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FEDERAL ENERGY REGULATORY COMMISSION

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)
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Modesto Irrigation District)

2007 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2007-5

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 April to May of most years to study relative survival of smolts released at various river flows of different mainstem and tributary river reaches.

This report, an update of FERC Report 2006-6, summarizes the available recovery data for the 2003-2006 basin release groups. Updated sections were limited to juvenile recoveries at Mossdale for 2006 basin releases and adult ocean harvest that include 2007 recovery data; only the updated sections will be included in this report. The principal focus of the CWT report is the Tuolumne River smolt survival studies, which have spanned from 1986 to 2005. Relative survival indices for upper and lower Tuolumne release groups were 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 in the west-central Delta. The updated adult survival index for expanded ocean harvest for the 2005 release was 4.38 based on 2007 ocean harvest data.

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 of <0.4 with low flows (<700 cfs) to relatively high survival of ≥ 0.6 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. However, many results exceed 1.0 in several tests at more than 1,000 cfs. Also, tests in some years: (1) were determined invalid for varying reasons, (2) resulted in extended migration periods such that the “study flow” had to be adjusted, and (3) resulted in wide-ranging estimates of survival.

CWT releases in the Merced, Stanislaus, and San Joaquin rivers that originated from the Merced River Hatchery are summarized in Table 1 for the 2003-2007 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 is on the results of Tuolumne River smolt survival study releases. Included are updated release and recovery data for all tag codes used in the basin since 2003. This report updates Report 2006-6 (TID/MID 2007), which included data available through 2006.

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. 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.

Tag recoveries are made from (1) captured adipose-clipped juvenile salmon obtained 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.

An independent CWT paired smolt release was made by CDFG in the Tuolumne River in 2005 and updated adult ocean harvest recoveries from 2007 are included in this report.

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 (Figure 1, 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. (1997-2006).

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 (2008) and includes preliminary 2007 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 2006 and 2007 was not available. 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. 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 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, accounting for different numbers in the release groups. Adult recoveries are (1) expanded estimates for fish recovered from the ocean harvest port surveys, and (2) 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 Chipps 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 2nd group had anomalous recoveries.

3. RESULTS AND DISCUSSION

3.1 Updated Adult Survival Index Results for Tuolumne River CWT Smolt Released in 2005

The updated ocean harvest survival index for 2005 CWT smolt releases was 4.38 based on preliminary 2007 expanded ocean harvest data (Table 2). As noted in Sec. 2.2, this value may indicate potential problems between the paired release groups made in 2005

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 smolts and all releases were made within mid-April 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, adult ocean and spawner recoveries, and excluding those years determined to be invalid (1990, 1994, 1997 – FERC Report 2002-4). These are plotted with unadjusted release flow at La Grange - the power trendline R² value is 0.455. Figure 4 has the same indices, plotted with adjusted La Grange flows (no adjustment for 1986 and 2005 release flows) - the power trendline R² value is similar at 0.442. 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 categories of adjusted La Grange flows:

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 0.28 to 0.35 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, 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 4.38. 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 Other Data in Table 1

Table 1 includes CWT recovery data from: (1) Merced River smolt releases made between 2003-2006, (2) Stanislaus River smolt releases made in 2003-2006, (3) Lower San Joaquin River/Delta smolt releases made in 2003-2006 which originated from the Merced Hatchery.

3.4 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 refinement similar to 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.

Only 2 CWT's were recovered during the 2007 ocean harvest season from releases made between 2003 and 2006. Both recoveries originated from the lower Merced release location at Hatfield made in 2004 and 2005 and resulted in minimal changes to Figure 5 from the 2006 report. This updated figure 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 0.22.

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 smolts. 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.

There were no CWT's recovered during the 2007 ocean harvest for releases made in 2003 and 2006. The only change to Figure 6 is the Mossdale survival index for 2006. This figure 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.

3.5 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 review is needed of existing data for the Merced, Stanislaus, and San Joaquin Rivers.

