THE INFLUENCE OF SAN JOAQUIN RIVER INFLOW, CENTRAL VALLEY AND STATE WATER PROJECT EXPORTS AND MIGRATION ROUTE ON FALL-RUN CHINOOK SMOLT SURVIVAL IN THE SOUTHERN DELTA DURING THE SPRING OF 1989

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SUPPLEMENTAL ANNUAL PROGRESS REPORT

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Part C

The Influence of San Joaquin River Inflow, Central Valley and State Water Project Exports and Migration Route on Fall-run Chinook Smolt Survival in the Southern Delta during the Spring of 1989.

Fisheries Assistance Office[1]

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1 This report is written with the California Department of Fish and Game - Region 4, Fresno and reflects cooperative efforts between the Interagency Ecological Study Program for the Bay/Delta Estuary and CDFG - Region 4.

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INTRODUCTION

San Joaquin system chinook salmon runs have declined substantially from historic levels. Positive correlations between mean spring outflow in the San Joaquin River at Vernalis and escapement to the spawning tributaries 2 1/2 years later continues to indicate the importance of spring flows to the survival of outmigrating chinook smolts (DFG 1987). These analyses have focused our attention on the spring outmigration of fall-run smolts. However, the relationship reveals little about the mechanisms by which increased tributary releases resulting in increased Delta inflow enhance smolt survival. Available information suggests that improvements in smolt survival may be obtained by increasing San Joaquin tributary flows in conjunction with avoiding the diversion to the State Water (SWP) and Central Valley (CVP) Projects export facilities in the Delta via upper Old River or other routes. Hence, intuitively one might expect higher mortalities when SWP/CVP diversions exceed the San Joaquin River inflow to the South Delta. This is because a high percentage of the San Joaquin River flow and presumably smolts are then 1) diverted directly toward the export facilities directly, or 2) their migration through the south Delta is delayed and mortality occurs through various causes including further direct losses at the facilities and indirect losses in the Delta channels.

Cooperative studies by the Interagency Program and the Department of Fish and Game Region 4 since 1985 have been designed to evaluate factors influencing smolt survival both in the San Joaquin tributaries and in the Southern Delta. Results of this work were provided to the State Water Resoures Control Board Bay/Delta Hearing in 1987 (DFG Exhibit 15 and USFWS Exhibit 31).

Smolt survival in the South Delta during the spring of 1989 was measured under high and low CVP and SWP export levels with a stable San Joaquin inflow to the Delta. These two test conditions provided an inflow/export ratio that was small (about 0.2) and one that was high (about 1.2). Variable inflow/export ratios could also be attained by holding exports stable and varying inflow or by varying both.

The 1989 studies were designed to answer two primary questions: 1) Is there a difference in smolt survival through the Southern Delta under high versus low export levels with low stable San Joaquin River inflow? and 2) Are there differences in the survival of smolts released in upper Old River versus those released in the San Joaquin just downstream of its split at the head of Old River at either high or low export levels? Previous efforts had been made to answer question two but not question one. Establishing the appropriate hydraulic and operation conditions for the 1989 tests required considerable coordination between biologists and engineers relative to stabilizing inflow and varying export rates. Although 1989 was a dry year, flexibility

in numerous power licenses and agreements in the tributaries, in conjunction with water quality standards and water project requirements throughout the Delta-Central Valley System (and Trinity River), were "balanced" to create the hydrological test conditions. Survival was estimated using mark/recapture methodology of coded wire tagged fall-run chinook smolts of hatchery origin. Smolts were released at varying sites in the Delta and recovered by midwater trawl at Chipps Island and in the future will be recovered from the ocean fishery. Additional recoveries were made at the CVP/SWP fish salvage facilities to denote the timing and routes of migration and relative mortality in relation to the hydraulic conditions present.

METHODS

Chinook smolts from Feather River Hatchery and Merced River Fish Facility were tagged with coded-wire nose tags (CWT) and their adipose fin clipped for later identification. Fish were released in groups from about 50,000 to 100,000 fish under high and low CVP/SWP export levels at three sites in the San Joaquin River Delta and near the mouth of the Stanislaus River (Figure 1).

Site Number	Name	Location
1 -	Mouth of Stanislaus River	At the confluence of the San Joaquin River
3 -	San Joaquin River at Dos Reis Park	Dos Reis County Park
2 -	Upper Old River	On Stewart Tract, 0.3 miles west of the San Joaquin River
4 -	San Joaquin River at Jersey Point	On Sherman Island, 0.7 miles west of Shads' Landing

With the exception of the Jersey Point site, releases were made on an ebbing tide or high slack for consistency and to assure immediate downstream migration. Due to the short distance from

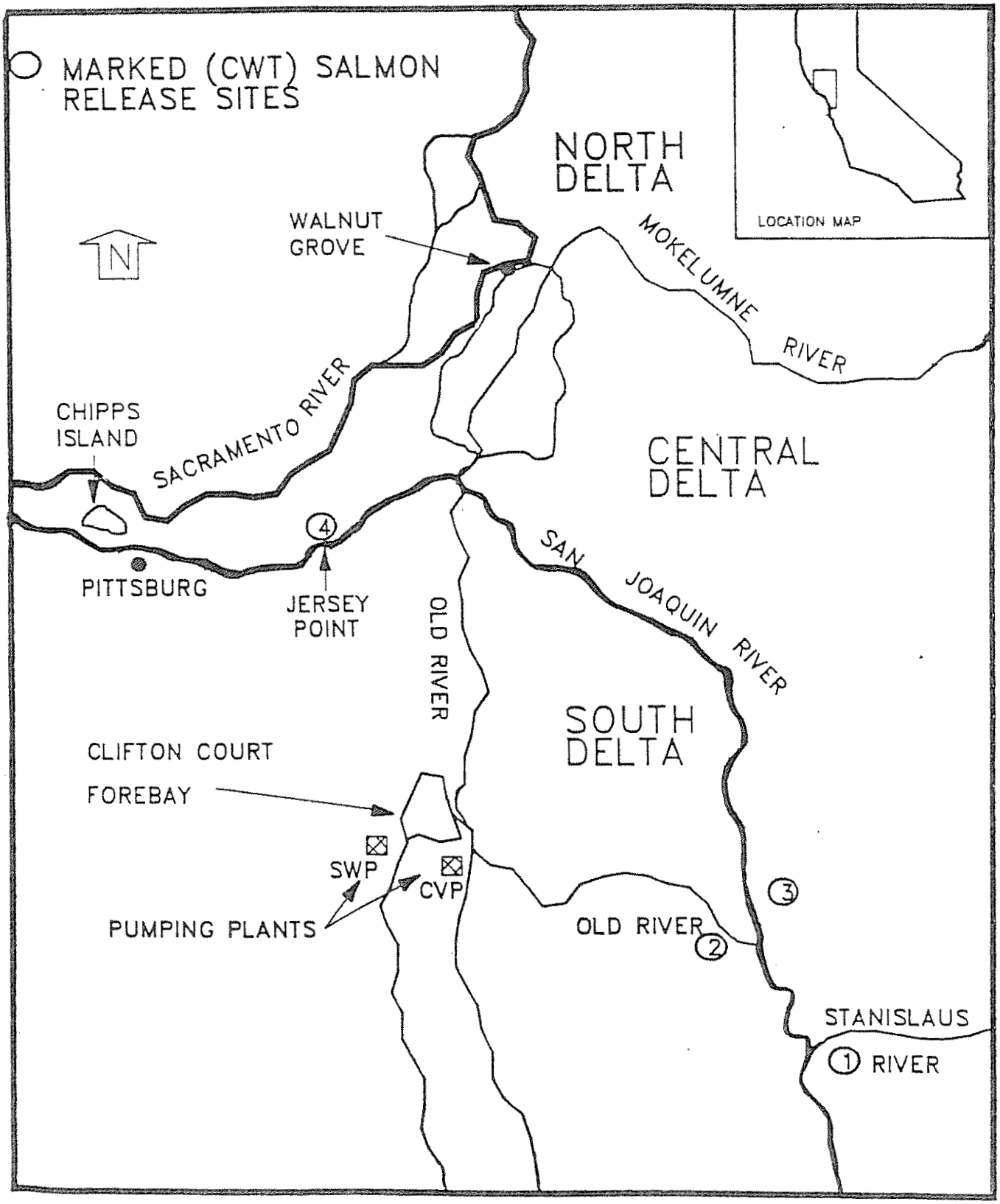

FIGURE 1. RELEASE SITES OF CODED WIRE-TAGGED (CWT) SALMON USED IN APRIL-MAY, 1989, IN THE SAN JOAQUIN RIVER DELTA.

