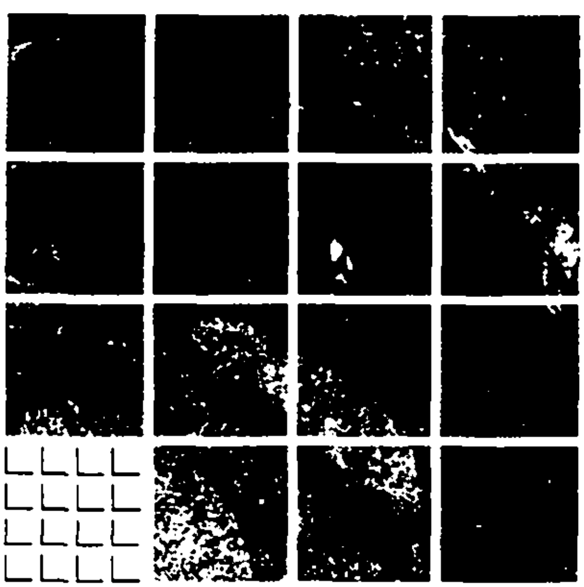
E N T R I X

RESULTS OF FISH PASSAGE MONITORING AT THE VERN FREEMAN DIVERSION FACILITY SANTA CLARA RIVER, 1994 - 1998

FINAL REPORT

Prepared for:

UNITED WATER CONSERVATION DISTRICT
Santa Paula, CA



Prepared by:

ENTRIX, INC.
Walnut Creek, CA

Project No. 324402

March 14, 2000

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Prepared for:

UNITED WATER CONSERVATION DISTRICT
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Project No. 324402

March 14, 2000

LETTER OF TRANSMITTAL

TO:			
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COMPANY:	Area Recovery Coordinator NMFS, Protected Resources Division	**PROJECT NO:**	
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CITY, ST, ZIP	Santa Barbara, CA 93101-3351		

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1.0 INTRODUCTION

This report describes the fish passage monitoring at the Vern Freeman Diversion in 1998 and summarizes the results of the 5-year monitoring program. The 1998 monitoring season was the fifth and final year of the study, which examines the upstream movement of adult steelhead and the downstream movement of juvenile steelhead past the Vern Freeman Diversion Facility. The five-year monitoring study began with the 1994 trapping season (winter 1993-1994), and ended with the 1998 trapping season (winter 1997-1998). Summaries of fish trap operational dates, passage facility utilization, migrational peaks, and stream flows are presented along with an evaluation of the overall effectiveness of fish passage facilities. More detailed results of preliminary monitoring conducted from 1991-93 were previously presented in ENTRIX (1993). More detailed results of the 1994 through 1997 trapping seasons were provided in separate annual reports (ENTRIX 1994, 1995, 1996, 1999).

1.1 BACKGROUND

The Santa Clara River is intermittent and 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 no flow) during the dry summer and fall months, but subject to 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 for passage.

The Santa Clara River supplies water for domestic, municipal and agricultural uses in the basin primarily through groundwater recharge at United Water Conservation District's (UWCD) Saticoy and El Rio spreading grounds. Water is diverted at Saticoy, approximately 16.8 kilometers upstream from the ocean, 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 Freeman Diversion Improvement Project to improve the existing diversion works on the Santa Clara River. This action was taken at the direction of the State Water Resources Control Board to combat seawater intrusion in the Oxnard Coastal Plain aquifers. This intrusion results from overdraft of the groundwater to supply water for irrigation, industrial, and municipal uses. The improvements included the construction of a permanent concrete riverbed stabilization structure and diversion. These improvements were necessary for the UWCD to maintain its ability to divert water to groundwater recharge basins in the Oxnard Plain Forebay Basin. Historical in-river aggregate mining had destabilized and degraded the

Santa Clara River bed, which had down-cut 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.

In addition to the stabilization and diversion works described above, UWCD also equipped the new diversion structure with facilities to allow the upstream and downstream migration of steelhead trout (*Oncorhynchus mykiss*). These facilities were designed in consultation with fish passage experts from the California Department of Fish and Game (CDFG) and the National Marine Fisheries Service (NMFS). These facilities include a two-entrance denil fish ladder and a fish by-pass facility, which included a state-of-the-art fish screen. The efficacy of these facilities in allowing steelhead trout to migrate past the diversion is the subject of this study and will be evaluated in this report.

The project was permitted through U.S. Army Corps of Engineers (COE) 404 Permit No. 86-116-T5. 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 California Department of Fish and Game (CDFG), United States Fish and Wildlife Service (USFWS) and the COE. The plan centered on the installation of a counting device (consisting of counting tubes) that became operational in February of 1993. To assess the efficacy of the counting tubes, a fish trap was installed upstream of the tubes to capture steelhead once they had passed through the tubes and prevent them from moving back downstream through the tubes. However, high debris loads and the passage of numerous lampreys through the tubes, prevented the counters from functioning properly and they were unable to provide a reliable count of the number of adult steelhead passing through the ladder. As a result, the counting tubes were removed at the beginning of the 1996 sampling season. The counting tubes were replaced by a trap formed by the guide bars of the downstream funnel and the upstream trash rack. This trap was used to assess upstream passage in 1996 and 1997. In June of 1997, CDFG requested that the trap be taken out of service, as the final listing for steelhead was expected before the next sampling season. Therefore, no upstream passage information is available for the 1998 sampling season. Because of the difficulties with the counting tubes, 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 fifth year of the required five year study.

1.2 SPECIES COMPOSITION

The fish assemblage in the Santa Clara River system 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 the southern California steelhead trout (*Oncorhynchus mykiss*) (which was federally listed as endangered under the Endangered Species Act [ESA] in August 1997, after the 1997 sampling season), 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*). The native range of the arroyo chub and the Santa Ana sucker is the Los Angeles basin where they are considered species of special concern by the California Department of Fish and Game (Moyle et al. 1995). 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.*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), channel catfish (*Ictalurus punctatus*), mosquitofish (*Gambusia affinis*), as well as hatchery rainbow trout from out-of-basin stocks. Although the upstream reaches of the mainstem Santa Clara River provide habitat for several of the fish species listed above, the lower Santa Clara River (in the vicinity of the Vern Freeman Diversion Facility) serves primarily as a migration corridor for steelhead and lamprey. Tributaries provide most of the spawning and rearing habitat for these fish (Puckett and Villa 1985). No other federally or state protected species of fish inhabit the Santa Clara River in the vicinity of the Vern Freeman Diversion.

1.2.1 STEELHEAD

Maintaining the steelhead trout population was the impetus for the construction of the fish ladder at the Vern Freeman Diversion. The Santa Clara River historically supported steelhead, although the size of the population 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 (Puckett and Villa 1985). Spawning and rearing of the young takes place in upstream tributaries. Historically, Santa Paula and Sespe creeks were utilized as the primary spawning and rearing habitat, with several smaller streams also providing habitat. Piru Creek was used sporadically by steelhead, but the habitat was considered poor because of low summer flows and high water temperatures (CDFG 1957, USFWS 1992).

The decline in the steelhead population in the Santa Clara River is probably related to a number of factors including urban and agricultural development, loss of habitat, planting of hatchery fish, drought, and ocean conditions. The old Vern Freeman Diversion impeded upstream migration and entrained emigrating smolts. In Santa Paula Creek, the Santa Paula Diversion blocks upstream access and reduces or eliminates flow downstream of the diversion during the dry season. 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 5 cubic feet per second (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 steelhead spawning and rearing habitat in the basin.

Severe droughts can reduce the quantity and quality of spawning and rearing habitat in upstream tributaries. In addition, streamflows necessary to breach the sand bar at the mouth of the river and which are sufficient to allow for steelhead passage to and from the ocean may be reduced or absent during dry years. The steelhead population in the nearby Santa Ynez River experienced a large scale decline after the drought of 1947-1951 (the second driest five year period since 1890) (Bedwell 1952, Lantis 1967, ENTRIX 1995). The drought of 1987-1991 was the third-driest five year period since 1890 and may also have resulted in a reduction of steelhead populations. Oceanic conditions, most notably El Niño events, may also affect the survival rate of emigrating juvenile and adult steelhead (McEwan and Jackson 1996). During El Niño events, coastal water temperature increases and productivity decreases. Thus, juvenile steelhead may need to migrate further offshore to find suitable conditions. In addition, adult steelhead would have to migrate back through the relatively warm, unproductive waters to reach their natal rivers.