4. REFERENCES

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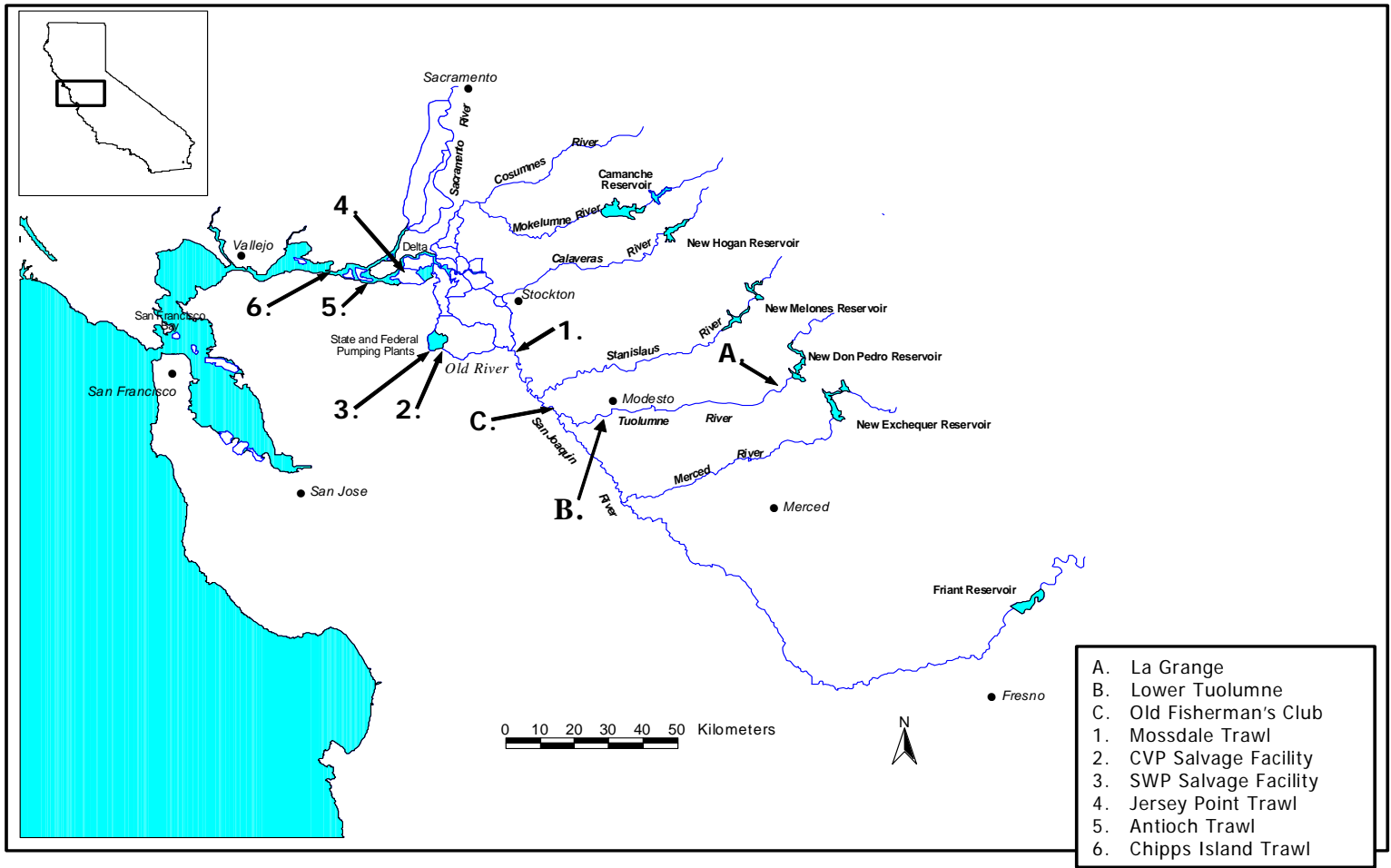
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Tuolumne River CWT Release Locations and Smolt Recovery Sites

