TASK 15. RIVER AND DELTA MORTALITY

15.1 OBJECTIVE

The objective of the mark and recapture studies was to document the mortality of out-migrating chinook salmon in the river between Camanche Dam and Lake Lodi, in Lake Lodi, and in the Delta. BioSystems also attempted to identify the factors which contribute to losses of chinook salmon smolts in Lake Lodi.

15.2 METHODS

15.2.1 Lake Lodi Pilot Studies 1990

Two pilot studies were conducted on 24 May and 12 June 1990 to assess smolt mortality in Lake Lodi. In the first study, 2,195 smolts were batch marked at the MRFH using the Panjet mark technique in which a small amount of water soluble dye (Alcian Blue, 64 mg/ml) is injected into the fin rays of smolts using spring pressure. In the second study, 1,900 smolts were batch marked at the hatchery. The caudal fins were Panjet marked in the first pilot study and the left pelvic fins were marked in the second study. This marking technique has been widely used in fisheries studies (Hart and Pitcher 1969; Starkie 1975; Solomon and Templeton 1976; Pitcher and Kennedy 1977; Harcup et al. 1984).

After marking, a random sample of smolts (n=57) was measured and weighed and their general condition noted. In the first pilot study, the number of fish that died from handling and marking was monitored by placing all marked smolts in two 1.2 m x 1.2 m holding units (0.63 cm mesh) in the end raceway at the hatchery for 24 hr. A total of 959 marked smolts (44% of total) died during the 24-hr holding period. These fish probably died as a result of high concentrations of metabolic waste and low levels of dissolved oxygen in the holding units caused by debris from the hatchery raceways that clogged the mesh. Because of this high mortality, it was decided that fish would not be held in the hatchery during the second pilot study.

In both studies, marked smolts were transported in an Eagar transportation tank (supplied by CDFG) and released downstream at the confluence of Lake Lodi and the Mokelumne River (Highway 99 Bridge). At the release site, a subsample (n=50) of smolts was held in the river for 12 hr to monitor the mortality resulting from transportation and handling.

After release, the CDFG smolt trap and the BioSystems fyke net trap at Woodbridge Dam was monitored for recaptured smolts (see Task 14). A subsample of recaptured smolts were measured for size comparison with smolts prior to release.

15.2.2 River Mortality Study 1991

The Panjet marking methods described above also were used during the 1991 river mortality studies. The 1991 study was more comprehensive and more smolts were released. Marked smolts were released in the river at Camanche Dam, near the confluence of the river and Lake Lodi at Bruella Road, and in Lake Lodi near the WID Canal.

Groups of smolts were Panjet marked using different fin combinations to identify the groups. On 11-12 May, 23-24 May, and 5-7 June, approximately 5,000 marked smolts were released at each river site and 500 were released in front of the diversion screens at the mouth of the WID Canal. In all, 30,687 marked smolts were released into the river and 1,594 were released at the diversion screens sites.

All fish were marked at the MRFH. After marking, a random sample of smolts were measured and weighed. In 1991, all marked fish were held in the EBMUD holding tanks for a 24-hr period to record any deaths caused by marking and handling. Fish were then transported downstream to the release sites. At the Camanche Dam and Bruella Road release sites, 100 marked smolts were held in the river for 8 to 12 hr to observe any delayed mortality resulting from handling.

The CDFG smolt trap and the BioSystems fyke trap installed at Woodbridge Dam were monitored daily for marked smolts. The number of recaptured smolts and their fin markings were recorded. When large numbers of marked smolts were trapped, only a subsample of smolts (n=50) was processed. All recaptured fish were then transported to the estuary for release in the estuary at Rodeo (Bennett's Marina).

15.2.3 Predator Study 1991

Variable-mesh gill nets (mesh size 2.5-12.7 cm) were set in Lake Lodi to study predation on migrating smolts in front of the diversion screens at the mouth of the WID Canal. Gill nets were set on 24 May and 7 June, 1991 to coincide with the release of marked smolts. On each occasion, five gill nets were used; after 24 hr the gill nets were removed and all captured fish were counted, measured, and weighed. The stomach contents of the trapped fish were examined for salmon parts. A number of steelhead rainbow trout stomachs were examined for the presence of salmon smolts during monitoring of the out-migration traps at Woodbridge Dam in 1990 and 1991 (Task 14).

15.2.4 Coded Wire Tagging

15.2.4.1 1991

In 1991, two groups of approximately 100,000 smolts were injected with coded wire tags at the MRFH from 30 March to 24 April 1991. In batches of 20, the smolts were anesthetized with MS222 and their adipose fins removed. A team of four operators then injected standard

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1-mm coded tags into the fishes' heads using EBMUD's four MK IV tag injectors (Northwest Marine Technologies, Washington).

