RESULTS OF FISH PASSAGE MONITORING AT THE VERN FREEMAN DIVERSION FACILITY, SANTA CLARA RIVER, 1995

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1.0 INTRODUCTION

The 1995 monitoring season marks the second year of a five year study assessing the upstream movement of adult steelhead and the downstream movement of juvenile steelhead past the Vern Freeman Diversion Facility. Additional observations of fish usage of the upstream fish ladder were made between 1991 and 1993 prior to the start of the present study. A semi-permanent trap was fished for 7-days in 1991, for 2-days in 1992, and observations of fish usage in the fish ladder were made daily from 17 February through 17 May, 1993. The 5-year monitoring study began with the 1994 trapping season, and will continue through the 1998 trapping season. This report presents the results of the 1995 trapping season, and discusses the 1995 results in relation to the previous data collected. Pertinent data collected prior to 1995 will be presented in tables to facilitate this discussion. The results of the 1991 through 1994 trapping season are presented in ENTRIX (1993 and 1994).

1.1 BACKGROUND

The Santa Clara is an intermittent river that drains portions of Los Angeles and Ventura counties in southern California. The mainstem Santa Clara River flows through a narrow alluvial valley onto a large coastal plain, and is fed by several tributaries that flow out of local mountains. The major tributaries are Santa Paula, Sespe and Piru creeks. Streamflow is typical of most southern California rivers; extremely low (often zero) during the dry summer and fall months, but can reach relatively high peak flows during winter storms. During the low flow period, a sand bar forms at the mouth of the Santa Clara River estuary, forming an intermittent barrier to fish migration to or from the ocean. Fish also are prevented from migrating through the lower Santa Clara River until sufficient rainfall in the basin provides adequate streamflow to allow for passage.

The Santa Clara River supplies water for domestic, municipal and agricultural uses in the basin primarily through groundwater recharge. Water is diverted at Saticoy, approximately 16.8 kilometers upstream from the ocean, by the United Water

Conservation District (UWCD) into a series of percolation ponds to recharge the Oxnard Coastal Plain aquifers. Prior to 1989, the diversion consisted of an earthen dike. In 1991, the UWCD constructed the Vern Freeman Diversion Improvement Project to improve the existing diversion on the Santa Clara River in Ventura County, California. This action was taken at the direction of the State Water Resources Control Board to reduce sea water intrusion in the Oxnard Coastal Plain aquifers resulting from groundwater overdrafting to supply water for irrigation, industry, and municipal uses. The improvements, consisting primarily of a permanent concrete riverbed stabilization structure, were necessary for the UWCD to maintain its ability to divert water to groundwater recharge basins in the Oxnard Plain Forebay Basin. Historic in-river aggregate mining destabilized and degraded the Santa Clara River bed, which had lowered approximately 22 feet opposite the diversion headworks since 1928, when diversions began. This down-cutting of the river bed also contributed to repeated failures of the previous sand dike diversion structure. The permanent concrete structure, completed in 1991, has since halted the headcutting, stabilized the river bed both upstream and downstream of the project, and improved the ability of UWCD to divert streamflow to groundwater recharge basins.

The project was permitted through U.S. Army Corps of Engineers (COE) 404 Permit No. 86-116-T5. The Freeman Diversion also includes a two-entrance denil fish ladder, a fish screen, and by-pass facilities as described in Special Condition A of the COE 404 permit. Special Condition B of the 404 permit focuses on the fisheries mitigation features of the project, and states:

> "B. The District shall institute a plan for evaluation of the mitigation features of the project to determine their effectiveness at accomplishing their designated purpose. This evaluation process may include studies on fish movement, flows and timing and will be conducted for a period of 5 years after the project is completed. The plan is to be developed by the District within 18 months of permit issuance and is to be approved by the COE in consultation with the involved resource agencies. The implementation of the plan shall include the installation of some functional, mutually agreeable device for counting fish passage through the ladder."

An appropriate study plan (ENTRIX 1991) to monitor steelhead utilization of the fish ladder was developed and approved by the Department of Fish and Game (CDFG),

United States Fish and Wildlife Service (USFWS) and the COE. The plan centered on the installation of a semi-permanent fish trap and counting device that became operational in February of 1993. Prior to the installation of the semi-permanent fish trap and counter, upstream fish migration was monitored with a temporary trap (described in ENTRIX 1991) in 1991 and 1992. A number of details pertaining to the operation of the semi-permanent fish trap and counting device required refinement after installation. As a result, an agreement was reached between UWCD and CDFG to view the 1993 trapping season as a preliminary year to work out the details of the operating procedures. The five year monitoring phase began with the 1994 water year. Accordingly, this report documents the second year of the required five year study.

1.2 SPECIES COMPOSITION

The fish assemblage in the Santa Clara River is comprised of five native species (including two subspecies of stickleback), four species native to southern California streams that have been introduced into the system, and several species that are not native to California, but have been introduced into the system. Fish native to the Santa Clara River Basin include steelhead (rainbow) trout (*Oncorhynchus mykiss*), Pacific lamprey (*Lampetra tridentata*), partially armored threespine stickleback (*Gasterosteus aculeatus microcephalus*) and the unarmored threespine stickleback (*G. a. williamsoni*), a federally and state listed endangered species. The tidewater goby (*Eucyclogobius newberryi*) (also a federally listed endangered species) and Pacific staghorn sculpin (*Leptocottus armatus)* are primarily estuarine species which are seldom found upstream in freshwater habitats.

Fish found in the Santa Clara river that are native to southern California, but not to the Santa Clara River system include Santa Ana sucker (*Catostomus santaanae*) and the arroyo chub (*Gila orcutti*), both of which are considered species of special concern by Moyle et al. (1989) The native habitat of the arroyo chub and the Santa Ana sucker is the Los Angeles basin, and their native streams have been highly degraded as a result of urbanization. Two additional species native to California have established populations in the Santa Clara River, the Owens sucker (*C. fumeiventris*) and the prickly sculpin (*Cottus asper*). The Owens sucker, native to the Owens River, was apparently introduced through the transfer of water (through the Los Angeles Aqueduct) into the basin. The prickly sculpin is native to coastal streams as far south as the Ventura River (the next drainage to the north), but the population in the Santa Clara River is thought to have

entered the basin through transfer of water (through the State Water Project into Pyramid Lake from the Sacramento River system) (Bell 1978). Several additional species have been stocked into reservoirs throughout the basin and are occasionally found in the river, including threadfin shad (*Dorosoma peteneses*), bullhead (*Ameiurus spp.*) and green sunfish (*Lepomis cyanellus*), as well as hatchery reared rainbow trout (*O. mykiss*). Although the mainstem Santa Clara River provides habitat for several of the fish species listed above, the lower Santa Clara River (in the vicinity of the Vern Freeman Diversion) serves primarily as a migration corridor for steelhead and lamprey, with tributaries providing most of the spawning and rearing habitat (Pucker and Villa 1985).

1.2.1 STEELHEAD

Maintaining the steelhead trout population was the impetus for the construction of the fish ladder over the Vern Freeman Diversion. The Santa Clara River historically supported a population of steelhead, although the size of the run was never quantified. Steelhead (and lamprey) use the lower Santa Clara River as a migration corridor and do not spawn or rear in this portion of the river (Pucker and Villa 1985). Spawning and rearing of the young takes place in upstream tributaries. Historically, Santa Paula, Sespe and Piru creeks were utilized as the primary spawning and rearing habitat, with several smaller streams also providing habitat.