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

Survival Indices (all data) Tuolumne CWT smolt studies

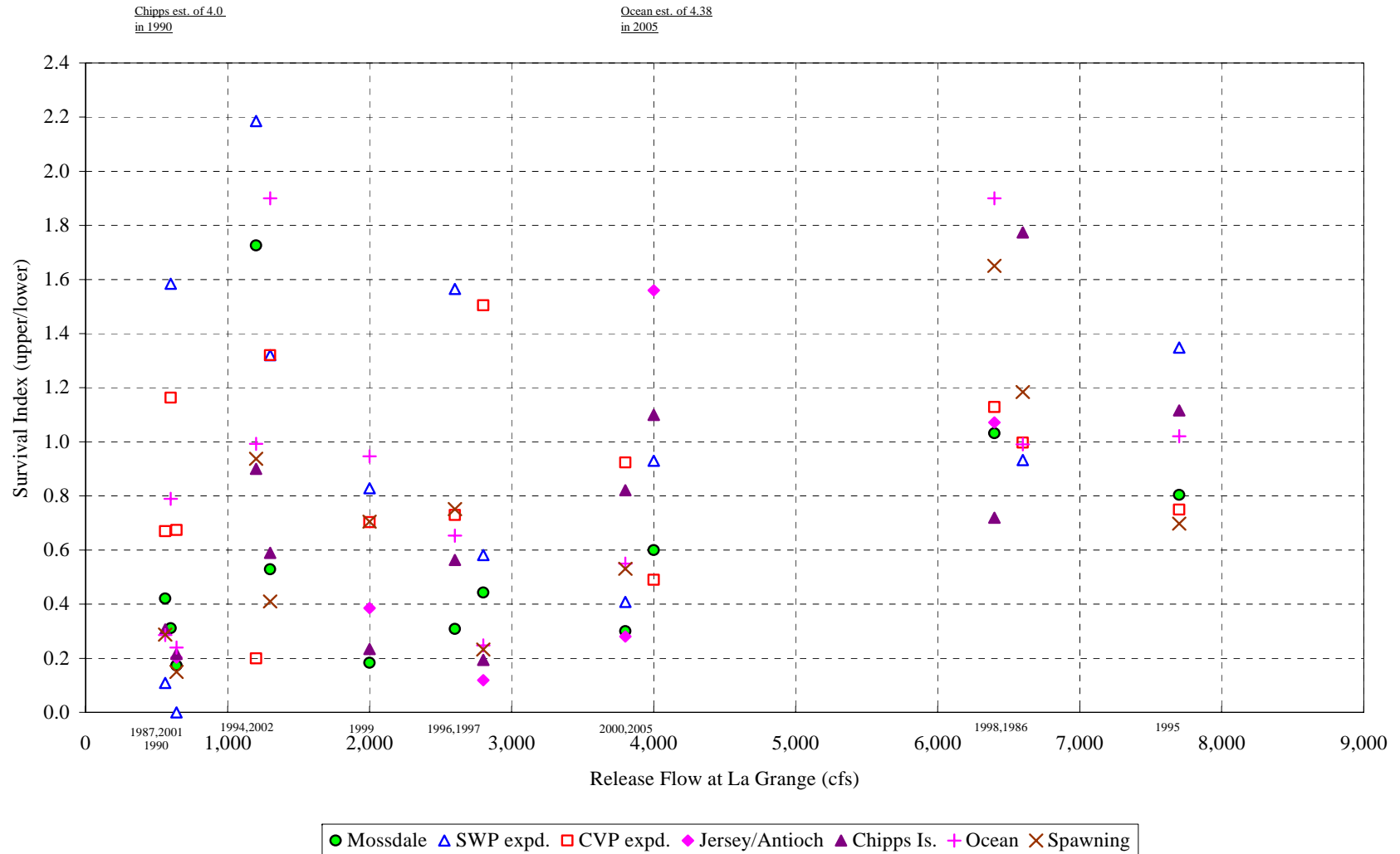


Figure 2. Survival indices of all Tuolumne CWT smolt studies plotted at initial flow.

Ocean est. of 4.38 for 2005

For 1986, 1987, 1995 and 1996 the combined trawl index was for Chipps, only.

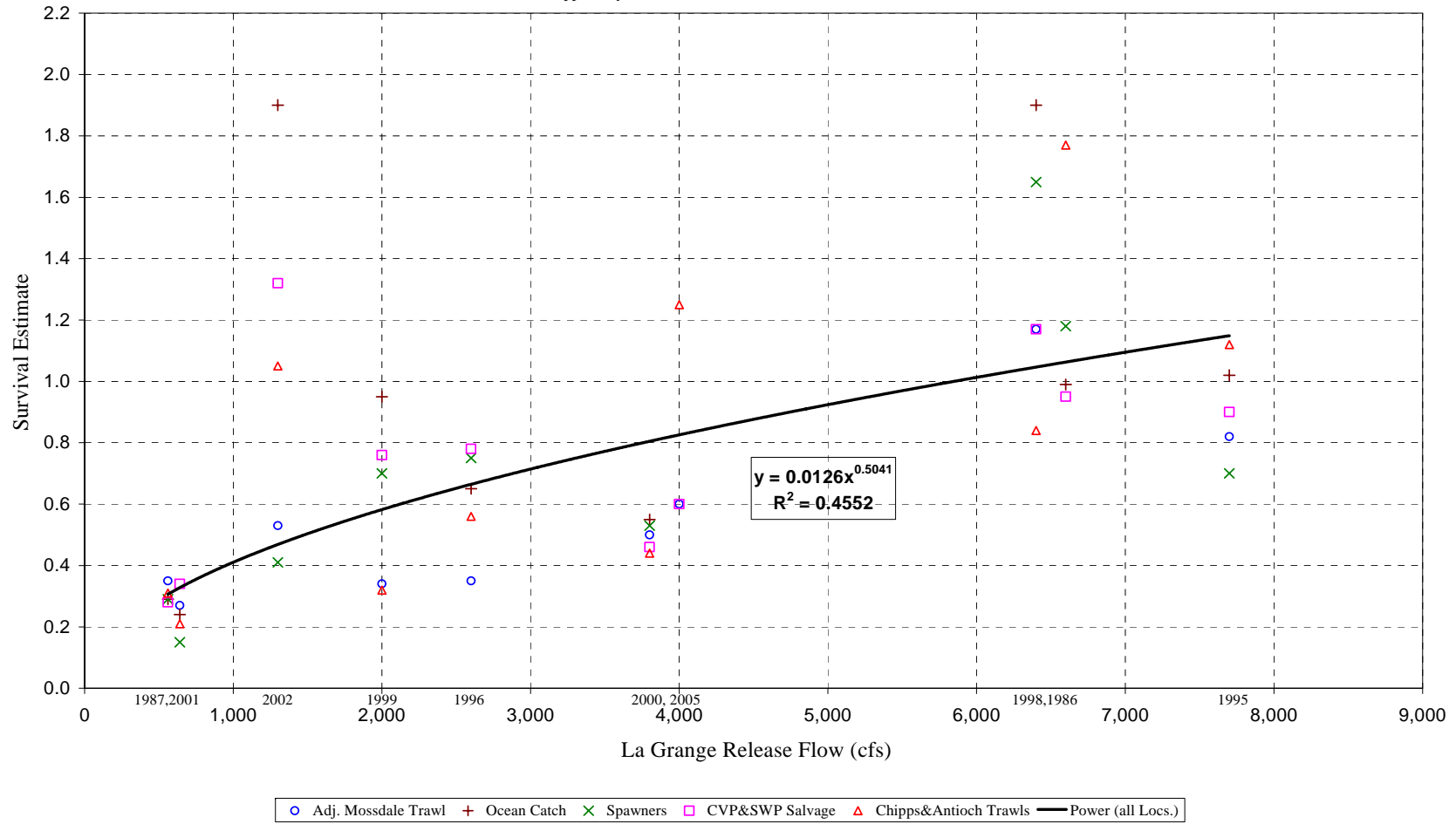


Figure 3. Survival indices using adjusted Mossdale values, adult ocean harvest, spawners, combined CVP & SWP salvage, and combined Chipps and Antioch trawl of validated Tuolumne CWT smolt studies (excluding 1990, 1994, 1997) plotted at initial flow.