Jersey Point to Chipps Island (12 miles) and potential short travel time, we had concern that we might miss sampling the Jersey Point group. Therefore, we released both Jersey Point "control groups" on a flooding tide in an attempt to spread their distribution, to expose them to central Delta conditions for similar time periods, and to increase their chance of being adequately sampled at Chipps Island. Fish sizes (as number of smolts/pound) were taken from hatchery truck planting receipts.

Recoveries of the tagged fish were made daily by mid-water trawl (10-20 minute tows/day) at Chipps Island (from April 19 to June 30). The number of tagged fish recovered divided by the number released and corrected for the fraction of time and channel width sampled yielded a survival index between the release point and Chipps Island for each CWT release group (See USFWS 1987). Additional recoveries were made at the CVP and SWP fish facilities between April 20 and May 18 and will be made in the ocean fishery over the next three years. Facility recoveries were expanded to account for the fraction of time sampled, typically a ten minute sample every two hours. The 95% confidence limits around the expanded tag recovery values are estimated to be about $\pm$ 25% at that level of sampling effort (Personal communication, Dennis McEwan and Barry Collins, DFG, Stockton, Ca). Project salvage crew effort was supplemented by biological aids to assure CWT smolts were recovered for later decoding. Facility sample data also were collected to enable the catches to be expanded to

estimate total salvage of CWT smolts. Coded wire tags were double or triple read to assure accuracy. Detailed specifics of each CWT release group are provided in Table 1.

The need for stable San Joaquin River flows at Vernalis for the 1989 smolt studies in the South Delta necessitated coordinated water management throughout the San Joaquin basin. Management actions to stabilize inflows at Vernalis at ~2000 cfs for about 3 to 4 weeks from late April to early May included: Purchase of New Melones storage in 1988 and wheeling 20,000 acre feet to San Luis Reservoir to augment 1989 spring releases in the San Joaquin River via Newman Wasteway; Cooperative offstream water storage evaluation in the North Grassland in the fall-winter of 1988-89 and subsequent spring dewatering of duck clubs in late April, 1989, again to augment spring flows; East side tributary flow manipulations per existing agreements (Table 2, see Nokes, 1988 and Loudermilk, 1988 for further details). An effort was made to coordinate west-side irrigation diversions (Banta-Corbona Irrigation District, Patterson Water District, West Stanislaus Irrigation District, and El Solyo Irrigation District) from the San Joaquin River.

In CVP pumping was curtailed to near 1,800 cfs and inflow to Clifton Court Forebay by the SWP was ceased between May 2-9 to achieve the low export condition with an inflow/export ratio of near 1.0. The radial gates at Clifton Court Forebay were operated the morning of May 2, but remained closed from midday through

Table 1. Release and survival information for coded wire tagged smolts released in the Southern Delta and its tributaries in April and May of 1989.

	Release Location	Tag Code	Effective # Released	Release Date	Release Time	Fish /lb	Water Temperature(°F) of River	Water Temperature(°F) of Truck	Survival to Chips Island
HIGH EXPORT	★Lower Stanislaus River	B6-01-01 B6-14-11	74073	4-19	1330	71.9	65.0	50.0	.21
	▵San Joaquin River at Dos Reis Park	H6-31-14	52962	4-20	1100	76.0	69.0	54.0	.14
	▵Upper Old River	H6-31-13	51972	4-21	1200	73.9	67.0	54.0	.09
	▵San Joaquin River at Jersey Point	H6-01-11-01-11 H6-01-11-01-12	56816	4-24	1430	119.5	64.0	50.0	.88
LOW EXPORT	★San Joaquin River at Dos Reis Park	H6-01-11-01-07 H6-01-11-01-08 H6-01-11-01-13	75983	5-2	1600	75.0	71.0	62.0	.14
	★Lower Stanislaus River	B6-14-12	46169	5-3	1300	74.8	66.0	68.0	X
	★Upper Old River	H6-01-11-01-04 H6-01-11-01-05 H6-01-11-01-06	74309	5-3	1700	75.8	70.0	62.0	.05
	▵San Joaquin River at Jersey Point	H6-01-11-01-09 H6-01-11-01-10	56233	5-5	1100	98.8	68.0	54.0	.96

★ Fish from Merced River Fish Facility

▵ Fish from Feather River Fish Hatchery
X Unusable results due to temperature and transport stress on smolts

Table 2. Tributary streamflow schedules (cfs) and resulting San Joaquin River flow at Vernalis, 15 April 1989 through 15 May 1989.

	Grasslands[1]	Newman W.W.[2]	Merced River[3]	Tuolumne River[4]	Stanislaus River[5]	San Joaquin River at Vernalis[6]
April 15	0	0	235	100	820	1599
16	0	200	235	100	814	1491
17	0	500	235	100	817	1570
18	392	300	235	100	838	1735
19	397	300	235	100	815	1925
20	412	450	235	100	818	2074
21	445	450	235	100	808	1980
22	391	450	235	100	815	2043
23	430	450	235	100	817	2066
24	421	200	235	100	752	2168
25	387	100	235	100	617	2236
26	333	200	235	550	617	2396
27	315	400	235	550	610	2340
28	286	400	235	550	607	2396
29	234	600	235	550	607	2495
30	227	800	285	550	608	2645
May 1	146	800	285	133	906	2670
2	142	500	285	133	1260	2446
3	161	200	285	75	1270	2553
4	189	200	285	75	1270	2570
5	148	200	285	3	1240	2380
6	132	200	285	3	1230	2244
7	114	200	285	3	1080	2165
8	0	0	285	3	1000	2188
9	0	0	285	3	1020	2117
10	0	0	285	3	1030	2117
11	0	0	285	3	951	2117
12	0	0	285	3	870	2117
13	0	0	285	3	868	2117
14	0	0	285	3	855	2117
15	0	0	285	3	865	2117
Acre Feet=	11307	16062	16033	8525	54523	133246[7]

1. Estimated dewatering "Offstream Storage Area" dewatering plus private wetlands, Los Banos & Volta Wildlife Mgt. Area in the N. & S. Grassland (ag drainage/fishery/wetland storage)
2. Scheduled Delta Mendota Canal release to San Joaquin River (20,000 a.f. DFG/Ducks Unlimited/Grasslands Purchase).
3. Release @ Crocker-Huffman Dam near Snelling, Ca. (fishery plus riparian supplies).
4. Release @ La Grange Dam near La Grange, Ca. (fishery supply).
5. Release @ Goodwin Dam near Knights Ferry, Ca. (fishery plus WQ. supplies).
6. USGS Station.
7. Tributary contributions (106,450 a.f.) does not equal Vernalis inflow (133,246 a.f.) due to accretion flows (26,796 a.f.).