Steelhead populations have declined within the watershed. The old Vern Freeman Diversion may have impeded upstream migration and entrained emigrating smolts. The Santa Paula Diversion blocks upstream access on Santa Paula Creek and reduces flow downstream of the diversion. Santa Felicia Dam blocks upstream access on Piru Creek approximately 10 kilometers upstream of its confluence with the Santa Clara River. A minimum release of five cfs is maintained at the dam which may provide spawning and rearing habitat for steelhead in the lower creek. Sespe Creek has historically been heavily stocked with hatchery reared rainbow trout, but remains substantially undeveloped and probably provides the best existing spawning and rearing habitat for steelhead in the basin.

2.0 METHODS

The study design for this program is presented in ENTRIX (1991). The study was designed to monitor the upstream (adult) and downstream (juvenile) migrations of steelhead trout through the fish ladder. In 1993, a semi-permanent fish trap was installed in the fish ladder (prior to 1993, a temporary trap and fyke net were placed in the ladder during high flow events to monitor fish movement upstream through the diversion facility). Under agreement with the CDFG, USFWS and COE, the fish ladder is to be operated throughout the upstream migration period in the Santa Clara River at the Vern Freeman Diversion Dam provided certain flow and elevation criteria are met (i.e., the headwater elevation is between 160-164 ft. msl per the COE 404 permit). The ladder is also occasionally closed during periods of high sediment transport associated with large storm events and when sand is flushed from the mouth of the diversion intake. Closing the ladder during these periods reduces the build up of sand and debris at the fish trap, reduces blockage of the counting tubes, and allows for more consistent and efficient ladder operation.

2.1 UPSTREAM MIGRATION

A denil type fish ladder provides access for upstream migrating fish around the diversion structure. During periods of high streamflow, a relatively high velocity current is required to attract upstream migrating fish into the fish ladder. The water surface elevation inside the fish ladder (at the downstream fish entrance) is maintained 1.5 feet higher than the river outside the fish ladder. The head created by this elevational difference results in a water velocity flowing out of the fish ladder at a calculated eight feet per second.

Steelhead migrating upstream through the fish ladder are directed by a series of guide bars which directs the fish into the counting tubes. A screen "funnel" (300 mm high by 100 mm wide) was placed at the upstream end of the counting tubes. The funnel allows steelhead to easily move into the trap, while making it difficult for fish to move back out

of the trap. The guide bars are spaced sufficiently far apart to allow lamprey (but not adult steelhead) to migrate unhindered past the trap. The trap was formed by the upstream trash rack and downstream guide bars (metal slats) and their supports. This forms a holding compartment measuring approximately 10' by 15'.

The trap is serviced at least once per day during the sampling season. During servicing, the fish ladder is drained, and the debris and sand that collects around the trap are removed. The fish trap is checked during this time. In addition, the rest of the fish ladder is surveyed for fish stranded as a result of dewatering the ladder.

Fish collected in the trap (or captured in the ladder during dewatering for trap maintenance) are identified to species and measured (fork length (FL) or total length (TL) depending upon caudal configuration of the individual species) to the nearest millimeter (mm). Photographs are taken of representative individuals. Scale samples are taken from rainbow trout for age determination. Steelhead and lamprey are then released upstream of the trap to continue their upstream migration.

Lamprey are counted in the ladder during dewatering for maintenance. Because lamprey are able to swim through the trap without being captured, these counts underestimate their true abundance. It is not known how long lamprey take to migrate through the ladder. If a lamprey remains in the fish ladder for more than one day, it may be counted on consecutive days. To determine the proportion of lamprey that remain in the ladder for more than one day, a sub-sample of lamprey are marked with a small notch in the dorsal fin and released back into the ladder. The number of marked and unmarked lamprey are recorded each day to estimate the percentage remaining in the ladder for two or more days. Lamprey that are not marked are typically collected and released upstream of the diversion.

2.1.1 FISH COUNTER EFFICIENCY

Prior to each sampling season, the efficiency of the counting device to detect fish is tested by pulling hatchery rainbow trout (average length approximately 300 mm FL) through the counting tubes. A plastic tie clip is attached through the mouth/gill of a hatchery-reared rainbow trout with two lines attached to the clip, one line running upstream and the second line running downstream through a counting tube. The fish are directed to the

counting tube through a 300 mm PVC pipe, and pulled by means of the lines upstream and downstream through the tubes to test the counter's ability to detect and record the passage of a fish. Both of the tubes are tested in this manner.

2.2 DOWNSTREAM MIGRATION

Downstream-migrating steelhead smolts entering the diversion facility are prevented from entering the diversion canal by a fish screen. A fish by-pass allows the smolts to exit the diversion and return back to the river downstream of the diversion structure to continue their migration to the ocean. During periods when streamflow between the diversion and the ocean is not contiguous, fish are rescued by being collected in a trap consisting of a mesh cage that can be lowered into the chamber adjacent to the weir, through which all by-pass water (and fish) flows. In 1994 and 1995, the trap was enabled throughout the sampling period to verify the existence of steelhead smolts in the system. Smolts collected in the bypass trap are collected on a daily basis, counted, measured (FL) and scale samples may be collected for age determination. The smolts are then either released into the river through the by-pass, or, if flow was not contiguous to the lagoon, smolts are transported by truck to the lagoon.

3.0 1995 Results of Fish Passage Monitoring at the Vern Freeman Diversion Facility

3.1 Upstream Migration

The upstream fish ladder and trap were operated from 6 January to 20 May, 1995. Streamflow conditions were extremely high in January and March of 1995, and the upstream ladder was closed on several occasions as a result of the associated high sediment load carried by the high streamflows (Figure 3-1).

3.1.1 Steelhead

One adult steelhead measuring 635 mm length was captured in the fish trap on 2 March 1995. Scale analysis indicated that the fish was four-years old, with a freshwater residency of 2 year and a saltwater residency of 2 years before returning to spawn. The steelhead was released upstream of the diversion to continue its spawning migration.

An additional adult steelhead or rainbow trout was captured downstream of the diversion by an UWCD maintenance worker on 13 March. The fish was observed in a pool that had been cut off from the river as the streamflow receded. The fish was photographed, measured (420 mm total length), and released upstream of the diversion. Based on the photographs, the fish appeared to be wild (fully developed fins). However, it is not known if the fish was an upstream migrating steelhead, or a resident fish that reared in a reservoir (both Piru and Castaic reservoirs over topped their dams in March). No scale sample was collected from the fish, therefore no information is available on the age of the fish or its life history.