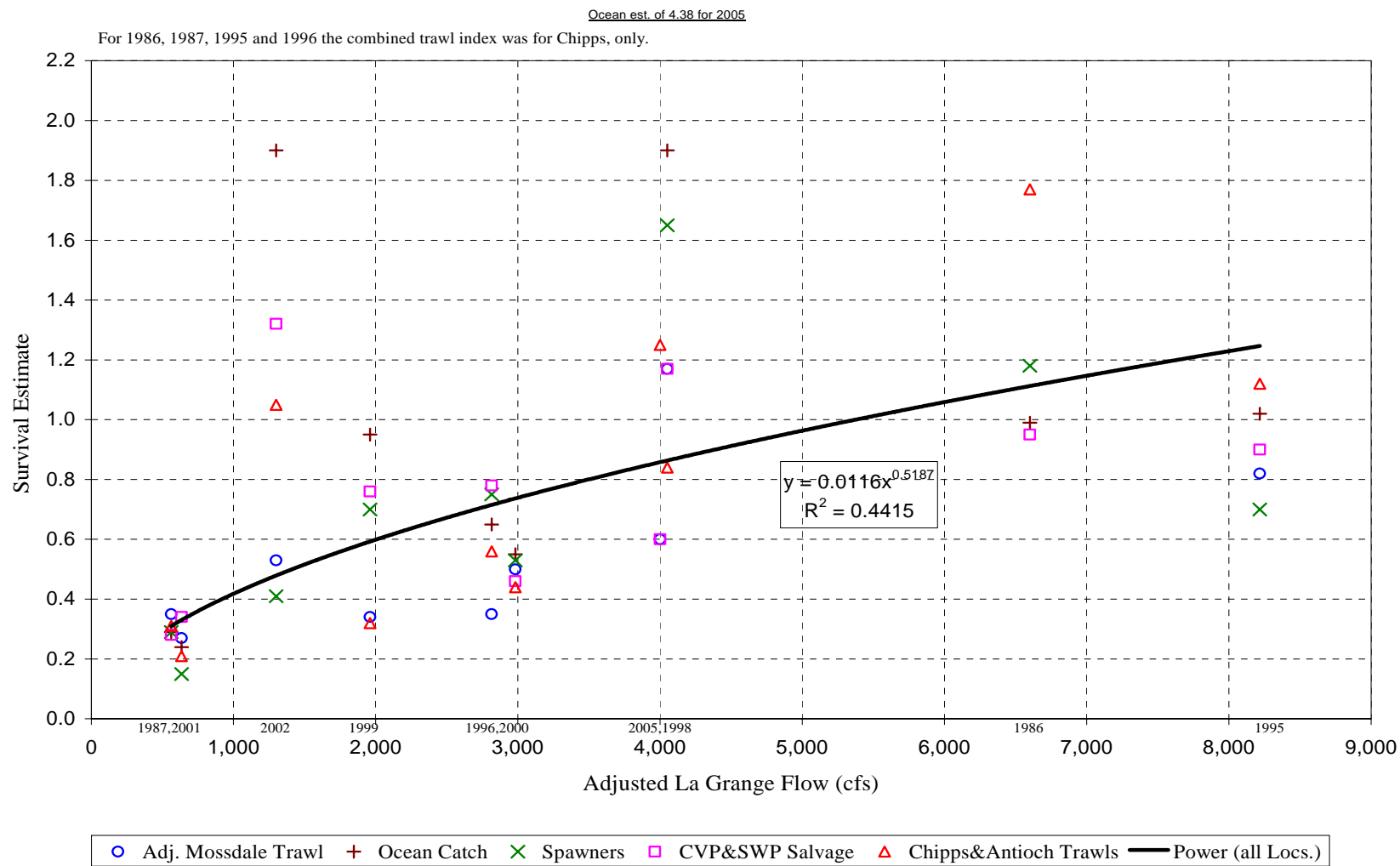


Figure 4. Survival indices using adjusted Mossdale values, adult ocean harvest, spawners, combined CVP & SWP salvage, and combined Chipps and Antioch trawl of validated Tuolumne CWT smolt studies (excluding 1990, 1994, 1997) plotted at adjusted flow.

Survival Estimates excl. 1994, 97-1)
 1995-2006 MERCED RIVER CWT SMOLT RELEASES
 "1 = first, 2 = second, 3 = third, L = late (after May 10)"

