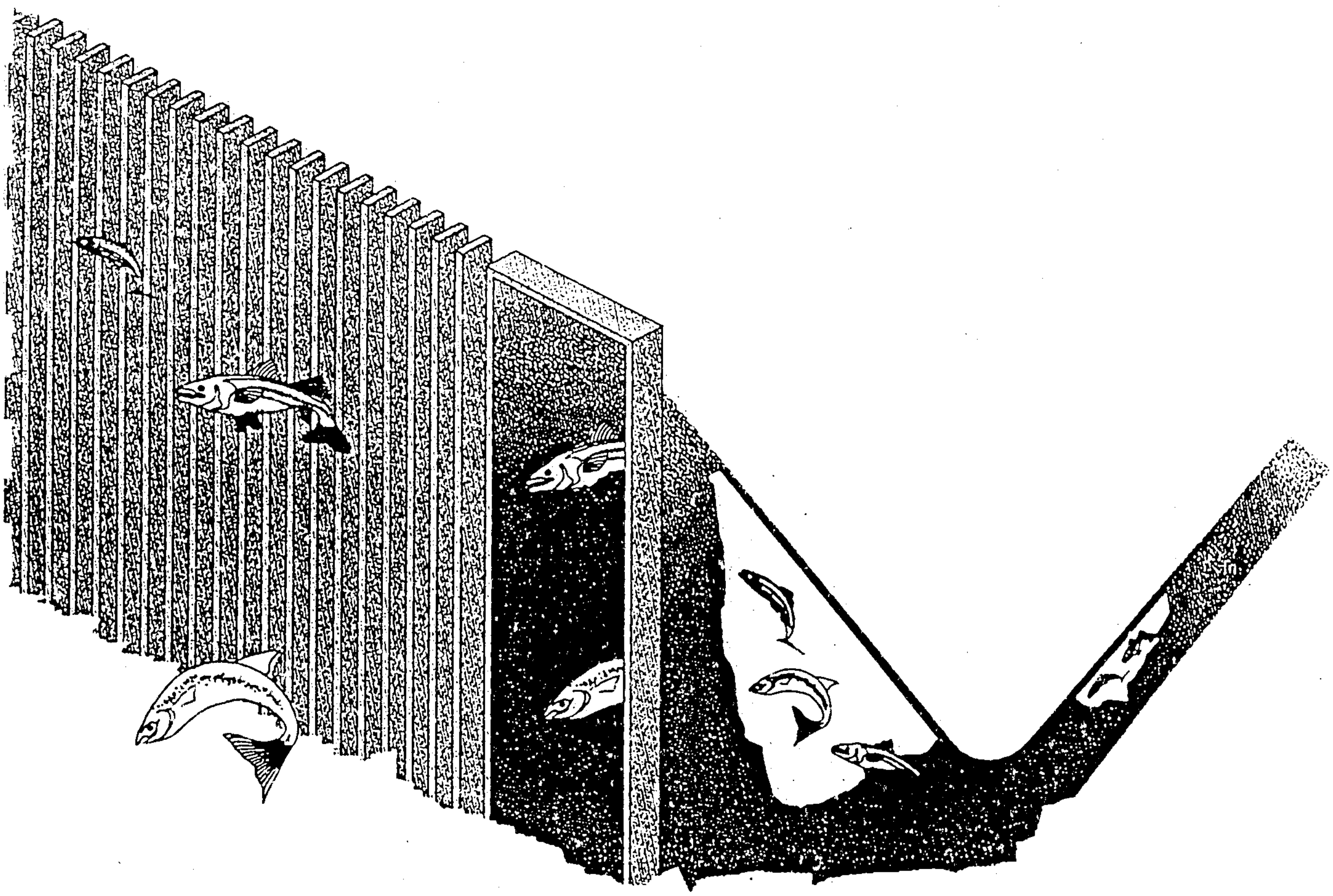

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Evaluation of the Subsampling Procedure to Estimate Fish Salvage at the Tracy Fish Collection Facility

Tracy, California

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EVALUATION OF THE SUBSAMPLING PROCEDURE TO ESTIMATE FISH SALVAGE AT THE TRACY FISH COLLECTION FACILITY TRACY, CALIFORNIA 1993-1996

BY

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PREFACE

Reclamation's Tracy program has evolved from a focused effort on predator removal in the early 1990s to a comprehensive activity aimed at significant improvement and/or replacement of the Tracy Fish Collection Facility (TFCF). The program is now known as the Tracy Fish Facility Improvement Program (TFFIP) and is concerned with fishery protection issues for Reclamation and the Central Valley of California. The present report is the eighth volume in the Tracy Studies series. The first volume discusses the 1991-1992 predator removal program and intake channel studies (Liston et al. 1994). The second volume summarizes the 1991-1992 fish egg and larvae continuous sampling program (Hiebert 1994). The third volume evaluates louver efficiency experiments conducted in 1993 (Karp et al. 1995). Puckett et al. (1996) in volume 4 examines some factors that may influence the fish salvage estimates. Volume 5 describes a field test of a video imaging system for counting fish eggs (Hiebert et al. 1997). Volume 6 discusses physical parameters related to continuous monitoring of fish egg and larvae entrainment (Siegfried, In preparation). Volume 7 further examines louver efficiencies in the secondary system (Bowen et al., In preparation). This volume evaluates the effectiveness of using the 10-minute holding tank subsample to estimate the 2-hour fish salvage.

ABSTRACT

The Bureau of Reclamation's Tracy Fish Collection Facility was constructed in the mid-1950s to divert fish from exported Central Valley Project flows. Numbers of fish diverted and collected are estimated 12 times daily (every 2 hours) as they enter a holding tank. This subsampling procedure has been in operation since 1993. Prior to that, a single day and single night subsample were used in the expansion of the daily salvage estimate. In this study, we evaluated the relationship between the 12 subsamples and the actual holding tank collection under a variety of flow, debris, tide, time of year, and time of day conditions. From 1993 to 1996, we collected 210 pairs of entrainment data (i.e., the 110-minute salvage and the following 10-minute salvage subsample). Nonparametric correlation analyses of the entrainment rates (i.e., the #fish/minute entrained in the collection tank) suggest that the current subsampling operation effectively estimates fish salvage and debris load. The correlation between the subsample and actual collection was highest for species that are more abundant. Size comparisons for striped bass (*Morone saxitilis*) and white catfish (*Ictalurus catus*) indicate that larger fish are less prevalent in the 10-minute subsample than the 110-minute collection. We believe that the current system, which counts 8 percent of the daily entrainment, is adequate and that efforts be made to improve the handling and holding components of the overall operation.

INTRODUCTION AND BACKGROUND

The Central Valley of California includes the Sacramento River drainage from the north, the San Joaquin drainage from the south, and outflows from several east-side tributaries. These systems converge in the central portion of the state forming a large natural estuary (western portion known as the Delta) where the hydraulics are influenced by many factors including tides, precipitation, freshwater outflows, export pumping, irrigation practices, etc. (Figure 1). The Central Valley Project (CVP) was authorized by Congress in 1934 to regulate flows in the Central Valley of California to provide water for irrigation. The CVP has been operated by the U.S. Bureau of Reclamation (Reclamation) since its inception.