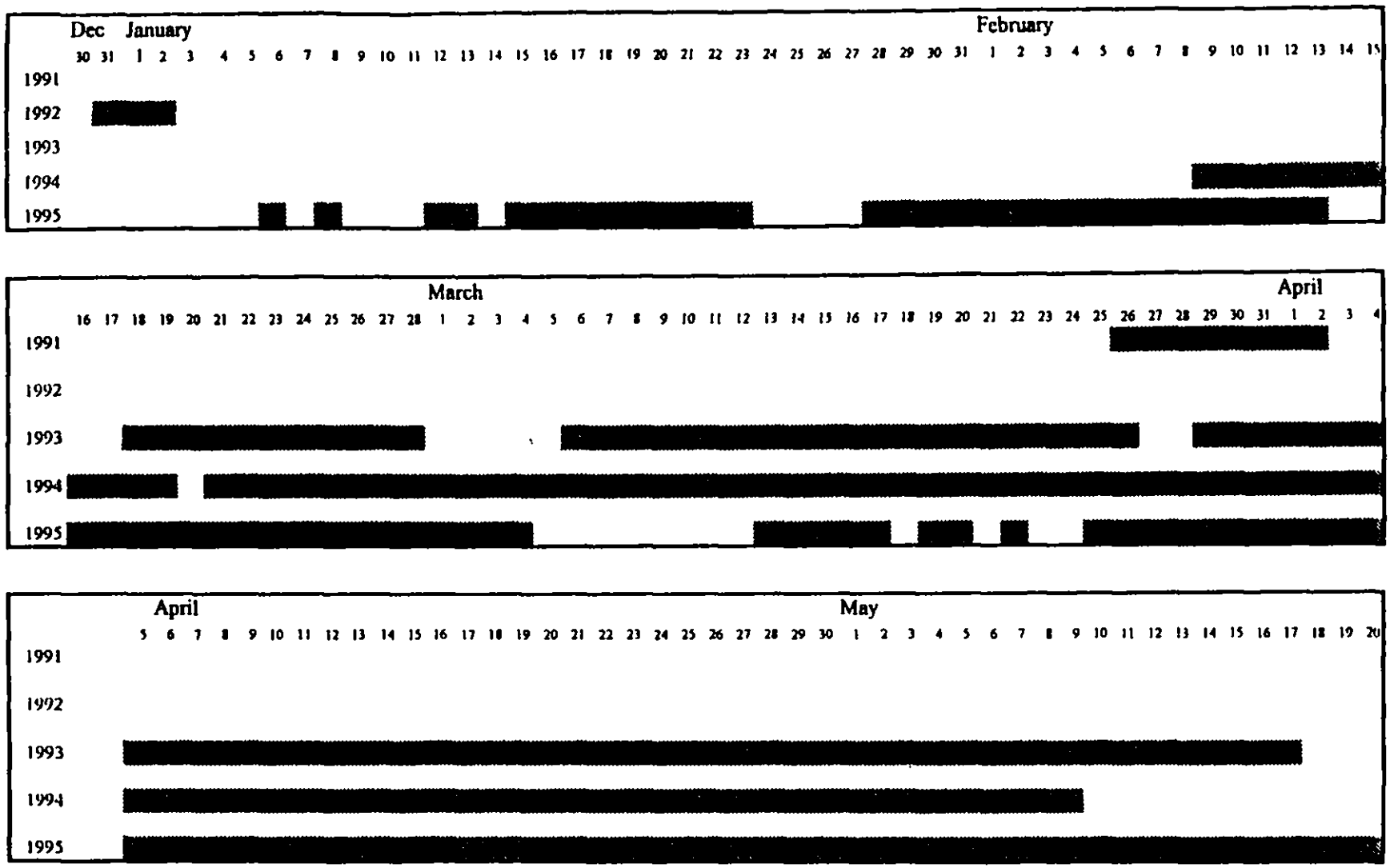

Figure 3-1. Dates That the Upstream Migrant Trap Was in Operation, Vern Freeman Diversion, Santa Clara River, 1991-1995.

3.1.2 TRAP CALIBRATION AND RESULTS OF FISH COUNTING DEVICES

The counting tubes were calibrated by pulling hatchery rainbow trout (approximately 300 mm FL) through the tubes in both the upstream and downstream direction. Each tube was monitored by a separate counting device. The movement of trout through the tubes was detected at settings between a sensitivity setting of 7 and 10 (with a sensitivity setting of 10 being the most sensitive), although none of the settings consistently counted the correct number of times that a fish was pulled through the tubes per test. Sensitivity settings of "8" and "9" performed the best, and these settings were used throughout the 1995 trapping season. The inconsistent performance of the counting devices during calibration may have been a result of the relatively small fish used in the calibration test. Adult steelhead captured in the trap in 1994 and 1995 measured 475 and 635 mm FL, respectively. However, fish in this size range were not available at the local hatchery, and the test had to be conducted with the smaller sized fish. Using relatively small fish for the calibration test, the sensitivity settings used during the 1994 and 1995 may have been to sensitive. The sensitive settings may have resulted in the counting device being more susceptible to detecting (and thus "counting") Pacific lamprey and/or debris passing through the counting tubes.

The number of counts recorded for each tube were highly variable and generally were not reliable (Appendix A). Several potential reasons exist for the variability in the counts which will be discussed in Section 4.1.2.

3.1.3 PACIFIC LAMPREY

A total of 368 adult Pacific lamprey were counted in the fish ladder in 1995. Lamprey were observed in the ladder from 18 January through 18 May. The ladder was closed on 20 May at the request of CDFG. The daily counts of lamprey in the ladder were very low at the time that the upstream ladder was closed, and the adult run of lamprey appeared to be essentially completed. Approximately 46 percent of the Pacific lamprey run past the fish ladder during the first two weeks of February (Table 3-1) After this initial pulse, the weekly counts remained fairly consistent through mid-April, before slowly tapering off to near zero by mid-May. The upstream migrating lamprey ranged in length from 485 to 750 mm, averaging 610 mm in length (Figure 3-2).

Table 3-1. Number of Pacific Lamprey Trapped in the Fish Ladder Structure by Month, Vern Freeman Diversion, Santa Clara River, 1994[1] and 1995.

Month	Week Ending	1994[2]	1995[3]
January	7	—	0
	14	—	0
	21	—	1
	28	—	2
February	4	0	95
	11	0	74
	18	1	35
	25	19	16
March	4	11	24
	11	7	2
	18	283	4
	25	240	20
April	1	201	20
	8	133	34
	15	13	10
	22	—	9
	29	—	2
May	6	—	10
	13	—	8
	20	—	2
	27	—	—
June	4	—	
	11	—	
Total		**908**	**368**

[1]Data from ENTRIX (1994)

[2]Upstream migrant trap was operated from 4 February through 9 April, 1994.

[3]Upstream migrant trap was operated from 6 January through 20 May, 1995.

