120	34	22		46		-	-	-	3		7	31	5		
	560 cfs	30,703		RDP	16APR87	374	109	184		71		-	-	4		25	142	12		
	w/o HORB	31,869	RDP	16APR87	339	91	213		62		-	-	-	5		25	141	8		
	06-45-02	30,937		16APR87	353	117	204		79		-	-	-	8		23	82	9		
	TOTAL	UPPER	89,599	85	55	OLGB	RM diff. = 38	354	128	65	593	138	1648	-	-	5	0.05	23	100	8
	TOTAL	LOWER	93,509	82	64	RDP		1066	317	601	5685	212	2569	-	-	17	0.18	73	365	29
1990	H601110201	23,494	OLGB	30APR90	-	19	40		23		-	-	-	1		0	0	0		
	H601110202	21,766		30APR90	-	12	27		11		-	-	-	1		0	0	0		
	LG FLOW:	H60111014	OLGB	30APR90	-	21	45		25		-	-	-	1		2	12	0		
	600 cfs	H60111015		30APR90	-	11	34		18		-	-	-	1		1	5	0		
	w/o HORB	H601110203	MAPES	01MAY90	-	47	29		26		-	-	-	1		1	1	0		
	H601110204	26,067		01MAY90	-	47	21		21		-	-	-	0		1	17	0		
	H601110205	24,905		01MAY90	-	75	2		27		-	-	-	0		0	0	0		
	TOTAL	UPPER	93,653	83	52	OLGB	RM diff. = 50	-	63	146	878	77	440	-	-	4	0.04	3	17	0
	TOTAL	LOWER	78,235	72	66	MAPES		-	169	52	463	74	316	-	-	1	0.01	2	18	0
1994	0601110302	27,803	OLGB	23APR94	-	85	2	7	1	12	-	-	-	2		24	86	39		
	LG FLOW:	0601110303		23APR94	-	62	2	40	1	12	-	-	-	1		23	86	44		
	1200 cfs	0601110304	OLGB	23APR94	-	60	2	4	0	0	-	-	-	0		24	81	31		
	w/ HORB	0601110305		MAPES	24APR94	-	47	0	0	3	48	-	-	1		28	110	46		
	0601110306	25,029		MAPES	24APR94	-	25	2	14	2	24	-	-	1		15	43	27		
	TOTAL	UPPER	83,408	85	51	OLGB	RM diff. = 50	-	207	6	51	2	24	-	-	3	0.03	71	253	114
	TOTAL	LOWER	50,058	82	62	MAPES		-	72	2	14	5	72	-	-	2	0.04	43	153	73
1995	H61110311	29,989	OLGB	04MAY95	-	22	28	474	48	510	-	-	-	8		87	290	50		
	LG FLOW:	H61110312		04MAY95	-	16	13	177	43	461	-	-	-	5		96	337	59		
	7700 cfs	H61110313	OLGB	04MAY95	-	20	17	277	55	572	-	-	-	8		108	373	54		
	w/o HORB	H61110314		SERVICE	05MAY95	-	23	19	236	57	607	-	-	5		91	315	67		
	H61110315	27,770		SERVICE	05MAY95	-	23	19	203	67	707	-	-	7		96	310	82		
	TOTAL	UPPER	83,549	86	48	OLGB	RM diff. = 41.5	11	58	58	928	146	1543	-	-	21	0.25	291	1000	163
	TOTAL	LOWER	53,298	89	51	SERV.RD		11	46	38	439	124	1314	-	-	12	0.22	187	625	149
1996	H61110506	21,501	OLGB	26APR96	-	25	2	18	14	192	-	-	-	0		1	3	2		
	LG FLOW:	H61110507		26APR96	-	16	2	8	7	84	-	-	-	2		2	9	2		
	2600 cfs	H61110508	OLGB	26APR96	-	23	4	24	11	132	-	-	-	1		3	8	5		
	w/ HORB	H61110509		SERVICE	27APR96	-	67	2	24	13	180	-	-	1		3	10	4		
	H61110510	27,745		SERVICE	27APR96	-	89	2	0	17	240	-	-	3		4	13	5		
	TOTAL	UPPER	67,155	88	49	OLGB	RM diff. = 41.5	222	64	8	50	32	408	-	-	3	0.04	6	20	9
	TOTAL	LOWER	50,460	90	57	SERVICE		133	156	4	24	30	420	-	-	4	0.07	7	23	9
1997	H61110607	35,004	OLGB	22APR97	4	8	1	12	7	84	1		-	1		3	6	18		
	H61110608	33,695		22APR97	5	12	3	16	16	204	2		-	0		7	29	11		
	LG FLOW:	H61110609	OLGB	22APR97	4	10	1	8	8	96	3		-	1		8	30	7		
	2800 cfs	H61110610		OLGB	22APR97	0	2	0	0	1	12	0		-	1		1	3	2	
	w/ HORB	H61110604	SERVICE	23APR97	52	14	4	28	4	48	19		-	6		25	83	55		
	H61110605	32,297		SERVICE	23APR97	66	22	3	14	6	72	13		-	2		21	84	46	
	H61110606	27,075		SERVICE	23APR97	43	20	2	6	7	84	7		-	4		11	46	26	
	TOTAL	UPPER	93,501	71	48	OLGB	RM diff. = 41.5	13	32	5	36	32	396	6	0.01	3	0.04	19	68	38
	TOTAL	LOWER	72,464	75	56	SERVICE		161	56	9	48	17	204	39	0.11	12	0.17	57	213	127

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

Tuolumne River																				
RELEASE YEAR	TAG NO.	EFFECT. RELEASE	AVG. FL (mm)	RIVER SITE	RELEASE DATE	SMOLT RECOVERIES										OCEAN				
						PUSHNET/ RS TRAP	MOSS- DALE	SWP PUMPS	EXPAND. SWP	CVP PUMPS	EXPAND. CVP	JERSEY PT. (ANTIOCH)	JERSEY(ANT) SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	CATCH	SPAWN EXPD.		
LG FLOW: 6400 cfs w/o HORB	1998	61110703	32787	OLGB	15APR98	51	1	6	26	284	26	0.14	25	0.42	31	94	22			
		61110704	26633	OLGB	15APR98	40	0	0	22	280	4	0.03	5	0.09	24	75	21			
		61110705	27404	OLGB	15APR98	30	1	6	25	312	8	0.05	19	0.36	32	104	27			
		61110706	7234	OLGB	15APR98	9	2	22	7	84	0	0.00	2	0.13	14	45	8			
		61110707	25754	OFC(SJR)	16APR98	34	0	0	17	212	13	0.09	17	0.35	12	44	10			
		61110708	22006	OFC(SJR)	17APR98	30	0	0	18	220	5	0.05	19	0.45	11	41	14			
	TOTAL	UPPER	94058	83	51	OLGB	RM diff.	130	4	34	80	960	38	0.05	51	0.25	101	318	78	
	TOTAL	LOWER	47760	86	59	OFC(SJR)	= 53.5	64	0	0	35	432	18	0.07	36	0.40	23	85	24	
LG FLOW: 2000 cfs w/o HORB	1999	06-46-01	25534	OLGB	17APR99	10	56	355	41	339	6	0.05	3	0.07	23	84	26			
		06-46-02	25679	OLGB	18APR99	17	67	475	58	542	6	0.05	2	0.05	28	91	36			
		06-46-03	25008	OLGB	19APR99	18	61	390	62	538	3	0.03	2	0.05	29	88	35			
		06-46-04	25121	OFC(SJR)	18APR99	49	78	426	83	883	11	0.10	11	0.27	30	92	49			
		06-46-05	25836	OFC(SJR)	19APR99	115	94	559	52	466	15	0.12	9	0.21	31	93	43			
	TOTAL	UPPER	76221	86	OLGB	RM diff.	202	45	184	1220	161	1419	15	0.04	7	0.06	80	263	97	
	TOTAL	LOWER	50957	85	OFC(SJR)	= 53.5	164	172	985	135	1349	26	0.11	20	0.24	61	185	92		
LG FLOW: 3800 cfs w/ HORB	2000	06-45-56	23603	OLGB	13APR00	17	13	59	1	12	5	0.05	6	0.13	23	72	38			
		06-45-57	22096	OLGB	15APR00	15	4	22	2	24	2	0.02	1	0.02	24	81	28			
		06-45-58	26975	OLGB	15APR00	8	10	59	0	0	3	0.03	5	0.11	22	68	31			
		06-45-59	23071	OFC(SJR)	16APR00	33	27	116	1	12	12	0.12	4	0.09	44	141	53			
		06-45-60	21698	OFC(SJR)	14APR00	49	20	95	1	12	10	0.10	5	0.12	35	106	60			
	TOTAL	UPPER	72674	74	OLGB	RM diff.	241	40	27	140	3	36	10	0.03	12	0.09	69	221	97	
	TOTAL	LOWER	44769	74	OFC(SJR)	= 53.5	82	47	211	2	24	22	0.11	9	0.10	79	247	113		
LG FLOW: 620 cfs w/ HORB	2001	06-44-12	24600	OLGB	22APR01	38	0	0	0	0	2	0.02	2	0.04	2	7	7			
		06-44-13	22758	OLGB	22APR01	40	0	0	1	12	6	0.05	2	0.04	4	23	3			
		06-44-14	21527	OLGB	22APR01	32	0	0	0	0	10	0.09	4	0.09	5	15	4			
		06-44-43	22051	OFC(SJR)	28APR01	165	0	0	0	0	35	0.30	13	0.28	17	58	33			
		06-44-44	24393	OFC(SJR)	26APR01	262	2	12	1	12	25	0.19	12	0.23	18	66	28			
	TOTAL	UPPER	68885	82	52	OLGB	RM diff.	109	110	0	1	12	18	0.05	8	0.06	11	45	14	
	TOTAL	LOWER	46444	84	68	OFC(SJR)	= 53.5	427	2	12	1	12	60	0.25	25	0.26	35	124	61	
LG FLOW: 1300 cfs w/ HORB	2002	06-44-06	24976	OLGB	24APR02	65	2	12	1	12	3	0.020	1	0.020	10	33	1			
		06-44-67	24813	OLGB	24APR02	63	2	12	0	0	5	0.037	7	0.141	5	18	2			
		06-44-68	25220	OLGB	24APR02	51	2	18	1	12	3	0.023	0	--	6	21	2			
		06-44-61	25701	OFC(SJR)	26APR02	116	1	6	0	0	1	0.007	6	0.111	4	14	2			
		06-44-69	23870	OFC(SJR)	29APR02	25	2	15	1	12	2	0.015	3	0.063	3	11	6			
	TOTAL	UPPER	75009	86	54	OLGB	RM diff.	1008	179	6	42	2	24	11	0.026	8	0.053	21	72	5
	TOTAL	LOWER	49571	86	62	OFC(SJR)	= 53.5	141	3	21	1	12	3	0.011	9	0.087	7	25	8	
TOTAL	05-51-36	75696	OLGB	18APR05	97	39	210	29	349	5	0.013	7	0.047	2	7					
	~4000 cfs	05-11-69	47376	OFC(SJR)	20APR05	101	29	141	37	444	2	0.008	4	0.038	1	3				
	TOTAL	UPPER	75696	OLGB	RM diff.	97	39	210	29	349	5	0.013	7	0.047	2	7				
	TOTAL	LOWER	47376	OFC(SJR)	= 53.5	101	29	141	37	444	2	0.008	4	0.038	1	3				