Immediately following tagging, smolts were released through quality control devices (QCD) to check tagging and to identify smolts that had lost their tags. The devices separated tagged smolts from untagged fish into holding tanks. Untagged fish were again passed through the system to be retagged. Throughout the whole operation, operator and injector efficiency was monitored both by inspection and dissection of tagged smolts. At 2-hr intervals, 200 previously tagged smolts were reinserted through the QCDs to verify tagging. In addition, a subsample of smolts (n=10) was dissected on a daily basis to check tag depth and placement within the smolt's head. High tag loss would indicate operator problems or injector malfunction.

Halfway through the first marking schedule, it became apparent that untagged smolts were not being separated from the tagged population. It is likely that a large number of untagged smolts were released into the holding tanks with tagged smolts. The filters in the QCD were clogged, which hindered water pressure and prevented smolts from being separated. After the problem was identified the filters were cleaned at frequent intervals.

To record mortalities resulting from tagging and handling, the smolts were maintained in the EBMUD tanks for 5 days immediately following tagging and were then held in the raceways for a further 15 days. After 20 days, a subsample of 2,000 smolts was removed from the raceways and checked for coded wire tags using one of the injector QCDs. The number of smolts without tags was used to adjust the total number tagged in the raceway. Prior to release of both groups, a subsample (n=400) of smolts was measured and weighed.

The total number of smolts was also estimated by volumetric analysis conducted by CDFG. The total number of tagged smolts estimated by volumetric methods was adjusted to account for the percentage of tag loss described above. On two occasions during the second coded wire tag operation, accuracy of this method was tested by comparing totals obtained during volumetric analysis to totals obtained by the QCDs. During the first test (18 April), CDFG estimated a total of 64,340 smolts using volumetric analysis and the QCD total tag count was 63,613 fish, a difference of 1.1 percent. Similarly, during a second test on 23 April, CDFG estimated 39,815 smolts and the QCD recorded 39,584 smolts, a difference of 0.6 percent.

All coded wire tagged (CWT) smolts were removed from the hatchery and released by CDFG at New Hope Marina, below the confluence of Delta waters and the Lower Mokelumne River. The first group was released on 23 April and the second group was released on 6 May. At the release site, 100 smolts were held for 8 hr to record any post transportation mortality. The total number of recaptured smolts, along with recovery rates and decoding, was carried out by M. Kjelson (U.S. Fish and Wildlife Service [USFWS]) during routine sampling near Chipps Island in the Sacramento River.

15.2.4.2 1992

The methods employed during 1992 were similar to those used during 1991, except that a different location was used during 1992 CWT operations to reduce handling stress and to avoid problems with the QCD filters encountered in 1991. The CWT equipment was set up at one of the hatchery's raceways instead of using separate holding tanks. After tagging, smolts were released directly into the raceway. Daily mortalities for both CWT groups were recorded by CDFG personnel.

Tagged fish were injected with coded wire tags from 24 March to 17 April 1992. All tagged smolts were released by CDFG at New Hope Marina: the first group was released on 21 April and the second was released on 6 May 1992. Post transportation mortality was also monitored at the release site.

15.3 RESULTS

15.3.1 Pilot Studies 1990

Of the 2,195 smolts marked at the hatchery, 959 died in the hatchery and an additional 19 died during transport. Therefore, a total of 1,217 smolts (adjusting for mortality) were released during the first pilot study near the confluence of Lake Lodi and the river (Highway 99 Bridge). None of the smolts (n=100) held in the river died. Overall, 123 smolts (10.1%) were recaptured at Woodbridge Dam. The majority (56.1%) of marked smolts were recaptured within 8 days of being released (Table 15.1); however, marked smolts continued to be caught until 12 June, 20 days after release. More marked smolts (82.9%) were recaptured in the CDFG box trap than in the fyke trap (Table 15.1). On 27 May, water spilled over Woodbridge Dam possibly taking some smolts with it; these fish would not have been captured. Therefore, it is suspected that the survival rate of marked smolts during the first pilot study was underestimated.

During the second pilot study, 1,800 smolts of the original marked 1,900 were released immediately into the river near the confluence of Lake Lodi and the river (Highway 99 bridge); subsequent mortalities caused by the effects of marking and transporting were determined by monitoring the remaining 100 smolts at the release site for 12 hr. During this 12 hr period, 8 percent of the subsample died and the remainder were released into the river. Adjusting for mortalities, it was estimated that 1,748 smolts were actually released on 12 June. A total of 509 marked smolts (29.1%) were recaptured, mostly (97%) in the CDFG trap (Table 15.1). Most recaptured smolts (75.8%) were taken within 5 days of release; however, the last smolts were recaptured in the traps on 2 July, or 20 days after release.

The average lengths of recaptured fish was greater than those of fish measured prior to release (Table 15.2), an indication of growth.

Table 15.1. Total number of smolts released and recaptured during the 1990 pilot studies. Daily percentage recapture is also reported.