The study design for this program was presented in ENTRIX (1991). The study was designed to monitor the upstream (adult) and downstream (juvenile) migrations of steelhead trout through the fish passage facilities. Upstream migration was monitored through a fish trap placed at the top of the denil fish ladder. This trap was installed in late 1993 and operated through water years 1994 to 1997. It was removed in 1998 at the request of CDFG following the listing of southern California steelhead as endangered under the ESA. Downstream migration was monitored though the placement of a downstream migrant trap in the fish bypass facilities. Trapping at this facility occurred from 1994 through 1998. The operation of these facilities and the processing of the fish captured are described below.

2.1 UPSTREAM MIGRATION

A denil type fish ladder provides passage over the diversion structure for fish migrating upstream. During periods of high streamflow, a relatively high velocity current is believed to be needed 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 though operation of the fish exit gate and the auxiliary water gate. The head created by this elevation difference results in a water velocity flowing out of the fish ladder at a calculated 8 feet per second.

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 provided certain headwater elevation criteria are met (i.e., the headwater elevation is between 160 to 164 feet per the COE 404 permit). UWCD has voluntarily extended the operation of the ladder between storm events when another storm was predicted to be entering the basin, when they could not divert their entire capacity, or simply to provide a few more days of passage. From 1991 through 1996, the upstream ladder was closed on occasions when streamflows exceeded 20,000 cfs or when turbidity readings exceed 2,000 NTU. These closures took place for the sole purpose of keeping the upstream fish trap and the ladder clear of obstructing debris and sediments, which could result in longer closure times as the facility was cleared of this debris. This allowed for more consistent and efficient ladder operation. In 1997, the turbidity level that would trigger closure of the fish ladder was increased to 3,000 NTU. During the 1998 water-year, the upstream migrant trap in the fish ladder was removed at the request of CDFG. This greatly reduced sediment and debris buildup within the ladder. As a result, UWCD experimented with fish ladder operations throughout storm events (regardless of turbidity levels or sediment loads) to evaluate appropriate operating criteria for the ladder without the fish trap. It is still too early to determine if continuous operation of the fish ladder (without the upstream trap) will be feasible due to the varying and frequently high sediment loads that are characteristic of the Santa Clara River during storm events. However, UWCD is working to determine the most favorable operating protocol for passage.

2.1.1 Upstream Migrant Trap

Steelhead migrating upstream through the fish ladder were directed by a series of guide bars into the upstream migrant trap. A screen "funnel" (300 mm high by 100 mm wide) was attached to the upstream end of the guide bars. The funnel allowed steelhead to easily move into the trap, while making it difficult for fish to move back out of the trap. The guide bars were spaced sufficiently far apart to allow lamprey (but not adult steelhead) to migrate past the trap unhindered. The trap was formed by the upstream trash rack and downstream guide bars (metal slats) and their supports. This formed a holding compartment measuring approximately 6 by 15 feet.

The trap was serviced once per day during the sampling season. During servicing, the fish ladder was drained, and surveyed for fish that may have been stranded as a result of de-watering the ladder. The debris and sand that had collected around the trap were removed at this time.

Fish collected in the trap (or captured in the ladder during de-watering for trap maintenance) were identified to species and measured to the nearest millimeter (mm) fork length (FL) or total length (TL) depending upon the caudal fin configuration of that species. Photographs were taken of representative individuals. Scale samples were taken from rainbow trout for age determination. Tissue samples were collected from steelhead/rainbow trout for mitochondrial Deoxyribose Nucleic Acid (mtDNA) and/or nuclear DNA analysis during the 1995, 1996, and 1997 seasons. These samples were collected by clipping a small portion of the caudal fin. Steelhead and lamprey were then released upstream of the trap to continue their upstream migration.

2.2 Downstream Migration

Downstream-migrating steelhead smolts and other fish entering the diversion facility are prevented from entering the diversion canal by a state-of-the-art, self cleaning, 3/16-inch slot opening, wedge-wire fish screen which directs the fish to the downstream fish by-pass facility. The fish by-pass facility allows smolts and other fish to exit the diversion facilities and return to the river downstream of the diversion. During periods when flow between the diversion and the ocean is not contiguous (and for the purpose of conducting this study), fish are collected in a trap. Smolts trapped during these conditions are transported by truck to the lagoon downstream. Lamprey trapped are also trucked to the lagoon where doing so does not jeopardize steelhead. Other species are returned to the river upstream of the diversion.

The trap consists of a mesh cage that can be lowered into a chamber, adjacent to the fish by-pass weir, through which all by-pass water flows. The trap is situated so that it captures all of the water passing through the by-pass. Fish are retained within the trap until they are processed. The downstream trap was used throughout the study (1994-1998) to verify the existence of steelhead smolts in the system. Steelhead smolts collected in the by-pass trap were counted, measured (FL) and scale samples were collected for age determination. In 1995 and 1996, tissue samples were collected for genetic analysis. A few tissue samples were also collected in 1997, but stress caused by high water temperatures made it inadvisable to collect tissue samples from most of the smolt captured during that year. Tissue samples were not collected in 1994 or 1998. The tissue samples collected during the 1995 emigration period were processed to determine their mtDNA genotypes. Samples collected during other years have not been processed, but have been retained for potential evaluation at a later date.

Juvenile Pacific lampreys (ammocoetes) and spawned-out adults also were collected in the downstream trap. Lamprey collected in the downstream trap were counted, measured, and released below the fish by-pass facility or transported to the lagoon when doing so would not jeopardize steelhead smolts. Fish of other species were enumerated, and up to ten individuals of each species were measured to the nearest millimeter fork or total length, depending on their caudal configuration.

Rainbow trout collected in the downstream trap and the diversion canal were separated into four categories. These categories were: wild smolts, wild resident rainbow trout, hatchery-reared rainbow trout, and hatchery-reared smolts. The descriptions of the four types are described below:

- Wild smolts 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. Smolts were also characterized by proportionately larger heads, slimmer bodies, and a longer caudal peduncle than resident rainbow trout (Beeman et al. 1995).

- Wild rainbow trout had perfectly formed fins, but had more color than smolts. In addition, "resident rainbow trout" did not possess the typical body configuration characteristic of smolts (described above). It was assumed that these were not outmigrating juvenile steelhead. Included in the wild rainbow trout category were any rainbow trout fry.

- Hatchery-reared rainbow trout had fins that showed excessive wear as a result of rubbing against concrete raceways. The hatchery-reared rainbow trout were proportionately longer, "fatter," and darker in color than the wild fish.

- Hatchery-reared smolts had fins showing excessive wear similar to hatchery rainbow trout, but were noted as being bright silver in color.

Unusually warm water temperatures in 1997 required ENTRIX to employ additional steps to reduce stress on steelhead smolt captured in the downstream trap. These steps included shading the trap, cooling transport water with ice, aerating transport water with oxygen, and minimizing handling by simply enumerating the fish during particularly stressful conditions. In these instances, no scale or tissue samples were collected.

Additionally, because rapidly fluctuating river levels caused a lack of flow through the trap on some occasions, siphons were installed to maintain a small volume of flow. On one occasion, a piscivorous bird was observed emerging from the trap, so netting was placed over the trap to exclude them. These steps were continued, as appropriate in 1998. In 1998, UWCD completed automation of the head regulator gates at the diversion. This modification maintains a relatively constant water level in the forebay, ensuring that there is a continuous flow of water to the trap area.

The downstream migrant trap was not operated during the early portion of the emigration season in 1998 due to delays in obtaining a permit from NMFS. The trap was placed into operation on April 15, 1998 and trapping was discontinued on July 17 of that year. The late start of downstream migrant trapping likely contributed to the low number of smolts captured during 1998. However, precipitation and flow events during 1998 were the highest on record. As a result, the Vern Freeman diversion spilled through June 29, 1998 and water was released through the fish ladder until July 3, 1998. We surmise that many of the down-migrants, which otherwise would have been directed into the trap, either passed over the diversion structure or down the fish ladder.