Notes:

- 1990 groups had different origin, rearing conditions, and sizes
- 1994 lower release occurred prior to pulse
- 1996 recoveries at Shiloh and Mossdale are considered to be invalid; also a high tag loss rate
- 1997 fish sizes were small; also a high tag loss rate
- River mile differences range from 38 to 53.5 miles
- 2002 Mossdale survival indices were calculated using tagcode 06-44-61 only, for the lower release group.

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

Table 3.  
Tuolumne River Smolt Survival Releases and Recoveries

Release Year	Effective Release	Release Site	Recovery Sites									Trawl Combined Antioch & Chipps
			Salvage Expanded Mossdale	Salvage Expanded SWP	Trawl Jersey Pt. (Antioch)	Trawl Chipps Island	Ocean Catch Expd.	Spawners	Salvage Combined SWP & CVP			
1986	99,148	OLGB	-	6573	3312	-	34	1905	118	9885		
	103,474	MAPES	-	7351	3465	-	20	2006	104	10816		
1987	89,599	OLGB	128	593	1648	-	5	100	8	2241		
	93,509	RDP	317	5685	2569	-	17	365	29	8254		
1995	83,549	OLGB	58	928	1543	-	21	1000	163	2471		
	53,298	SERV.RD	46	439	1314	-	12	625	149	1753		
1996	67,155	OLGB	64	50	408	-	3	20	9	458		
	50,460	SERVICE	156	24	420	-	4	23	9	444		
1998	94,058	OLGB	130	34	960	38	51	318	78	994	89	
	47,760	OFC(SJR)	64	0	432	18	36	85	24	432	54	
1999	76,221	OLGB	45	1220	1419	15	7	263	97	2639	22	
	50,957	OFC(SJR)	164	985	1349	26	20	185	92	2334	46	
2000	72,674	OLGB	40	140	36	10	12	221	97	176	22	
	44,769	OFC(SJR)	82	211	24	22	9	247	113	235	31	
2001	68,885	OLGB	110	0	12	18	8	45	14	12	26	
	46,444	OFC(SJR)	427	12	12	60	25	124	61	24	85	
2002	75,009	OLGB	179	42	24	11	8	72	5	66	19	
	49,571	OFC(SJR)	141	21	12	3	9	25	8	33	12	
2005	75,696	OLGB	97	210	349	5	7	7		559	12	
	47,376	OFC(SJR)	101	141	444	2	4	3		585	6	

Table 4.

## Tuolumne Smolt Survival Indices -- excluding 1990, 1994, and 1997

2002 Mossdale using 1st lower group only; and for 1986, 87, 95 and 96 the combined trawl is for Chipps, only.

Release Year	LG Flow (cfs)	Adjusted LG Flow	Adjusted	Salvage	Salvage	Trawl	Trawl	"adult"	"adult"	Combined Trawl	Combined Salvage
			Moss-dale	SWP	CVP	Jersey Pt.	Chipp's	Ocean Catch	Spawn		
1986	6,600	6,600		0.93	1.00		1.77	0.99	1.18	1.77	0.95
1987	560	563	0.35	0.11	0.67		0.31	0.29	0.29	0.31	0.28
1995	7,700	8,217	0.82	1.35	0.75		1.12	1.02	0.70	1.12	0.90
1996	2,600	2,816	0.35	1.57	0.73		0.56	0.65	0.75	0.56	0.78
1998	6,400	4,050	1.17		1.13	1.07	0.72	1.90	1.65	0.84	1.17
1999	2,000	1,960	0.34	0.83	0.70	0.39	0.23	0.95	0.70	0.32	0.76
2000	3,800	2,982	0.50	0.41	0.92	0.28	0.82	0.55	0.53	0.44	0.46
2001	640	634	0.27		0.67	0.20	0.22	0.24	0.15	0.21	0.34
2002	1,300	1,300	0.53	1.32	1.32	2.42	0.59	1.90	0.41	1.05	1.32
2005	4,000	4,000	0.60	0.93	0.49	1.56	1.10			1.25	0.60

Table 5.

RELEASE YEAR	Merced Smolt Survival Index -- All Values (upper/lower) Excluding 1994 and 1997-1											Ant.&Chipp's		
	CRESSEY (cfs)	SNELLING (cfs)	MOSS- DALE	SWP PUMPS	SWP EXPD.	CVP PUMPS	CVP EXPD.	JERSEY POINT	J. PT. SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	SPAWN Comb.	Salvage Trawl Comb.
1994	554	952												
1995	3940	3880	0.58	0.75	1.00	0.81	0.81			0.75	0.75	0.81	1.06	0.86
1996	1210	1240	0.83	1.50	0.56	0.79	0.78			0.38	1.00	1.50	2.44	0.78
1997	1420	1580												0.38
1997	578	474	0.00	0.00	0.00	0.04	0.04			0.00	0.00	0.00	0.03	0.00
1998	3220	3030	1.02			0.72	0.72	0.97	1.00	1.16	1.35	1.25	1.32	0.72
1998	2390	2350	0.69	0.63	0.74	0.51	0.49	0.84	1.00	0.62	0.59	0.87	1.09	0.50
1999	1340	1300	0.70	0.82	0.82	0.37	0.33	0.34	0.36	0.37	0.35	0.48	0.61	0.48
1999	1320	1350	0.17	0.16	0.13	0.16	0.12			0.24	0.25	0.10	0.13	0.24
2000	295	304	0.22	0.30	0.29	0.72	0.72	0.43	0.45	0.95	0.94	0.25	0.48	0.31
2000	1750	1820	0.30	0.16	0.15	1.01	1.01	0.54	0.54	0.81	0.79	0.45	0.54	0.27
2001	1310	1220	0.32	0.17	0.17	0.00	0.00	0.31	0.32	0.17	0.17	0.53	0.76	0.12
2001	900	1170	0.34	0.00	0.00			0.50	0.52	0.46	0.36	0.15	0.52	0.00
2002	196	215	0.01	0.03	0.03	0.01	0.01	0.06	0.05	0.13	0.11	0.00	0.00	0.01
2002	439	479	0.18	0.00	0.00	0.00	0.00	0.09	0.09	0.00	0.00	0.21	0.19	0.00
2003	681	719	0.43	0.47	0.52	0.52	0.52	0.39	0.38	0.26	0.27	0.43	0.70	0.52
2003	519	555	0.36	0.00	0.00			0.77	1.00	0.00	0.00	1.28	0.10	1.53
2003	1490	1490	0.40					0.36	0.40	0.95	0.95	0.31	0.51	0.71
2004	486	776	0.16	0.00						0.00	0.00			0.50
2004	846	1040	0.12	0.00		0.00				0.49	0.47			0.49
2004	1500	1590	0.36	0.18		0.55				0.00	0.00			0.00
2005	2630	2610	0.52	1.06	0.82	0.94	0.94	0.00	0.00	0.72	0.56		0.92	0.62
2005	1780	1860	0.38	7.47	5.87	0.37	0.37	0.14	0.15	0.44	0.34		0.55	0.33
2005	1960	2140	0.15	1.40	1.40	0.40	0.40	0.00	0.00	1.21	1.20		0.77	0.61
2006	4170	4380		0.44	0.50	1.25	1.50	0.11	0.17	0.66	0.39		1.30	0.44
2006	4170	4240		0.64	1.28	0.43	0.49	0.00	0.00	0.85	1.05		0.53	0.64

**Table 6.**

Stanislaus River															
All data															
YEAR	SMOLT SURVIVAL INDEX (Upper / Lower corrected for release group number)														
	GDWN YEAR	VNS FLOW	PUSHNET FLOW	MOSS- RST	DALE PUMPS	SWP SWP	EXPD. PUMPS	CVP CVP	EXPD. SURV.	J. Pt. IS.	J. PT. SURV.	CHIPPS CATCH	CHIPPS OCEAN	SPAWN Comb Salvage	ANT&Chipps Trawl
1986	1100				0.47	0.50	1.37	0.77		0.61	0.61	0.68	0.46	0.59	0.61
1988	920	0.27	0.33	0.93	0.89	0.29	0.27			0.81	0.78	0.35	0.74	0.54	0.81
1989	820		0.39	0.53	0.59	0.86	0.81			0.29	0.29	0.41	0.64	0.63	0.29
1999	1260			0.00	0.00	1.41	1.41					1.01	1.18		
2000	1490	0.56	0.44	0.34	0.78	0.78				0.65	0.97	0.51	0.19	0.51	0.65
2001	600		1.98										0.00		
2002	740	0.41						1.03	1.05	2.05	2.09		0.51		1.28
2003	1520		1.28					0.34	0.36			1.35	3.38		0.51
2006	5620				1.03	1.96	0.00	0.00	0.24	0.24			2.09		0.19

2000 and 2003 flows adjusted for graphing  
2006 flow at Orange Blossom Br.