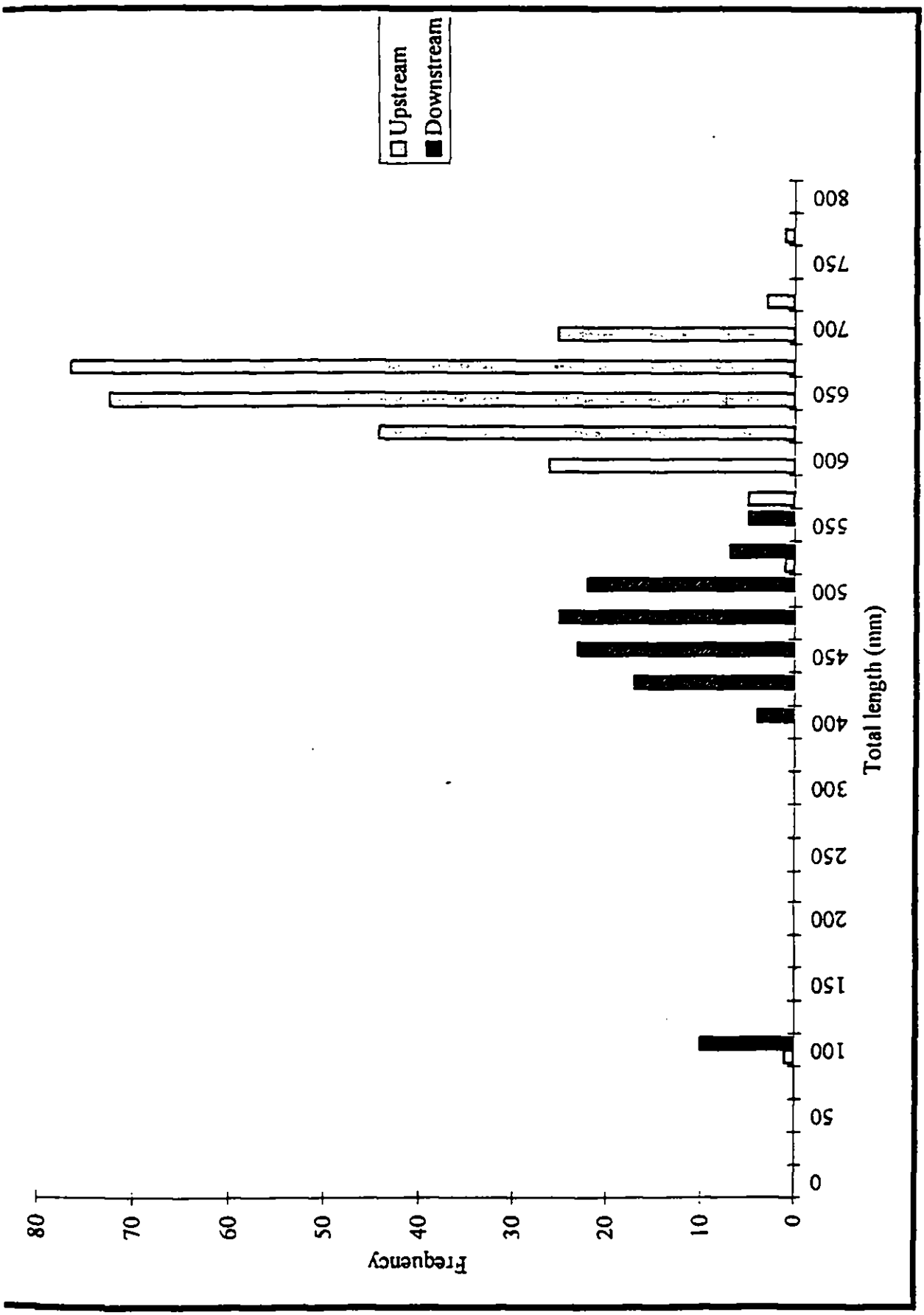

Figure 3-2. Length-Frequency Histogram of Pacific Lamprey Captured in the Upstream and Downstream Migrant Traps, Vern Freeman Diversion Dam, Santa Clara River, 1995.

In January and February a total of 115 upstream migrating lamprey were marked and placed back in the fish ladder to estimate the number of lamprey that require more than one day pass through the fish ladder. A total of nine (7.8 percent) marked were lamprey were recaptured the day after they had been marked. No lamprey required more than one day to pass through the ladder.

3.2 DOWNSTREAM MIGRATION

3.2.1 STEELHEAD SMOLTS

The downstream migrant trap was operated on a daily basis from 7 January through 4 June. After 4 June, the downstream migrant trap was closed, but late migrating smolts were collected in front of the fish screen. The fish screen area was surveyed on a weekly basis beginning 11 June through 27 July. Smolts captured in the downstream trap area were released into the river to continue their downstream migration when streamflow was contiguous with the lagoon. When streamflow was insufficient to permit downstream migration to the lagoon, the smolts were transported by truck and released into the upper end of the lagoon. A total of 111 wild (presumably steelhead) smolts and 63 hatchery rainbow trout were captured during the 1995 sampling season at the Vern Freeman Diversion facility (Table 3-2). The hatchery trout were generally easy to distinguish from the juvenile steelhead. The fins of hatchery trout generally show excessive wear as a result of rubbing against concrete raceways. The hatchery fish also tended to be longer, "fatter," and darker in color than the wild fish. The trout classified as wild were typically bright silver in color, their fins were fully formed and did not show signs of unusual wear, and their scales were easily removed.

Wild smolts were recorded in the fish trap between 23 January and 23 June. A total of eight smolts were captured prior to the last week in April. Between 23 April and 30 May, 92 smolts were captured at the diversion facility. The outmigration of smolts quickly declined, with only 12 smolts captured during June.

The majority (69 of 81) smolts were aged as being-one-year old (1+) (1994 cohort). The remaining 12 smolts were aged as two-years-old (2+) (1993 cohort). However, the scales of many of the larger individuals were unreadable (i.e., the fish could not be aged from

Table 3-2. Weekly Summary of Steelhead Smolt Caught in the Downstream Migrant Trap, Vern Freeman Diversion, Santa Clara River, 1994[1] and 1995.

Month	Week Ending	1994[2]	1995[3]
January	7	—	0
	14	—	0
	21	—	0
	28	—	1
February	4	0	1
	11	0	0
	18	0	1
	25	0	0
March	4	0	0
	11	0	0
	18	4	0
	25	10	2
April	1	23	0
	8	17	0
	15	8	0
	22	16	2
	29	2	11
May	6	2	27
	13	1	25
	20	0	16
	27	0	10
June	3	—	5
	10	—	6
	17	—	1
	24	—	0
July	1	—	0
	8	—	0
	15	—	0
	22	—	0
	29	—	0
Total		**83**	**111**

[1]Data From ENTRIX (1994)

[2]Downstream migrant trap closed on 25 May, 1994.

[3]Downstream migrant trap closed on 27 July, 1995.

scale samples collected). In addition, scales were not collected from all specimens captured in the downstream migrant trap. The remaining 31 smolts were assigned to an age class based on their length compared to smolts of a known age. Except for one fish, all of the smolts less than 203 mm in length were aged as one year old. Thus all of the smolts less than 203 mm in length that were not aged were classified as a 1+. Conversely, all of the smolts greater than 203 mm in length that were not aged were classified as a 2+. On the basis of this analysis, 82.2 (88) percent of the smolts captured were age 1+ and 17.8 (19) percent were age 2+ (Figure 3-3).

Overall, smolts ranged in size from 77 to 248 mm (Figure 3-3). The one-year-old smolts ranged from 77 to 203 mm in length, averaging 165 mm. The two-year-old smolts ranged in size from 169 to 248 mm in length, averaging 219 mm.

Sixty-three hatchery rainbow trout were collected in the downstream trap between 21 February and 21 May. Ninety percent (57) of the hatchery fish were captured between the last week in April and the third week in May. The hatchery trout ranged in length from 195 to 336 mm, averaging 243 mm (Figure 3-4).

3.2.2 Pacific Lamprey

A total of 113 lamprey were captured in the downstream migrant trap in 1995 (Table 3-3). Lamprey were captured in the trap between the first week in February and the second week in June, with 44 percent of the captures recorded during the first two weeks in May. Pacific lamprey ranged in length from 110 to 508 mm TL (Figure 3-2). Lamprey captured in the downstream migrant trap comprised two distinct length groups, a small group (approximately 110 to 120 mm) that did not possess well developed eyes, and a larger group (355 to 508 mm TL) that may have been spent spawners from the 1994 spawning run.

3.2.2.1 Non-Anadromous Fish

Six additional species were caught in the downstream trap (and occasionally in the fish ladder) in 1995, including arroyo chub, prickly sculpin, Santa Ana sucker, partially