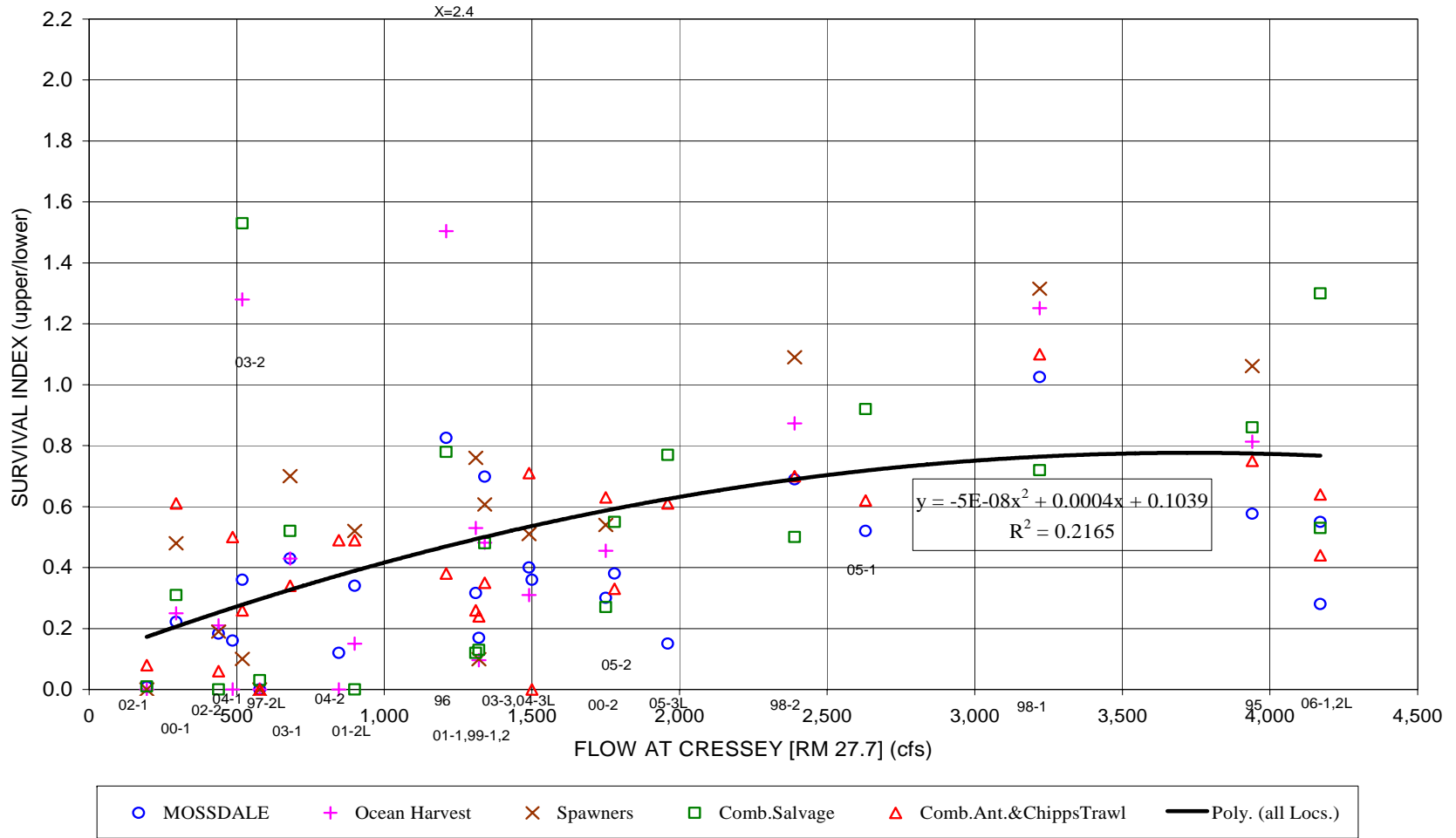


Figure 5. Merced River survival indices for Mossdale, ocean harvest, spawners, combined CVP & SWP salvage, and combined Antioch and Chipps trawl plotted at release flow at Cressey.