The Delta Division of the CVP includes one of two large pumping plants in the south Delta (the other is the State-operated Harvey O. Banks Delta Pumping Plant). The Tracy Pumping Plant (TPP), Tracy Fish Collection Facility (TFCF), and Delta Mendota Canal (DMC) operate to convey water southward for irrigation, municipal, and industrial needs in the south central valley. The TPP draws water off the Old River channel of the lower San Joaquin River into the inlet to the DMC (known as the intake channel) where it passes through the TFCF (Figure 2). The TFCF is a large fish diversion and salvage facility that operates to divert fish from the flow before it is lifted into the DMC by the TPP. These facilities are located in the south Delta about 9 miles northwest of Tracy, California.

The TFCF uses a system of louvers and bypasses to divert fish from the exported flow (Figure 2). Fish that are louvered are bypassed into large collection tanks to await transport back to the Delta. A daily fish salvage estimate is determined by taking a subsample of louvered (or entrained) fish every 2 hours on the even hour the facility is in operation. To accomplish this, fish (and debris) are diverted into a different collection tank for 10 minutes of each 2-hour period. This tank is drained at the end of the 10-minute period and all fish identified and counted. The number of fish, by species, is then multiplied by 12 to obtain an estimate of the 2-hour salvage. The 12 salvage estimates are summed to obtain a daily (24-hour) salvage estimate. In addition, fish are measured four times a day to obtain an estimate of the sizes of fish being entrained. These procedures have been in operation since the inception of the facility in the late 1950s, although the practice of using all 12 counts to estimate salvage was begun in 1993 (Bates et al. 1960; S. Barrow, personal communication). The purpose of this study was to determine whether the 10-minute subsample provides a good estimate of fish abundance in the preceding 110-minute period.

METHODS

The study was conducted at the TFCF from 1993-1996. As part of the daily salvage operation, fish and other entrained material collect in one of four large concrete holding tanks measuring 6.1 m (20 ft) in diameter with 5.0-m (16.6-ft) high side walls. Fish are retained in the tanks by a 4.5-m

(14.8-ft) high, 24-m (8-ft) wide screen that surrounds the fish-lift bucket well. Water continually enters and flows through the screen and out into the intake channel (to the DMC) while the facility is running. During holding tank drawdowns, the screen is lifted and fish are flushed into the bucket for removal. Typical operations are such that one tank is used for the continual salvage collection. This operation is interrupted for 10 minutes every 2 hours to take a subsample of fish being entrained (bypassed into the collection tanks). This subsample is collected in a different holding tank. Following this, bypass flows are then returned to the first holding tank. The 10-minute fish counts are used to estimate salvage over the preceding 2-hour period. A holding tank may collect water and all entrained material for up to 24 hours depending on time of year. The tanks are drained and fish removed more often in the spring because of endangered species concerns.

To examine the separate entrainment samples, we collected fish and debris in one tank for 110 minutes and then switched to another tank for 10 minutes. The 110-minute collection was removed from the holding tank and placed into a 1,892-L (500-gal) rectangular tank with flow-through water. We then were able to sort the debris from fish and examine the whole collection. The 10-minute count was examined in the circular tank used in the typical operation. For each collection, we recorded date, time of day, length of collection, debris load, tide stage, export flow and fish composition, abundance, and size [total length (TL)]. All fish greater than 20 mm TL were identified and counted. We examined as many collections as manpower and facility operations allowed.

Data Analysis

Fish count data were converted to entrainment rates (i.e., number of fish entrained or collected/minute) for analyses. We then used box and whisker plots and correlation analyses to compare the salvage rates between the subsample (10-minute count) and the actual sample (110-minute count; Analytical Software 1996). In a box and whisker plot, the box encloses the middle half of the data and is bisected by the median value. Vertical lines (whiskers) at the top and bottom indicate the range of typical data values. Spearman Rank Correlation (Zar 1996) was used to examine the relationship between the two variables (i.e., is the collection subsample representative of the whole collection). In this analysis, r_s values range from -1 to +1, with a score of zero indicating no relationship while either minus (-) or plus (+) scores indicates a relationship.

Paired zero data (i.e., both the 10- and 110-minute collections yielded no fish of a particular species) were considered "real" data during those times of the year when the species could be present in the TFCF entrainment. For example, striped bass (*Morone saxitilis*), American (*Alosa sapidissima*) and threadfin shad (*Dorosoma petenense*), and white catfish (*Ictalurus catus*) may be collected year round, thus, all data were included in these analyses. However, some species like delta smelt (*Hypomesus transpacificus*) are only observed January through June, so paired zero data from outside that period were not included. Correlations of entrainment rates were only conducted on species that had a sample size equal to or greater than 30. American and threadfin shad were lumped together for the analyses because we had some difficulty differentiating the young. Some count data were estimated at the time of collection, and so deleted from the correlation analyses. Length distributions for striped bass and white catfish were compared between the 10- and 110-minute samples using the Wilcoxan Rank Sum test (Analytical Software 1996)

RESULTS AND DISCUSSION

A total of 210 pairs of holding tank data (110-minute sample and subsequent 10-minute subsample) were collected and evaluated. We handled 165,120 fish comprising 40 species (Table 1). Estimates of exported flows ranged from 13.0 to 180.8 m^3/s (459 to 6,388 ft^3/s) in the primary channel and from 0.4 to 5.1 m^3/s. (15 to 180 ft^3/s) in the secondary channel (Figure 3).

Paired samples were collected in all months (Figure 4) and from all times of the day (Figure 5). Only 10 samples were collected in 1993 as this was the design year. We collected 60 samples in 1994, 59 samples in 1995, and 81 samples in 1996.

Comparison of box and whisker plots of entrainment rates for all fish combined and individual species indicated no obvious differences between the subsample and the actual salvage. Further analyses suggest that the 10-minute fish count is highly correlated with the total number of fish accumulating in the holding tanks (r_s=0.9, N=210 pairs of holding tank data; Table 2). This relationship was high for species that dominated the entrainment, including shad (r_s=0.9, N=209), white catfish (r_s=0.8, N=208), striped bass (r_s=0.7, N=203), chinook salmon (*Oncorhynchus tschawtscha*) (r_s=0.7, N=172), splittail (*Pogonichthys macrolepidotus*) (r_s=0.7, N=196), and channel catfish (*Ictalurus punctatus*) r_s=0.6, N=210 . The two counts were not as strongly correlated for less abundant fish [delta smelt r_s=0.4, N=135; bluegill (*Lepomis macrochirus*) r_s=0.4, N=210] and only weakly related for fish infrequently observed [crappie (*Pomoxis annularis and P. nigromaculatus*) r_s=0.3, N=210; bass (*Micropterus salmoides and M. dolomieui*) r_s=0.3, N=210; steelhead (*Oncorhynchus mykiss*) r_s=0.3, N=155, etc., Table 3]. However, all calculated r_s were greater than the tabled critical values (p>0.01) for the Spearman Rank Correlation (Zar 1996), and we concluded that the entrainment subsample and actual entrainment were similar. Correlation analyses were not conducted on Sacramento blackfish (*Orthodon microlepidotus*), Tule perch (*Hysterocarpus traski*), and the remaining species included in Table 1 because the number of paired samples containing non-zero data was less than 30.