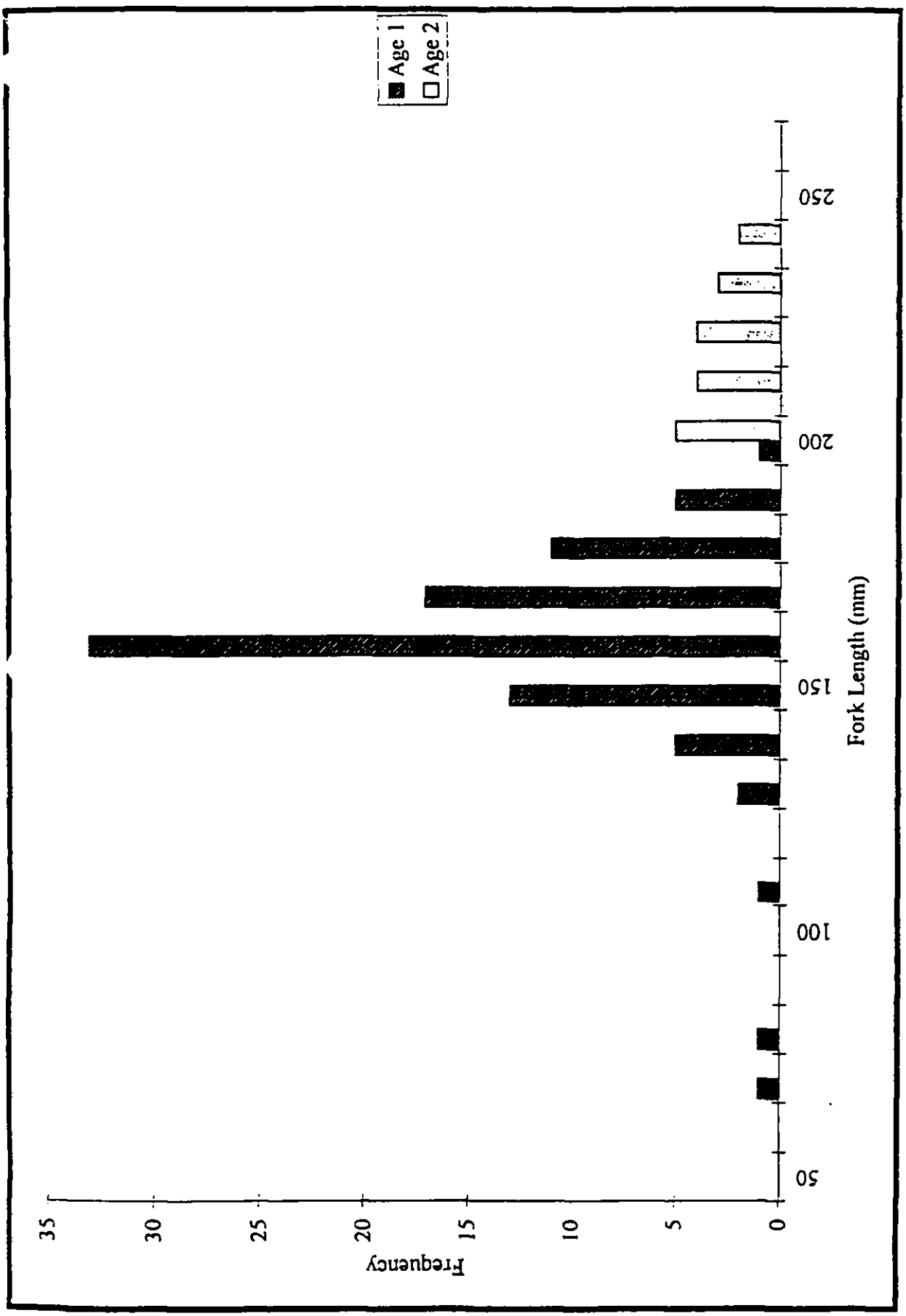

Figure 3-3. Length-Frequency Histogram of Outmigrating Smolts Captured in the Downstream Migrant Trap, Vern Freeman Diversion Dam, Santa Clara River, 1995.

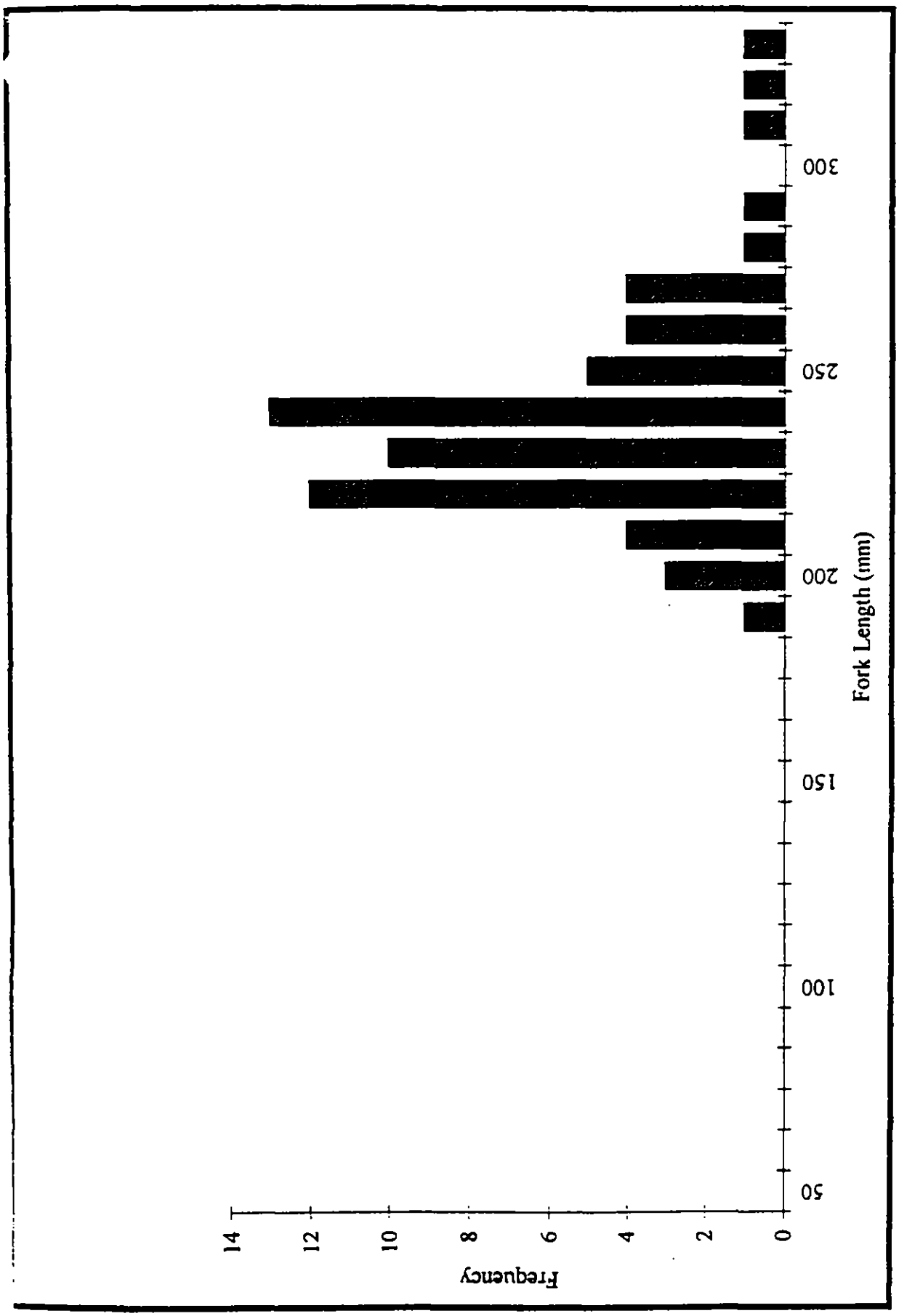

Figure 3-4. Length-Frequency Histogram of Hatchery Reared Rainbow Trout Captured in the Downstream Migrant Traps, Vern Freeman Diversion Dam, Santa Clara River, 1995.

Table 3-3. Weekly Summary of Pacific Lamprey Caught in the Downstream Migrant Trap, Vern Freeman Diversion, Santa Clara River, 1994[1] and 1995.

Month	Week Ending	1994[2]	1995[3]
January	7	—	0
	14	—	0
	21	—	0
	28	—	0
February	4	0	2
	11	0	3
	18	0	1
	25	0	0
March	4	0	2
	11	2	1
	18	18	1
	25	20	0
April	1	13	10
	8	10	6
	15	5	4
	22	0	8
	29	0	18
May	6	1	32
	13	1	5
	20	0	3
	27	—	5
June	3	—	9
	10	—	3
	17	—	0
	24	—	0
July	1	—	0
	8	—	0
	15	—	0
	22	—	0
	29	—	0
Total		**70**	**113**

[1] 1994 data from ENTRIX (1994)

[2] Downstream migrant trap closed on 25 May, 1994.