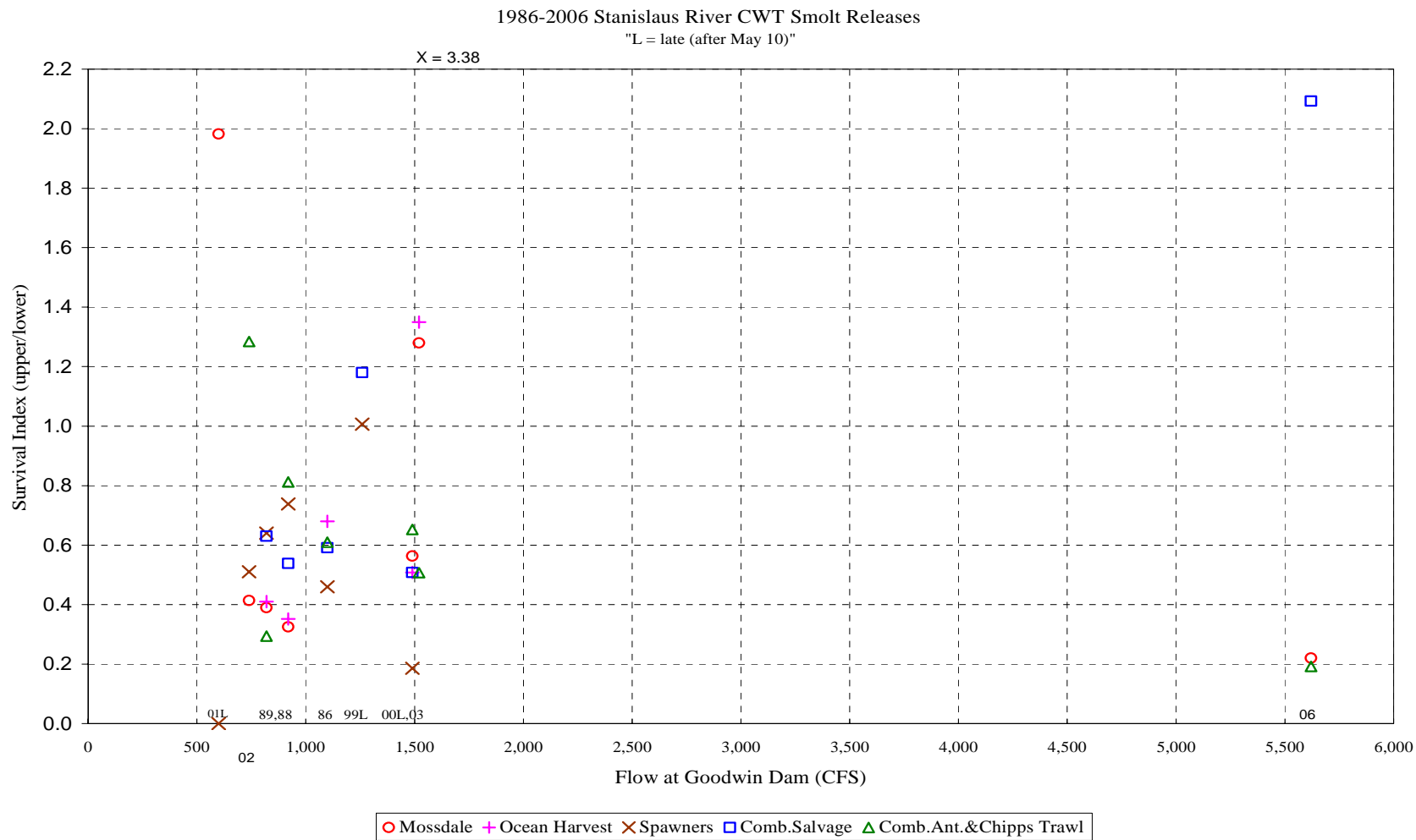


Figure 6. Stanislaus River survival indices for Mossdale, ocean harvest, spawners, combined CVP & SWP salvage, and combined Antioch and Chipps trawl plotted at release flow at Goodwin Dam.

Table 1. San Joaquin River CWT (2003-2006)

SAN JOAQUIN RIVER	JUVENILE SALMON CWT RELEASES										JUVENILE RECOVERIES										ADULT OCEAN RECOVERIES										ADULT INLAND TOTAL					Age 2 to 5
	TAG NO.	EFFECTIVE RELEASE	RELEASE SITE	DATE	SMOLTS/ YEARLING	SJR PUSH. /SCREWTRAP	MOSSDALE	SWP	CVP	CHIPPS	JERSEY Antioch	ESTIMATED			2+			3+			4+			1+ - 4+												
												COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL							
BY02	06-02-82	24563	DFP	21APR03	SMOLTS		32	0	2	0	1	0	5	5	4	0	4	0	0	0	0	0	0	0	0	0	0	9	2	2		4				
	06-02-83	26036	DFP	21APR03	SMOLTS		29	0	1	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2		3				
	06-27-42	24179	DFP	21APR03	SMOLTS		27	1	2	1	1	0	8	8	2	0	2	0	0	0	0	0	0	0	0	0	10	4	2		6					
	06-27-48	24706	MOSSDALE	22APR03	SMOLTS		17	0	0	2	2	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	3	0	1		1					
	06-27-43	25480	MOSSDALE	22APR03	SMOLTS		16	0	0	3	2	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	5	1	0		1					
	06-27-44	24649	JERSEY PT	25APR03	SMOLTS						57	71	0	99	99	127	27	154	7	5	12	0	0	0	265	23	20			43						
TOTAL		74778	DFP				88	1	5	3	6	0	13	13	6	0	6	0	0	0	0	0	0	0	0	19	7	6		13						
TOTAL		50186	MOSSDALE				33	0	0	5	4	0	0	0	5	3	8	0	0	0	0	0	0	0	0	8	1	1		2						
TOTAL		24649	JERSEY PT							57	71	0	99	99	127	27	154	7	5	12	0	0	0	265	23	20			43							
BY02	06-27-45	24815	DFP	28APR03	SMOLTS		29	0	1	0	0	0	0	0	3	3	6	0	0	0	0	0	0	0	0	6	0	1		1						
	06-27-46	25319	DFP	28APR03	SMOLTS		28	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0		2						
	06-27-47	24758	DFP	28APR03	SMOLTS		34	0	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	0	0	4	1	0		1						
	06-27-49	24219	MOSSDALE	29APR03	SMOLTS		27	0	1	0	0	0	3	3	2	0	2	0	0	0	0	0	0	0	0	5	2	1		3						
	06-27-50	24505	MOSSDALE	29APR03	SMOLTS		8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		1						
	06-27-51	25950	JERSEY PT	02MAY03	SMOLTS						39	36	0	124	124	240	52	292	6	5	11	0	0	0	427	17	15		32							
TOTAL		74892	DFP				91	0	2	0	0	0	0	0	7	3	10	0	0	0	0	0	0	0	10	3	1		4							
TOTAL		48724	MOSSDALE				35	0	1	1	0	0	3	3	2	0	2	0	0	0	0	0	0	0	5	2	2		4							
TOTAL		25950	JERSEY PT							39	36	0	124	124	240	52	292	6	5	11	0	0	0	427	17	15		32								
BY03	06-27-52	23440	DFP	22APR04	SMOLTS		186	1	2	0	1	0	0	0	3	0	3	0	0	0	0	0	0	0	0	3	0	0		0						
	06-27-53	21714	DFP	22APR04	SMOLTS		145	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0						
	06-27-54	23328	DFP	22APR04	SMOLTS		155	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0							
	06-27-55	23783	DFP	22APR04	SMOLTS		219	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0							
	06-46-70	25319	MOSSDALE	23APR04	SMOLTS		15	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0							
	06-45-82	23586	MOSSDALE	23APR04	SMOLTS		15	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0							
	06-45-83	24803	MOSSDALE	23APR04	SMOLTS		33	1	0	2	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	2	0		0							
	06-45-80	22911	JERSEY PT	26APR04	SMOLTS		0	0	1	25	22	2	12	14	48	66	114	1	0	1	129	2														
TOTAL		92265	DFP				705	2	7	3	2	0	0	0	3	0	3	0	0	0	0	0	0	3												
TOTAL		73708	MOSSDALE				63	1	2	3	1	0	0	0	2	0	2	0	0	0	0	0	0	2												
TOTAL		22911	JERSEY PT				0	1	25	22	22	2	12	14	48	66	114	1	0	1	129															
BY04	06-46-72	23414	DFP	02MAY05	SMOLTS		7	5	38	5	0	0	0	0	5	0	5																			
	06-46-73	23193	DFP	02MAY05	SMOLTS		11	2	25	2	2	0	0	0	3	0	3																			
	06-46-74	23660	DFP	02MAY05	SMOLTS		17	7	37	4	3	0	3	3	0	0	0																			
	06-46-75	23567	DFP	02MAY05	SMOLTS		11	4	19	1	1	0	0	0	0	0	0																			
	06-46-97	22302	DOS REIS	03MAY05	SMOLTS		1	0	1	1	1	0	0	0	0	0	0																			
	06-46-98	24149	DOS REIS	03MAY05	SMOLTS		0	0	1	3	3	0	0	0	0	0	0																			
	06-45-91	22675	DOS REIS	03MAY05	SMOLTS		0	0	1	3	3	0	0	0	0	0	0																			
	06-45-88	22767	JERSEY PT	06MAY05	SMOLTS		0	0	32	31	31	0	3	3	24	3	27																			
TOTAL		93834	DFP				18	119	12	6	6	0	3	3	8	0	8																			
TOTAL		69126	DOS REIS				1	0	3	7	7	0	0	0	0	0	0																			
TOTAL		22767	JERSEY PT				0	0	32	31	31	0	3	3	24	3	27																			
BY04	06-45-84	22777	DFP	09MAY05	SMOLTS		10	19	16	2	1	0	0	0	5	0	5																			
	06-45-85	22968	DFP	09MAY05	SMOLTS		18	15	6	1	1	0	0	0	0	0	0																			
	06-45-86	23012	DFP	09MAY05	SMOLTS		13	17	14	3	3	0	0	0	2	0	2																			
	06-45-87	22806	DFP	09MAY05	SMOLTS		15	9	7	0	2	0	0	0	0	0	0																			
	06-45-89	21443	DOS REIS	10MAY05	SMOLTS		1	0	3	5	5	0	0	0	4	0	4																			
	06-45-90	23755	DOS REIS	10MAY05	SMOLTS		0	0	2	2	2	0	0	0	0	0	0																			
	06-46-99	23448	DOS REIS	10MAY05	SMOLTS		0	0	1	0	0	0	0	0	0	0	0																			
	06-47-00	23231	JERSEY PT	13MAY05	SMOLTS		0	0	38	27	27	3	11	14	11	8	19																			
TOTAL		91563	DFP				60	43	6	7	7	0	0	0	7	0	7																			
TOTAL		68646	DOS REIS				1	0	6	7	7	0	0	0	4	0	4																			
TOTAL		23231	JERSEY PT				0	0	38	27	27	3	11	14	11	8	19																			
BY05	06-47-13	24703	MOSSDALE	04MAY06	SMOLTS		4	2	0	7	5	0	0	0																						
	06-47-14	24315	MOSSDALE	04MAY06	SMOLTS		11	1																												