2.3 STREAMFLOW AND TURBIDITY MEASUREMENTS

Flow records for the Santa Clara River are available from two sources: The USGS Gaging Station at Montalvo (this gage was out of service in 1994) and UWCD's operation logs. UWCD's staff records flow levels though the diversion and the fish passage facilities every morning at approximately the same time (0730 hours) from staff gage readings. They also estimate the amount of water spilling over the crest of the diversion based on water surface elevation at the diversion. From these values, UWCD calculates the flow above the diversion.

Turbidity measurements are recorded daily by UWCD when the diversion is in operation.

2.4 TEMPERATURE

Water temperature monitoring was conducted during the 1997 water year. Maximum/minimum recording thermometers were placed instream during the steelhead out-migration period. CDFG installed an Onset HOBO electronic thermograph in the well containing the downstream trap on April 14 and collected temperature data through April 22. On April 16, ENTRIX installed a second Onset HOBO unit in the trap well and another near the auxiliary water intake to the fish ladder. All of the HOBO units were set to record temperature on an hourly interval. The ENTRIX units were left in place until June 13, the end of the 1997 monitoring year. For each day in the period of record, these hourly data were averaged to determine the mean daily temperature. Maximum and minimum temperatures were also identified.

This section of the report provides a brief overview of the 1998 data, followed by a summary of the results from 1994 through 1997. Specific details regarding the results of the 1994 through 1997 sampling seasons can be found in the annual reports for those years (ENTRIX 1994, 1995, 1996, and 1999).

3.1 PRECIPITATION AND FLOW

3.1.1 1998 SEASON

Rainfall in the 1998 water-year was the highest on record, with a total of 45 inches of precipitation at Santa Paula (Figure 3-1). Daily rainfall totals at the Santa Felicia Dam are presented in Table 3-1. With the exception of a few isolated flow events in the early part of the year, peak river flows occurred during the later part of January and extended well into June (Figure 3-2), providing ample flow for the entire steelhead migration period. The diversion structure spilled until June 29 and there was sufficient river flow to operate the fish ladder until July 3.

Mean daily flows above the diversion ranged from 84 cfs to 60,000 cfs between December 1 and May 31 (the primary migration period). The median daily flow was 2,076 cfs and the average daily flow was 2,840 cfs. River flows immediately below the diversion ranged from 0 to 60,000 cfs during this same period. The median and mean flows were 1,955 and 2,653 cfs, respectively. The diversion spilled for 131 days out of 182 days during this period. Mean daily flows below the diversion generally exceeded 1,000 cfs for the period between February 2 and May 31.

3.1.2 PREVIOUS YEARS

Based on the rainfall gage in Santa Paula, 1994 and 1996 were relatively dry years with rainfall totals of 13.4 and 13.9 inches respectively (median rainfall at Santa Paula is 15.1 inches). 1995 was a very wet year, with 25.3 inches and 1997 experienced 18.4 which is above normal rainfall. Streamflows generally reflect rainfall patterns in the basin, as little of the precipitation received falls as snow. As is shown by UWCD's rainfall gage at Santa Felicia Dam, the distribution of rainfall in 1997 was unusual in that all significant rainfall was received prior to February (Table 3-2). In all other years, a significant portion of the total annual rainfall was received in February, March and April.

Flows during each of the years sampled reflect the rainfall patterns, being highest in 1998 and 1995, and lowest in 1996 (flow data are not available for 1994). In 1997, UWCD was able to divert all of the flow after February 19, prior to the peak of the outmigration

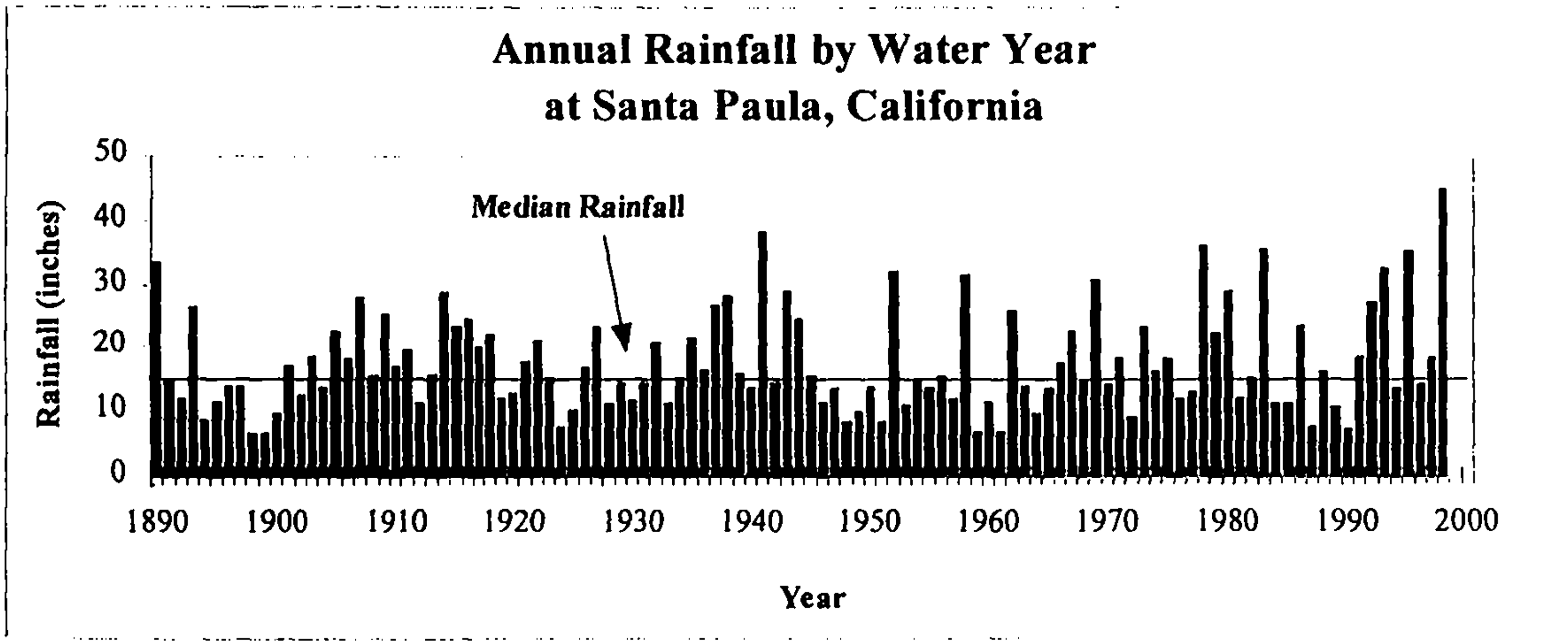


Figure 3-1 Annual Total Precipitation at Santa Paula, California (data provided by UWCD).