DATE	DFG BOX TRAP	FYKE NET	TOTAL	PERCENTAGE RECAPTURE	DAILY RECAPTURE PERCENTAGE	WATER TEMPERATURE (°C) AT WOODBRIDGE DAM[1]
FIRST PILOT STUDY -DATE OF RELEASE: 24 MAY NUMBER RELEASED: 1,217						
26 May	21	8	29	2.4	23.6	NA
27 May	2	1	3	0.2	2.4	16.5
28 May	0	0	0	0.0	0.0	NA
29 May	21	3	24	2.0	19.5	17.1
30 May	1	1	2	0.2	1.6	16.1
31 May	11	0	11	0.9	8.9	15.2
1 June	3	0	3	0.2	2.4	16.4
2 June	8	2	10	0.8	8.1	16.9
3 June	0	0	0	0.0	0.0	NA
4 June	9	1	10	0.8	8.1	18.9
5 June	7	3	10	0.8	8.1	19.7
6 June	6	1	7	0.6	5.7	20.4
7 June	5	0	5	0.4	4.1	20.8
8 June	3	1	4	0.3	3.3	21.2
9 June	1	0	1	0.1	0.8	21.5
10 June	0	0	0	0.0	0.0	NA
11 June	3	0	3	0.2	2.4	21.3
12 June	1	0	1	0.1	0.8	20.9
TOTAL	102	21	123	10.1		
SECOND PILOT STUDY - DATE OF RELEASE: 12 JUNE NUMBER RELEASED: 1,748						
13 June	84	0	84	4.8	16.5	20.9
14 June	46	8	54	3.1	10.6	19.7
15 June	141	1	142	8.1	27.9	19.2
16 June	103	3	106	6.1	20.8	19.5
17 June	23	0	23	1.3	4.5	19.1
18 June	45	2	47	2.7	9.2	19.7
19 June	14	0	14	0.8	2.8	19.4
20 June	9	0	9	0.5	1.8	19.0
21 June	6	0	6	0.3	1.2	19.5
22 June	3	0	3	0.2	0.6	19.5
23 June	3	0	3	0.2	0.6	20.0
24 June	0	0	0	0.0	0.0	20.0
25 June	6	0	6	0.3	1.2	20.0
26 June	3	0	3	0.2	0.6	20.3
27 June	1	1	2	0.1	0.4	19.0
28 June	0	0	0	0.0	0.0	19.5
29 June	3	0	3	0.2	0.6	19.5
30 June	2		2	0.1	0.4	19.3
1 July	1	0	1	0.1	0.2	20.0
2 July	1	0	1	0.1	0.2	19.3
TOTAL	494	15	509	29.1		

[1]Average of grab samples taken in the upper and lower fish trap at Woodbridge Dam.

Table 15.2. Mean total length (mm) of smolt released and recaptured during 1990 pilot studies.

	N	TOTAL LENGTH (mm) MEAN	SD
RELEASED FISH			
Pilot Study 1	57	98.6	9.9
Pilot Study 2	57	115.9	11.2
RECAPTURED FISH			
Pilot Study 1	30	113.7	22.2
Pilot Study 2	30	124.9	6.5

15.3.2 River Mortality 1991

Mean daily flows at the WID Canal and in the river below Woodbridge Dam are illustrated for the mortality study period in Figure 15-1. Water temperatures ranged from 17° C on 12 May to 22.5° C on 2 July. Canal flows were dependent on river flows and the increasing demand from irrigation systems. Diversion flows increased from 68 cfs (1 May) to 221 cfs (30 June), corresponding with increased releases from Camanche Dam (see Task 14).

Overall, 15,322 marked smolts were released at Camanche Dam, 15,365 smolts were released at Bruella Road, and 1,594 were released at the diversion screens at the mouth of the WID Canal (Table 15.3). The first release coincided with peak out-migration and the final groups were released at the end of the out-migration period. Recapture rates for the three combined releases were 20.9 percent of those released at Camanche Dam, 22.8 percent of those released at Bruella Road, and 23.5 percent of those released at the diversion screen. A total of 600 smolts (200 smolts/release period) were retained for 8-hr monitoring; of these, only two smolts (0.3%) died, indicating that post-handling mortalities were low.

The individual results and recapture rate for each release group and site are shown in Table 15.3. A higher survival rate was observed during the first release period (11-12 May) at the Camanche site (36.6%) and Bruella Road site (35.0%). Of those released at the fish screens, 40.4 percent were recovered (Table 15.3). Fewer marked smolts were recaptured during the second release period (23-24 May). The poorest recovery rate was observed during the third release period (5-7 June) when only 5.3 percent, 10.0 percent, and 14.6 percent of smolts released at Camanche Dam, Bruella Road, and the fish screens respectively, were recovered (Table 15.3; Figure 15-2).