Table 3. Mean daily Hydrological data for the San Joaquin River Delta during CWT Chinook Salmon studies in April and May 1989. Total exports = CVP Export plus Clifton Court Forbay inflow. Q West is estmate of San Joaquin River Flow at Jersey Point

Date	San Joaquin River @ Vernalis	Upper Old River Flow (cfs)	% of S.J. Diverted to Upper Old River	Clifton Court Forebay Inflow Inflow (cfs)	SWP Export (cfs)	CVP Export (cfs)	Vernalis Inflow Total exports	Q West Flow (cfs)
4-21	1980	2017	102	6447	6310	3932	0.19	-2798
4-22	2043	2039	100	6278	6314	3932	0.20	-2504
4-23	2066	2062	100	6447	6319	3925	0.20	-2613
4-24	2168	2122	98	6215	6315	3947	0.21	-2180
4-25	2231	2183	98	6249	6320	3962	0.22	-2113
4-26	2397	2348	98	6181	6320	3949	0.23	-1159
4-27	2341	2246	96	6103	6320	3967	0.23	-1490
4-28	2397	2300	96	6233	6315	3993	0.23	-1489
4-29	2497	2370	95	6516	6285	4069	0.24	-1980
4-30	2648	2433	92	6517	6275	4074	0.25	-2125
5-1	2672	2136	80	4341	2363	3703	0.33	116
5-2	2447	1712	70	974	368	2645	0.68	3900
5-3	2581	1685	66	0	322	1797	1.21	5154
5-4	2570	1696	66	0	277	1796	1.24	4638
5-5	2380	1595	67	0	360	1792	1.33	4167
5-6	2247	1526	68	0	358	1798	1.25	3994
5-7	2168	1515	70	0	343	1802	1.20	3700
5-8	2192	1466	67	0	218	1798	1.09	1173
5-9	2121	1440	68	0	249	1786	1.04	1110
5-10	2121	1545	73	811	336	2760	.69	1433
5-11	2121	1757	83	1777	2054	3161	.41	1808
5-12	2121	1905	90	3892	4476	3146	.28	-3401
5-13	2121	1905	90	4995	4628	3145	.27	-4400
5-14	2121	1884	89	4683	4261	3142	.29	-4196
5-15	2121	1926	91	3892	4660	3277	.27	-3677
5-16	1691	1606	95	5102	3833	3387	.23	-5285
5-17	1720	1703	99	6394	5092	3387	.20	-3870

May 9. Total project "exports" (CVP export plus inflow to Clifton Court Forebay) were about 10,000 cfs from April 21 to 30th resulting in a high export condition with an inflow/export ratio of about 0.25. CWT smolts were released during these divergent water conditions. Voluntary deferred exports during May 2-9, 1989 at the SWP and CVP were about 46,000 and 21,000 acre feet, respectively. The recovery of this deferred export occurred later in 1989.

Flow estimates, delta exports, tidal data and Clifton Court inflows were obtained from the Department of Water Resources (DWR). Temperature data were from measurements made at the time of release. Water quality (contaminant) monitoring data were obtained from DWR and the Regional (IV) Water Resources Control Board. Detailed physical/hydraulic conditions for 1989 are provided in Tables 2 and 3.

We foresaw several potential problems in meeting our experimental design criteria and interpreting our results. These included: 1) a low export period of only seven days that may not have been long enough for the CWT smolts to migrate through the Southern Delta under the low inflow conditions (~2,000 cfs at Vernalis) before they would be impacted by the return to high export levels and reverse flows in the western Delta Channels, 2) relatively low numbers of tagged fish per release group that would decrease the chance of recovery at Chipps Island if survivals were low, and 3) high water temperatures and relatively high loading densities

were present in the hatchery truck for the second release at mouth of the Stanislaus. This may have stressed the smolts and lowered survival by an unknown amount. We also acknowledged that this was the first year we have conducted an experiment of this type and the results would represent only one year's data. Thus, conclusions would need to be drawn with caution and the need for repeated experiments emphasized.

Results and Discussion

Comparison of Survival at High versus Low Exports

Survival of tagged smolts released under low export conditions was not greater than for those released under high export conditions (Table 4). This was an unexpected result as we believed conditions for survival should have improved when exports were lowered, since direct losses at the Project facilities were decreased, flow in the mainstem San Joaquin was increased and reverse flows in the Delta were eliminated.

We detected no differences in survival to Chipps Island between the two test conditions for fish released in the San Joaquin River at Dos Reis Park (Table 4). Smolts released in Upper Old River during high export period had greater survival than those released under low exports, although the absolute difference was small (0.09 versus 0.05) and may not reflect any real difference given sample variability and other uncontrollable factors.

Table 4. Comparison of Smolt Survival Indices for CWT smolts released in the San Joaquin River Delta at 1) the mouth of the Stanislaus River, 2) in Upper Old River and in the San Joaquin River at 3) Dos Reis Park and 4) at Jersey Point.

	1989 High Export	1989 Low Export
Mouth of Stanislaus River	.21	0*
San Joaquin River at Dos Reis	.14	.14
Upper Old River	.09	.05
San Joaquin River at Jersey Point	.88	.96

* Unusable result due to temperature stress on smolts and handling

Survival of fish released at the mouth of the Stanislaus River also was higher for the high export condition than for the low export (Table 4). We believe that this comparison was not valid since the survival index (0.00) for the low export period was biased low due to stress caused by high temperatures and high loading densities in the hatchery truck as noted earlier. The 0.21 survival index for the high export period was expected to be lower than that for the smolts released at Dos Reis Park since all of the San Joaquin River flow and presumably most of the tagged fish (at least on flood tide) were diverted into upper Old River (Table 3) at that time. In addition, CWT smolts released into upper Old River just two days later had very low survival (0.09).

Conversely, sample variability and uncertainties in smolt behavior to variable experimental conditons may prevent us from concluding that the relatively small differences in survival for these three release sites were real. It is evident that there is a need for additional release groups, better control of test conditions and a more complex experimental design to improve our chances of understanding this system.

We did observe a high survival for both groups of tagged chinook released at Jersey Point in the western San Joaquin River with a slightly higher survival index for those released under low export conditions (Table 4). Again, the difference of .08 units may not be real.

Smolts released in 1989 at both Dos Reis Park and in Upper Old River had lower survival than in previous years although the difference was greater for the Dos Reis fish (Table 5). With the exception of 1985, the data from upper Old River is low for all years. Given that they are released in a direct path to the CVP and SWP export facilities and Clifton Court Forebay where they are exposed to a combination of predation, handling stress, screen inefficiences and temperature problems, high mortality for the Old River release group is not surprising. Due to the consistently low survival data with the Upper Old River group it seems more profitable to concentrate on the results from the Dos Reis release group in attempting to understand the low, unexpected survival we observed under the low export period.

Smolt survivals for both Dos Reis groups in 1989 were lower than other years (Table 5). The low survival for the 1989 high export Dos Reis group is not surprising given that hydrological conditions (high CVP exports and high inflow to Clifton Court Forebay, and high reverse flows at Jersey Point) appear less favorable than in all previous years (Table 6).

It is important to note that Q west is a calculated value from DWR-DAYFLOW and is characterized with some uncertainty since tidal fluctuations are not part of the calculation. Hence it should be considered an index that is more representative of actual flow when viewed as an average of a week or so.

Table 5. Comparison of Smolt Survival Indices for CWT smolt releases in the San Joaquin River Delta in Upper Old River and in the San Joaquin River at Dos Reis Park.

Year	Upper Old River	San Joaquin River Dos Reis Park
1985p	.62	.59
1986p	.20	.34
1987p	.16	.82
1989p	.09	.14
1989c	.05	.14

P= Pumping (D1485)

C= Partial Export Curtailment

Table 6. Average Hydrologic Conditions and Smolt Survival During South Delta CWT Smolt Studies Between 1985 and 1989. Q West = Estimated San Joaquin River flow at Jersey Point.