The fish salvage (fish collection) and salvage estimating process (subsampling process) are influenced by many factors including type of water year and debris load (Karp et al. 1995; Puckett et al. 1996). Each of the study years differed hydrologically: 1993 was an above normal/slightly wet year, 1994 a critical year (unusually dry), 1995 a wet year (unusually wet), and 1996 a wet year (designations based on Sacramento River indices). The numbers and types of fish salvaged differed from year to year due in large part to the differences in water year types.

Introduced fish, and in particular, striped bass, threadfin and American shad, and white catfish generally dominate the TFCF salvage (1995 was an exception due to the high water; Table 3). The dryness of 1994 may be reflected in the relatively high numbers of striped bass observed in the paired collections (65.4 percent of all striped bass collected). In below normal water years (low, freshwater outflow), export pumping in the south Delta creates conditions such that water moves toward the export facilities rather than downstream to San Francisco Bay (Arthur et al. 1996). Consequently, fish like the striped bass, which use the interior Delta canals in the early summer, are drawn toward the South Delta fish facilities and become abundant in the entrainment. We also saw more smelt in 1994 [65.6 percent of all delta, longfin (*Spirinchus thaleichthys*), and wakasagi (*Hypomesus nipponensis*)] relative to 1995 or 1996. These fish also appear to be more vulnerable to entrainment at the TFCF in below normal water years.

The unusually high runoff in 1995 flooded shorelines and other low-lying areas, creating ideal spawning conditions, and young splittail and Sacramento blackfish were numerous in the May and June samples (98.0 percent of all splittail captures, 96.9 percent of all Sacramento blackfish captures). These two species are generally uncommon in the TFCF salvage (Table 3), yet at times in 1995, the collection system was literally overflowing with small fish (and debris). Many young chinook salmon were also entrained in 1995 (52.3 percent of all salmon captures). Precipitation and outflow in the Central Valley were again high in 1996. Threadfin and American shad dominated the salvage and were most abundant in the July samples (80.1 percent of all shad captures). Catfish were salvaged all 4 years but also were most abundant in 1996 (55.7 percent of all white catfish captures, 64.9 percent of all channel catfish captures).

Many of the fish salvaged at the TFCF are young fish, as shown in Figure 6, for three of the more sensitive species (large individuals of all species are generally excluded by the 2-inch spacings on the trashrack). However, there is some concern that the 10-minute collection may be misrepresenting the size entrainment for some fish, particularly large striped bass and white catfish, because these fish can find refuge within the plumbing and avoid immediate capture. We examined 38 pairs of length data in which a minimum of 9 striped bass and/or 9 white catfish had been measured from both the 10- and 110-minute samples (Table 4). The size distributions for these species were similar in 84.2 percent of the samples (32 of 38 pairs). Fish were significantly larger in the 110-minute collection in five of the six remaining pairs ($p<0.05$).

The TFCF is typically inundated with large amounts of debris that varies in type and quantity seasonally and yearly. This debris includes everything from sand, peat fibers, and small clams in the spring to huge mats of aquatic vegetation (water hyacinth, Brazilian pondweed) in the fall/winter. Large timbers and human litter are also drawn into the facility. Figure 7 shows the range of debris load in kilograms entrained during each 2-hour collection. The greatest debris loads we observed occurred in May and June 1995 in response to the high runoff conditions that year. For a time, the facility was inundated with huge quantities of sand and small clams. Although more debris was entrained in the subsample on average as compared to the actual sample, correlation analysis suggests that the subsample can be used to estimate the debris load over the preceding period (N=147 paired collections; mean kg/minute entrainment rate = 0.11 for the subsample and 0.07 for the actual sample, r_s=0.7).

CONCLUSIONS AND RECOMMENDATIONS

Fish counts have been taken throughout the day since the facility began operation, but until recently, only one day and one night count (about 1 percent of the daily salvage) was being used to estimate salvage. The current system examines about 8 percent of the total entrainment (i.e., twelve 10-minute counts for each 24-hour period). The moderate to high correlations we noted for all fish combined and several individual species suggest that a collection subsample taken every 2 hours is adequate for estimating holding tank entrainment under present operating conditions (i.e., dramatic tide, debris, and flow influences). Although some conditions were under-represented in our study (i.e., early morning hours and fall months), we believe that the current sampling system is providing a clearer picture of the numbers and types of fishes entering the facility.

However, a consequence of the increased subsampling is that more fish are handled, and possibly stressed. This may increase mortality in the holding tanks and eventually in the river following release. Since the goal of the TFCF is to salvage fish, we recommend to continue with the present system and to try to reduce stress and improve survival of fish handled and confined during the subsampling and holding operations. Following these improvements, we could then test other counting systems to determine if a different procedure (e.g., more frequent subsampling, longer duration, or random) might provide a more accurate estimate of fish entrainment during critical times (e.g., when rare fish are present or when the system is overloaded with fish and/or debris).

Debris is known to affect louver efficiences (Karp et al. 1995) and also the salvage estimating process. For example, the lift bucket at times gets jammed with branches, and some or the entire fish count subsample may be lost. In addition, clumps of vegetation in the count tank interferes with capture and counting of the fish. There are ongoing studies investigating ways to remove debris from the system to improve accuracy of the fish subsampling operation.

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Table 1. Summary of fish collected in the entrainment study, 1993-1996, Tracy Fish Collection Facility, Tracy, California.

Species	Number of Fish Counted	Relative Abundance (%)	Size (range, total length mm)
Splittail (*Pogonichthys macrolepidotus*)	60,300	36.5	20 - 465
American (*Alosa sapidissima*), and threadfin shad (*Dorosoma petenense*)	50,672	30.7	20 - 464
Striped bass (*Morone saxitilis*)	23,527	14.2	20 - 520
White catfish (*Ictalurus catus*)	13,571	8.2	20 - 460
Sacramento blackfish (*Orthodon microlepidotus*)	6,426	3.9	23 - 200
Chinook salmon (*Oncorhynchus tschawtscha*)	2,121	1.3	35 - 298
Bluegill (*Lepomis macrochirus*)	1,751	1.1	23 - 196
Channel catfish (*Ictalurus punctatus*)	1,640	1.0	21 - 402
Yellowfin goby (*Acanthogobius flavimanus*)	722	<1.0	20 - 200
Inland silverside (*Menidia beryllina*)	651	<1.0	20 - 94
Common carp (*Cyprinus carpio*)	536	<1.0	22 - 566
Largemouth bass (*Micropterus salmoides*)	499	<1.0	20 - 400
Delta smelt (*Hypomesus transpacificus*)	416	<1.0	20 - 74
Golden shiner (*Notemigonus crysoleucas*)	429	<1.0	50 - 290
Prickly sculpin (*Cottus asper*)	425	<1.0	20 - 188
Shimofuri goby (*Tridentiger trigonocephalus*)	313	<1.0	20 - 186

Table 1. Summary of fish collected in the entrainment study, 1993-1996, Tracy Fish Collection Facility, Tracy, California (continued).