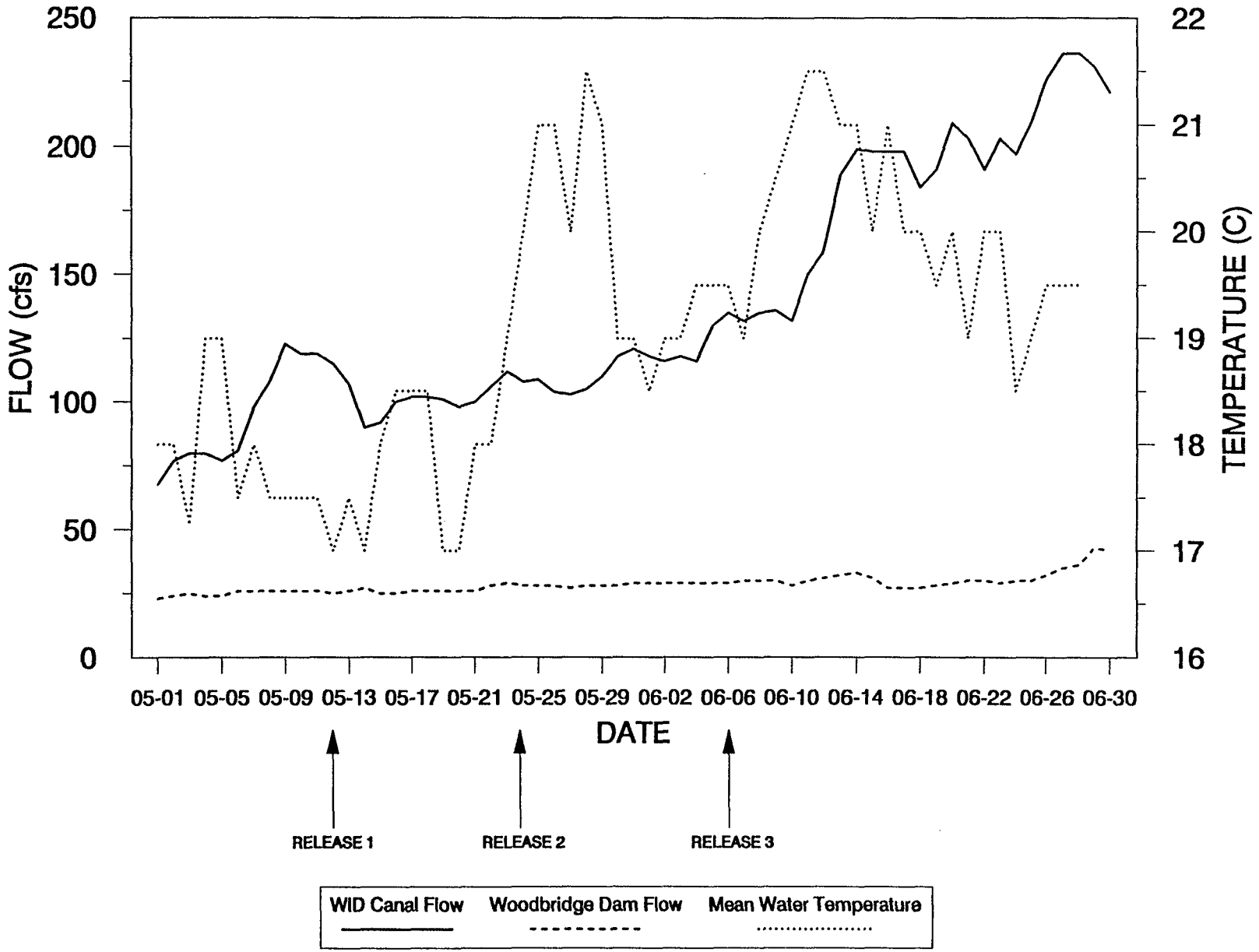

Figure 15-1. Mean daily flows recorded at the WID Diversion Canal and below Woodbridge Dam (USGS Station #11325500) and mean temperature taken in the upper and lower fish ladders during the 1991 mortality study period (1 May - 30 June).