[3] Downstream migrant trap closed on 27 July, 1995.

armored threespine stickleback, bullhead and green sunfish. The number of fish caught varied by month and species. Prickly sculpin were the most abundant species captured (106) followed by arroyo chub (93) (Table 3-4).

Table 3-4. Non-Anadromous Fish Collected in the Vern Freeman Diversion Fish Ladder and Downstream Migrant Trap, Santa Clara River, During 1994[1] and 1995.

Month	Species	1994[2]	1995[3]
January	arroyo chub	—	7
	prickly sculpin	—	36
	Santa Ana sucker	—	2
	threespine stickleback[4]	—	1
	bullhead	—	6
	green sunfish	—	0
February	arroyo chub	5	32
	prickly sculpin	91	24
	Santa Ana sucker	0	8
	threespine stickleback[4]	4	0
	bullhead	3	0
	green sunfish	0	1
March	arroyo chub	26	9
	prickly sculpin	38	16
	Santa Ana sucker	29	3
	threespine stickleback[4]	4	0
	bullhead	14	1
	green sunfish	1	0
April	arroyo chub	48	5
	prickly sculpin	1	6
	Santa Ana sucker	3	2
	threespine stickleback[4]	4	1
	bullhead	0	1
	green sunfish	0	0
May	arroyo chub	26	3
	prickly sculpin	0	11
	Santa Ana sucker	2	1
	threespine stickleback[4]	1	0
	bullhead	3	1
	green sunfish	1	0

Table 3-4. Non-Anadromous Fish Collected in the Vern Freeman Diversion Fish Ladder and Downstream Migrant Trap, Santa Clara River, During 1994[1] and 1995 (concluded).

Month	Species	1994[2]	1995[3]
June	arroyo chub	—	7
	prickly sculpin		13
	Santa Ana sucker		1
	threespine stickleback[4]		3
	bullhead		0
	green sunfish		0
Season total	**arroyo chub**	**105**	**51**
	prickly sculpin	**130**	**106**
	Santa Ana sucker	**34**	**17**
	threespine stickleback[4]	**13**	**5**
	bullhead	**20**	**9**
	green sunfish	**2**	**1**

[1]Data from *ENTRIX* 1994

[2]1994 Monitoring season extended from 7 February through 11 May.

[3]1995 Monitoring Season extended from 6 January through 16 June.

[4]Identified in the field as partially armored threespine stickleback.

4.1 UPSTREAM MIGRATION

Steelhead trout were captured in the upstream and downstream migrant traps in 1994 and 1995. The capture of the upstream migrants indicates that steelhead trout are attracted to, and are able to negotiate, the fish ladder over the Vern Freeman Diversion structure. In addition, the presence of juveniles in the downstream trap indicates that the fish screen and by-pass system allowed smolts diverted from the river to return downstream of the diversion to continue their migration to the ocean. Adult Pacific lamprey were also captured in the fish ladder. However, uncertainty exist as to the age group of many of the lamprey captured in the downstream trap. Because of this uncertainty, the upstream and downstream trapping result for Pacific lamprey will be discussed together.

4.1.1 ADULT STEELHEAD

One adult steelhead was captured in the fish ladder in both 1994 and 1995. Based on scale analysis, the adult captured in 1994 was part of the 1992 cohort, having spent one year in freshwater and one year in the ocean (age 2+) before returning to spawn. The adult captured in 1995 was aged as a 4+, having spent two years in freshwater and two years in the ocean (1991 cohort). One additional adult trout was captured below the diversion in a side channel that had been cut off from the main river as the streamflow dropped. The fish, collected by the UWCD staff, was measured, photographed, and released upstream of the diversion. Scale samples were not collected from the fish. Based on photographic evidence, the fish appears to be wild (e.g., fully formed fins). However, the fish exhibited fairly heavily spotting dorsal-ventrally, which suggest that the fish had not resided in the ocean. The Santa Clara River experienced high streamflows, and both Piru and Castaic reservoirs spilled during 1995. Thus, the fish may have been a resident rainbow trout that moved down out of one of the reservoirs, out

of Sespe Creek, or an upstream migrant with an unusual color pattern. The fish was released upstream of the diversion.

The 1994 and 1995 adult steelhead "run" in the Santa Clara River consisted of one adult (possibly two in 1995), and based on photographs, all of the fish appeared to be female (lack of a well developed kype (hooked jaw) common to mature males). However, female steelhead have been reported to spawn with resident males (Shapovalov and Taft 1954). Therefore the lack of an anadromous mate would not prevent these fish from successfully spawning.

4.1.2 Fish Counting Device

The fish counters were checked each day the fish ladder was in operation, and a record was kept of daily counts (Appendix A). The counters were "zeroed", if necessary, each day that they were in operation. Although only one steelhead was captured in the upstream trap, counts were recorded on several days. Pacific lamprey may have been responsible for a number of the counts. For example, the only two days in which counts were recorded in January coincided with the only two days in which lamprey were observed in the ladder. Starting on 1 February, lamprey were observed in the fish ladder on an almost daily basis, and counts were recorded every day. The majority of the counts were recorded from the lower tube. Because lamprey are able to pass through the fish ladder without being captured, it was not possible to correlate the daily counts with the number of lamprey moving through the ladder.

The counters, primarily the counter monitoring the upper tube, occasionally went out of calibration. On these occasions the counts were disregarded. On two occasions, the lower tube was filled with sand and silt, and the counters register extremely high counts. The counters did register extremely high counts on several occasions for which no explanation was readily apparent. It is possible that the tubes were dewatered during routine maintenance that went unrecorded, or exceptionally high debris loads in the water column resulted in erroneous counts.

Due to the relatively high number of non-steelhead related counts and the low number of adult steelhead migrating upstream in 1994 and 1995, it is not possible to rely on the use

of counters to monitor the upstream passage of adult steelhead through the fish ladder in these years.

4.2 DOWNSTREAM MIGRATION

4.2.1 JUVENILE STEELHEAD

The purpose of the downstream trap is to capture smolts when flow in the river between the diversion and the ocean is discontinuous. When streamflow is continuous to the ocean, fish diverted into the facility are shunted through the fish by-pass and returned via a pipe back into the river downstream of the diversion structure. When streamflow is discontinuous (i.e., the entire flow is being diverted), the smolts are collected in the downstream migrant trap and transported downstream to the lagoon where they can continue their migration to the ocean. However, the downstream trap was monitored continuously in 1994 and 1995 to document the presence of smolts in the river. Only the portion of the river that was diverted was sampled. Therefore, the results of the downstream migrant trapping are only indicative of the minimum number of smolts that migrated downstream.

The numbers of rainbow trout/steelhead counted in the downstream trap provide information on the seasonal timing, size ranges and age classes of outmigrating smolts. The number of downstream migrating wild rainbow trout captured in the downstream migrant trap in 1994 and 1995 were 83 and 111, respectively (the mean daily streamflow in 1995 was considerably higher compared to 1994, thus a greater number of smolts were captured even though the percentage of water sampled (diverted) was considerably less). The rainbow trout were presumably outmigrating (smolting) juvenile steelhead based on their size range, age, and general body shape and color, as well as their capture in the downstream migrant trap.

Smolts outmigrated primarily as one-year-old fish in 1994 and 1995. Age 1+ smolts comprised 68.0 and 82.2 percent of the outmigrants in 1994 and 1995, respectively. Age 1+ smolts were slightly larger, on average, in 1994 compared to 1995 (175 mm compared to 165 mm FL). Age 2+ smolts comprised 30.6 and 17.8 percent of the out migrants in

1994 and 1995, respectively. Age 2+ smolts average approximately 220 mm in 1994 and 1995. Only one age 3+ smolt has been captured during the two years of trapping (1994).