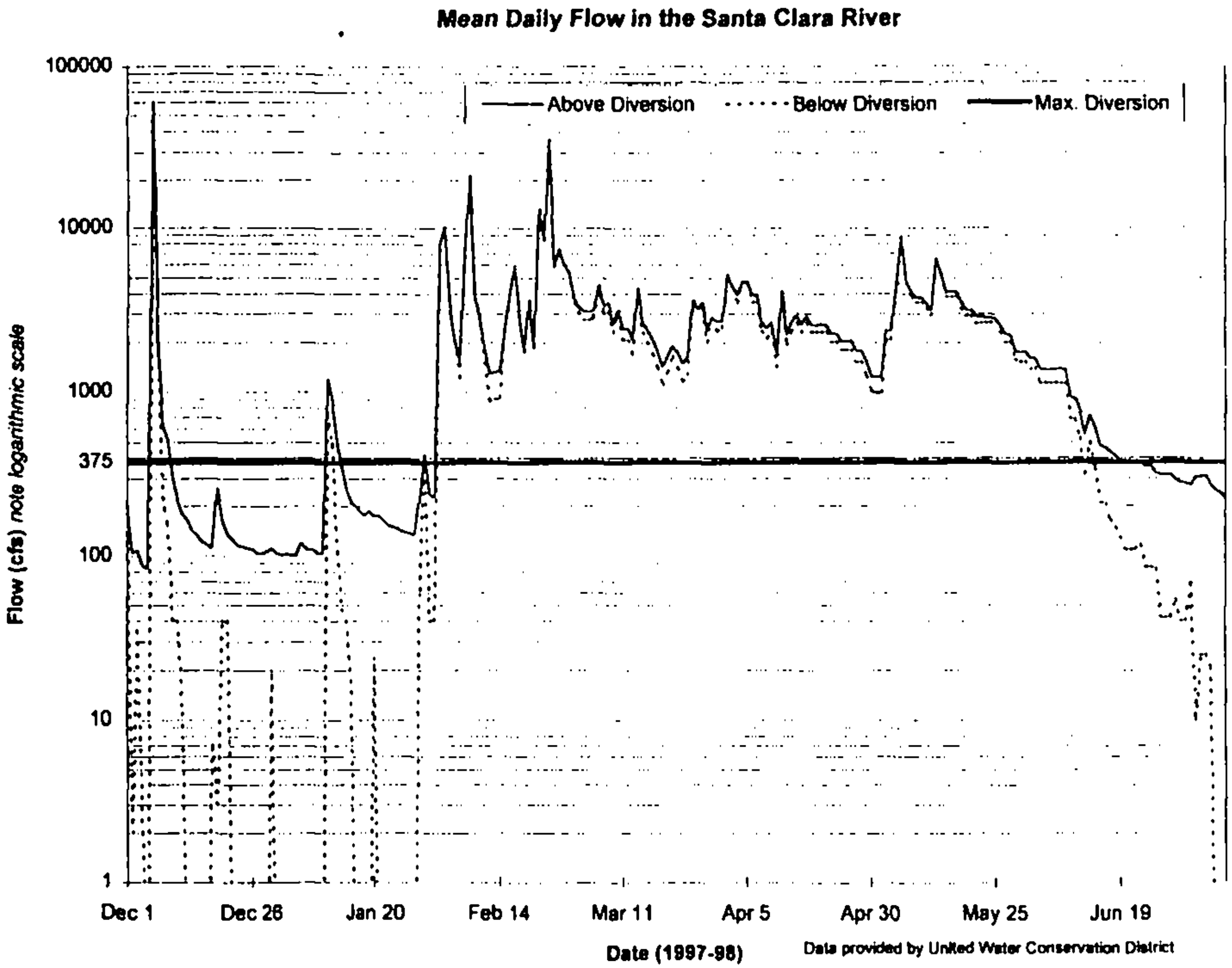


Figure 3-2 Mean Daily Flows December 1, 1997 to May 31, 1998.

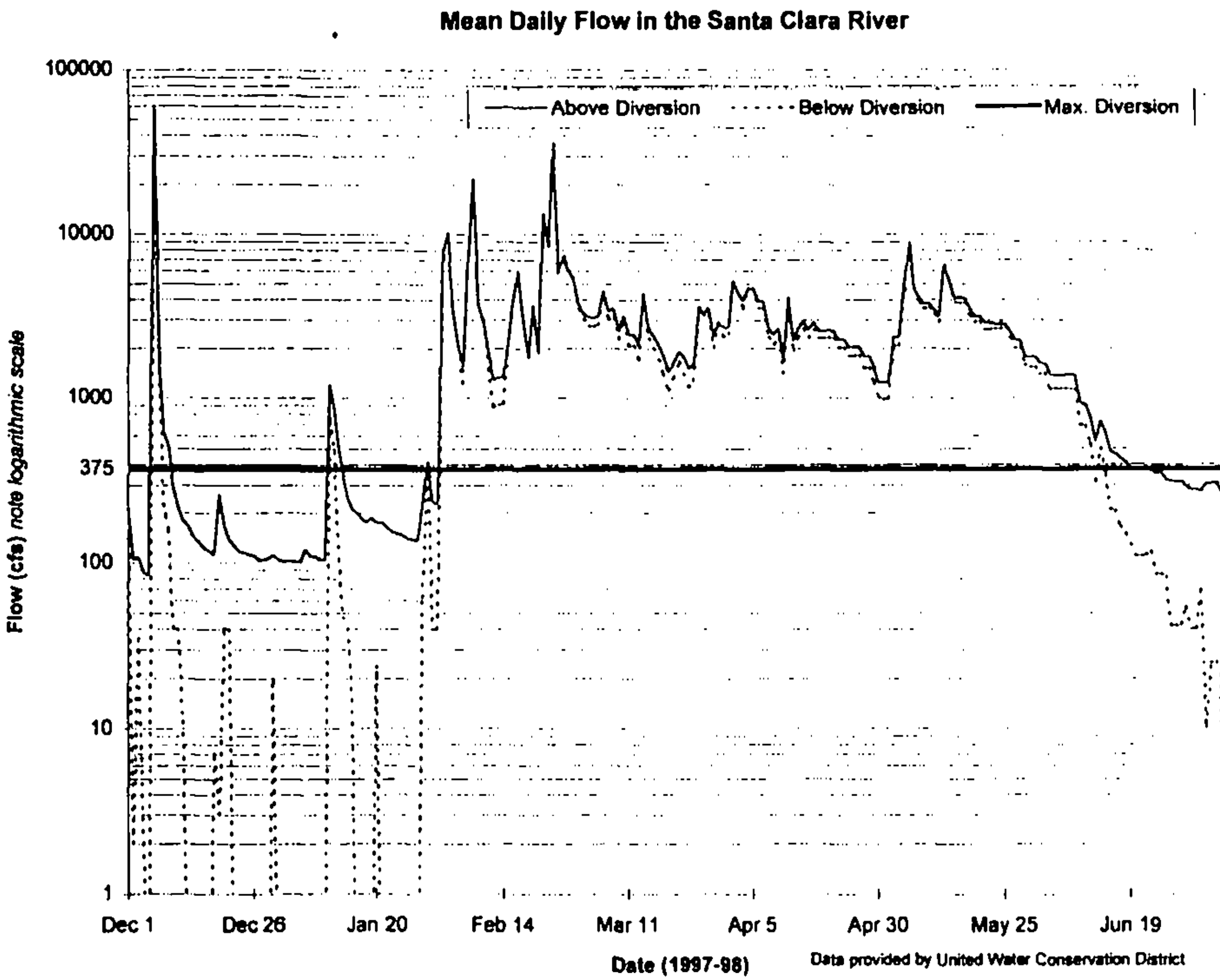


Figure 3-2 Mean Daily Flows December 1, 1997 to May 31, 1998.

Table 3-1 1998 Rainfall at Santa Felicia Dam, California (data from UWCD gauge).

Date	Rainfall Total
11/10	0.06
11/11	0.74
11/12	0.08
11/13	0.1
11/14	0.27
11/15	0.04
11/16	0.13
11/26	TR
11/27	0.95
11/28	TR
11/30	0.12
12/1	0.95
12/6	5.24
12/7	0.25
12/8	0.17
12/15	0.05
12/19	0.79
1/3	0.02
1/4	TR
1/5	0.5
1/9	TR
1/10	1.33
1/11	0.03
1/13	0.04
1/16	0.18
1/19	0.4
1/29	0.75
1/30	0.03
1/31	TR
2/1	0.05
2/2	1.81
2/3	1.93
2/4	1.13

Date	Rainfall Total
2/7	2.06
2/8	2.69
2/9	0.5
2/14	0.05
2/15	1.82
2/17	1.3
2/20	0.76
2/22	3.03
2/23	1.76
2/24	2.78
3/6	0.76
3/14	0.64
3/25	1.7
3/26	0.85
3/28	0.47
3/29	0.2
4/1	0.6
4/2	0.12
4/4	0.21
4/5	0.4
4/6	0.19
4/7	0.02
4/12	0.69
4/15	0.32
5/2	0.19
5/3	0.27
5/4	0.19
5/5	0.6
5/6	1.89
5/7	0.27
5/12	0.04
5/13	1.36
5/14	0.04

Table 3-2 Monthly Rainfall Totals at Santa Felicia Dam, 1995-1998.