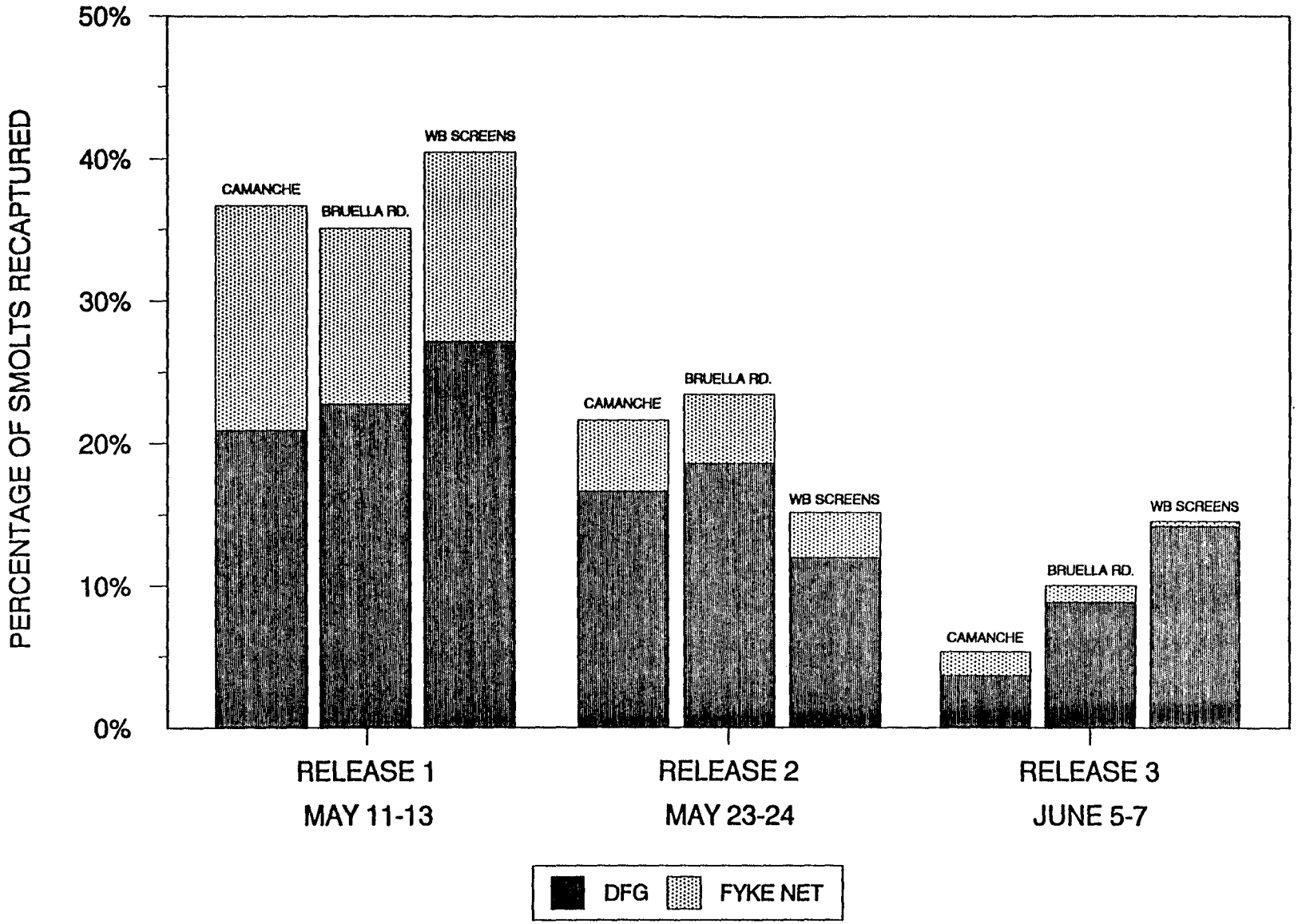

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Figure 15-2. Survival rate of smolts released in 1991 in the Mokelumne River near the MRFH, Bruella Road, and the WID screens in Lake Lodi. Fish were recaptured at Woodbridge Dam.

Table 15.3. Total number of smolts released and percentage recaptured during 1991 in-river mortality studies.

	TOTAL RELEASED	NUMBER RECAPTURED TOTAL	NUMBER RECAPTURED PERCENT	NUMBER RECAPTURED BY LOCATION CDFG BOX TRAP		BIOSYSTEMS FYKE NET	
CAMANCHE DAM							
First Release	5,033	1,843	36.6%	1,051	57.0%	792	43.0%
Second Release	5,036	1,088	21.6%	837	76.9%	251	23.1%
Third Release	5,253	278	5.3%	190	68.3%	88	31.7%
TOTAL	15,322	3,209	20.9%	2,078	64.8%	1,131	35.2%
BRUELLA BRIDGE							
First Release	5,118	1,793	35.0%	1,163	64.9%	630	35.1%
Second Release	5,096	1,194	23.4%	948	79.4%	246	20.6%
Third Release	5,151	515	10.0%	454	88.2%	61	11.8%
TOTAL	15,365	3,502	22.8%	2,565	73.2%	937	26.8%
DIVERSION SCREENS							
First Release	542	219	40.4%	147	67.1%	72	32.9%
Second Release	502	76	15.1%	60	78.9%	16	21.1%
Third Release	550	80	14.6%	78	97.5%	2	2.5%
TOTAL	1,594	465	29.2%	285	61.3%	90	19.4%

Smolts released during the first and second release periods experienced moderate temperatures and diversion flows (Figure 15-1). Smolts in the third release group were subjected to increasing diversion flows and increased Lake Lodi temperatures (Figure 15-1), and had lower survival rates (Figure 15-2). In addition to effects of increased diversion flows and water temperatures, the results of these mortality studies demonstrate that in-river mortality is actually low; if the opposite were true, a substantially lower survival rate of those smolts released at river sites would have been expected.