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

Tuolumne River																			
RELEASE YEAR	TAG NO.	EFFECT. RELEASE	AVG. RIVER RELEASE			DATE	SMOLT RECOVERIES								OCEAN				
			FL (mm)	WT	SITE		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	SPAWN EXPD.	
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	
LG FLOW:	61110705	27404			OLGB	15APR98	30	1	6	25	312	8	0.05	19	0.36	32	104	27	
6400 cfs	61110706	7234			OLGB	15APR98	9	2	22	7	84	0	0.00	2	0.13	14	45	8	
w/o HORB	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	
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	
LG FLOW:	06-46-03	25008			OLGB	19APR99	18	61	390	62	538	3	0.03	2	0.05	29	88	35	
2000 cfs	06-46-04	25121			OFC(SJR)	18APR99	49	78	426	83	883	11	0.10	11	0.27	30	92	49	
w/o HORB	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	
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	
LG FLOW:	06-45-58	26975			OLGB	15APR00	8	10	59	0	0	3	0.03	5	0.11	22	68	31	
3800 cfs	06-45-59	23071			OFC(SJR)	16APR00	33	27	116	1	12	12	0.12	4	0.09	44	141	53	
w/ HORB	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	
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	
LG FLOW:	06-44-14	21527			OLGB	22APR01	32	0	0	0	0	10	0.09	4	0.09	5	15	4	
620 cfs	06-44-43	22051			OFC(SJR)	28APR01	165	0	0	0	0	35	0.30	13	0.28	17	58	33	
w/ HORB	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	
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	
LG FLOW:	06-44-68	25220			OLGB	24APR02	51	2	18	1	12	3	0.023	0	--	6	21	2	
1300 cfs	06-44-61	25701			OFC(SJR)	26APR02	116	1	6	0	0	1	0.007	6	0.111	4	14	2	
w/ HORB	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	
2005	05-51-36	75696			OLGB	18APR05	97	39	210	29	349	5	0.013	7	0.047	7	21		
~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	7	21		
TOTAL	LOWER	47376			OFC(SJR)	= 53.5	101	29	141	37	444	2	0.008	4	0.038	1	3		