Species	Number of Fish Counted	Relative Abundance (%)	Size (range, total length mm)
Black crappie (*Pomoxis nigromaculatus*)	210	<1.0	27 - 290
Mosquitofish (*Gambusia affinis*)	128	<1.0	20 - 45
Redear sunfish (*Lepomis microlophus*)	114	<1.0	128 - 230
Pacific lamprey (*Lampetra tridentata*)	98	<1.0	88 - 400
Longfin smelt (*Spirinchus thaleichthys*)	89	<1.0	28 - 53
Wakasagi smelt (*Hypomesus nipponensis*)	87	<1.0	24 - 73
Bigscale logperch (*Percina macrolepida*)	82	<1.0	20 - 127
Steelhead (*Oncorhynchus mykiss*)	79	<1.0	34 - 445
Brown bullhead (*Ictalurus nebulosus*)	65	<1.0	30 - 351
Starry flounder (*Platichthys stellatus*)	26	<1.0	40 - 125
Warmouth (*Lepomis gulosus*)	23	<1.0	48 - 156
Goldfish (*Carassius auratus*)	19	<1.0	35 - 365
Threespine stickleback (*Gasterosteus aculeatus*)	19	<1.0	31 - 133
Tule perch (*Hysterocarpus traski*)	18	<1.0	110 - 195
Smallmouth bass (*Micropterus dolomieui*)	14	<1.0	68 - 180
White crappie (*Pomoxis annularis*)	14	<1.0	31 - 283
Staghorn sculpin (*Leptocottus armatus*)	9	<1.0	39 - 81

Table 1. Summary of fish collected in the entrainment study, 1993-1996, Tracy Fish Collection Facility, Tracy, California (continued).

Species	Number of Fish Counted	Relative Abundance (%)	Size (range, total length mm)
Sacramento squawfish (*Ptychocheilus grandis*)	8	<1.0	54 - 240
Sacramento sucker (*Catostomus occidentalis*)	6	<1.0	22 - 51
White sturgeon (*Acipenser transmontanus*)	5	<1.0	210 - 350
Red shiner (*Cyprinella lutrensis*)	4	<1.0	25 - 90
Green sunfish (*Lepomis cyanellus*)	3	<1.0	120 - 130
Black bullhead (*Ictalurus melas*)	1	<1.0	108

Table 2. Summary of fish entrainment rates and correlation analyses from the entrainment evaluation, Tracy Fish Collection Facility, Tracy, California, 1993 - 1996.

Species	Time	Number of paired samples	Mean (# fish/min)	Range (# fish/min)	Spearman rank correlation (r_s values)
All fish	10 min	210	5.6	0-351	.9
	110 min	210	6.1	0-423	
Shad[1]	10 min	209	1.7	0-48.1	.9
	110 min	209	1.9	0-39.9	
White catfish	10 min	208	0.6	0-14.9	.8
	110 min	208	0.6	0-17.8	
Striped bass	10 min	203	0.5	0-11.4	.7
	110 min	203	0.4	0-6.4	
Chinook salmon	10 min	172	0.1	0-2.3	.7
	110 min	172	0.1	0-0.9	
Splittail	10 min	196	2.2	0-316.0	.7
	110 min	196	2.6	0-380.7	
Channel catfish	10 min	210	0.08	0-1.6	.6
	110 min	210	0.07	0-0.9	
Yellowfin goby	10 min	210	0.03	0-0.9	.5
	110 min	210	0.03	0-0.8	
Delta smelt	10 min	135	0.02	0-0.7	.4
	110 min	135	0.03	0-0.5	
Prickly sculpin	10 min	203	0.04	0-1.9	.4
	110 min	203	0.02	0-0.8	
Bluegill	10 min	210	0.09	0-1.1	.4
	110 min	210	0.07	0-1.3	
Inland silverside	10 min	210	0.03	0-2.1	.4
	110 min	210	0.03	0-0.9	
Steelhead	10 min	155	0.006	0-0.1	.3
	110 min	155	0.005	0-0.04	
Common carp	10 min	210	0.03	0-1.5	.3
	110 min	210	0.02	0-1.9	

Table 2. Summary of fish entrainment rates and correlation analyses from the entrainment evaluation, Tracy Fish Collection Facility, Tracy, California, 1993 - 1996 (continued).

Species	Time	Number of paired samples	Mean (# fish/min)	Range (# fish/min)	Spearman rank correlation (r_s values)
Golden shiner	10 min	210	0.02	0-1.1	.3
	110 min	210	0.02	0-0.3	
Bass[2]	10 min	210	0.02	0-0.6	.3
	110 min	210	0.02	0-0.8	
Crappie[3]	10 min	210	0.01	0-1.0	.3
	110 min	210	0.01	0-0.3	
Shimofuri goby	10 min	210	0.01	0-0.5	.2
	110 min	210	0.01	0-0.5	

[1] Includes American and threadfin shad.
[2] Includes largemouth and smallmouth bass.
[3] Includes white and black crappie.

Table 3. Relative abundance of the top ten fish species salvaged at the Tracy Fish Collection Facility, Tracy, California, 1993-1996.

Species	1993 (%)	1994 (%)	1995 (%)	1996 (%)
Striped bass	54.8	52.3	5.3	5.5
Threadfin shad	21.1	22.0	13.2	38.2
American shad	4.2	8.7	13.1	30.4
White catfish	6.7	9.4	9.3	14.2
Bluegill	1.6	1.9	1.3	3.0
Channel catfish	0.8	0.9	1.3	1.9
Splittail	1.6	--	50.0	1.6
Chinook salmon	0.2	--	1.0	1.3
Yellowfin goby	7.7	1.1	--	1.0
Largemouth bass	--	0.4	--	0.9
Sacramento blackfish	--	--	1.3	--
Common carp	--	--	1.2	--
Inland silverside	0.5	1.2	--	--
Delta smelt	--	0.6	--	--

Table 4. Comparison of striped bass and white catfish total lengths between the 10-minute and 110-minute collections (significant differences were determined using the Wilcoxan Rank Sum Test).

Sample (10/110 minute)	Number of fish	Total length (mm) Mean	SD	P[1]
		Striped Bass		
1	25/66	23.8/25.0	2.853/3.442	0.1575
2	16/16	24.6/25.1	2.9882/3.3758	0.7203
3	15/61	25.7/25.1	3.432/3.475	0.5225
4	13/22	28.1/101.6	9.827/119.57	0.1013
5	18/90	44.9/57.6	9.226/60.671	0.8079
6	39/74	45.1/53.6	7.724/37.457	0.2562
7	22/17	49.0/104.9	47.665/111.52	0.0490[a]
8	24/31	97.3/103.0	21.110/16.869	0.1746
9	9/14	97.9/114.2	14.615/39.513	0.2314
10	10/35	100.6/109.0	6.62/24.57	0.5757
11	24/38	102.1/109.9	16.437/52.630	0.6594
12	20/12	103.3/126.3	32.332/48.291	0.0703
13	24/23	104.8/129.9	22.039/56.587	0.2825
14	16/16	108.4/170.3	28.128/100.49	0.0302[a]
15	9/13	108.9/109.1	28.423/17.250	0.6165
16	20/36	110.3/113.7	19.120/21.204	0.6878
17	24/28	115.8/127.4	31.010/62.186	0.6729
18	10/22	131.3/94.7	62.407/33.581	0.2723

Table 4. Comparison of striped bass and white catfish total lengths between the 10-minute and 110-minute collections (significant differences were determined using the Wilcoxan Rank Sum Test) (continued).