The daily recapture rates for all release groups indicated that the majority of smolts were recaptured within 5 or 6 days (Figure 15-3). After the first release, 65.7 percent of smolts released at the mouth of the WID Canal were recaptured in 3 days and 63.5 percent of river

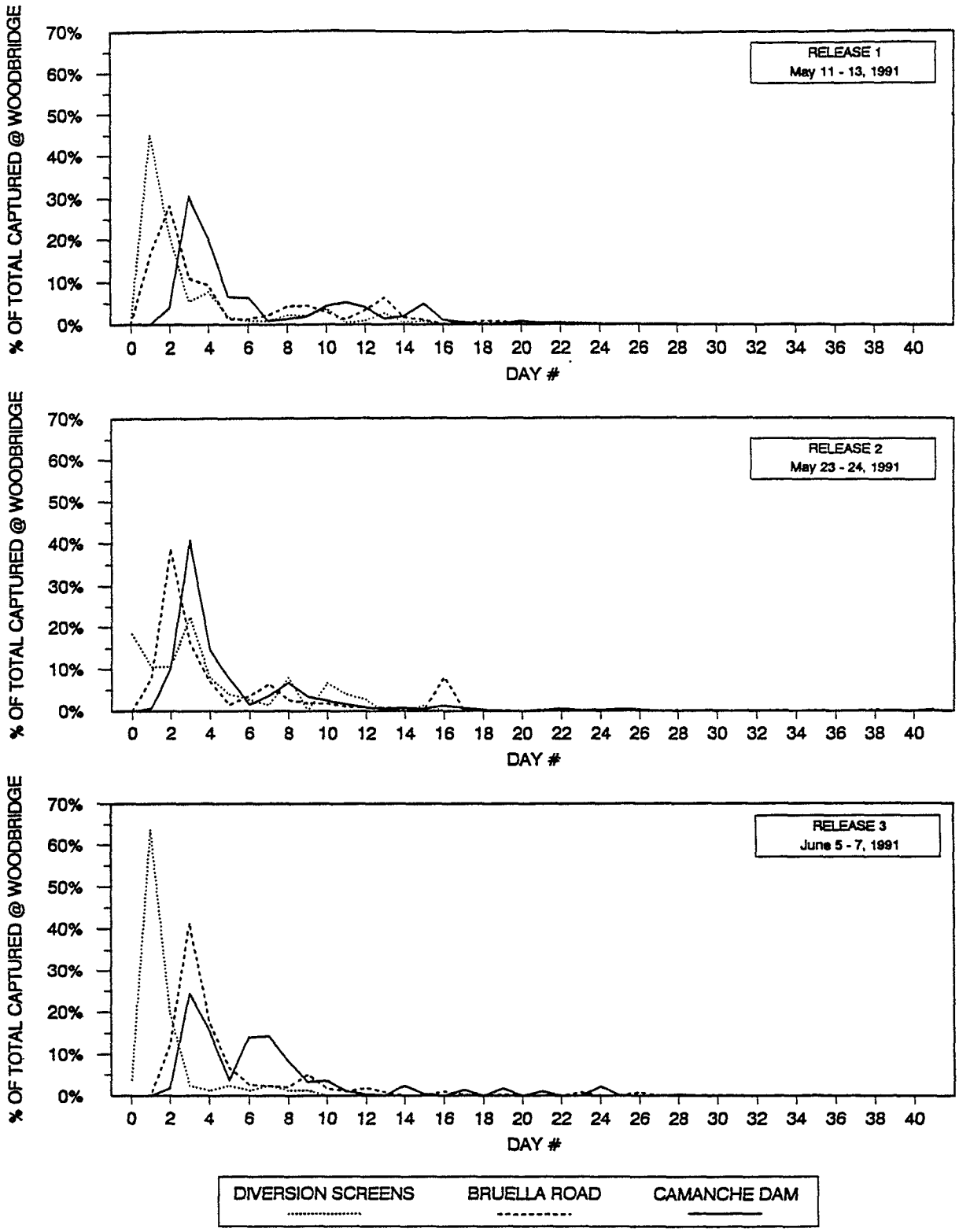

Figure 15-3. Daily percentage recapture rates for all three release groups and release periods.

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fish were recaptured in 4 days. Similarly, after the second and third releases, the majority (>70%) of smolts were recaptured within 5 days of release. Marked smolts were recaptured for up to 40 days following release at the river sites and up to 24 days following release at the diversion screens (Figure 15-3).