	Water Year			
Month	1995	1996	1997	1998
October	1.53	0	1.93	0
November	0.71	0.06	2.58	2.49
December	1.13	2.52	8.28	7.45
January	21.85	0.92	6.30	3.28
February	1.97	8.95	0.55	21.67
March	8.68	2.69	0	4.62
April	1.07	1.12	0	2.55
May	0.97	0.47	0	4.85
June	0.49	0	0	0

Table 3-3 Dates of Operation of the Upstream Fish Ladder, 1994 – 1997

Year	1994	1995	1996	1997	1998*
1st Day Operated	Feb 18	Jan 1	Feb 2	Nov 1	Dec 8
Last Day Operated	May 3	May 20	Mar 24	Feb 19	Jul 17
No. Days/Nov	0	0	0	5	0
No. Days/Dec	0	0	0	11	6
No. Days/Jan	0	15	0	18	6
No. Days/Feb	10	27	8	19	16
No. Days/Mar	31	22	14	0	29
No. Days/April	30	30	0	0	30
No. Days/May	3	20	0	0	31
No. Days/June	0	0	0	0	30
No. Days/July	0	0	0	0	3
TOTAL No. Days	**77**	**114**	**22**	**53**	**151**

*Upstream trap operated but not monitored.

season. This was not the case in 1996, when the diversion spilled on four occasions during January through March. In 1995 the diversion spilled over 1,000 cubic feet per second of water (and a lot more on many days) from early January to early May, and continued to spill over 100 cubic feet per second until June 2. Ladder releases continued until July 3.

3.2 UPSTREAM MIGRATION

At the request of CDFG, upstream migration was not monitored during the 1998 water year. The fish ladder was operated for a total of 162 days during 1998, because of the extremely high flows and frequent storm events. Therefore, it is likely that fish were provided ample opportunity for upstream migration over the course of the migration period. Storm events and resultant river flows likely breached the sand bar at the mouth of the lagoon by December 6, 1997 with river flows that day of 60,000 cfs. Storms on January 10, 1998 and February 2, 1998 would have reopened the sand bar (if it had closed) and the bar likely stayed open through at least June 8, as river flows exceeded 1,000 cfs for almost this entire period (February 2 – June 8) (Figure 3-2). The fish ladder was operated for 11, 8, 20, 29, 30, 31, 30, and 3 days in December through July, respectively (Figure 3-3). The last day of ladder operation was July 3.

3.2.1 PREVIOUS YEARS

In previous years the upstream fish trap has been put into service as early as November 1 (in 1997), but generally was first operated in January or February (Table 3-3). The upstream trap has been operated for between 22 and 114 days, depending on the year. The trap was operated for the fewest days in 1996, a dry year, and for the most days in 1995 a wet year. In most years the ladder has been operated mostly during the months of February, and March. In 1997, however, the last day the trap was operated was February 19.

Adult steelhead have been captured in the upstream trap in previous years. One adult steelhead was captured in the fish ladder in both 1994 and 1995, and two adults were collected in 1996. All four adult fish were captured in the upstream trap during the month of March. The four steelhead captured in the upstream trap ranged in length from 263 to 635 mm FL and from two to four years in age.

3.3 DOWNSTREAM MIGRATION

The downstream by-pass was operated by UWCD whenever they were diverting water during the 1998 season. The downstream migrant trap was put into operation on April 15, 1998 after ENTRIX received its Section 10a Scientific Collection permit from NMFS. The downstream trap was operated continuously until July 17, except for 6 days when UWCD was not diverting water (Figure 3-4). The trap was operated for 16 days in April, 26 days in May, 29 days in June, and 17 days in July (a total of 88 days). Two

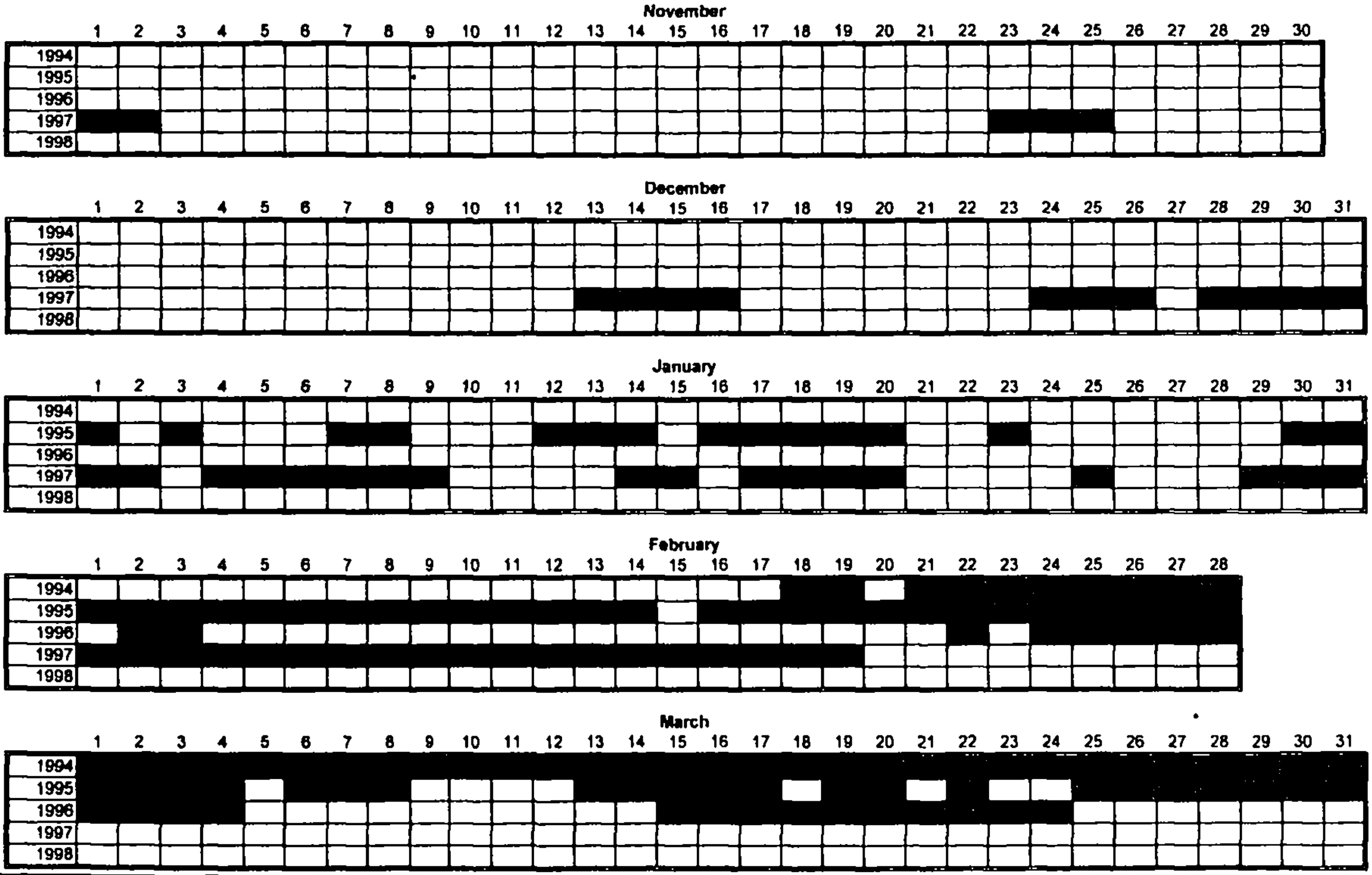


Figure 3-3 Fish Ladder Operating Dates, 1994-1998 Season.

Ladder in Operation.