Table 8

Lower Merced release to Mossdale (paired groups)

Relative Survival Indices							
Lower MR to Lower TR (95, 96, 97 used the Service Rd release site)							
Year	Flow Nwmm	Flow VNS	Mossdale	Ocean Catch	Inland Adult	Comb. Salvage	Comb. Ant/Chipp
1995	13,500	22,500		1.48	0.68	1.22	0.59
1996	1,650	6,500		0.51	0.41	0.35	0.50
1997	1,200	6,000		0.95	0.77	0.94	0.53
1998	13,600	22,500		0.74	0.90	1.80	1.31
1999	2,200	6,900		0.43	1.23	1.10	0.98
2000(1)	1,400	6,300		1.02	0.82	0.73	1.10
2000(2)	1,900	5,600					0.75
2001	1,200	4,100		0.68	0.74	0.65	2.01
2002	1,000	3,400		0.72	0.42	0.70	0.77
2003(1)	1,000	3,200					
2003(2)	1,200	3,200					
2004	1,000	3,200					
2005(1)	2,700	7,200	1.33			0.63	0.77
2005(2)	3,100	9,700					
2006(1)	14,400	28,000					
2006(2)	12,300	24,700					
Lower MR to Lower Stan.							
Year	Flow Nwmm	Flow VNS	Mossdale	Ocean Catch	Inland Adult	Comb. Salvage	Comb. Ant/Chipp
1995		22,500					
1996		6,500					
1997		6,000					
1998		22,500					
1999		6,900					
2000(1)		6,300					
2000(2)		5,600					
2001		4,100					
2002		3,400	0.26	-----	1.40	-----	1.05
2003(1)		3,200					
2003(2)		3,200	1.11	0.36	10.78	-----	0.54
2004		3,200					
2005(1)		7,200					
2005(2)		9,700					
2006(1)		28,000	0.60			0.30	1.27
2006(2)		24,700					
Lower MR to Durham Ferry Park							
Year	Flow Nwmm	Flow VNS	Mossdale	Ocean Catch	Inland Adult	Comb. Salvage	Comb. Ant/Chipp
1995		22,500					
1996		6,500					
1997		6,000					
1998		22,500					
1999		6,900					
2000(1)		6,300	2.28	0.47	0.52	0.80	0.68
2000(2)		5,600	0.75	1.20	1.68	0.90	0.78
2001		4,100	4.33	0.38	0.47	0.85	0.59
2002		3,400	0.81	0.39	0.66	0.29	0.51
2003(1)		3,200	2.04	1.11	0.73	1.30	2.46
2003(2)		3,200	1.23	0.61	3.83	0.26	-----
2004		3,200	0.57			0.37	0.79
2005(1)		7,200					
2005(2)		9,700	2.55			0.56	0.31
2006(1)		28,000					
2006(2)		24,700					
Lower TR to Mossdale							
Year	Flow Nwmm	Flow VNS	Mossdale	Ocean Catch	Inland Adult	Comb. Salvage	Comb. Ant/Chipp
1995		22,500					
1996		6,500					
1997		6,000					
1998		22,200	0.29	0.87	1.08	14.63	0.56
1999		6,900	0.69	0.69	1.19	1.23	0.73
2000(1)		6,300	4.98	0.67	0.73	0.53	0.67
2000(2)		5,600					
2001		4,100				0.53	0.49
2002		3,400	3.42	0.62	0.57	0.25	1.00
2003(1)		3,200					
2003(2)		3,200					
2004		3,200					
2005(1)		7,200					
2005(2)		9,700					
2006(1)		28,000					
2006(2)		24,700					

----- division by zero

Vernalis flow was derived over a 10-day period using a 2 day offset for Merced releases and 1 day offset for Tuolumne

Newman flow was derived over a 10-day period

Values in shaded cells were excluded from graphs

Table 8

Lower Stanislaus to Mossdale (paired groups)

Durham Ferry to Mossdale

Relative Survival Indices							Relative Survival Indices						
Lower Stan. To Durham Ferry Park							Durham Ferry Park to Mossdale						
Year	Flow VNS	Mossdale	Ocean Catch	Inland Adult	Comb. Salvage	Comb. Ant/Chipp	Year	Flow VNS	Mossdale	Ocean Catch	Inland Adult	Comb. Salvage	Comb. Ant/Chipp
1995	22,500						1995	22,500					
1996	6,500						1996	6,500					
1997	6,000						1997	6,000					
1998	22,200						1998	22,200					
1999	6,900						1999	6,900					
2000(1)	6,300						2000(1)	6,300	2.22		1.16	1.02	0.73
2000(2)	5,600						2000(2)	5,600					
2001	4,100						2001	4,100			1.04	0.82	1.15
2002	3,400	3.13		0.00	0.47		2002	3,400	3.05	0.68	0.61	0.68	1.38
2003(1)	3,200						2003(1)	3,200	1.79	2.13	4.36	-----	0.67
2003(2)	3,300	1.11		1.70	0.36		2003(2)	3,300	1.69	1.30	0.65	1.30	0.00
2004	3,200						2004	3,200	8.94			2.56	1.00
2005(1)	7,200						2005(1)	7,200					
2005(2)	9,700						2005(2)	9,700					
2006(1)	28,000						2006(1)	28,000					
2006(2)	24,700						2006(2)	24,700					

Lower Stan. To Mossdale						
Year	Flow VNS	Mossdale	Ocean Catch	Inland Adult	Comb. Salvage	Comb. Ant/Chipp
1995	22,500					
1996	6,500					
1997	6,000					
1998	22,200					
1999	6,900					
2000(1)	6,300					
2000(2)	5,600					
2001	4,100					
2002	3,400	9.57		0.00	0.29	0.00
2003(1)	3,200					
2003(2)	3,300	1.87		2.22	0.23	0.00
2004	3,200					
2005(1)	7,200					
2005(2)	9,700					
2006(1)	28,000	7.50			12.49	0.56
2006(2)	24,700					