A higher proportion of smolts were recaptured in the fyke net during the first release period than were recaptured later in the second and third release periods (Table 15.3; Figure 15-2). This trend was especially noted in those fish released at the diversion screens; of the total recaptured from the third release group, only 2.5 percent were trapped in the fyke net, a decrease from 32.9 percent in the second release group (Table 15.3). These results suggest that attraction flows to the canal bypass are inadequate since a high percentage of smolts (up to 43%) are being recaptured in the fyke net located in the upper ladder. The study also demonstrates that, at increased diversion rates, attraction flows to the canal increase, resulting in more smolts entering the bypass pipeline to be recaptured in the box trap.

The mean length of marked smolts, before and after recapture, is given in Table 15.4. Generally, the length of recaptured smolts was greater than that of smolts before release.

15.3.3 Predation on Out-Migrating Smolts

A total of 26 fish were captured in five gill nets placed near the diversion screens: 20 fish (three largemouth bass, three squawfish, five steelhead rainbow trout, five Sacramento suckers, two golden shiners, one carp, and one hardhead [*Mylopharodon concephalus*]) were captured on 24 May and six fish (three squawfish, two steelhead rainbow trout, and one chinook smolt) were netted on 7 June. Stomach contents of the six squawfish, three largemouth bass, and seven steelhead rainbow trout were examined for presence of salmon smolts. Two squawfish, netted on 7 June, had a total of three smolts in their stomachs, and one largemouth bass, taken on 24 May, contained two smolts. The remaining largemouth bass and squawfish had no identifiable prey items. All stomachs of the seven steelhead rainbow trout were empty.

A total of 120 stomachs from steelhead rainbow trout collected in the CDFG trap during out-migration studies in 1990 were examined for prey remains; however, no smolts or parts were found. Similarly, in 1991, no smolt remains were found in the stomachs of 51 steelhead rainbow trout. In 1991, the main prey items found in steelhead rainbow trout stomachs were fry of bass (32.2%) and sculpin (25.8%).

15.3.4 Coded Wire Tagging

15.3.4.1 1991

For the 1991 coded wire tagging study, 111,956 smolts were tagged in the first release group (23 April) and 105,233 smolts were tagged in the second release group (6 May)(Table 15.5). Mortality rates following tagging and handling were only 1.2 percent in the first release

Table 15.4. Mean total length (mm) of smolt released and recaptured during 1991 smolt mortality studies.

	N	TOTAL LENGTH (mm) MEAN	SD
HATCHERY (RELEASED FISH)			
Group 1	290	114.2	12.0
Group 2	151	100.1	13.1
Group 3	150	120.6	16.5
CAMANCHE DAM (RECAPTURED FISH)			
Group 1	520	118.8	9.0
Group 2	287	117.0	10.6
Group 3	229	126.3	13.8
BRUELLA ROAD (RECAPTURED FISH)			
Group 1	434	118.1	10.4
Group 2	247	116.3	11.8
Group 3	201	120.8	15.2
DIVERSION SCREENS (RECAPTURED FISH)			
Group 1	52	112.9	10.4
Group 2	42	114.2	13.4
Group 3	29	117.0	13.9
TOTAL (ALL RECAPTURED FISH)			
Group 1	1,006	118.2	9.8
Group 2	576	116.5	11.4
Group 3	459	123.3	14.7

group and 0.9 percent in the second release group (Table 15.5), an indication that handling stress was relatively low.

The results of the quality control check just prior to release are given in Table 15.5. High tag loss occurred among the first group; 23 percent of smolts tested had no coded wire tags. It is suspected that this occurred as a result of the problems encountered with the water supply (see 1991 Methods). After cleaning the filters regularly, no further problems were apparent. Hence, it was assumed that approximately 23 percent of the first group of smolts in the raceways were not tagged.

Table 15.5. Total numbers of smolts injected with coded wire tags, number of mortalities, and total adjusted number initially released by CDFG at New Hope Marina, 1991.

TOTAL NUMBER OF FISH INITIALLY TAGGED

RELEASE GROUP	RELEASE DATE	TOTAL TAGGED (QCD)	MORTALITY DURING HOLDING	NET SMOLTS TAGGED (QCD # - MORT)	TOTAL TAGGED (CDFG VOLUMETRIC ESTIMATES)	DIFFERENCE BETWEEN CDFG & BIOSYSTEMS METHODS
1991						
1	23 April	111,956	1,321	110,635	103,950	6,685[1]
2	6 May	105,233	943	104,290	103,850	308
1992						
1	21 April	105,213	844	104,369	104,500	131
2	6 May	104,896	663	104,235	100,700	3,535

TOTAL NUMBER OF FISH RELEASED WITH TAGS

	TAG RETENTION RATES			
INITIAL NUMBER TAGGED	SAMPLE SIZE	NUMBER WITHOUT TAGS	PERCENTAGE WITHOUT TAGS	ESTIMATED NUMBER OF SMOLTS RELEASED WITH TAGS
1991				
103,950[2]	1,500	345	23.0%	80,041
104,290	2,100	21	1.8%	101,980
1992				
104,369	2,146	80	3.7%	100,508
104,235	2,131	44	2.1%	99,740[3]

[1]Larger difference due to the escape of fish from holding tanks between estimates of fish tagged using QCD and volumetric measurements.
[2]CDFG estimates of initial number of fish tagged were used due to loss of fish from holding tanks after the coded wire tags were implanted.
[3]Total number tagged has been adjusted to account for handling mortalities (2.3%).