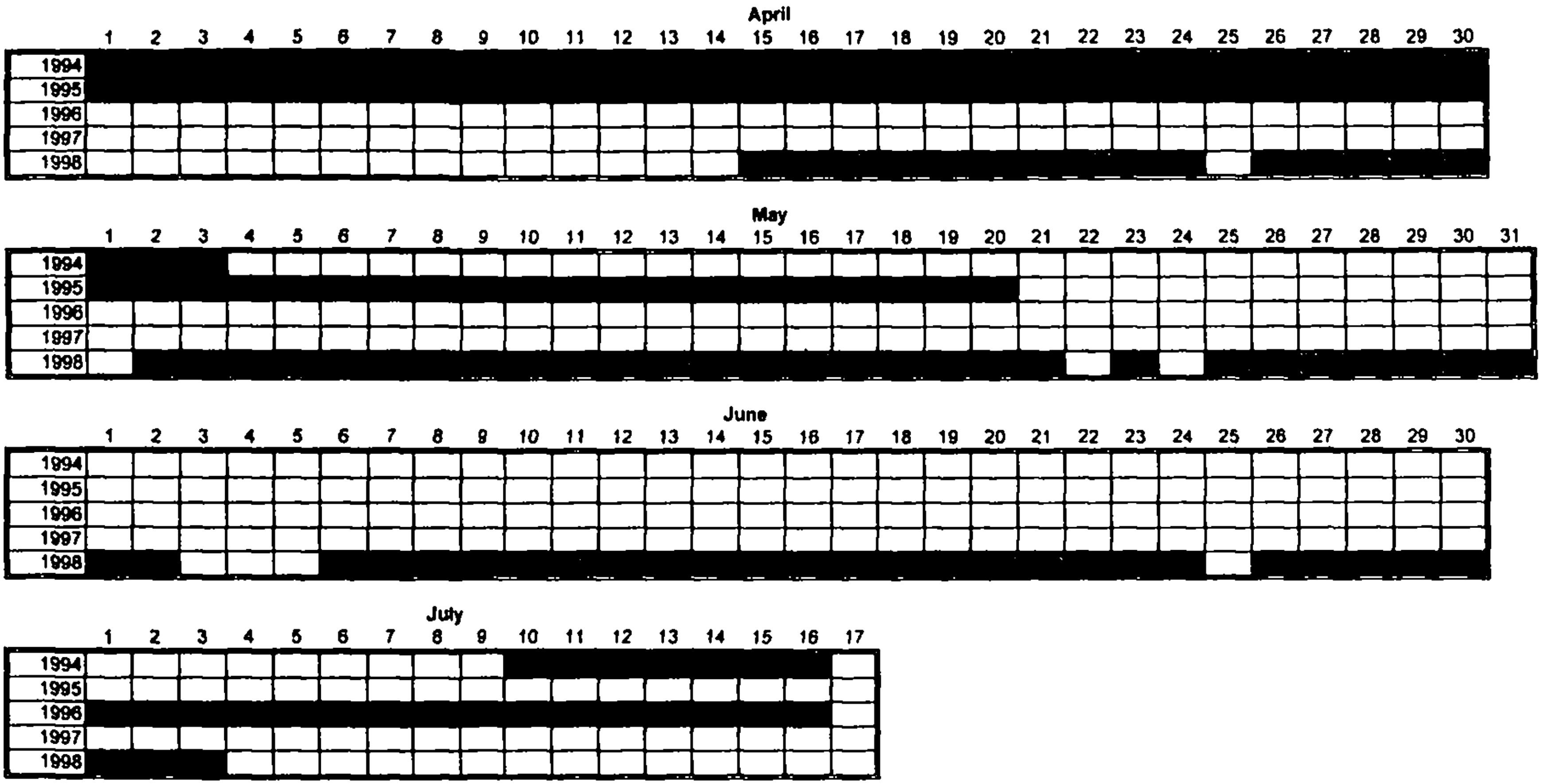


Figure 3-3 Fish Ladder Operating Dates, 1994-1998 Season. (Continued)

Ladder in Operation.

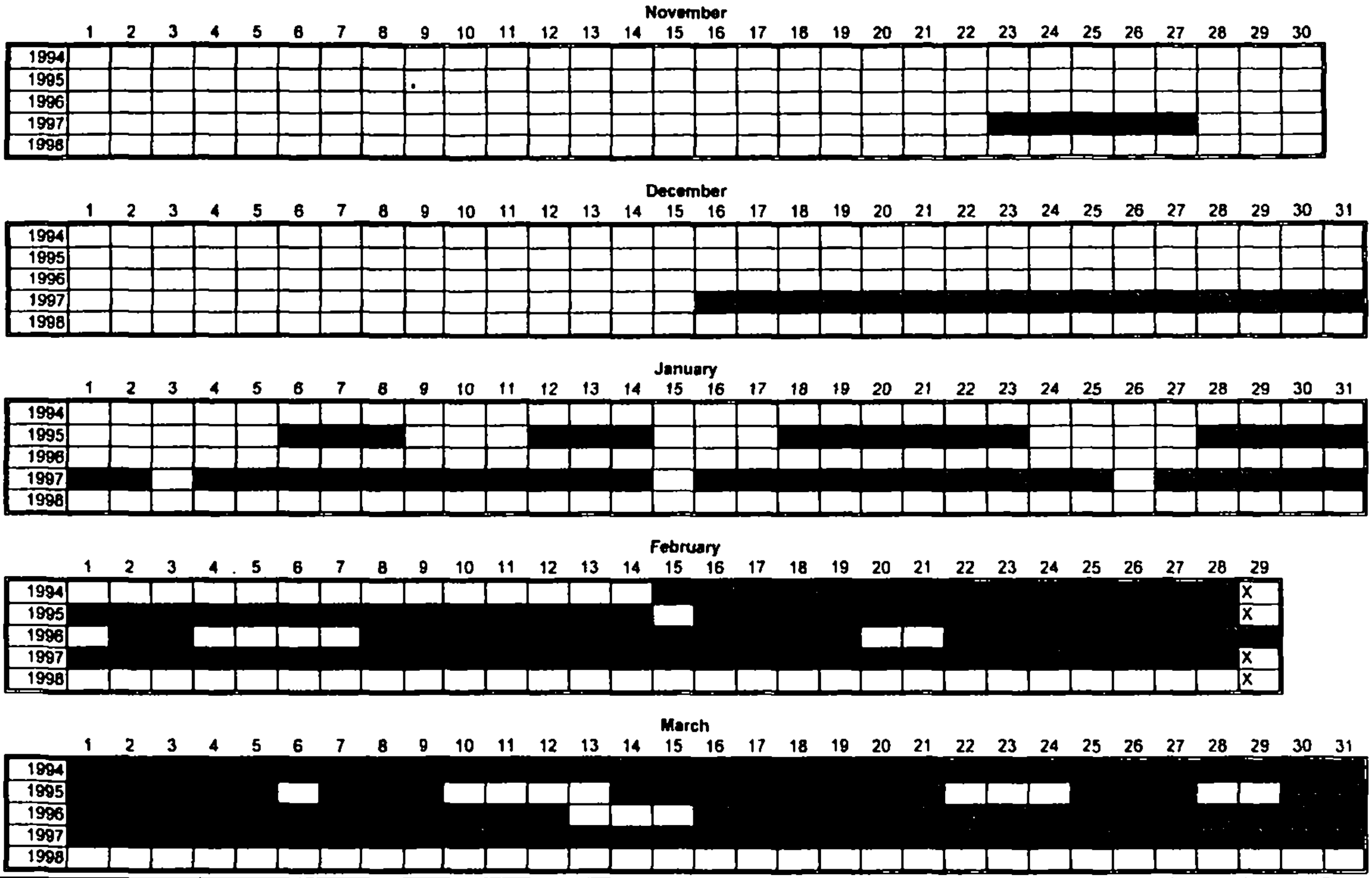


Figure 3-4 Dates of Operation of the Downstream Migrant Trap 1994-1998.

Downstream Trap in Operation.