Release Date	CVP Export	Clifton Court Inflow	Q West Flows	Survived to Chipps Islanad
Old River[1/]				
4-29-85	2593	2391	+ 1251	.62
5-30-86	3311	2228	+ 7772	.20
4-27-87	4282	2011	- 629	.16
4-21-89 (High Export)	3920	6327	- 2442	.05
5-03-89 (Low Export)	1797	0	+ 4330	.09
Dos Reis[2/]				
4-30-85	3045	3266	+ 587	.59
5-29-86	3061	2325	+ 7798	.34
4-27-87	3658	2435	+ 57	.82
4-20-89 (High Export)	3961	6336	- 2129	.14
5-02-89 (Low Export)	2114	356	+ 3107	.14
5-10-89 to 5-19-89	3219	4034	- 2342	.14

1/ Five day averages after release date

2/ Ten day averages after release date

Why was Smolt Survival Low During Low Export Conditions?

In considering why survival was less than expected for smolts released during the low export period, we examined the differences in various factors between the two test conditions and compared these conditions with data from previous years. The factors evaluated were: hydraulic conditions, patterns and timing of smolt recoveries at Chipps Island and the CVP/SWP fish facilities, migration rates, water temperatures, aberant contaminent levels, fish sizes and potential differences in physiological stress.

Hydraulic Conditions/Smolt Residence Time

The most plausible explanation we have found for the lack of improvement in survival under lowered export levels was that the period of low export was too short given the lower San Joaquin River inflow conditions. This prevented a portion of the tagged smolts released at the beginning of the low export period from effectively migrating past the mortality factors present in the Southern Delta before CVP export levels and inflow to Clifton Court Forebay were raised. The return to high exports resulted in high reverse flows in the Delta (reference Jersey Point, Q west) which potentially increased smolt residence time and again subjected at least a portion of the tagged smolts to South Delta mortality factors. This would have exposed these smolts to greater total in-channel mortalities associated with predation, high temperatures, unscreened Agriculture diversions, toxicity and other factors.

The seven day low export period extended from May 3 to 9 with transitional export levels on May 1-2 and May 10-11. It was followed by a rapid return to high CVP exports and high Clifton Court Forebay inflow with reverse flows reestablished in the western San Joaquin River (Qwest) (Tables 3 and 6 and Figure 2). The ratio of inflow/export decreased as planned from over 1.0 to below 0.3 (Table 3).

A review of mean tidal heights in the western San Joaquin River at Antioch, Ca. indicated that the Delta was "filling" during both the high and low export periods in 1989 as opposed to "draining" (Figure 3). This is a well known cyclic phenonemon occuring on two-week intervals with varying tidal amplitudes. Smolt migration rate might be influenced by this factor with more rapid migration and presumably better survival under a tidally induced "draining" condition in the Delta. However, evaluation of existing data from 1985, 1986, 1987 and 1989, indicated that this theory can not be refuted or supported with existing information. It is likely that we are unable to separate "cause and effect" mechanisms from this "relational data".

The high and nearly similar survivals for smolts released at Jersey Point in the western San Joaquin for the two test conditions (Table 4) suggest that the high negative flows seen at that location, during both the high export period (April 21-May 1) and during the post-low export period (May 10-19)(Figure 2), had only a minor, if any, effect on the overall survival of the Jersey Point groups. However, some fish from both groups were salvaged

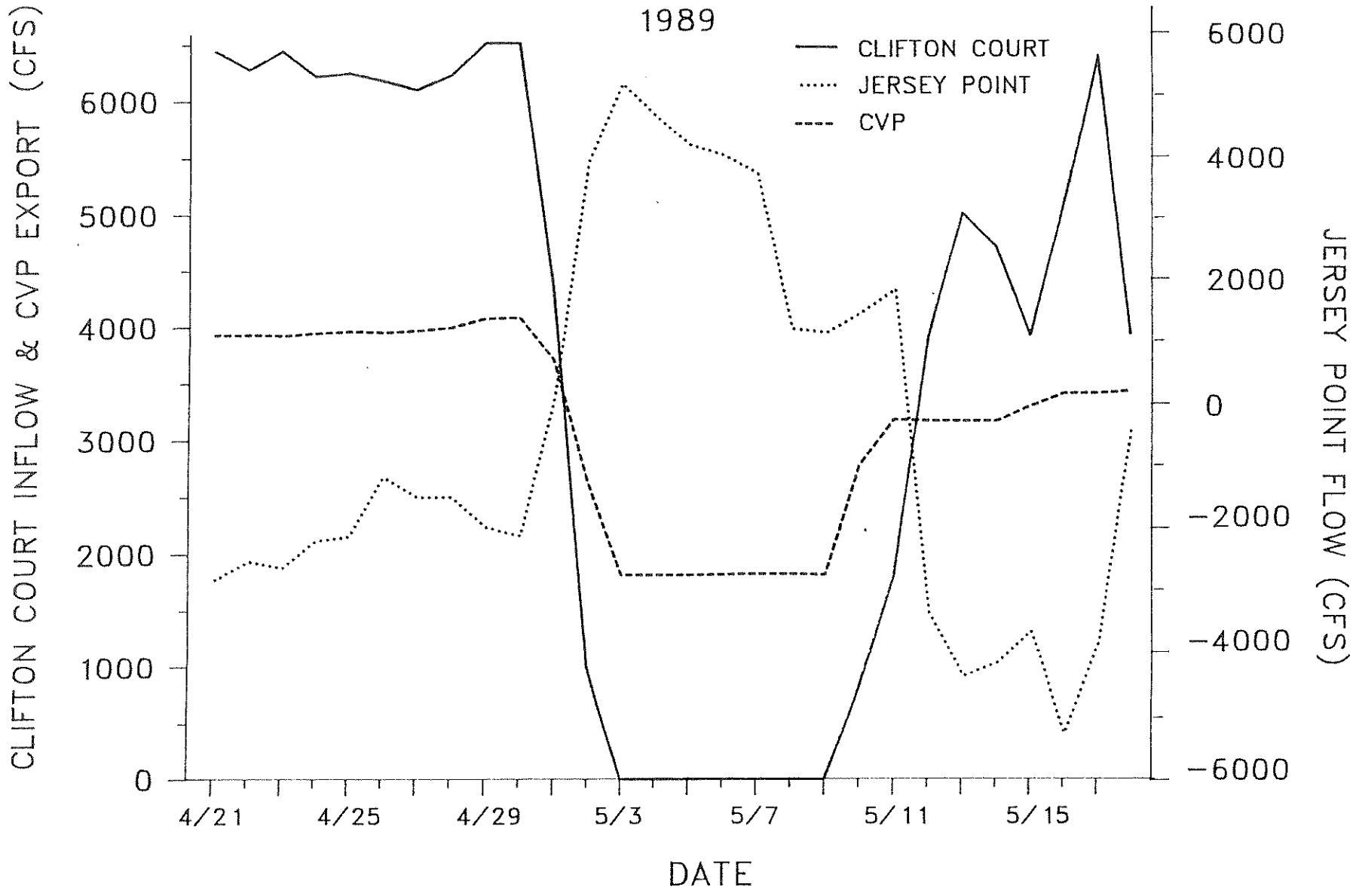

FIGURE 2. HYDROLOGICAL CONDITIONS TO WHICH THE CODED WIRE-TAGGED CHINOOK SALMON SMOLTS WERE EXPOSED DURING THE SPRING OF 1989. INCLUDING CLIFTON COURT FOREBAY INFLOW, CVP EXPORT AND SAN JOAQUIN RIVER FLOW AT JERSEY POINT.