A further discrepancy was noted in the tagged smolts in the first group. During tagging, some of the tagged smolts escaped from the holding tanks into the river through an unscreened stand pipe. Initially, it was estimated that 110,635 smolts (adjusted for mortality) had been tagged (Table 15.5); however, CDFG calculated that they released 103,950 smolts at New Hope Road, a difference of 6,685 smolts. Furthermore, CDFG had initially supplied approximately 128,000 smolts for tagging, which meant that an additional 17,365 untagged smolts had escaped into the river. This resulted in the unofficial release of 24,050 hatchery smolts into the river (17,365 without coded wire tags and 6,685 with coded wire tags). During the second tagging program, few problems occurred and tag retention by smolts was high (98.2%). CDFG estimated that 103,850 smolts were released and records indicated that 104,290 smolts were tagged, a difference of 308 smolts (Table 15.5). The number of fish that died in the raceways may account for these differences.

The mean lengths and condition factors for smolts in both CWT groups are reported in Table 15.6. For both release groups, a subsample of smolts (n=200) were retained in the river for 8 hours to monitor post transportation and handling mortalities. No mortalities were reported for either release group. Adjusting for tag loss, an estimated 80,041 and 101,980 tagged smolts were released during the first (23 April) and second (6 May) periods, respectively (Table 15.5). Water temperature at the release site ranged from 16.5° C (23 April) to 18.5° C (6 May).

Table 15.6. Mean lengths and condition factor of 1991 coded wire tagged smolts prior to release.

	TOTAL LENGTH (mm)			CONDITION FACTOR (K[TL])		
	N	MEAN	SD	N	MEAN	SD
1991						
Group 1 (22 April)	374	102.9	8.6	374	0.85	0.09
Group 2 (2 May)	400	103.6	11.2	400	0.81	0.08
1992						
Group 1 (20 April)	200	80.4	7.1	200	0.80	0.07
Group 2 (4 May)	180	90.3	8.5	180	0.81	0.09

The preliminary results of the Delta trawling studies, carried out by M. Kjelson of the USFWS, during April, May and June showed that 139 smolts from the first release group (23 April) were recaptured. The survival index for this first coded wire tagged group was estimated at 1.63 (P. Brandes, USFWS, pers. comm. 17 December 1991). However, fewer smolts were recaptured from the second release group (6 May), USFWS reported 48 smolts were recovered, resulting in an estimated survival index of 0.45. Similar results were obtained by USFWS from their coded wire tagged releases in the Lower Mokelumne River at Thornton in 1991. They released 47,289 coded wire tagged smolts on 18 April, and 45,706 coded wire tagged smolts on 9 May 1991; their survival indices were estimated at 1.56 (total number recaptured = 79) and 0.64 (total number recaptured = 84), respectively (P. Brandes pers. comm.).

15.3.4.2 1992

In 1992, 105,213 smolts were tagged from 24 March to 3 April and 104,898 smolts were tagged from 7 April to 17 April. Mortality rates after tagging and holding ranged from 0.6 percent to 0.8 percent (Table 15.5). High tag retentions were recorded for both group 1 (96.3%) and group 2 (97.9%).

For the second release group, CDFG estimated that 100,700 smolts were released, a difference of 3,535 smolts (Table 15.5). Inconsistences in volumetric analysis or tagged smolts escaping from the MRFH raceway may account for the difference. During the 1992 out-migration study at Woodbridge Dam, previously tagged smolts were captured in the traps. These tags are currently being analyzed to determine their origin and may provide insight into the discrepancy between CDFG and BioSystems' CWT estimates.

Mean total length for the first and second groups were 80.4 mm and 90.3 mm, respectively (Table 15.6). Mean condition factors for both release groups were similar (0.80 for first group, 0.81 for second group).

Transportation and handling mortality was 0 percent in the first group and 2.3 percent in the second group. As a result, it is estimated that 100,508 fish were released during the first period and 99,740 fish were released in the second period (Table 15.5). Water temperatures at the release site were 19° C (21 April) and 22° C (6 May).

Fifteen smolts were recapture from the first CWT group (21 April); the survival index for this group was estimated at 0.13 (P. Brandes, USFWS, pers. comm., 6 August, 1992). As in 1991, fewer smolts were recaptured from the second released CWT group. The USFWS reported only 6 smolts recovered from the second release groups resulting in a survival index of 0.06 (P. Brandes, USFWS, pers. comm. 6 August, 1992).