Sample (10/110 minute)	Number of fish	Total length (mm) Mean	SD	P[1]
		White Catfish		
1	12/53	72.3/89.5	40.603/72.015	0.6299
2	13/64	84.2/96.3	19.310/60.779	0.2036
3	10/24	87.6/126.2	53.229/71.778	0.1258
4	18/14	90.9/98.7	43.482/31.037	0.2545
5	22/15	95.0/101.2	12.181/36.283	0.9630
6	21/37	97.4/92.9	70.635/71.079	0.6918
7	13/24	105.8/148.9	59.604/64.506	0.0372[a]
8	15/26	107.1/144.0	25.478/53.186	0.0058[a]
9	9/26	125.2/111.0	37.164/58.540	0.1129
10	22/31	135.1/125.0	53.025/58.584	0.3387
11	12/19	165.8/170.5	45.395/57.573	0.8711
12	24/15	168.3/178.2	56.414/56.022	0.5067
13	9/28	174.3/168.0	34.616/70.360	0.8180
14	15/12	174.9/220.2	40.798/50.407	0.0168[a]
15	22/35	181.5/198.4	39.054/45.769	0.0794
16	13/21	188.2/146.6	36.166/83.321	0.4785
17	24/14	192.5/128.7	32.516/82.351	0.0093[a]
18	24/19	194.0/197.0	40.117/54.185	0.5409
19	9/27	196.9/179.7	8.638/49.467	0.4008
20	13/15	200.0/224.0	44.013/37.940	0.1971

[1]Significance value for the two-tailed test.
[a]P is less than $\alpha = 0.05$.

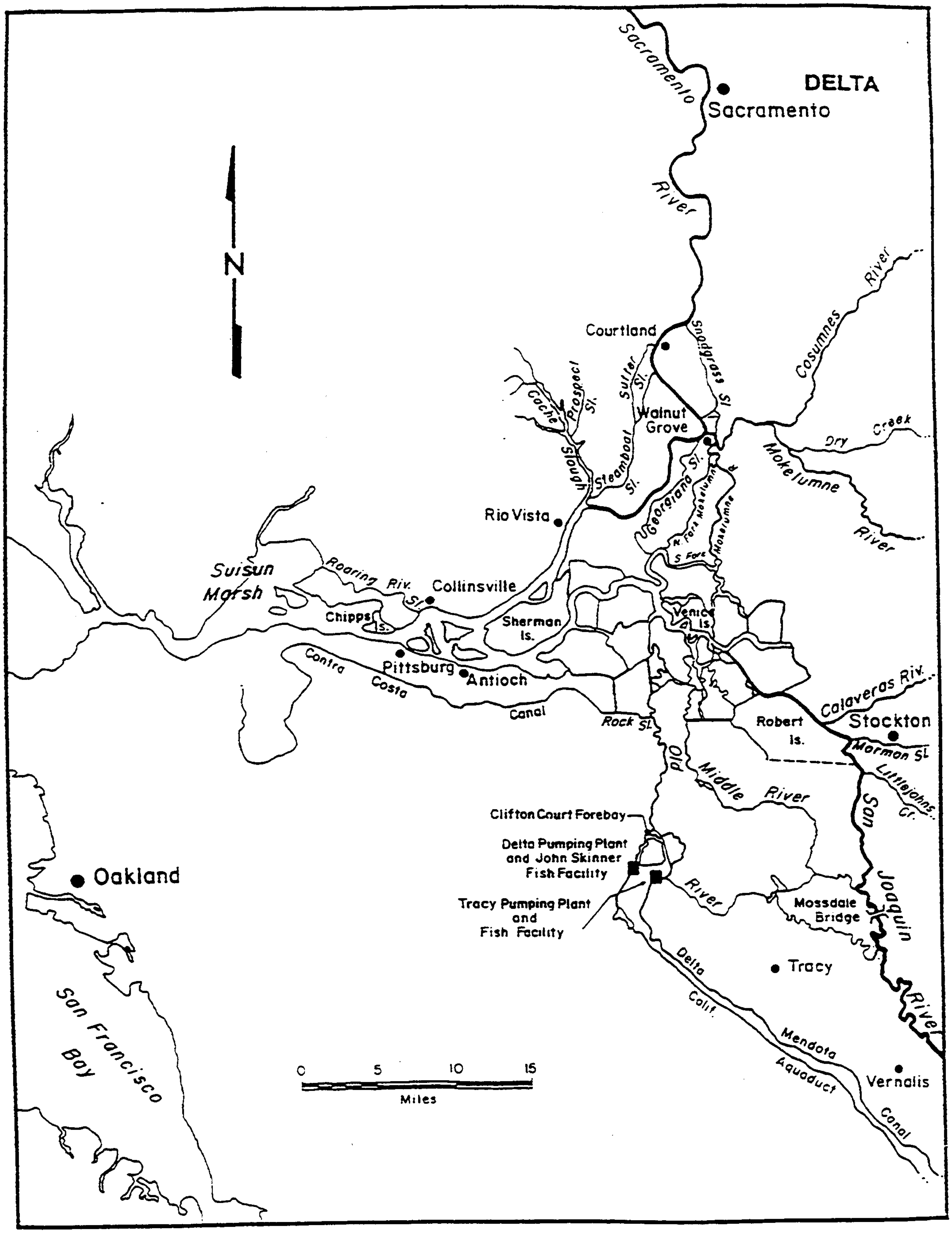

Figure 1. Map of the Sacramento-San Joaquin Delta showing the location of the Tracy Fish Collection Facility, Tracy, California.