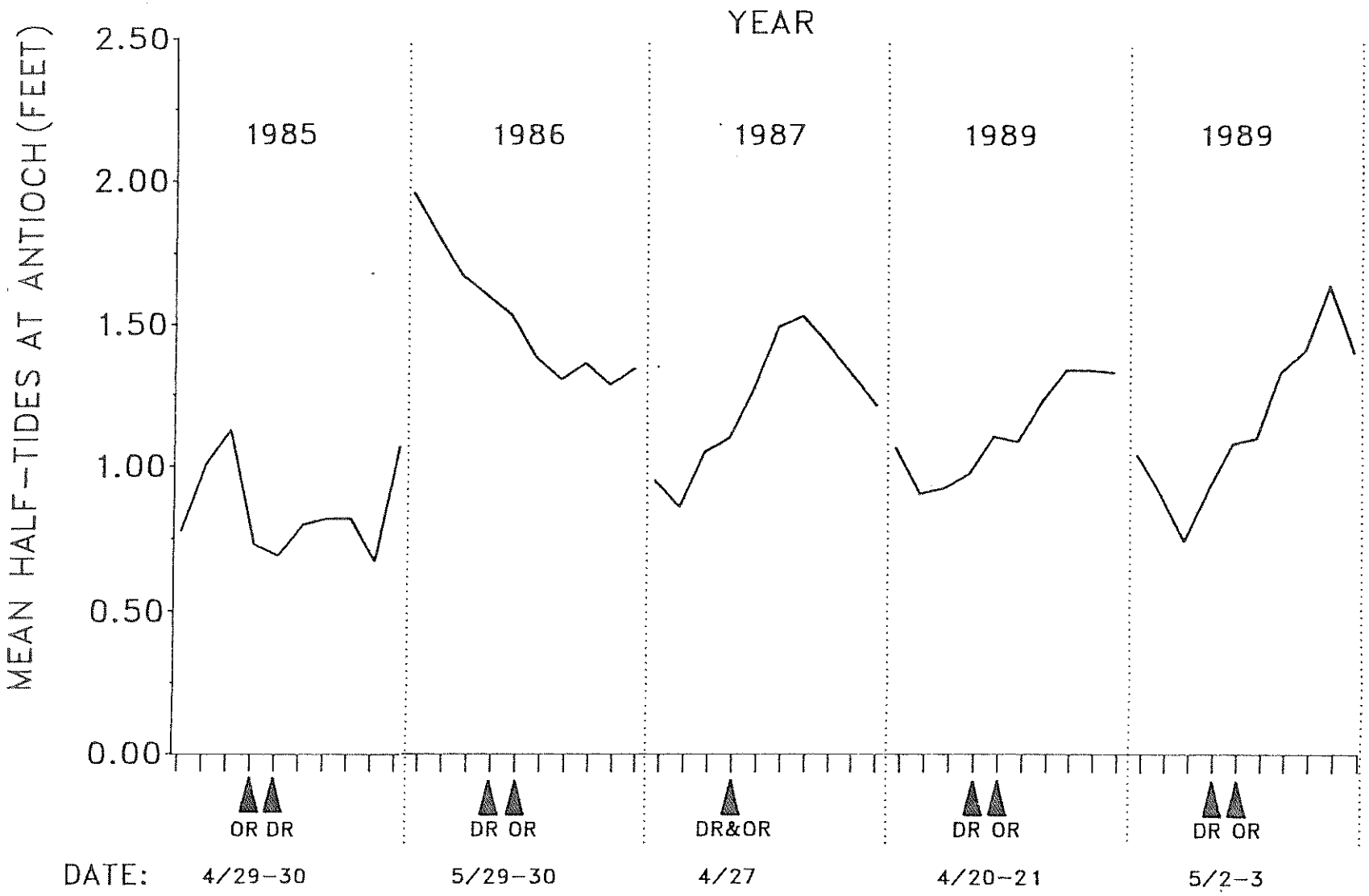

FIGURE 3. MEAN HALF-TIDES AT ANTIOCH OVER A TEN DAY PERIOD SURROUNDING CODED WIRE TAGGED CHINOOK SALMON SMOLT RELEASES (▲) AT UPPER OLD RIVER (OR) AND ON THE SAN JOAQUIN RIVER AT DOS REIS (DR) PARK FOR THE GIVEN YEARS.

at the State Facility. These observations, although based on only one years data, indicate that the conditions that caused high indirect mortality for the smolts released at Dos Reis were most pronounced in the San Joaquin River and other South Delta channels upstream (south and southeast) of Jersey Point.

Average net flow in the western San Joaquin (Qwest) during the ten days following smolt release does not explain the variability we have seen in our Dos Reis smolt survivals between 1985 and 1989 (Table 6). However, the three survivals of Dos Reis fish released before 1989 were higher and Qwest flows were all positive (Table 6). We believe that the lowest of the three survivals, that for 1986, may have been biased low due to our missing a portion of tagged smolts as they passed Chipps Island. This was supported by the fact that our peak recovery of that group was on the same day as our first recovery. This pattern is atypical of other years (Table 7). The pattern of recovery at Chipps Island for this group was most similar in 1985 and 1989.

The survival for the Dos Reis release group during the high export period in 1989 was the lowest we have seen and Qwest flow was strongly negative (Table 7). Survival was the same for the lower export period which was characterized by very positive Qwest flows initially and which then became strongly negative. As discussed below, the pattern of recovery at Chipps Island indicates that the Dos Reis CWT fish were still in the Delta after the seven day low export period.

Table 7. Days between release and recovery for CWT smolts released in the San Joaquin River at Dos Reis Park and in Upper Old River and recovered at Chipps Island, 1985-1989, and average San Joaquin river flow at Jersey point (Q west).

Upper Old River

Release Date	First Recovery	Peak Recovery	Last Recovery	Average Jersey[1/] Point Flow (cfs)
4-29-85	7	7	19	+ 1251
5-30-86	2	3	7	+ 7772
4-27-87	3	3	9	- 629
4-21-89 (High export)	4	5	13	- 2442
5-3-89 (Low export)	0	6	12	+ 4330

San Joaquin River (at Dos Reis)

Release Date	First Recovery	Peak No. Recovery	Last Recovery	Average Jersey[2/] Point Flow (cfs)
4-30-85	5	10	26	+ 587
5-29-86	4	4	10	+ 7798
4-27-87	4	10	17	+ 57
4-20-89 (High export)	0	8	19	- 2129
5-2-89 (Low export)	6	8	27	+ 470*

1/ Five days after release date

2/ Ten days after release date

* Average 20 days after release date

Smolt Migration Time/Pattern

Data from both 1989 and previous years indicated that the migration time for surviving smolts to reach Chipps Island from Dos Reis Park varied from 5 to 10 days based on the days between release date and the date the highest number of tagged fish were recovered at Chipps Island (Table 8). The migration times for the 1989 Dos Reis fish was similar to other dry years (1985 and 1987). The shorter travel time for the fish in 1986 reflect the higher San Joaquin River inflow relative to exports that year (Tables 3 and 8).

These "median" migration times do not reflect the period of time it took all the survivors of a given release group to reach Chipps Island which is better reflected by the number of days between release and last recovery (Table 7). The above discussion emphasizes the need for an adequate duration for the export curtailment condition if we are to generate a valid survival index for the low export period. Of equal importance is the influence of Delta inflow on the duration of the curtailment needed since smolt migration rate through the Southern Delta appears to increase as inflow rises. Greater inflow would reduce the duration of curtailment required. Lowering exports for one week in 1989 under the low inflow did not provide the desired test conditions.

Table 8. Migration time for Chinook Smolts released in the South Delta. Values are in days between date of release and date of maximum number of recoveries at Chipps Island.