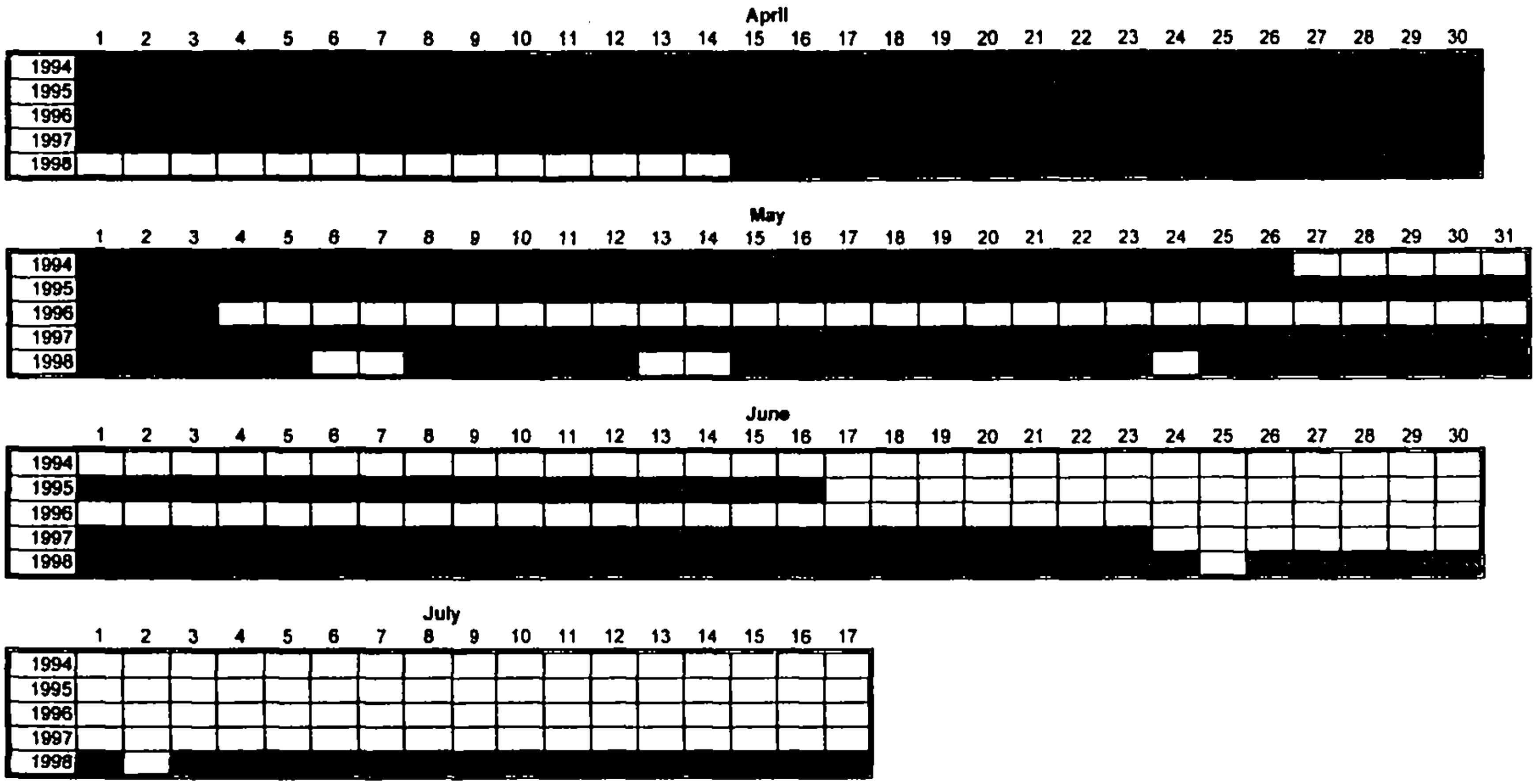


Figure 3-4 Dates of Operation of the Downstream Migrant Trap 1994-1998. (Continued)

Downstream trap in Operation.

Table 3-4 Catch of Steelhead Smolt in the Downstream Migrant Trap by Week, 1994-1998.

Month	Week Ending	1994[2]	1995[3]	1996[4]	1997[5]	1998[6]
November	21	–	–	–	–	–
	28	–	–	–	0	–
December	7	–	–	–	0	–
	14	–	–	–	0	–
	21	–	–	–	0	–
	28	–	–	–	0	–
January	7	–	0	–	0	–
	14	–	0	–	0	–
	21	–	0	–	0	–
	28	–	1	–	0	–
February	4	0	1	0	0	–
	11	0	0	0	0	–
	18	0	1	0	0	–
	25	0	0	0	1	–
March	4	0	0	0	0	–
	11	0	0	0	0	–
	18	2	0	1	11	–
	25	9	2	16	31	–
April	1	16	0	14	52	–
	8	25	0	28	46	–
	15	0	0	17	49	0
	22	15	2	5	139	0
	29	9	11	1	36	1
May	6	2	27	0	18	1
	13	3	25	–	22	0
	20	0	16	–	8	0
	27	0	10	–	1	0
June	3	–	5	–	0	0
	10	–	6	–	0	0
	17	–	1	–	0	0
	24	–	0	–	0	0
July	1	–	0	–	–	0
	8	–	0	–	–	0
	15	–	0	–	–	0
	22	–	0	–	–	0
	29	–	0	–	–	
Total		**81**	**111**	**82**	**414**	**2**

[1] Data From ENTRIX (1994)
[2] Downstream migrant trap operated through 25 May, 1994.
[3] Downstream migrant trap operated through 27 July, 1995.
[4] *Downstream migrant trap operated through 3 May, 1996.*
[5] Downstream migrant trap operated through 23 June 1997
[6] Downstream migrant was operated through July 17, 1998.

steelhead smolt were captured in 1998 (Table 3-4). One fish was captured during the week ending April 29, and the other fish was captured the following week. These smolt were 232 and 210 mm in length, respectively. These fish were released to the river downstream of the diversion to make their way to the ocean. Four rainbow trout]juveniles were also captured in the downstream trap. The four wild rainbow trout juveniles were dark in color and lacked any evidence of smoltification, as described in Section 2.2. These fish were captured between June 27 and July 11 and ranged in length from 59 to 192 mm in length. These fish were released immediately above the diversion. One fish captured on July 11 (192 mm) was recovered dead in the trap on July 12.

Only one downstream-migrant Pacific lamprey ammocete (total length 150 mm) was captured (Table 3-5). This fish was captured on July 2, 1998. Seven other species of fish were also captured in the downstream trap during the 1998 water year. These species included green sunfish, prickly sculpin, Santa Ana sucker, arroyo chub, threespine stickleback, bullhead, and largemouth bass (Table 3-6). The total number of captured fish for each species was relatively low, as compared to previous years. Over the course of the monitoring program, 10 species of fish were identified in the downstream migrant trap (in addition to steelhead and lamprey).

3.3.1 Previous Years

In 1994 through 1997, the downstream trap was operated for between 74 and 187 days per year (Figure 3-4, Table 3-7). Trapping was initiated between November 23 and February 15 and discontinued between May 3 and June 23. In 1995, trapping was conducted from November 23-27 following a storm event. Trapping resumed on December 16 and continued on a continuous basis from that point on. UWCD did not divert water for between 2 and 21 days during these years, when turbidity was too high. The downstream trap was not in operation during these periods. Trapping continued later in the wet years, 1995 and 1998 and in 1997 (a normal year), than it did in the drier years, 1994 or 1996. The date the trap was taken out of operation was based on the duration of time since a smolt had been captured and water temperature. This date was selected in consultation with CDFG and NMFS.

3.3.1.1 Size and Age Structure

Between 81 and 414 smolt were captured in the downstream migrant trap in any given year. 1994 had the lowest catch, while 1997 had by far the highest. Smolt ranged in size between 120 and 317 mm in length. Ages were determined for the fish based on length frequency analysis and scale readings collected between 1994 and 1997. However, because of concern for temperature stress in 1997, scales were collected from only a few fish and over half the smolt (246) could not be aged because their lengths were between that of the smallest observed Age 2+ smolt and the largest observed Age 1+ smolt. Across the years, Age 1 smolt ranged in length from 120 to 203 mm and Age 2 smolt ranged in length from 160 to 260 mm (Figure 3-5). Two Age 3 smolt were captured over the course of the study. These measured 317 mm and 284 mm.