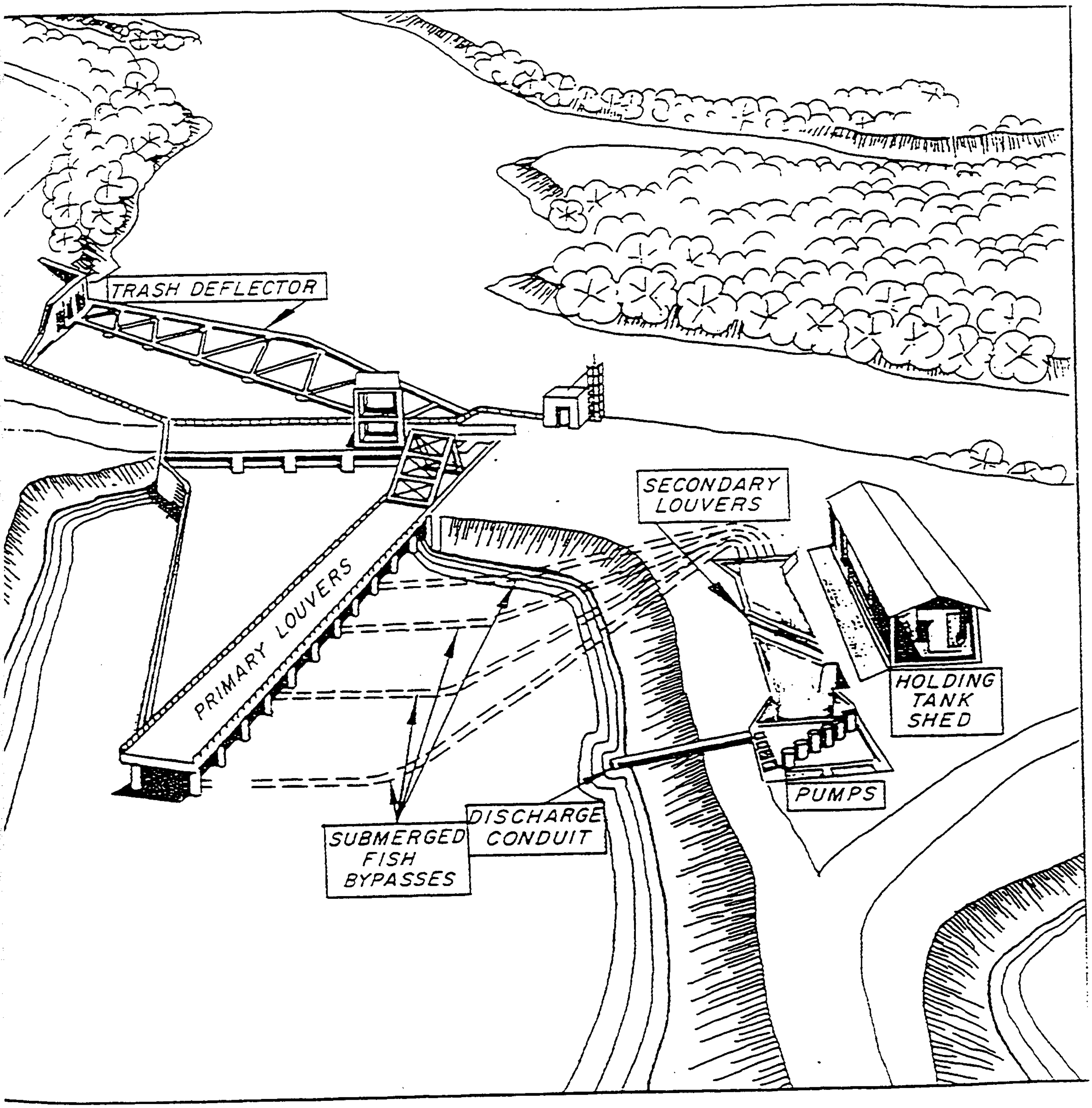

Figure 2. Schematic of the Bureau of Reclamation's Tracy Fish Collection Facility, Tracy, California.

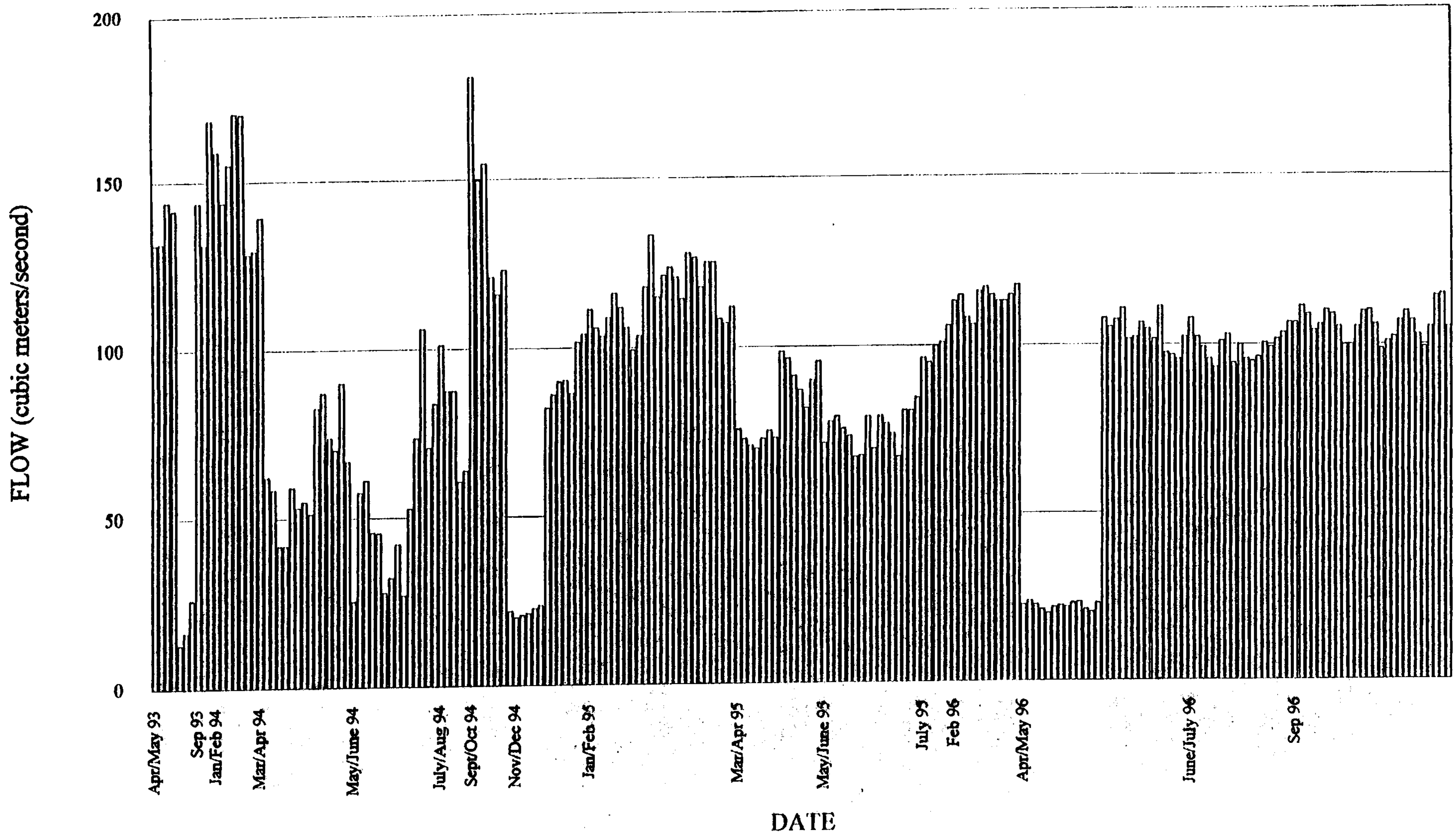

Figure 3. Summary of primary channel flows during the entrainment studies, 1993-1996, Tracy Fish Collection Facility, Tracy, California (cubic meters/second x 35.335 = cubic feet/second).