Release Site	1989 High Export	1989 Low Export	1987	1986	1985
Upper Old River	5	5	3	3	3
San Joaquin River at Dos Reis Park	8	8	10	4	10
San Joaquin River at Jersey Point	10	5	-	-	-

Based on 1986 results, when Vernalis inflow was about 7,000 cfs and the combined CVP/SWP diversion of about 5,400 cfs, the tagged smolts from the Dos Reis release in that year took about ten days to complete their migration through the Delta (Table 7). If total project diversions were decreased to near 2,000 cfs as in the 1989 low export period, it is possible that a Vernalis inflow of 6,000 cfs for a week may be sufficient to yield a valid test. The 1989 pattern of recovery at both Chipps Island (Figures 4 and 5) and the CVP and SWP fish facilities for the Dos Reis groups, (Appendices 1 a-b), indicate that a large fraction of the tagged smolts were in the Southern Delta well after the time that export and inflow levels were raised and the inflow/export ratio was again decreased.

The two Jersey Point groups showed a difference in migration times based on peak recoveries at Chipps Island (Table 8). Fish released under high reverse flows in the western San Joaquin took ten days to reach Chipps Island compared to five days during the low export period when initially flows in the western San Joaquin were positive. The time between release and last recovery at Chipps Island for both these groups was, however, lengthy (20 and 21 days). By comparison the Dos Reis Park groups took 19 and 27 days until the last CWT recovery was made (Table 7).

Some of the smolts from both of the Jersey Point release groups were drawn upstream to the SWP fish salvage facility (Figure 6) indicating that hydraulic conditions in the western San Joaquin

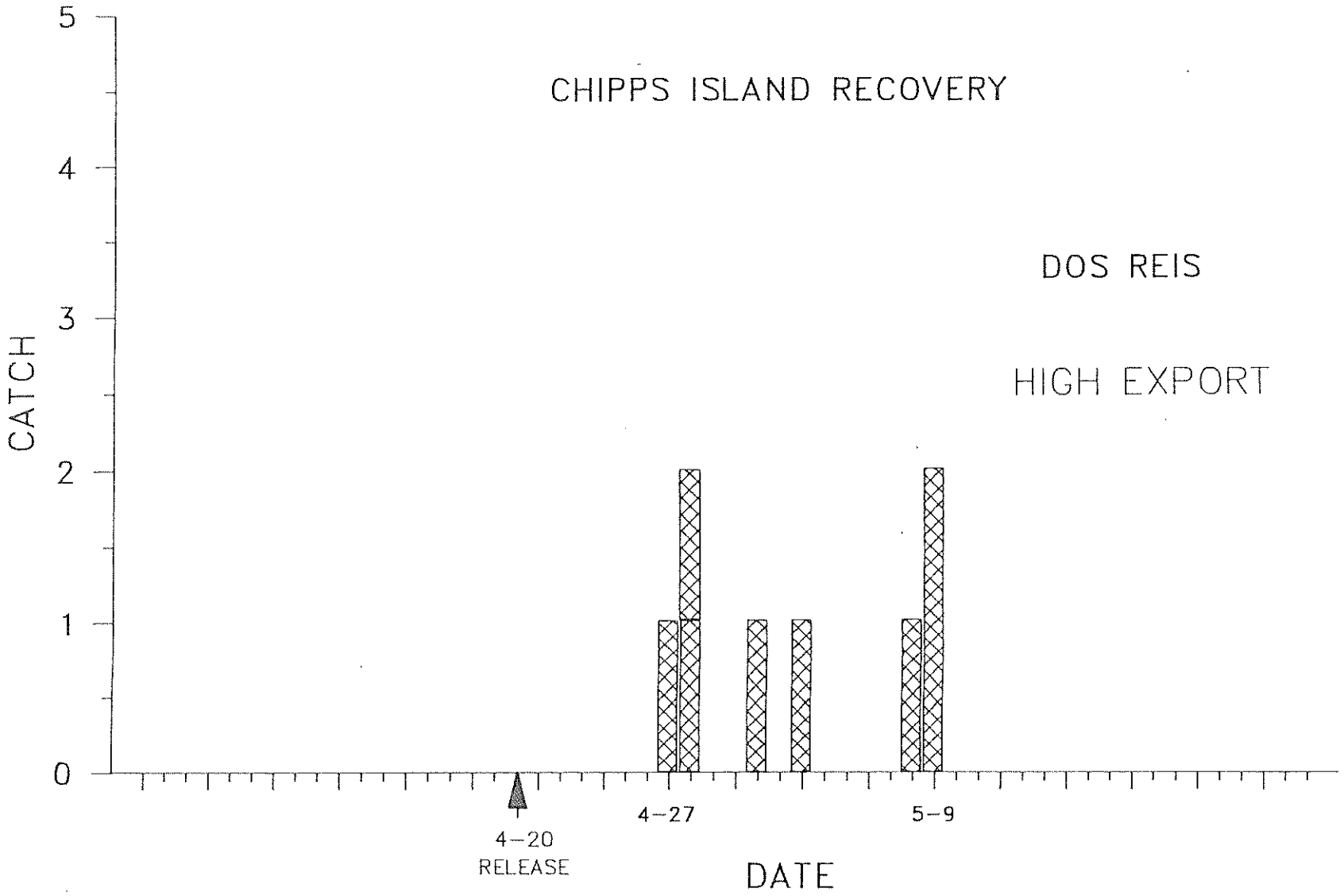

FIGURE 4. DAILY RECOVERIES AT CHIPPS ISLAND OF CODED WIRE-TAGGED CHINOOK SALMON SMOLTS RELEASED (▲) IN THE SAN JOAQUIN RIVER AT DOS REIS PARK ON 4/20/89.