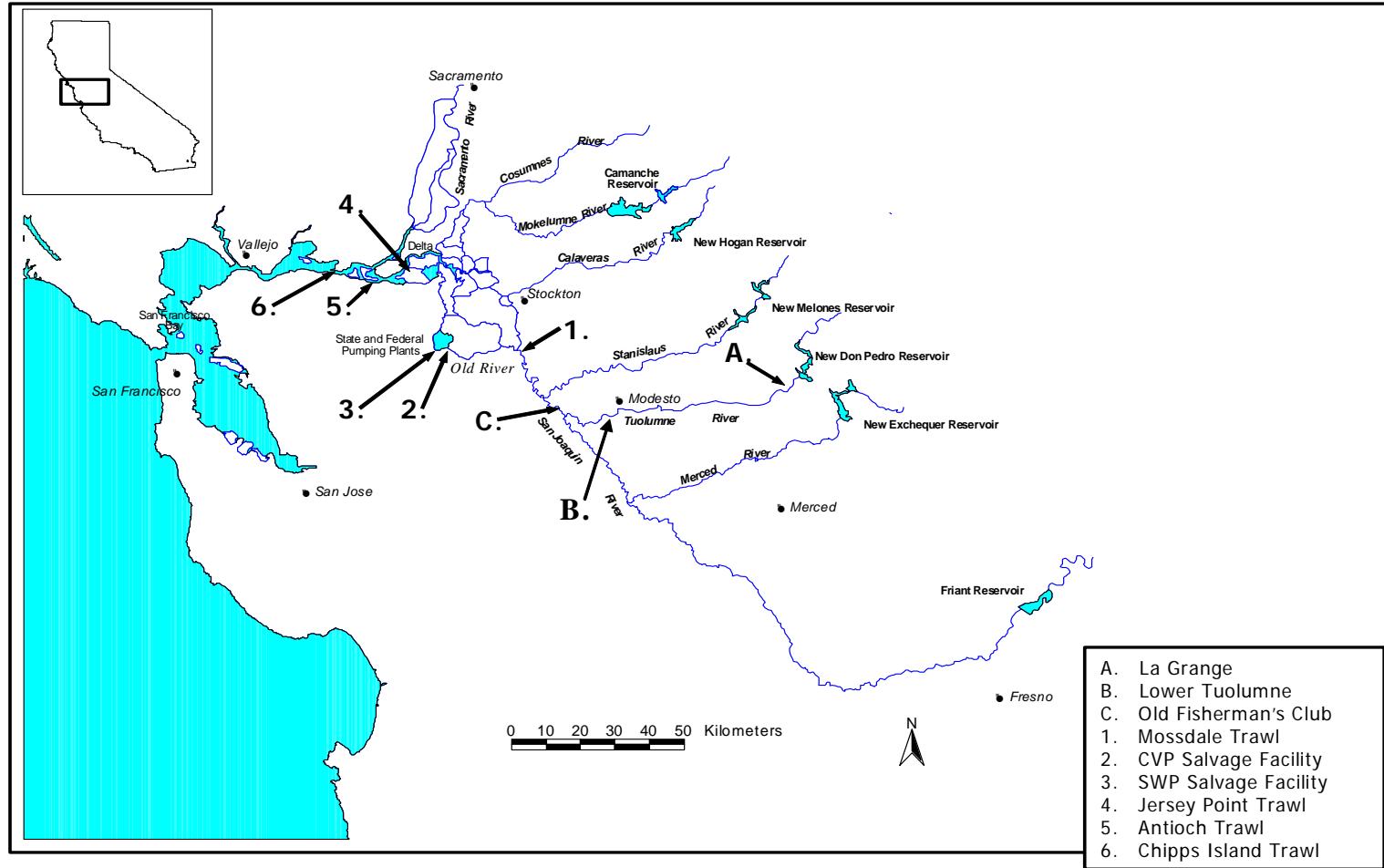


Figure 1. Tuolumne River CWT release locations and smolt recovery sites

### Survival Indices (all data) Tuolumne CWT smolt studies

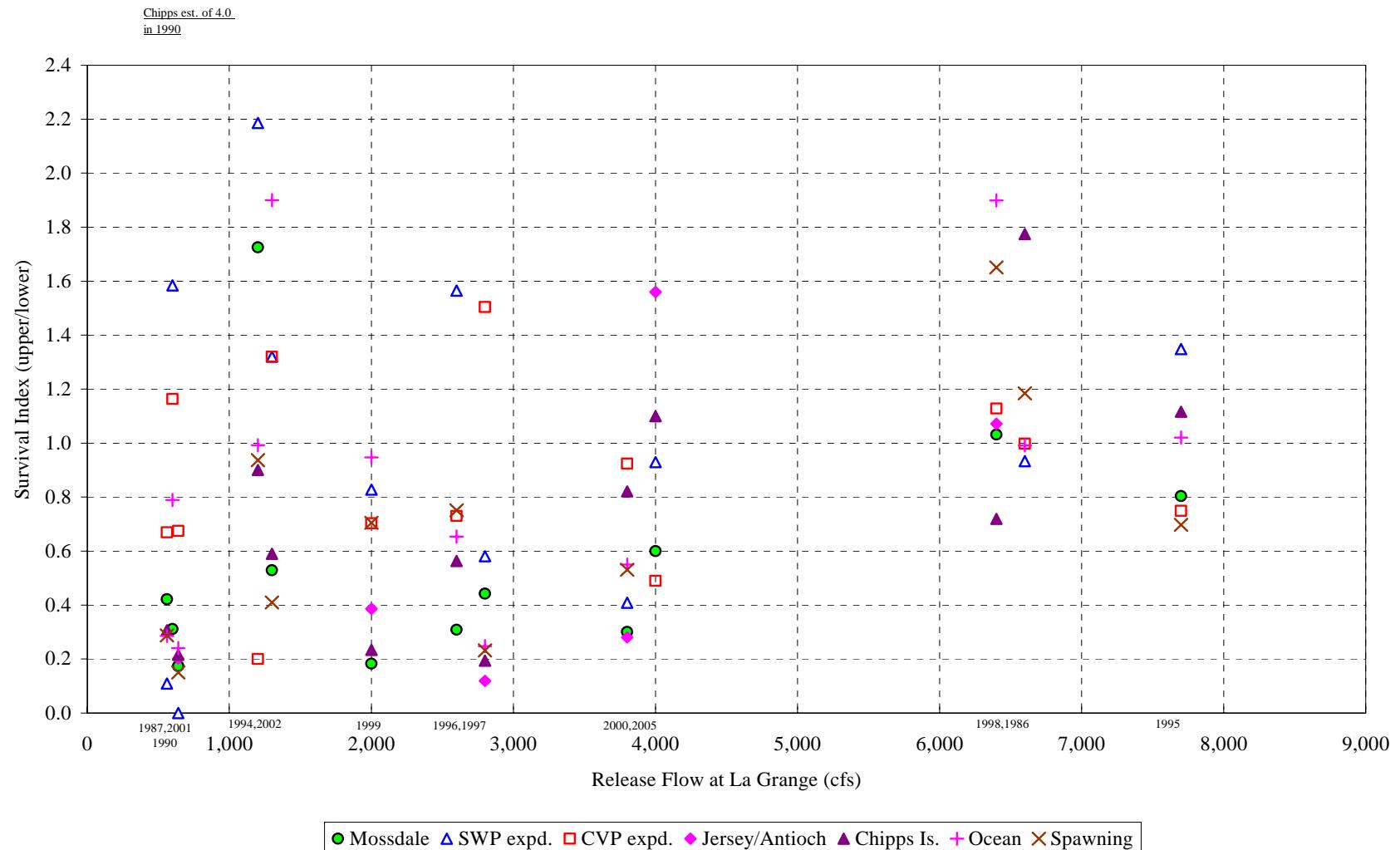


Figure 2. Survival indices of all Tuolumne CWT smolt studies plotted at initial flow.

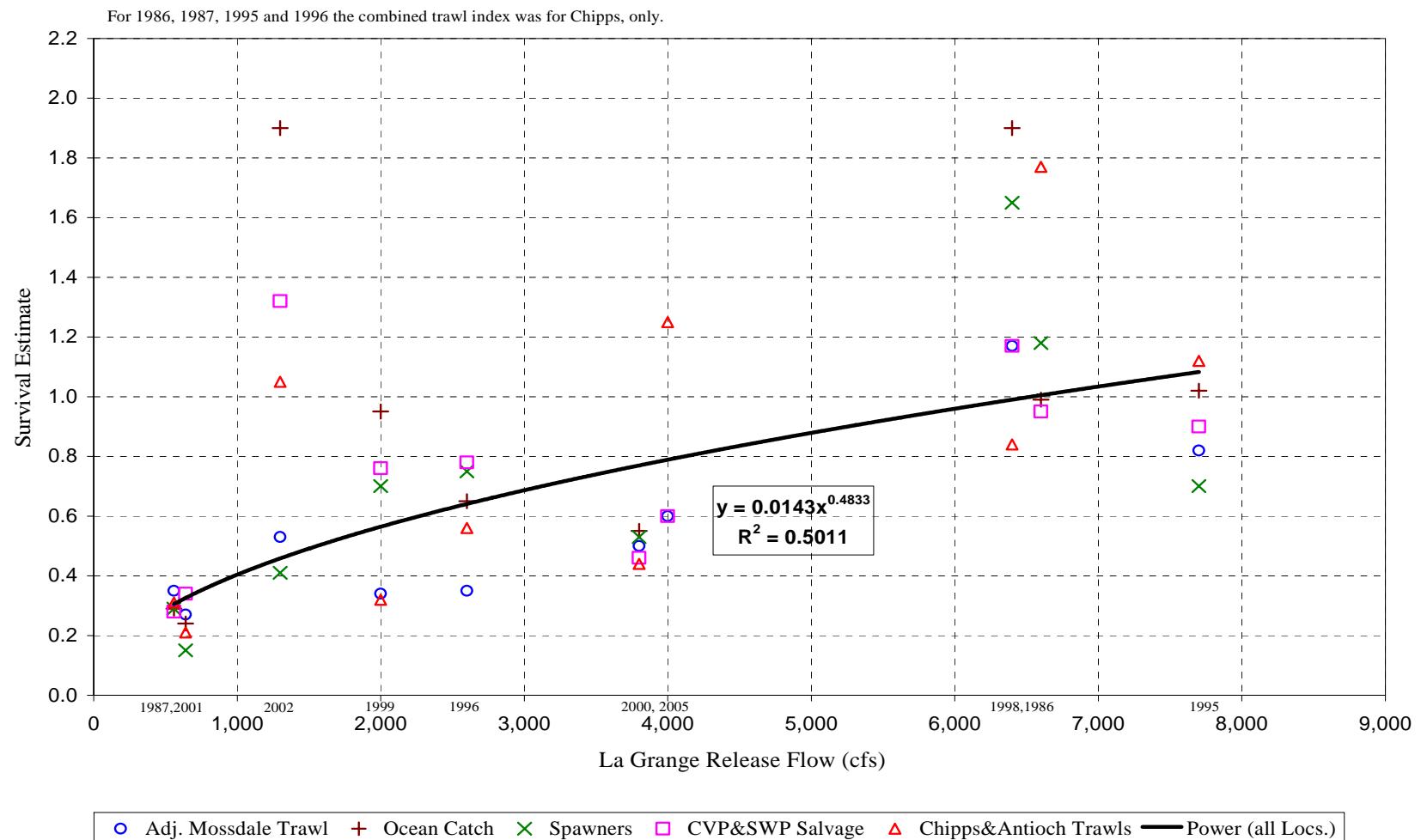


Figure 3. Survival indices using adjusted Mossdale values, adult ocean harvest, spawners, combined CVP & SWP salvage, and combined Chipps and Antioch trawl of validated Tuolumne CWT smolt studies (excluding 1990, 1994, 1997) plotted at initial flow.