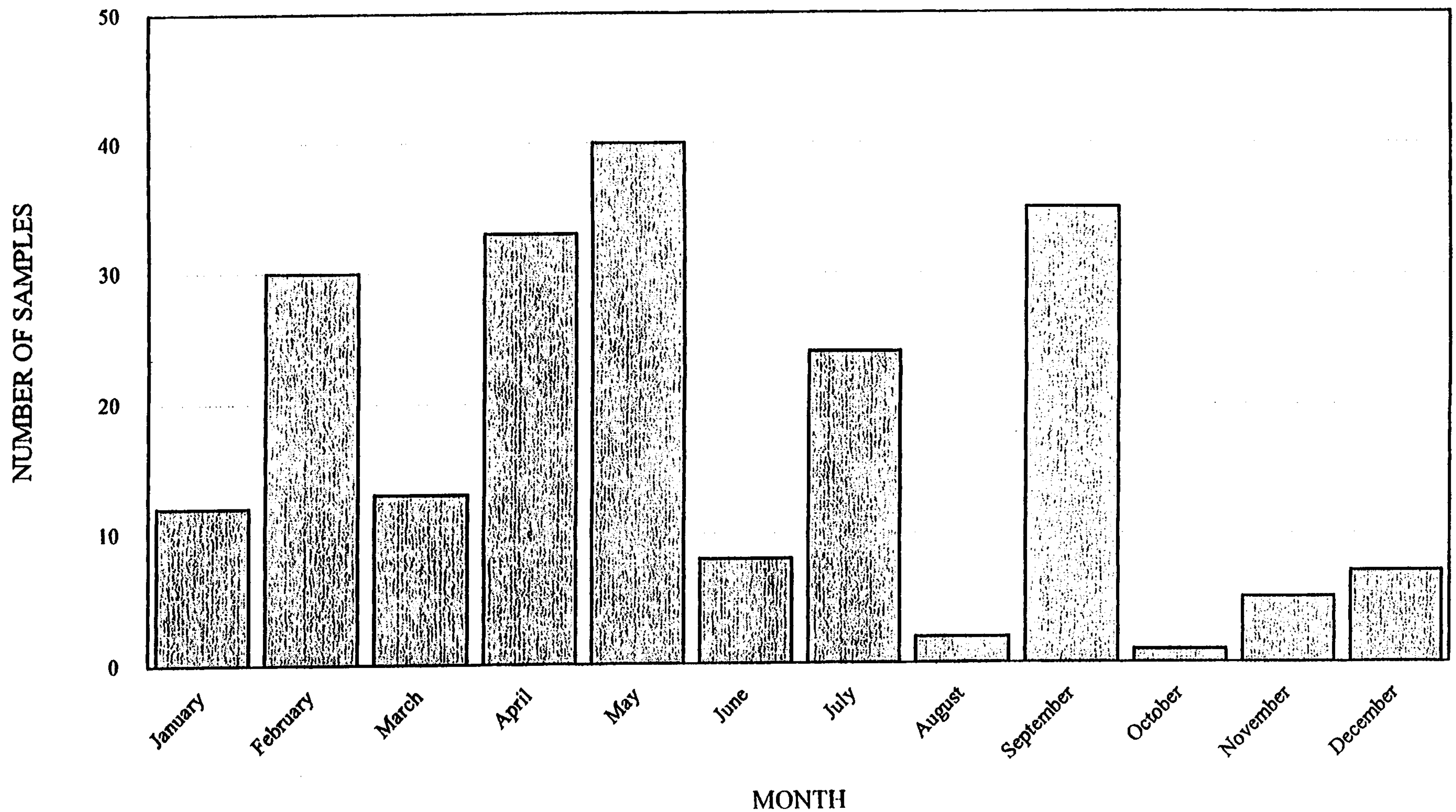

Figure 4. Distribution of paired holding tank samples by month from 1993-1996, Tracy Fish Collection Facility, Tracy, California.

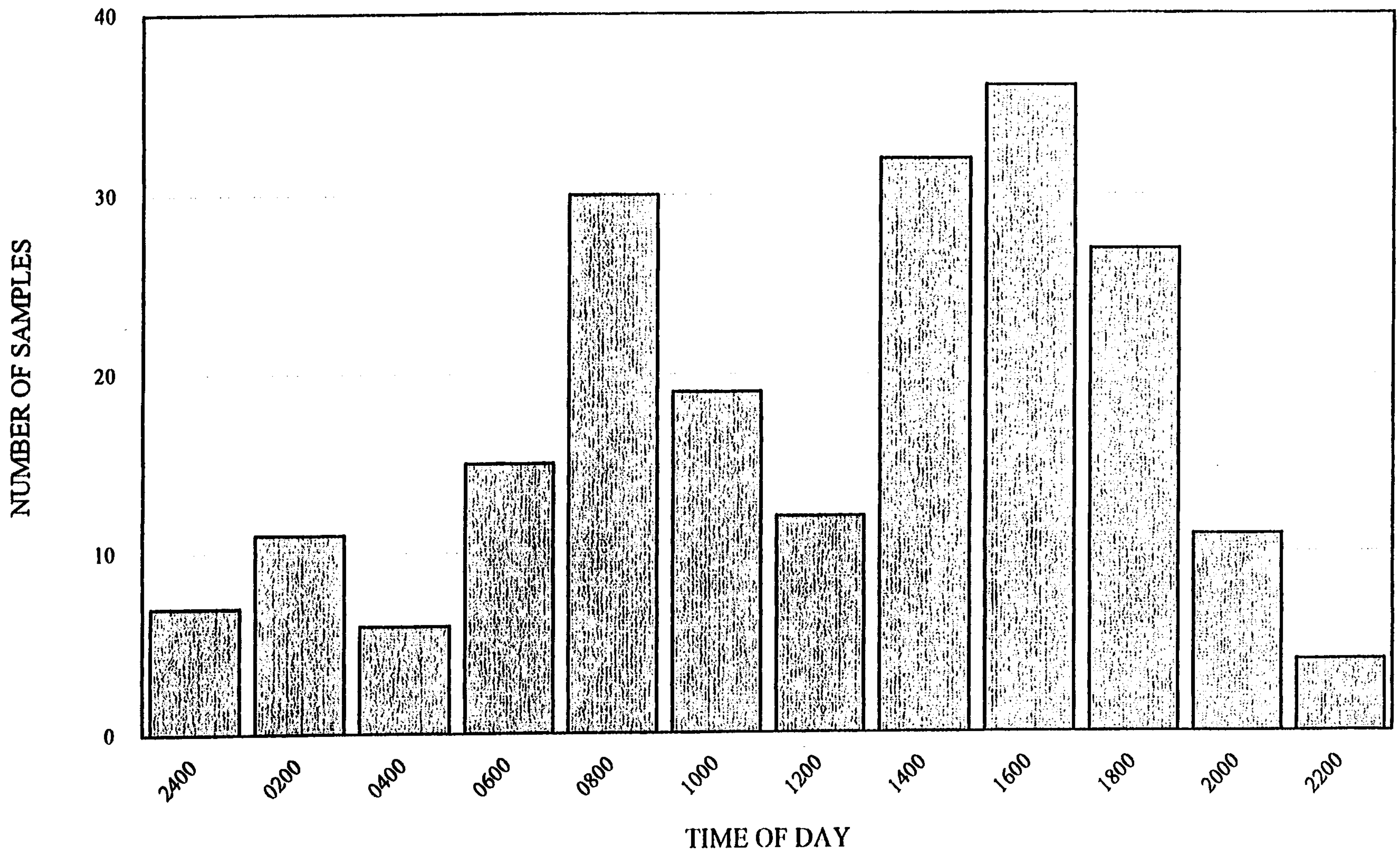

Figure 5. Distribution of paired holding tank samples by time of day from 1993-1996, Tracy Fish Collection Facility, Tracy, California.