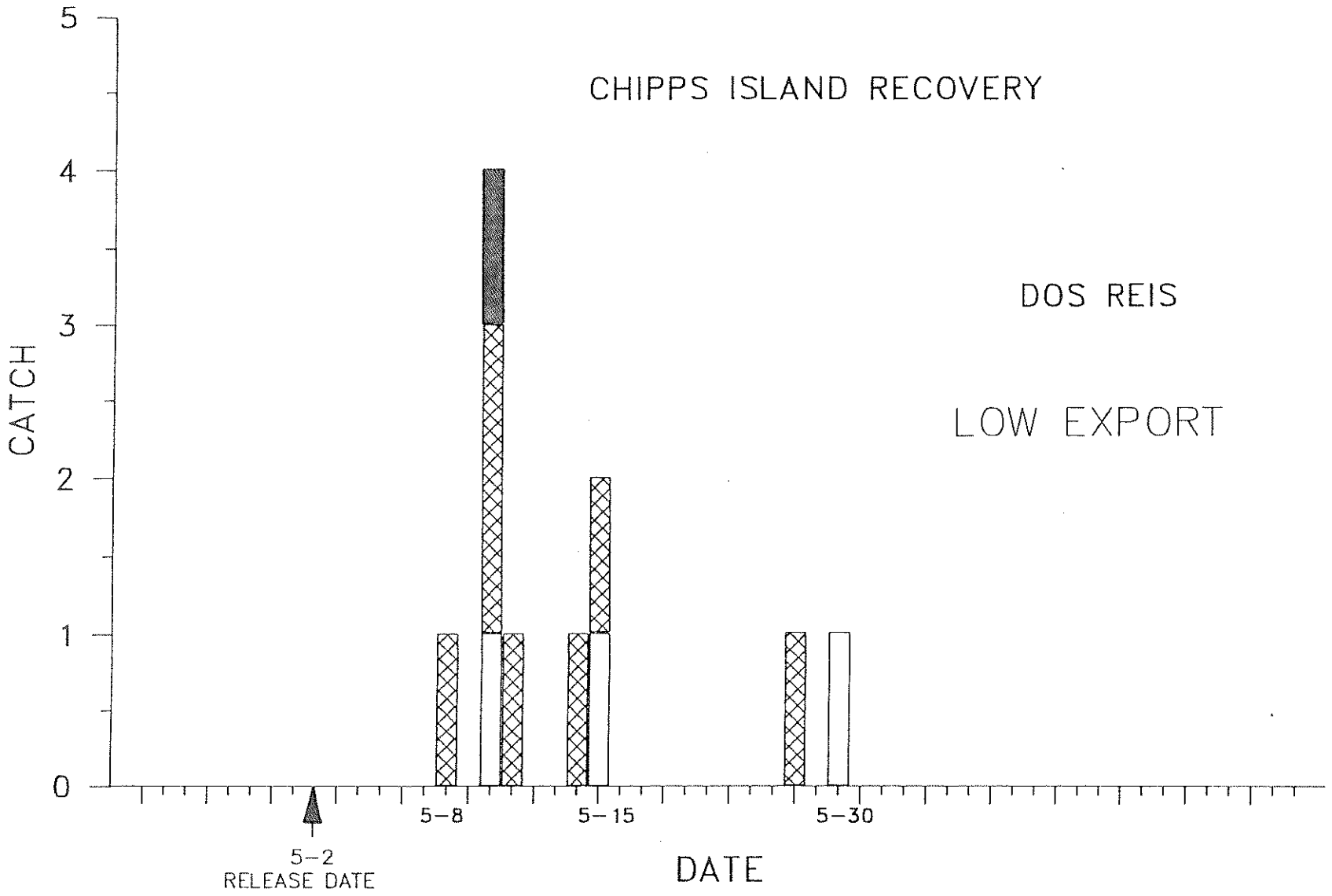

FIGURE 5. DAILY RECOVERIES AT CHIPPS ISLAND OF CODED WIRE-TAGGED CHINOOK SALMON SMOLTS RELEASED (▲) IN THE SAN JOAQUIN RIVER AT DOS REIS PARK ON 5/02/89. VARIED BAR PATTERNS (SOLID, HATCHED, OPEN) REFLECT DIFFERENT CODES USED ON THE SINGLE RELEASE DATE.

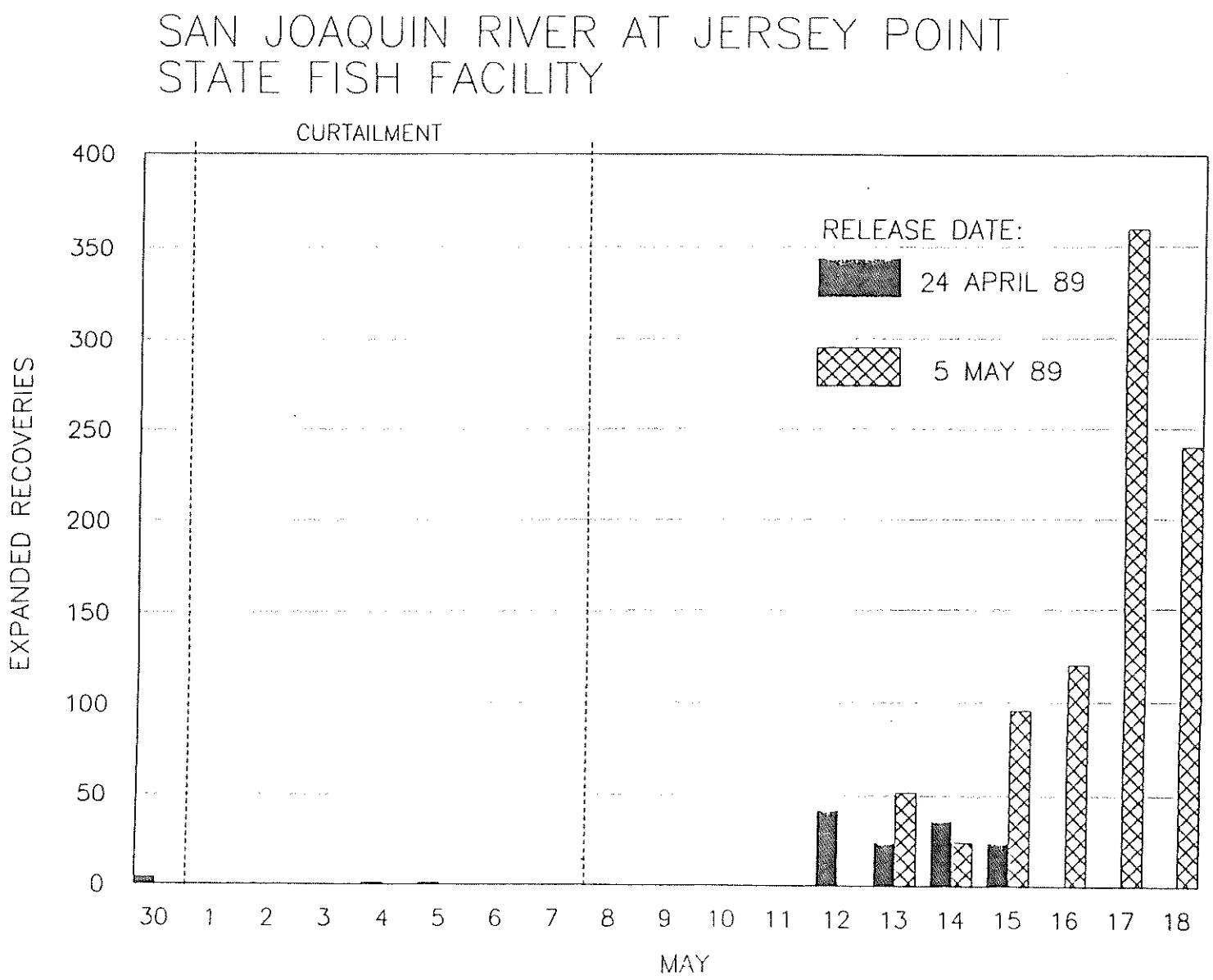

FIGURE 6. DAILY EXPANDED RECOVERIES FROM THE STATE FISH FACILITY OF CODED WIRE-TAGGED CHINOOK SALMON SMOLTS RELEASED IN THE SAN JOAQUIN RIVER AT JERSEY POINT ON APRIL 24 AND MAY 3, 1989

River during the 1989 experiment had an effect on these fish and their subsequent residence time in the Delta. However, the number of fish recovered at the State facility for the May 5th Jersey Point release group may have been biased due to the fact that the recoveries for May 17 and 18 were expanded from a recovery of one CWT fish from a one minute sample rather than the typical ten minute sample. None of the Jersey Point smolts were recovered at the CVP facility which is typical of CWT smolts released in the Central and Northern Delta.

Fish Facility Recoveries

The percentage of tagged smolts recovered at the CVP and SWP fish salvage facilities relative to the number released was very low (6.9 and 2%) for both Upper Old River releases made in 1989 when compared to past years (Table 9). Patterns of recovery of both release groups are shown in Appendices 1a-1d. The low recovery rate (2%) for the lower export period may be explained by the absence of flow into Clifton Court Forebay while the smolts migrated past the Federal and State intakes and downsteam in Old River and Victoria canal. The low recovery rate for the high export period may reflect higher in-channel or Clifton Court mortality during 1989. Past work by the Interagency Fish Facility Program has shown high mortality (average 83%) for tagged smolts in the Forebay that is attributed to predation by striped bass (Kano 1985).

Table 9. Percentage of the number of CWT Chinook Smolts released that were recovered at the State and Federal Fish Facilities.