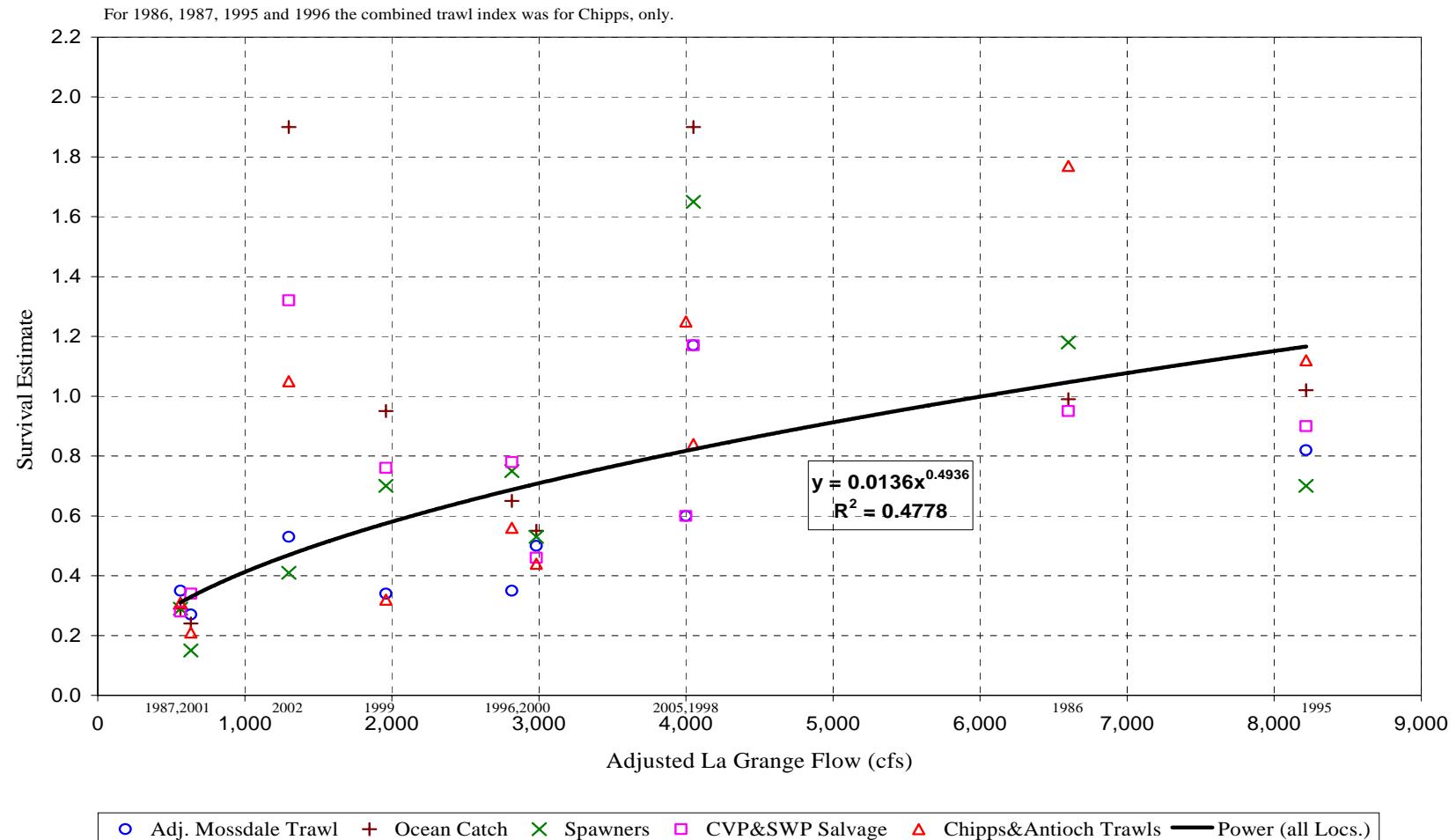


Figure 4. Survival indices using adjusted Mossdale values, adult ocean harvest, spawners, combined CVP & SWP salvage, and combined Chipps and Antioch trawl of validated Tuolumne CWT smolt studies (excluding 1990, 1994, 1997) plotted at adjusted flow.

### CWT recoveries of OLGB releases

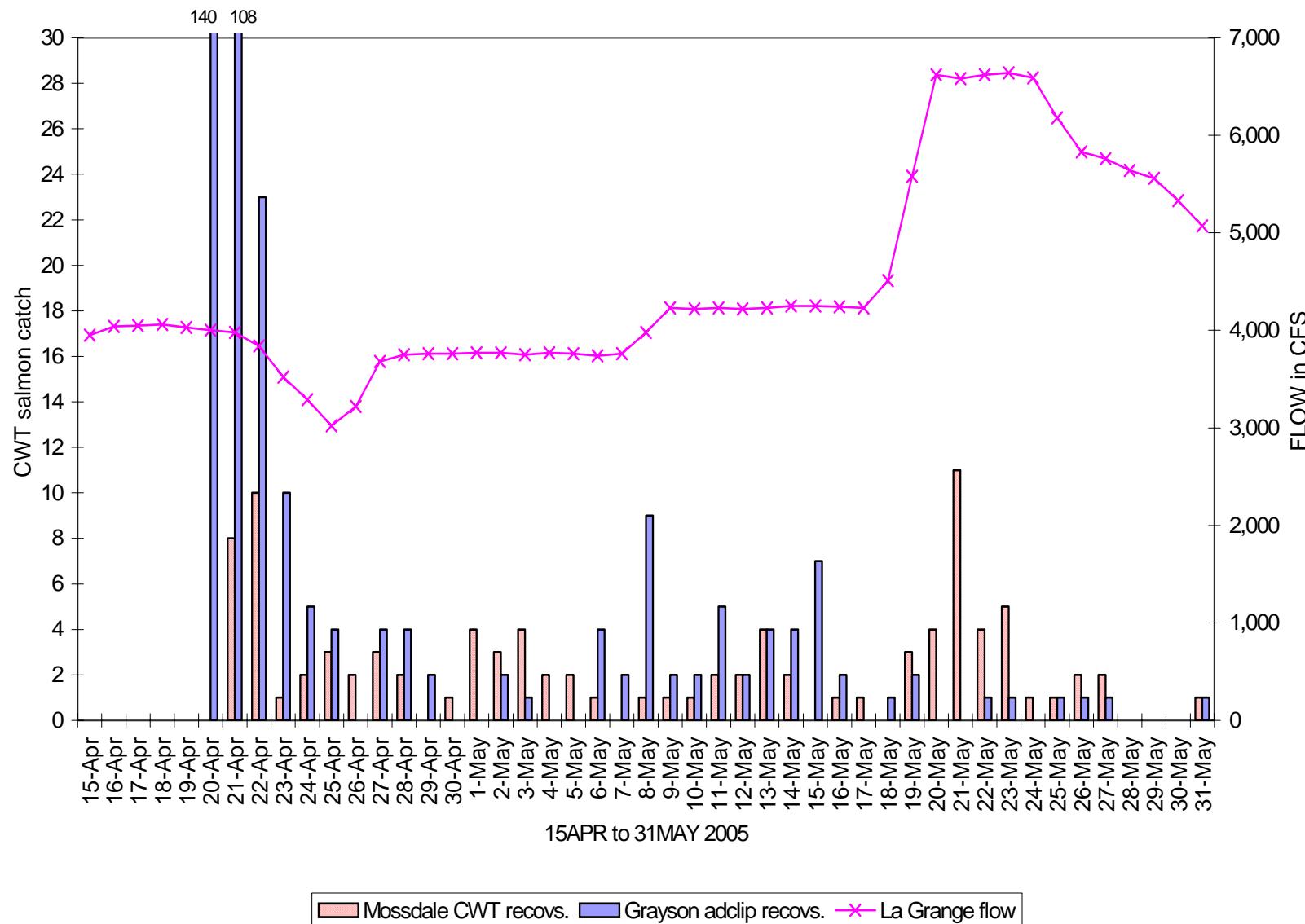


Figure 5. Daily CWT recoveries of Old La Grange Bridge releases at the Grayson screw traps and Mossdale trawl.

### Mossdale recoveries of Tuolumne CWT releases

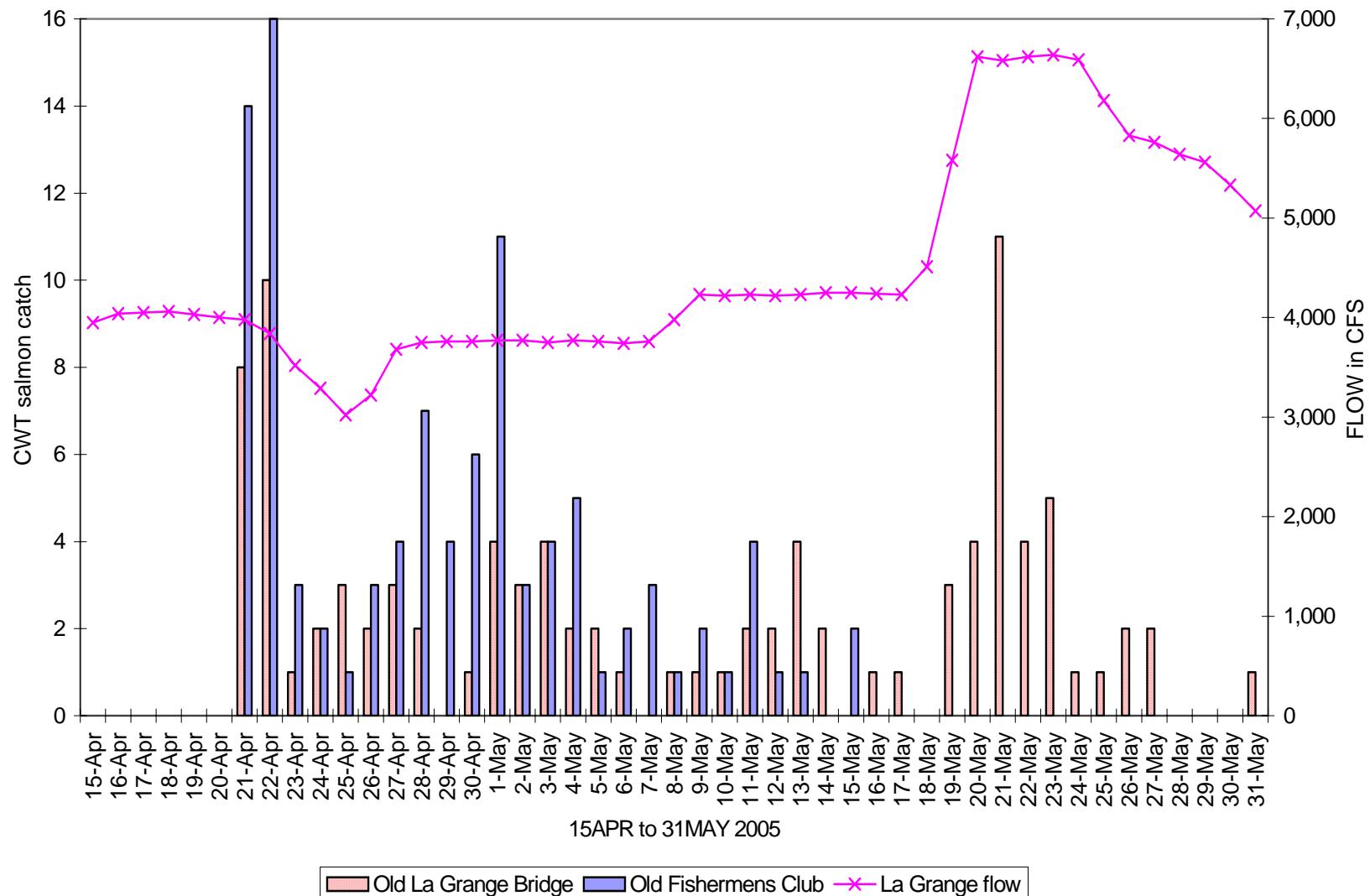


Figure 6. Daily CWT recoveries of the Tuolumne releases at the Mossdale trawl.