Based on the capture of in the downstream migrant trap, the 1994 outmigration of juvenile steelhead began in mid-March, peaked in early-April, and was over by the second week of May. In 1995, the outmigration period essentially began in late-April, peaked in early-May, and continued into early-June. The apparent delay in this years outmigration was likely related to the exceptionally high streamflows experienced in 1995 compared to 1994. The higher streamflow would have been expected to result in lower water temperatures for a longer period of time, which may have reduced growth rates of smolts. Thus the smolts would have had to remain in freshwater for a longer period of time to reach the appropriate size to smolt. Smolts also tend to outmigrate on the fall of the hydrograph (i.e., when streamflow is declining after peak flows).

Hatchery reared rainbow trout have been identified in the downstream migrant trap in 1993 and 1995. The CDFG stocks hatchery trout into a tributary of the Santa Clara River during the winter and spring to provide for a put-and-take fishery (Adams pers. comm. 1995). One hatchery rainbow trout was captured in 1993, and 63 were captured in 1995.

4.3 PACIFIC LAMPREY

Pacific lamprey have a life history pattern similar to steelhead in that the young are spawned and reared in freshwater, then migrate to the ocean were they grow and mature before returning too freshwater to complete their life cycle. Beamish (1980) reported that Pacific lamprey typically migrate into rivers in British Columbia from April through June, and remain in freshwater for approximately one year prior to spawning. In California, Pacific lamprey apparently migrate upstream between April and late-July (Moyle 1976), although in Trinity River in northern California Moffett and Smith (1950, cited by Wang 1986) reported adult lamprey migrating upstream in August and September. Spawning has been reported to occur between April and late July (Moyle 1976). The spawning migration in the Santa Clara River is regulated by streamflow, and has begun as early as late January in 1995 and as a late as mid-March in 1991, depending on the onset of winter rains. Adult lamprey are not thought to range far from their natal streams during the oceanic phase of their life history (Moyle 1976). The 1991, 1994 and 1995 data suggest that the lamprey are in close proximity to the mouth of Santa Clara

River just prior to the spawning season based on their presence in the fish ladder (approximately 16.8 kilometers inland) within two weeks of the sand bar breaching. Pacific lamprey were first observed in the fish ladder 10 days after the probable breaching date of the lagoon mouth in 1991 and 1994, and 13 days after the lagoon breached in 1995.

Adult Pacific lamprey apparently have little difficulty negotiating the fish ladder. Marking studies conducted in 1994 and 1995 found that approximately 92 percent of the lamprey were able to negotiate the ladder in less than 24 hours.

The adult Pacific lamprey run spanned an approximately three month period (late January though early May) in 1995, the only year to date that the entire lamprey spawning migration was sampled. Although the start of the lamprey run was missed in 1993, the run also continued into the first week of May.

The number of Pacific lamprey counted in the fish ladder has ranged from 74 in 1991 to 908 in 1994. However, an unknown number of adult lamprey potentially migrate through the fish ladder without being detected. In addition, the number of lamprey counted was dependent upon the length of time that the fish ladder was in operation. The fish ladder was in operation but not monitored during the beginning of the run in 1993, and the upstream migration of lamprey was still in progress when the fish ladder was closed in 1994. In 1995 essentially the entire lamprey run was monitored prior to the fish ladder being closed. In 1991, 74 adult lamprey were counted in the fish ladder, and streamflow sufficient for lamprey to migrate upstream continued for only four or five days after the cessation of monitoring.

Pacific lamprey tend to migrate upstream in surges (Moyle 1976). In 1994, the daily catch of lamprey ranged between 0 and 11 in the fish ladder between 17 February through 15 March (65 total). On March 16 and 18, 142 and 118 lamprey were collected in the fish ladder, and released upstream of the diversion, respectively. The fish ladder was closed on 16 March because the river elevation had declined below 160 ft. msl per the 404 permit. The fish ladder was reopened on the morning of 17 March to allow the lamprey spawning migration to continue. In total, 332 lamprey were collected in the fish ladder between March 13-19. The fish ladder was closed on 9 April in accordance with the 404 permit. At the time the ladder was closed, adult lamprey were still being observed in the fish ladder. In 1995, the lagoon mouth breached approximately one

month earlier and the upstream run of adult lamprey also peaked one month earlier compared to 1994. By 3 February, only three lamprey had been collected in the fish ladder. The lamprey run then peaked over the next two weeks when approximately 46 percent of the run was counted in the fish ladder. After this initial pulse of upstream migrants, the weekly number of lamprey observed in the ladder declined to a total of six lamprey captured between March 5-18. A smaller, secondary pulse of 74 upstream migrants occurred between 19 March and 8 April.

Adult lamprey collected in the fish ladder ranged in size from 535 to 700 in length in 1994, and from 485 to 750 mm in length in 1995 (although only one individual less than 535 mm was captured). Pacific lamprey averaged 610 mm TL in 1994 and 1995.

Adult Pacific lamprey in British Columbia do not feed in freshwater, and the total length of the adults decreased by an average of 20 percent by the time that spawning actually took place (Beamish 1980). Site specific data are not available on the amount of time that adult Pacific lamprey remain in freshwater prior to spawning in the Santa Clara River. In 1994, 117 spawned-out-full sized adult lamprey were captured in the downstream migrant trap beginning on 10 April. Lamprey die after spawning, and the adults captured appeared to have been spent spawners, slowly drifting downstream. This would suggest that spawning took place shortly after the adults entered freshwater. However, in 1995, no full-sized adult lamprey were captured in the downstream trap, but several apparently spawned out lamprey averaging 427 mm in length (range 355 to 510 mm) were captured in the downstream trap. This suggest that at least some of the adult lamprey from the 1994 run held over and spawned in 1995. If this is the case, then the adult lamprey decreased, on average, 183 mm in length, or 30 percent of their original body length, prior to spawning. This would also suggest that the 1995 upstream migrants did not spawn during this spring, but are holding over in freshwater to spawn in 1996.

The smaller-sized lamprey captured in the downstream trap in 1994 did not show signs of having spawned (i.e., they were not covered with sores and lesions associated with digging nest and spawning). The smaller sized Pacific lamprey were first captured in the downstream migrant trap on 10 March, and they were captured sporadically through 7 April. A total of 68 of the smaller lamprey were collected in 1994.

Pacific lamprey ammocoetes have been reported to average 130 mm (Beamish 1980) and 140 to 160 mm (Moyle 1976) in length when they metamorphose into adults and migrate

to the ocean. Although ammocoetes averaging approximately 110 mm in length have been collected and/or observed at various times during the surveys, they did not appear to be in the process of metamorphosing into adults (e.g., eyes were not visible). Ammocoetes in the 130 to 160 mm size class are probably small enough to pass though the screens of the downstream migrant trap, however, several smaller ammocoetes have been observed at various times in the diversion canal (upstream of the fish screens) and in the fish ladder.

4.4 NON-ANADROMOUS SPECIES

Six non-anadromous species have been collected in the Vern Freeman fish ladder and downstream migrant traps during the study. The most abundant species collected in 1994 and 1995 was the prickly sculpin. The sculpin were reported in Piru and Castaic creeks during a basin wide fisheries investigation (Bell 1978). The presence of prickly sculpin at the diversion site suggest that they expanded their range considerably since 1978. In 1994 and 1995, a total of 13 and 5 threespine stickleback were captured in the downstream trap, respectively. In 1995, the trap monitor examined threespine stickleback for the presence or absence of plates along their sides by running a finger nail along the side of the fish. In each case, at least two plates were counted which suggest that the threespine stickleback captured in 1995 were *G. a. microcephalus* (partially armored), and not the federally listed *G. a. williamsoni*. Arroyo chub and Santa Ana suckers were the only other species collected in relatively large numbers in 1994 and 1995.