Release Site	1989 High Export	1989 Low Export	1987	1986	1985
Upper Old River	6.9	2	27	74	20
San Joaquin River at Dos Reis Park	5	0.6	8	3	3
San Joaquin River at Jersey Point	0.2	1.6	NR	NR	NR

NR = No Release

Another possibility for the low facility recoveries is that louver screen efficiencies at the CVP facility may have been lower during the low export period resulting in lower salvage rates for smolts from the upper Old River release group. Louver efficiency is related to "approach" velocity past the louvers and is optimal for smolt sized salmon at a given range of velocities. This could have been different at the lower pumping level of about 1800 cfs CVP export in early May and we would expect that louver efficiency would be poorer at a lower velocity. Unfortunately, we have no data on the efficiences of the CVP louver screens.

Water Quality/Fish Characteristics

Our comparisons of both water quality and fish characteristics during the two tests did not provide clear evidence to explain the lower survivals during the low export period. Two issues were raised, that of potential fish stress and toxicity, which could have affected the results to some degree. Smolts raised and tagged at the Merced River Fish Facility were exposed to higher than normal water temperatures (50 to 54° versus 62 to 68°F) during transport (Table 1). These fish were used for the, lower Stanislaus, Dos Reis, and Upper Old River releases during the low export test period. Fish released at these sites during the high export test were from Feather River hatchery and exposed to normal transport temperatures. As discussed earlier, we believe the lower Stanislaus group released under low export conditions was adversely affected by both high transport temperature and high

truck loading density, and thus concluded its survival index of zero was unusable. We do not know the specific effect of the warmer truck temperatures (62°F) on the post-release survival of either the upper Old River or Dos Reis Park groups for the low export release. There was no indication that these two groups were stressed when observed at the release site.

Pesticide/herbicide monitoring by DWR on May 16, 1989 in the Southern Delta indicated that at the levels measured contaminants were not expected to be harmful to fish. Diuron, a common herbicide, was found to be at 0.09 ppb near Mossdale on May 11 and near Stockton at 0.25 ppb on May 10. Both were above baseline levels.

Pesticide montitoring by the Regional (V) Water Quality Control Board for EPA (Environmental Protection Agency) in June of 1989 indicated that levels of Eptam, Diazinon, and Carbaryl were at unacceptable levels based on EPA criteria (Wescot, 1989 and Foe, 1989). The results infer that "slugs" of contaminants in the San Joaquin River are not uncommom. Therefore, since no monitoring was done during the tagged smolt test periods, it is possible that toxicity could have contributed to the low survival observed during the low export period. No fish kills were reported, however, which might have been expected if contaminant levels were actually high enough to kill smolts.

Both temperature conditions and the sizes of tagged smolts at the time of release were similar for the low and high export periods and therefore did not explain the identical survivals for the Dos Reis fish under the two test conditions (Table 1).

We do not believe the higher temperature (up 2°F) during the lower export period was sufficient to lessen survival enough to overcome the increase in survival we expected with the decrease in exports. As noted earlier, this does not mean that high temperatures of 68-71 °F would not be detrimental to smolt survival in general. Field observations during trawling at Mossdale indicated that temperatures exceeding 67°F are stressful to chinook smolts. Data from the Sacramento River Delta indicates a linear and negative relationship between smolt survival and water temperature (USFWS, 1989.

The Jersey Point smolts were smaller than the other groups (99 to 119 per lb.) which would be expected to lessen their survival. Their survival, however, was much higher than for the other release groups (Table 4) suggesting that size-at-release differences in 1989 do not explain the low survivals for the Dos Reis releases.

We had some concern that fish from Feather River hatchery (released under high export conditions) might be hindered in some way in their migration out of the south Delta since their parental origin was from the Sacramento Basin. We could not evaluate this

concern but their survival was as high as those from the Merced Fish Facilitiy released under the low export conditions suggesting that this concern may not be warranted. It does however highlight the need for greater numbers of smolts from San Joaquin basin origin to conduct more valid tests in the San Joaquin basin and Southern Delta.

Effect of Migration Route on Survival

The survival of tagged smolts through the Southern Delta was again greater for those released in the San Joaquin River at Dos Reis Park than for those released in Upper Old River (Table 5). This result was true for both the low and high export periods. The differences in absolute values were small but the relative differences were rather large. As noted earlier, we suffer from a limited number of releases with which to test differences in a statistical sense. Based on data obtained since 1985, we see that in four of the five comparisons survival was better for smolts released in the San Joaquin River.

Several reasons have been proposed for the lesser survival we have again observed for the Upper Old River groups. Those smolts are exposed to a longer migration route and reverse flows in lower Old River, Middle River and other South Delta channels. Both of these conditions could expose the fish to longer in-channel predation, high Southern Delta temperatures, unscreened delta diversions and potential contaminants. In addition, smolts migrating west in Upper Old River are on a direct line to the CVP and SWP export

facilities where predation occurs in Clifton Court Forebay, at the trashracks and screens, and in the salvage channels of both facilities. While louver efficiency for smolt sized fish can be reasonably high (about 80%, as measured at the SWP) if approach velocities are satisfactory, some are lost directly to the pumps. Handling and trucking mortality also is present in the salvage process(Raquel, 1989).

The migration period to Chipps Island for both of the Upper Old River releases in 1989 was faster than for those released in the San Joaquin River at Dos Reis Park (Table 7 and 8). This trend also is true for earlier years and suggests, given the high percentage of flow and presumably smolts that are diverted into upper Old River, that at least in non-wet years, most of the naturally produced smolts are drawn into Upper Old River and those that survive to Chipps Island are being trucked to the Western Delta via the CVP/SWP salvage process.

It is interesting to note that the survival indices of fish released in upper Old River have decreased between 1985 and 1989. While this trend may not be real, again due to sample variation and our limited data, it could be reflecting some increase in either direct or indirect mortality over time in that part of the Delta.

Conclusions

1. Our measure of smolt survival in May of 1989 at low CVP/SWP export rates under a low, stable San Joaquin River inflow was biased low because the export curtailment period was too short to allow the tagged smolts to migrate through the Delta before high export conditions returned.

2. A short curtailment period of one week, as used in 1989 may be sufficient if a higher San Joaquin River inflow (~6000 cfs) was combined with low total exports (~2000 cfs) since there is some evidence that smolt migration rate appears higher at higher flows.

3. Survival of smolts released into upper Old River continued to be less than those released into the San Joaquin below the head of Old River.

4. Recoveries of CWT smolts released in upper Old River were much lower under high export conditions of April, 1989 than expected suggesting a low louver screen efficiency at the CVP facilities and/or higher mortalities in Clifton Court Forebay.

5. High survival indices observed for tagged smolts released at Jersey Point in the western San Joaquin River compared to those released at Dos Reis Park suggests that indirect mortality in the south Delta occurs upstream of Jersey Point.

6. Quantification of indirect Project losses (those occurring in the south Delta channels) of interest to Article 7 negotiations of the Four Pumps Agreement were not available from the 1989 study due to the limited release sites, lack of data as to what migration routes a given release group took, and facility loss estimates specific to release times and what fraction of a CWT group was exposed to both the CVP and SWP intakes. Meeting these needs requires considerable effort and long term committment.

Future Study Needs

There are a great variety of potential studies that would yield results to improve our understanding of smolt survival in the San Joaquin Delta. Many of these would require an increase in the supply of CWT smolts (preferably from the San Joaquin drainage) to conduct the studies effectively. The studies listed below are not necessarily listed by priority.

There is a need to:

1. Evaluate the survival of smolts under a wide range of inflow/export ratios with particular emphasis to ratios between 1.0 and 5.0 when inflow is greater than about 5000 cfs.

2. Document the proportion of smolts that are diverted into upper Old River under varied flows, export rates and tidal conditions.