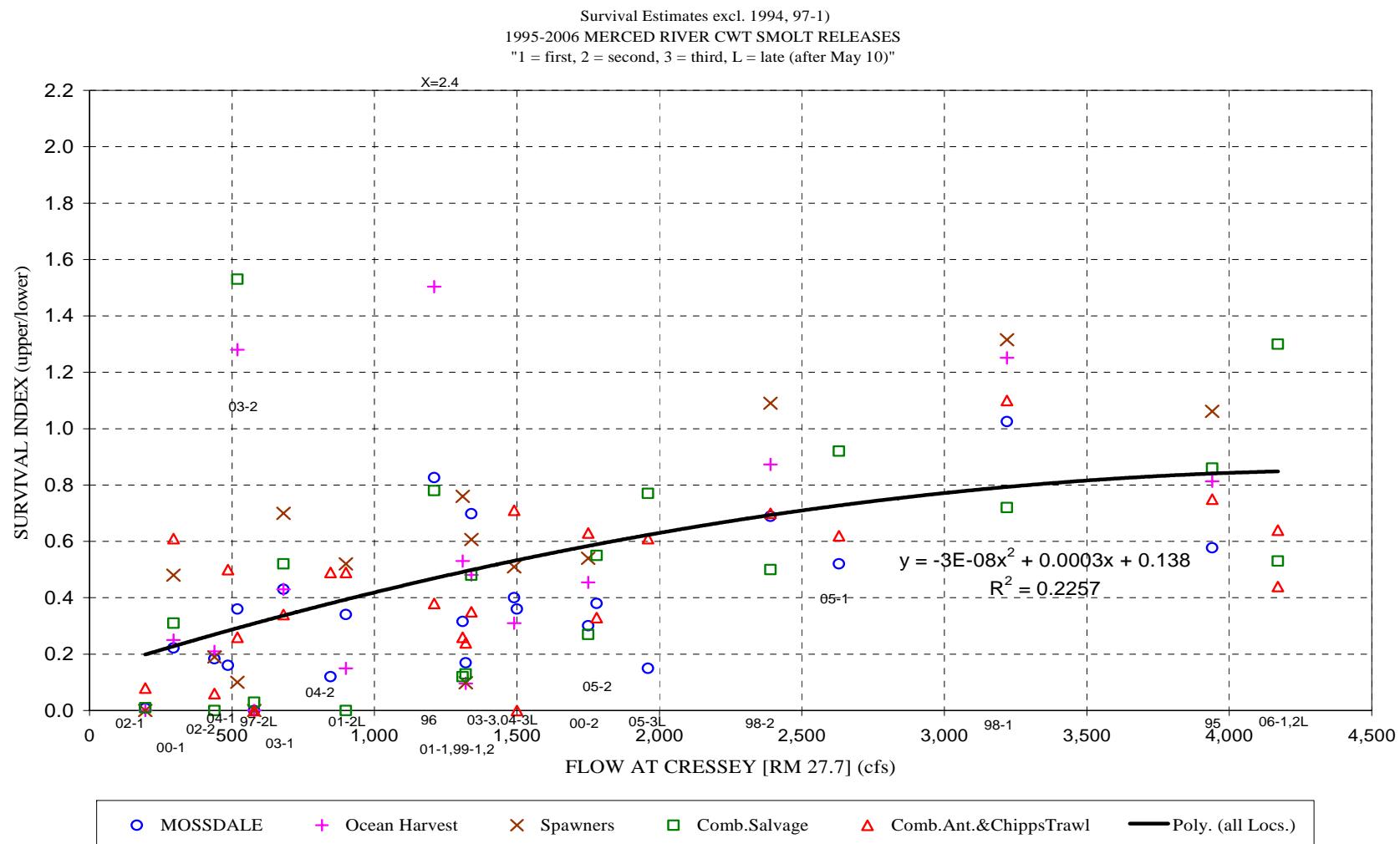


Figure 7. Merced River survival indices for Mossdale, ocean harvest, spawners, combined CVP & SWP salvage, and combined Antioch and Chipps trawl plotted at release flow at Cressey.

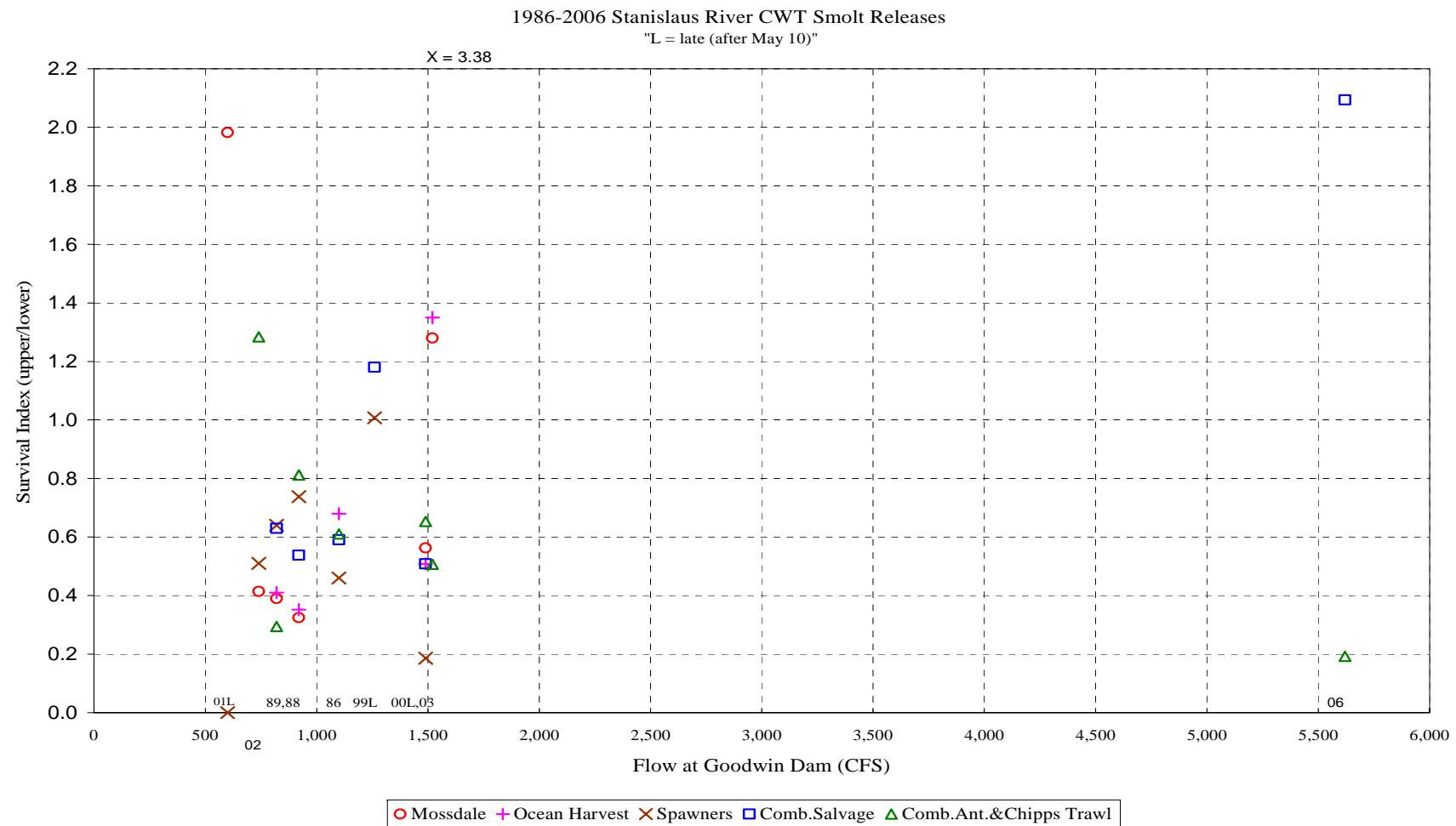


Figure 8. Stanislaus River survival indices for Mossdale, ocean harvest, spawners, combined CVP & SWP salvage, and combined Antioch and Chipps trawl plotted at release flow at Goodwin Dam.