Notes:

2002 Mossdale survival indices were calculated using tagcode 06-44-61 only, for the lower release group.

Table 3.
Tuolumne River Smolt Survival Releases and Recoveries

Release Year	Effective Release	Release Site	Recovery Sites								Trawl Combined Antioch & Chipps
			Mossdale	Salvage Expanded SWP	Salvage Expanded CVP	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	71	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	21		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 Mossdale	Salvage SWP Expd.	Salvage CVP Expd.	Trawl Jersey Pt. Antioch	Trawl Chipps	"adult" Ocean Catch	"adult" Spawn	Combined Trawl	Combined Salvage
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	<u>0.53</u>	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	4.38		1.25	0.60
							Flow Averages for yearly groups				
Avg. adj. LG high flow (1986, 1995, 1998, 2005)							5,717	2.07	1.18	1.25	0.91
Avg. adj. LG med. flow (1996, 1999, 2000, 2002)							2,265	1.01	0.60	0.59	0.83
Avg. adj. LG low flow (1987, 2001)							599	0.27	0.22	0.26	0.31

Table 5. Merced River Smolt Survival Indices

Merced Smolt Survival Index -- All Values (upper/lower) Excluding 1994 and 1997-1														Ant.&Chipp		
YEAR	RELEASE (cfs)	CRESSEY (cfs)	SNELLING DALE	MOSS- PUMPS	SWP EXP.	SWP EXP.	CVP PUMPS	CVP EXP.	JERSEY POINT	J. PT. SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	SPAWN	Salvage Comb.	Trawl Comb.
1994	554	952														
1995	3940	3880	0.577	0.746	0.998	0.808	0.811				0.746	0.750	0.813	1.061	0.86	0.75
1996	1210	1240	0.826	1.504	0.564	0.788	0.783				0.376	1.000	1.504	2.444	0.78	0.38
1997	1420	1580														
1997	578	474	0.000	0.000	0.000	0.036	0.036				0.000	0.000	0.000	0.000	0.03	0.00
1998	3220	3030	1.025			0.720	0.717	0.975	1.000	1.156	1.348	1.251	1.315	0.72	1.10	
1998	2390	2350	0.689	0.633	0.737	0.511	0.491	0.843	1.000	0.617	0.585	0.873	1.090	0.50	0.70	
1999	1340	1300	0.698	0.821	0.817	0.373	0.332	0.345	0.364	0.366	0.346	0.481	0.607	0.48	0.35	
1999	1320	1350	0.169	0.156	0.135	0.160	0.122			0.242	0.250	0.096	0.099	0.13	0.24	
2000	295	304	0.222	0.300	0.287	0.723	0.723	0.434	0.446	0.946	0.943	0.250	0.480	0.31	0.61	
2000	1750	1820	0.301	0.158	0.152	1.011	1.011	0.541	0.539	0.809	0.786	0.455	0.540	0.27	0.63	
2001	1310	1220	0.316	0.170	0.170	0.000	0.000	0.308	0.320	0.172	0.174	0.530	0.760	0.12	0.26	
2001	900	1170	0.340	0.000	0.000			0.500	0.520	0.464	0.358	0.150	0.520	0.00	0.49	
2002	196	215	0.008	0.033	0.034	0.006	0.006	0.056	0.050	0.130	0.111	0.000	0.000	0.01	0.08	
2002	439	479	0.183	0.000	0.000	0.000	0.000	0.086	0.087	0.000	0.000	0.210	0.190	0.00	0.06	
2003	681	719	0.430	0.472	0.525	0.525	0.525	0.394	0.375	0.262	0.267	0.430	0.700	0.52	0.34	
2003	519	555	0.360	0.000	0.000			0.766	1.000	0.000	0.000	1.280	0.100	1.53	0.26	
2003	1490	1490	0.400					0.357	0.400	0.951	0.952	0.310	0.510		0.71	
2004	486	776	0.16	0.000						0.000	0.000	0.000			0.50	
2004	846	1040	0.12	0.000		0.000				0.49	0.47	0.000			0.49	
2004	1500	1590	0.36	0.18		0.55				0.000	0.000				0.00	
2005	2630	2610	0.52	1.06	0.82	0.94	0.94	0.000	0.000	0.72	0.555			0.92	0.62	
2005	1780	1860	0.38	7.47	5.87	0.37	0.37	0.14	0.15	0.444	0.338			0.55	0.33	
2005	1960	2140	0.15	1.40	1.40	0.40	0.40	0.000	0.000	1.21	1.20	0.000		0.77	0.61	
2006	4170	4380	0.55	0.44	0.50	1.25	1.50	0.11	0.17	0.66	0.39			1.30	0.44	
2006	4170	4240	0.28	0.64	1.28	0.43	0.49	0.000	0.000	0.85	1.05			0.53	0.64	

Table 6. Stanislaus River Smolt Survival Indices

Stanislaus River															
All data SMOLT SURVIVAL INDEX (Upper / Lower corrected for release group number)															
YEAR	GDWN FLOW	PUSHNET RST	MOSS-DALE	SWP PUMPS	EXPD. SWP	CVP PUMPS	EXPD. CVP	J. Pt. SURV.	J. PT. IS.	CHIPPS SURV.	CHIPPS CATCH	OCEAN SPAWN	Comb Salvage	J,PT.&Chippis 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		0.22			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.