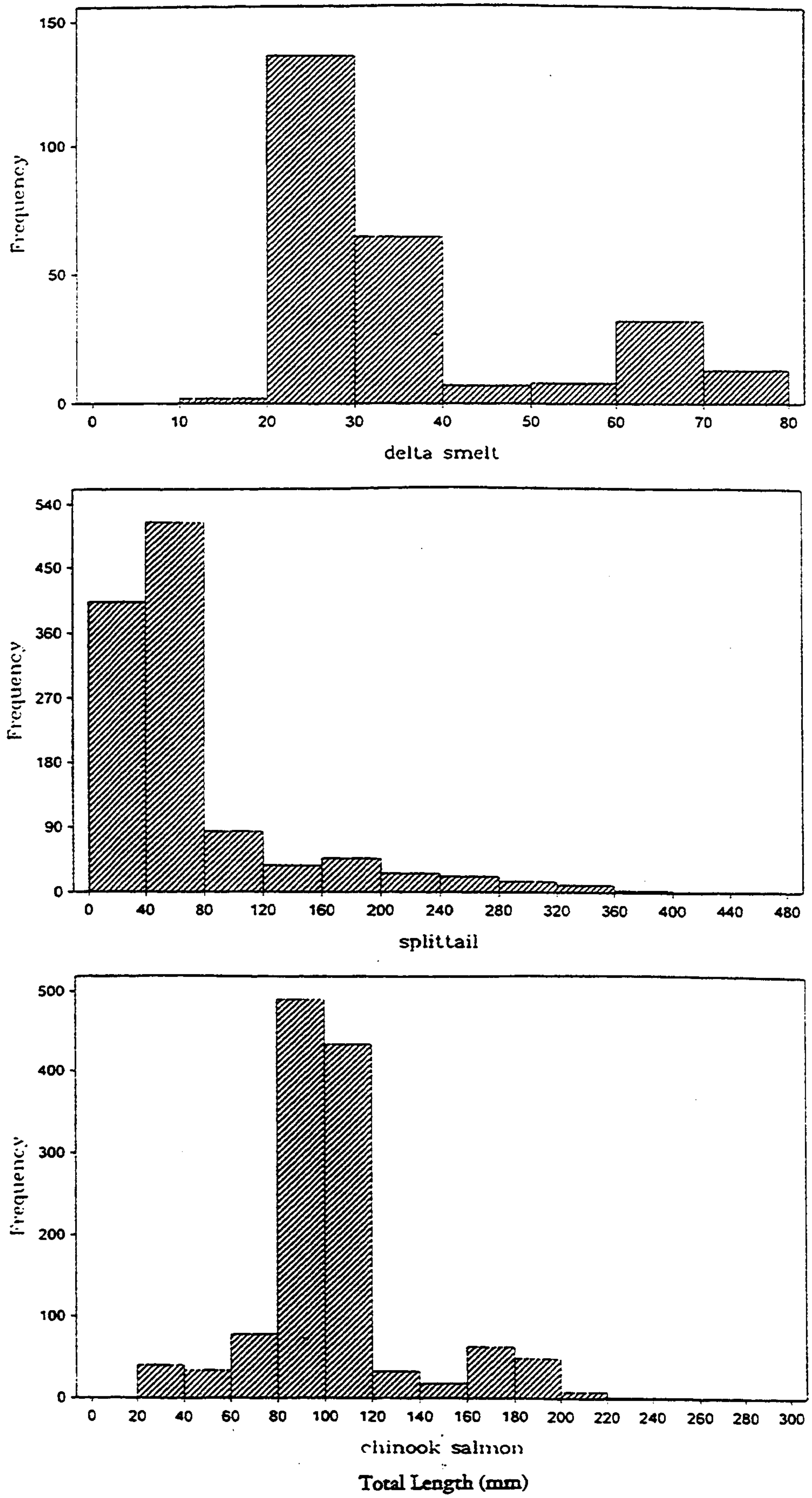

Figure 6. Length frequency distributions of delta smelt, splittail and chinook salmon collected during the entrainment studies, 1993 - 1996, Tracy Fish Collection Facility, Tracy, California.

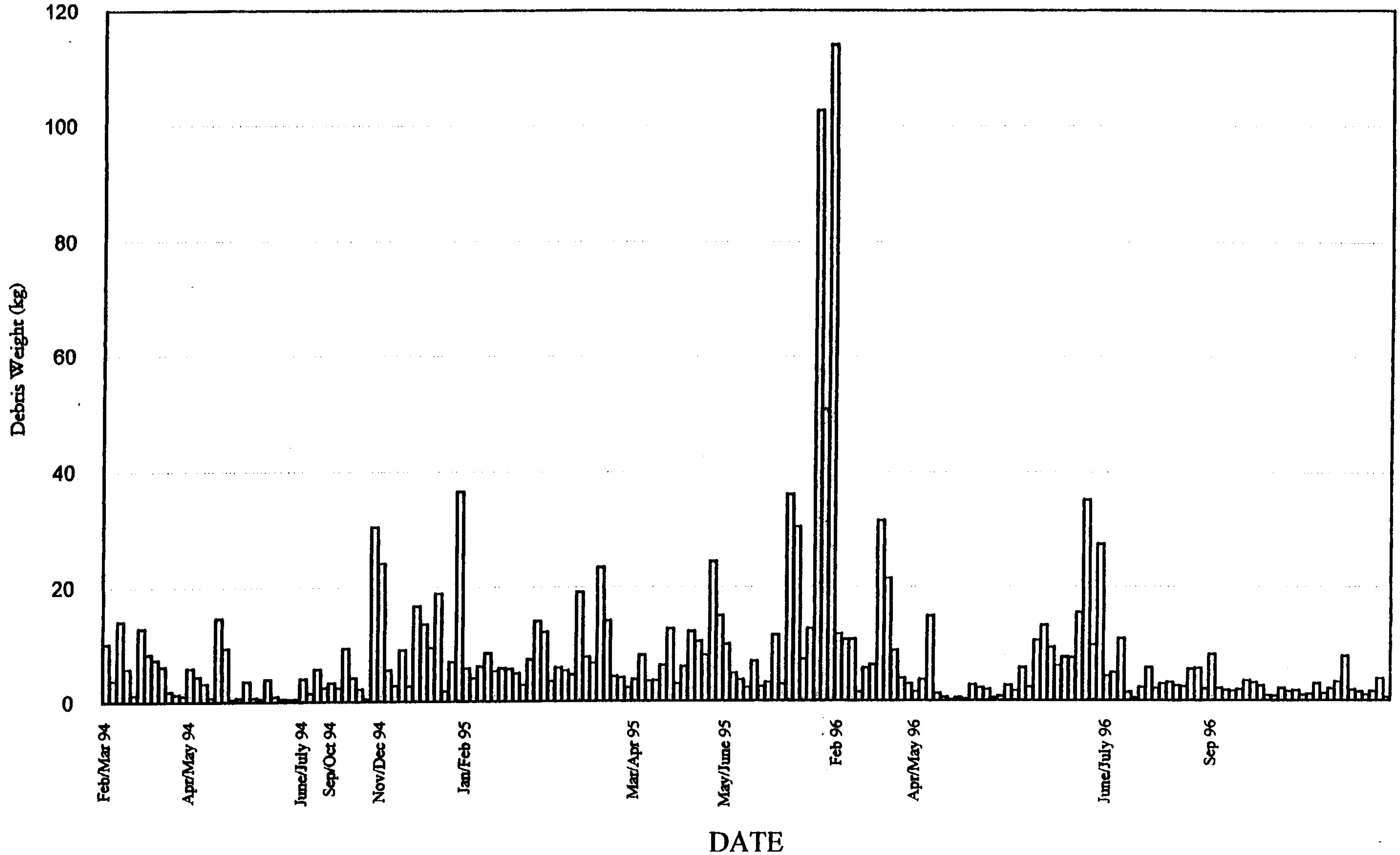

Figure 7. Summary of aquatic debris conditions (kg/2 hours collecting time) during the entrainment studies, 1994-1996, Tracy Fish Collection Facility, Tracy, California.

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