## APPENDIX

### Relative Survival of CWT salmon in reaches of the San Joaquin River

This appendix is an initial synthesis and review of relative survival for paired releases of coded-wire-tagged (CWT) smolt salmon originating from Merced River Hatchery in several reaches of the San Joaquin River (SJR) from the Merced River downstream to Mossdale, just upstream of Old River, during 1995-2006. Releases at Dos Reis were not used as that site is downstream of Old River. Here we considered CWT releases that were part of tributary survival studies, but were made with timing that allow relative survival estimates for SJR reaches. The exception is the Durham Ferry to Mossdale reach as those CWT releases were intended to provide survival information in that reach as part of overall Delta survival evaluations. The CWT release locations were:

1. lower Merced River at Hatfield State Park – River Mile (RM 1) near SJR RM 118
2. lower Tuolumne River (Service Road site at RM 9) in 1995-1997 upstream of the Tuolumne confluence at RM 84 or SJR at Old Fishermen's Club (OFC) since 1998 at SJR RM 81
3. lower Stanislaus River at mouth (Two Rivers site) at SJR RM 75
4. SJR at Durham Ferry Park (DFP) – RM 71
5. SJR at Mossdale – RM 56

For purposes of this review, the distance of any additional tributary reaches due to release location (of 1-9 miles) are not considered. CWT releases were made at various locations in a given year, allowing various pairings that included the following, in some cases overlapping, SJR reaches (corresponding reach length is indicated in RM):

1. Merced to Tuolumne - 34 (or to OFC - 37), to Stanislaus - 43, to DFP - 47, or to Mossdale - 62
2. Tuolumne to Stanislaus – 9 (or OFC to Stanislaus – 6), to DFP – 13 (or OFC to DFP – 10), or to Mossdale – 28 (or OFC to Mossdale – 25)
3. Stanislaus to DFP – 4, or to Mossdale – 19
4. DFP to Mossdale – 15

CWT release groups were considered suitable for pairing to determine relative survival if releases were made within 8 days of each other. The relative survival indices were calculated in the same manner as was done for tributary survival estimates and based on recovery in the Mossdale trawl, combined SWP and CVP fish salvage facilities, combined Antioch/Jersey and Chipps Island trawls, ocean harvest, and SJR basin inland spawners. Table 7 includes all of the paired CWT release groups, the number of recoveries made by locations/type, and the calculated survival indices between paired groups.

For the upper location of the CWT paired releases, a total of 30 were from the lower Merced River, nine from near the lower Tuolumne River (at either Service Road or OFC), five from the lower Stanislaus River, and six from DFP (Table 2). Relative survival indices were graphed for values <4.0, thereby excluding six unusually high results. Indices obtained from Mossdale recoveries with paired releases that included either DFP or Mossdale releases also had many unusually high values, probably due in large part to unequal capture probability resulting from the proximity of the recovery site to one or both release locations, thereby excluding another 34 estimates (the excluded indices are shaded in Table 8). The remaining indices were graphed with 10-day average flow following the latest date of the paired released.

Figure 1 includes all remaining paired survival indices within the entire SJR reach from the Merced River to Mossdale plotted with SJR flow at Vernalis. Most indices were obtained in the flow range of about 3,000-7,000 cfs, with a few releases done at 22,000-28,000 cfs. Figures 2-4 are exclusive subsets of Figure 1; the flow used in Figure 2 is the SJR at Newman as that location is in the SJR reach from the Merced River to Tuolumne River; the SJR flow at Vernalis is used for Figures 3-4.

Figure 2 has survival indices for the lower Merced to lower Tuolumne (Service Road or OFC) CWT paired releases - most indices are from 0.4 to 1.4. Figure 3 has survival indices for lower Merced releases paired with lower Stanislaus, DFP, and Mossdale releases and Figure 4 has survival indices for all paired groups within the lower Tuolumne to Mossdale reach (lower Tuolumne paired with the lower Stanislaus, DFP, and Mossdale; the lower Stanislaus paired with DFP and Mossdale; and DFP paired with Mossdale. Both Figures 3 and 4 have indices that are more variable, but with most in the 0.3-1.4 range.

In general, these survival indices as shown in Figures 1-4 appear to indicate little relationship to flow. Newman (2006) examined combined survival results using CWT recoveries from the Antioch trawl, Chipps Island trawl, and ocean harvest for paired releases at DFP and Mossdale using a statistical model and found no significant relationship with flow. Analyses of the additional upstream paired releases using such an approach with all recovery sources is recommended to help further examine survival within reaches of the SJR up to the Merced River.

## **REFERENCE**

Newman, Ken B. 2006. An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies. Report by the U. S. Fish and Wildlife Service to the CalFed Science Program, Project number SCI-06-G06-299.

1995-2006 San Joaquin Basin CWT smolt releases  
Lower Merced to Mossdale Reach (all paired groups)

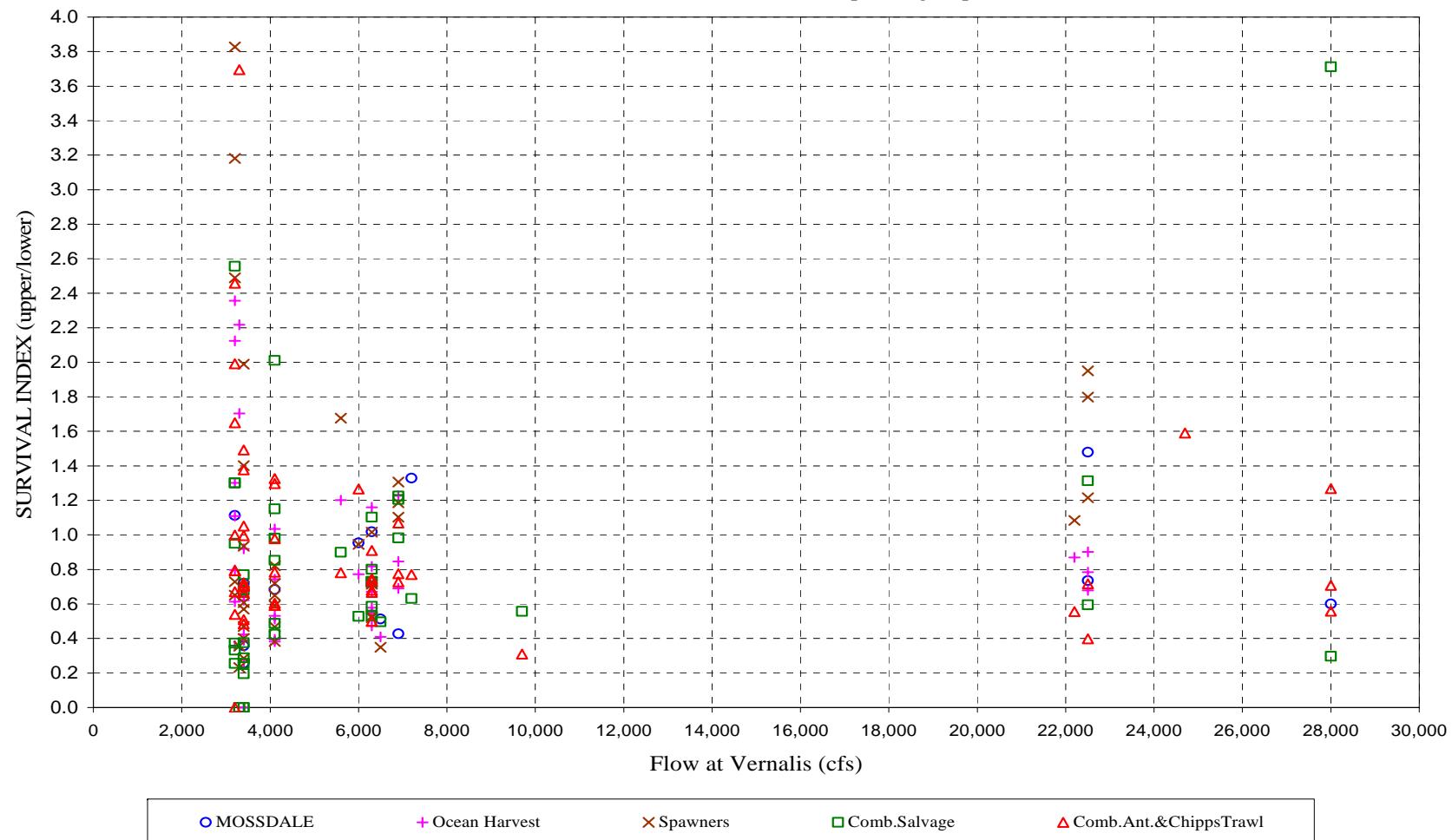


Figure 1. Lower Merced to Mossdale Reach (all paired release groups)

1995-2006 San Joaquin Basin CWT smolt releases  
Lower Merced to lower Tuolumne (paired group)