The Santa Clara River typically becomes dry over much of its lower reach (above and below the diversion), and unless suitable habitat exist in the lagoon for freshwater fish, the non-anadromous fish moving downstream in the vicinity of the diversion will be lost as the river dries.

5.0
CONCLUSIONS AND RECOMMENDATIONS

The fish monitoring results indicate that the fish passage facilities performed satisfactorily in 1994 and 1995. Although only one adult steelhead was captured in the upstream migrant trap in both years, there were no indications that steelhead were impeded or prevented from negotiating the fish ladder during the period of flow. In addition, the downstream fish by-pass facility functioned as designed. Smolts entering the diversion facility successfully passed from the diversion canal into the fish by-pass pipe where they would be returned to the river downstream of the diversion structure (as evidenced by fish caught in the downstream migrant trap). The 1995 trapping season marks the second year of the five year monitoring study. This study will continue through the 1998 migration period.

The electronic fish counter was not performing satisfactorily in 1995. However, it is highly unlikely that any adult steelhead were able to pass the trap and were accordingly counted herein. Pacific lamprey may be able to set off the counters as evidenced by the correlation between the onset of the lamprey run with the first recorded counts in the tubes. Although the fish counter was not able to accurately count the number of times a 300 mm rainbow trout was pulled though the tubes at a low sensitivity setting, the fish tested were considerably smaller than the steelhead captured in the trap (larger rainbow trout were not available at the Fillmore fish hatchery for testing). We suggest that the experimenting with a lower sensitivity setting on the counter for the 1996 trapping season until a setting is found that will detect steelhead passing through the counting tubes, but not lamprey. We also suggest finding and using larger test fish (>375 mm) to calibrate the counters.

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7.0
PERSONAL COMMUNICATIONS

Adams, J. 1995. Fish Hatchery Manager, Filmore Fish Hatchery, CA.

APPENDIX A

DAILY FISH COUNTER READINGS, VERN FREEMAN DIVERSION, SANTA CLARA RIVER, 1995

Table A-1. Fish Counter Readings, Vern Freeman Diversion, Santa Clara River, 1995.

	Upper Tube		Lower Tube			
Date	Upstream	Downstream	Upstream	Downstream	Sensitivity Setting	Comments
January 7	0	0	0	0	9	
8	0	0	0	0	9	
9	na	na	na	na	9	LC[1]
10	na	na	na	na	9	LC
11	na	na	na	na	9	LC
12	0	0	0	0	9	
13	0	0	0	0	9	
14	0	0	0	0	9	
15	na	na	na	na	9	LC
16	na	na	0	0	9	C[2]
17	0	0	0	0	9	
18	11	13	1	0	9	
19	0	0	0	0	9	
20	0	0	0	0	9	
21	0	0	0	0	9	
22	na	na	na	na	9	LC
23	0	0	0	0	9	
24	na	na	na	na	9	LC
25	na	na	na	na	9	LC
26	na	na	na	na	9	LC
27	na	na	na	na	9	LC
28	na	na	na	na	9	LC
29	0	0	0	0	9	
30	0	0	0	0	9	
31	3	2	7	2	9	
February 1	2	1	13	1	9	
2	2	0	14	1	9	
3	2	1	13	0	9	
4	2	0	8	0	9	
5	1	8	0	0	9	
6	3	0	20	2	9	
7	1	0	5	1	9	
8	3	0	12	4	9	
9	6	2	26	12	9	
10	9	1	26	12	9	
11	3	1	1	0	9	
12	0	0	0	0	9	
13	3	0	16	10	9	
14	2	1	0	0	9	

Table A-1. Fish Counter Readings, Vern Freeman Diversion, Santa Clara River, 1995 (continued).

	Upper Tube		Lower Tube			
Date	Upstream	Downstream	Upstream	Downstream	Sensitivity Setting	Comments
February 15	na	na	na	na	9	LC
16	0	0	2	8	9	
17	na	na	na	na	9	S[3]
18	na	na	3	3	9	C
19	3	0	1	0	9	
20	na	na	na	na	9	C
21	na	na	na	na	9	LC
22	na	na	na	na	9	C
23	na	na	na	na	9	C
24	na	na	na	na	9	C
25	na	na	na	na	9	C
26	na	na	na	na	9	C
27	5	1	1	0	9	
28	na	na	0	0	9	C
	na	na	na	na		C
March 1	na	na	1	0	9	C
2	na	na	1	0	9	C
3	na	na	1	0	9	C
4	na	na	0	0	9	C
5	na	na	0	0	9	C
6	na	na	na	na	9	LC
7	na	na	0	0	9	C
8	0	0	0	0	9	
9	75	184	0	0	9	
10	na	na	na	na	9	LC
11	na	na	na	na	9	LC
12	na	na	na	na	9	LC
13	na	na	na	na	9	LC
14	0	1	na	na	8	C
15	0	0	1	1	8	
16	0	0	0	0	8	
17	0	0	0	0	8	
18	na	na	na	na	8	LC
19	0	0	7	0	8	
20	0	0	6	0	8	
21	0	0	0	0	8	
22	0	0	na	na	8	C
23	na	na	na	na	8	LC
24	na	na	na	na	8	LC

ıble A-1. Fish Counter Readings, Vern Freeman Diversion, Santa Clara River, 1995 (continued).

	Upper Tube		Lower Tube			
Date	Upstream	Downstream	Upstream	Downstream	Sensitivity Setting	Comments
March 25	3	3	181	1,004	8	
26	S		S		8	
27	9	0	0	0	8	
28	0	0	0	0	8	
29	na	na	na	na	8	C
30	na	na	na	na	8	C
31	na	na	na	na	8	LC
April 1	na	na	na	na	8	C
2	0	0	7	1	8	
3	na	na	9	0	8	C
4	na	na	na	na	8	DW[4]
5	3,067	17,987	0	0	8	
6	0	0	8	0	8	
7	0	0	0	0	8	
8	na	na	3	0	8	C
9	0	0	10	0	8	
10	83	33	0	0	8	
11	na	na	na	na	8	C
12	na	na	0	0	8	C
13	na	na	24	21	8	C
14	0	0	0	0	8	
15	0	0	0	0	8	
16	0	0	2	0	8	
17	0	0	0	0	8	
18	0	0	0	0	8	
19	0	0	0	0	8	
20	0	2	1	0	8	
21	100	464	1	0	8	
22	na	na	na	na	8	DW
23	0	0	1	0	8	
24	0	0	1	0	8	
25	0	0	0	0	8	
26	0	0	0	0	8	
27	0	0	0	0	8	
28	0	0	0	0	8	
29	0	0	0	0	8	
30	0	0	6	4	8	

Table A-1. Fish Counter Readings, Vern Freeman Diversion, Santa Clara River, 1995 (concluded).

	Upper Tube		Lower Tube			
Date	Upstream	Downstream	Upstream	Downstream	Sensitivity Setting	Comments
May 1	0	0	0	6	8	
2	0	0	0	0	8	
3	0	1	11	10	8	
4	0	0	2	1	8	
5	0	0	0	0	8	
6	0	0	0	0	8	
7	0	0	67	279	8	
8	2	0	1	2	8	
9	0	0	0	0	8	
10	2	0	1	0	8	
11	2	0	1	7	8	
12	0	1	1	4	8	
13	0	0	2	0	8	
14	0	0	1	0	8	
15	1	1	3	0	8	
16	na	na	na	na	8	LC
17	0	0	3	1	8	
18	na	na	na	na	8	C
19	na	na	na	na	8	C
20	Ladder Closed for Season					

[1]L C - Ladder closed due to high streamflows/sediment load
[2]C - Counter out of calibration
[3]S - Silt/sand build up in tubes resulted in extraneous counts
[4]DW - Fish ladder was dewatered prior to the counting tubes being turned off