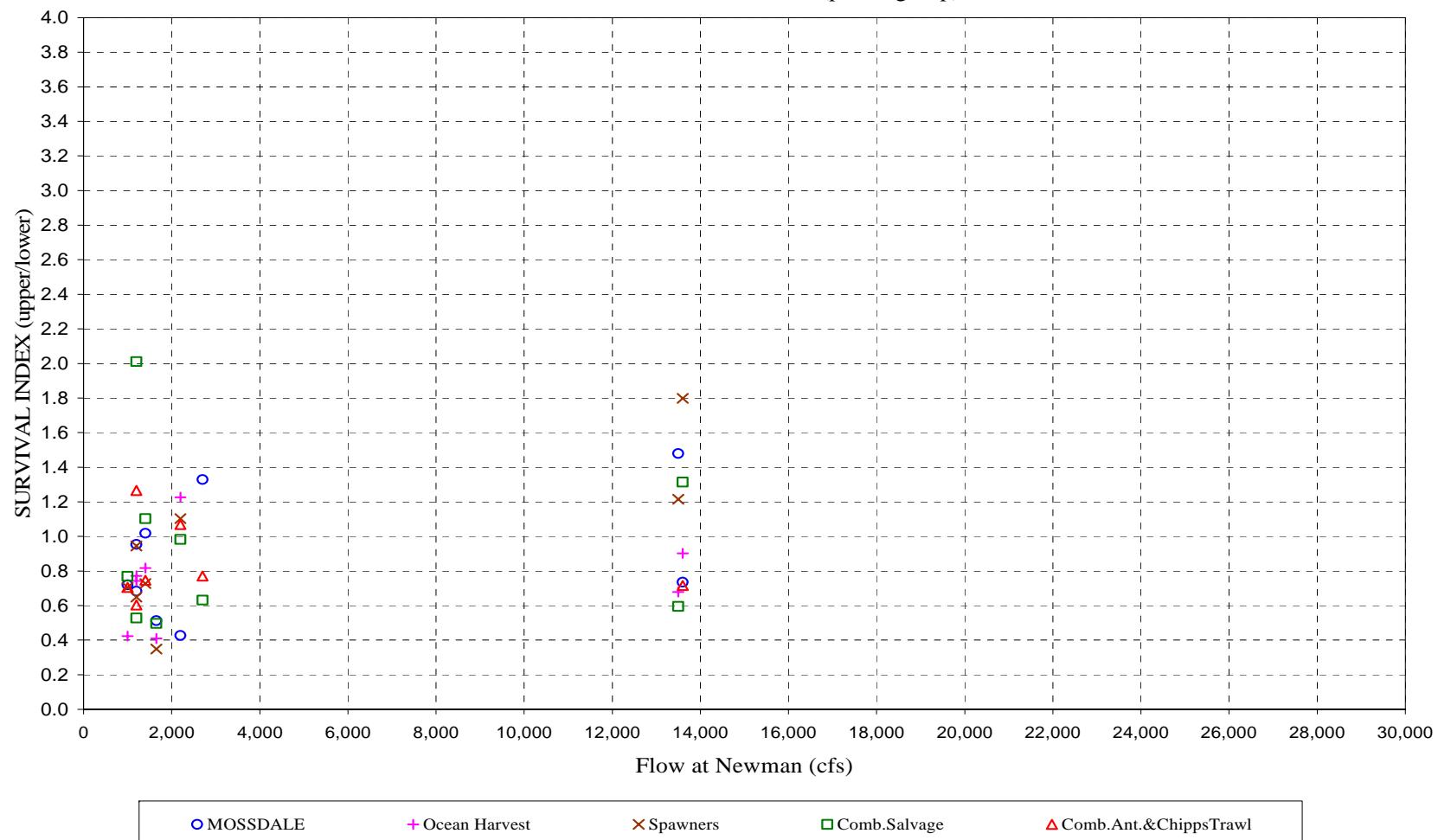


Figure 2. Lower Merced to lower Tuolumne (paired group)

1995-2006 San Joaquin Basin CWT smolt releases  
Lower Merced to Stan/DFP/Mossdale (paired groups)

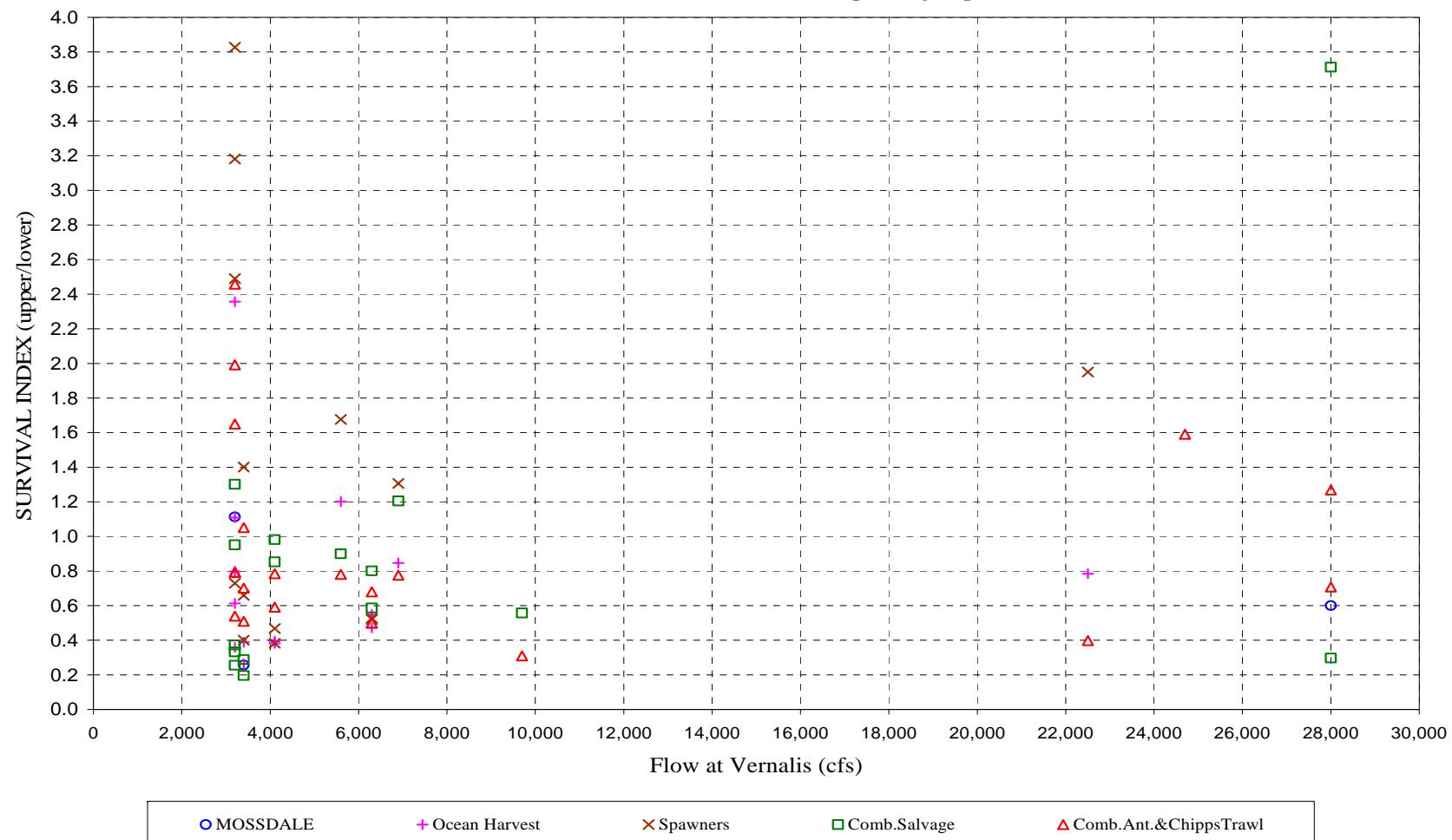


Figure 3. Lower Merced: to lower Stanislaus, Durham Ferry, and Mossdale (paired groups)

1995-2006 San Joaquin Basin CWT smolt releases  
Lower Tuolumne to Mossdale Reach (all paired groups)

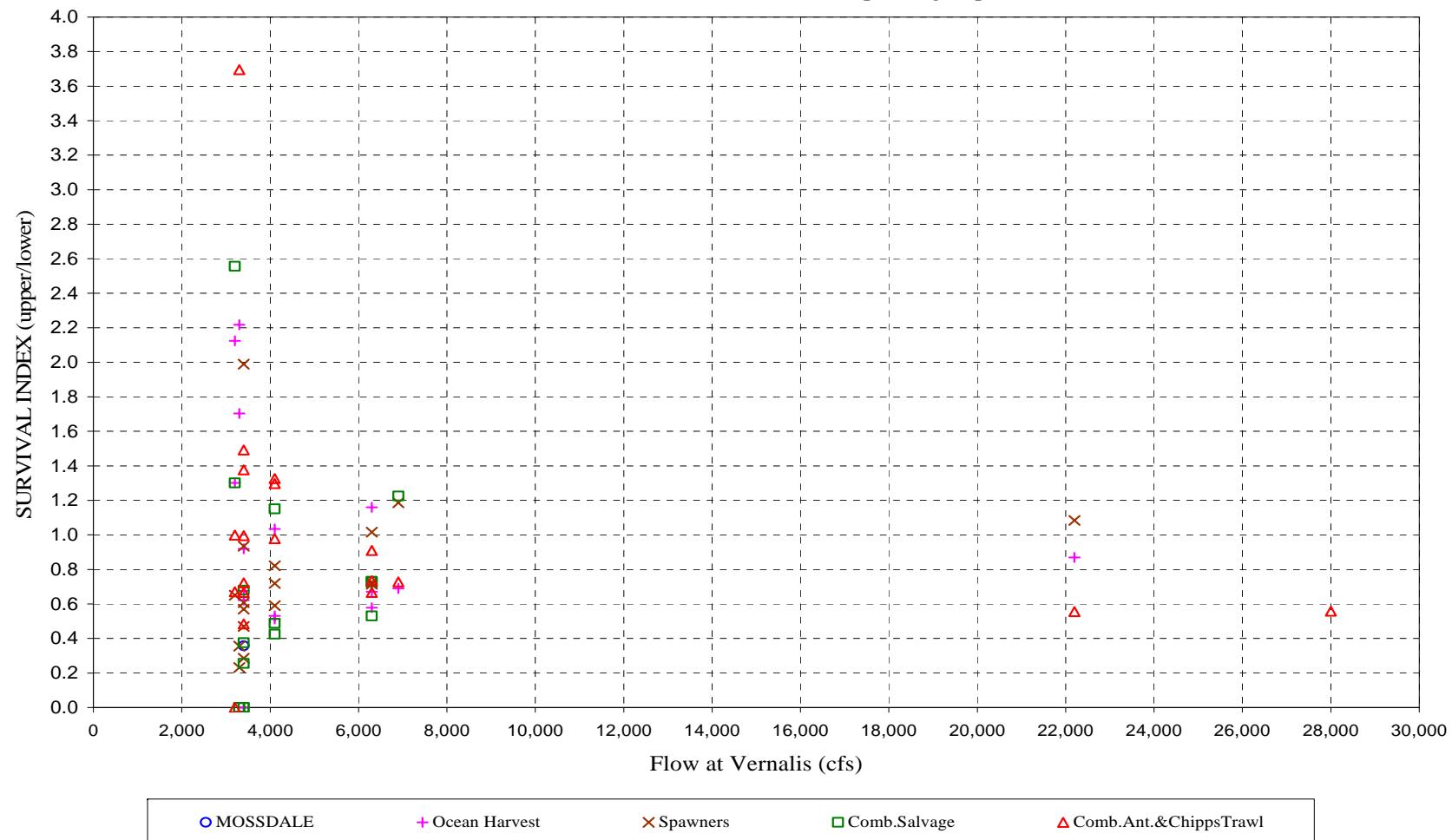


Figure 4. Lower Tuolumne to Mossdale Reach (all paired groups)