Table 3-5 Catch of Pacific Lamprey in the Downstream Migrant Trap by Week, 1994-1998.

Month	Week Ending	1994[2]	1995[3]	1996[4]	1997[5]	1998[6]
December	28	–	–	–	1	–
January	7	–	0	–	0	–
	14	–	0	–	0	–
	21	–	0	–	0	–
	28	–	0	–	0	–
February	4	0	2	–	0	–
	11	0	3	0	1	–
	18	0	1	1	0	–
	25	0	0	5	22	–
March	4	0	2	2	3	–
	11	2	1	0	4	–
	18	18	1	2	4	–
	25	20	0	18	2	–
April	1	13	10	12	1	–
	8	10	6	5	1	–
	15	5	4	2	0	0
	22	0	8	3	0	0
	29	0	18	4	0	0
May	6	1	32	0	0	0
	13	1	5	–	0	0
	20	0	3	–	0	0
	27	–	5	–	0	0
June	3	–	9	–	0	0
	10	–	3	–	0	0
	17	–	0	–	0	0
	24	–	0	–	0	0
July	1	–	0	–	–	0
	8	–	0	–	–	1
	15	–	0	–	–	0
	22	–	0	–	–	0
Total		**70**	**113**	**54**	**39**	**1**

[1] 1994 data from ENTRIX (1994)
[2] Downstream migrant trap operated through 25 May, 1994.
[3] Downstream migrant trap operated through 27 July, 1995.
[4] Downstream migrant trap operated through 3 May, 1996.
[5] Downstream migrant trap operated through 23 June 1997.
[6] Downstream migrant trap operated through July 17, 1998.
[7] Lamprey was captured in the canal.

Table 3-6 Catch of Resident Fish in the Downstream Migrant Trap by Month, 1994-1998.

Month	Species	1994[2]	1995[3]	1996[4]	1997[5]	1998[6]
November	arroyo chub	–	–	–	37	–
	prickly sculpin	–	–	–	25	–
	Santa Ana sucker	–	–	–	172	–
	threespine stickleback	–	–	–	0	–
	bullhead	–	–	–	4	–
	green sunfish	–	–	–	0	–
	Owens sucker	–	–	–	25	–
	Largemouth bass	–	–	–	5	–
	Mosquitofish	–	–	–	2	–
	Channel catfish	–	–	–	0	–
December	arroyo chub	–	–	–	58	–
	prickly sculpin	–	–	–	8	–
	Santa Ana sucker	–	–	–	53	–
	threespine stickleback	–	–	–	0	–
	bullhead	–	–	–	1	–
	green sunfish	–	–	–	1	–
	Owens sucker	–	–	–	0	–
	Largemouth bass	–	–	–	7	–
	Mosquitofish	–	–	–	20	–
	Channel catfish	–	–	–	2	–
January	arroyo chub	–	7	–	12	–
	prickly sculpin	–	36	–	14	–
	Santa Ana sucker	–	2	–	9	–
	threespine stickleback	–	1	–	0	–
	bullhead	–	6	–	0	–
	green sunfish	–	0	–	0	–
	Owens sucker	–	0	–	1	–
	Largemouth bass	–	0	–	10	–
	Mosquitofish	–	0	–	0	–
	Channel catfish	0	0	0	0	–
February	arroyo chub	5	32	138	47	–
	prickly sculpin	91	24	75	21	–
	Santa Ana sucker	0	8	51	10	–
	threespine stickleback	4	0	0	0	–
	bullhead	3	0	4	0	–
	green sunfish	0	1	16	1	–
	Owens sucker	0	0	0	5	–
	Largemouth bass	0	0	0	0	–
	Mosquitofish	0	0	0	2	–
	Channel catfish	0	0	0	0	–

Table 3-6 Catch of Resident Fish in the Downstream Migrant Trap by Month, 1994-1998. (Continued)

Month	Species	1994[2]	1995[3]	1996[4]	1997[5]	1998[6]
March	arroyo chub	26	9	93	51	–
	prickly sculpin	38	16	51	63	–
	Santa Ana sucker	29	3	68	26	–
	threespine stickleback	4	0	0	0	–
	bullhead	14	1	0	2	–
	green sunfish	1	0	1	2	–
	Owens sucker	0	0	0	9	–
	Largemouth bass	0	0	0	1	–
	Mosquitofish	0	0	0	0	–
	Channel catfish	0	0	0	0	–
April	arroyo chub	48	5	26	12	0
	prickly sculpin	1	6	10	7	0
	Santa Ana sucker	3	2	6	18	2
	threespine stickleback	4	1	0	0	0
	bullhead	0	1	1	0	0
	green sunfish	0	0	1	2	0
	Owens sucker	0	0	0	0	0
	Largemouth bass	0	0	0	0	0
	Mosquitofish	0	0	0	0	0
	Channel catfish	0	0	0	0	0
May	arroyo chub	26	3	5	15	0
	prickly sculpin	0	11	1	8	0
	Santa Ana sucker	2	1	0	2	0
	threespine stickleback	1	0	0	1	0
	bullhead	3	1	0	0	1
	green sunfish	1	0	0	2	1
	Owens sucker	0	0	0	0	0
	Largemouth bass	0	0	0	0	0
	Mosquitofish	0	0	0	1	0
	Bluegill	0	0	0	0	1
	Channel catfish	0	0	0	0	0
June	arroyo chub	–	7	–	52	0
	prickly sculpin	–	13	–	1	11
	Santa Ana sucker	–	1	–	2	2
	threespine stickleback	–	3	–	0	0
	bullhead	–	0	–	0	0
	green sunfish	–	0	–	3	1
	Owens sucker	–	0	–	0	0
	Largemouth bass	–	0	–	0	0
	Mosquitofish	–	0	–	0	0
	Channel catfish	–	0	0	0	0

Table 3-6 Catch of Resident Fish in the Downstream Migrant Trap by Month, 1994-1998. (Continued)

Month	Species	1994[2]	1995[3]	1996[4]	1997[5]	1998[6]
July	arroyo chub	–	–	–	–	14
	prickly sculpin	–	–	–	–	14
	Santa Ana sucker	–	–	–	–	17
	threespine stickleback	–	–	–	–	1
	bullhead	–	–	–	–	0
	green sunfish	–	–	–	–	2
	Owens sucker	–	–	–	–	0
	Largemouth bass	–	–	–	–	1
	Mosquitofish	–	–	–	–	0
	Channel catfish	–	–	–	–	0
Season total	**arroyo chub**	**105**	**51**	**262**	**284**	**20**
	prickly sculpin	**130**	**106**	**137**	**147**	**28**
	Santa Ana sucker	**34**	**17**	**125**	**292**	**21**
	threespine stickleback	**13**	**5**	**0**	**1**	**1**
	bullhead	**20**	**9**	**5**	**7**	**1**
	green sunfish	**2**	**1**	**18**	**11**	**4**
	Owens sucker	**0**	**0**	**0**	**40**	**0**
	Largemouth bass	**0**	**0**	**0**	**27**	**1**
	Mosquitofish	**0**	**0**	**0**	**25**	**0**
	Channel catfish	**0**	**0**	**0**	**2**	**0**
	Bluegill	**0**	**0**	**0**	**0**	**1**

[1] 1994 data from ENTRIX (1994)
[2] Downstream migrant trap operated through 25 May, 1994.
[3] Downstream migrant trap operated through 27 July, 1995.
[4] Downstream migrant trap operated through 3 May, 1996.
[5] Downstream migrant trap operated through 23 June 1997.
[6] Downstream migrant trap operated through July 17, 1998.

Table 3-7 Downstream Trap Operation, 1994-1998.

Water Year	First Day of Operation	Last Day of Operation	Number of Days Operated	Number of Day not Operated	Number of Smolt Captured
1994	Feb. 15	May 26	74	0	81
1995	Jan. 6	Jun. 16	141	21	111
1996	Feb. 2	May 3	83	9	82
1997	Nov. 23	Jun. 23	187	21	414
1998	Apr. 15	Jul. 17	88	6	2

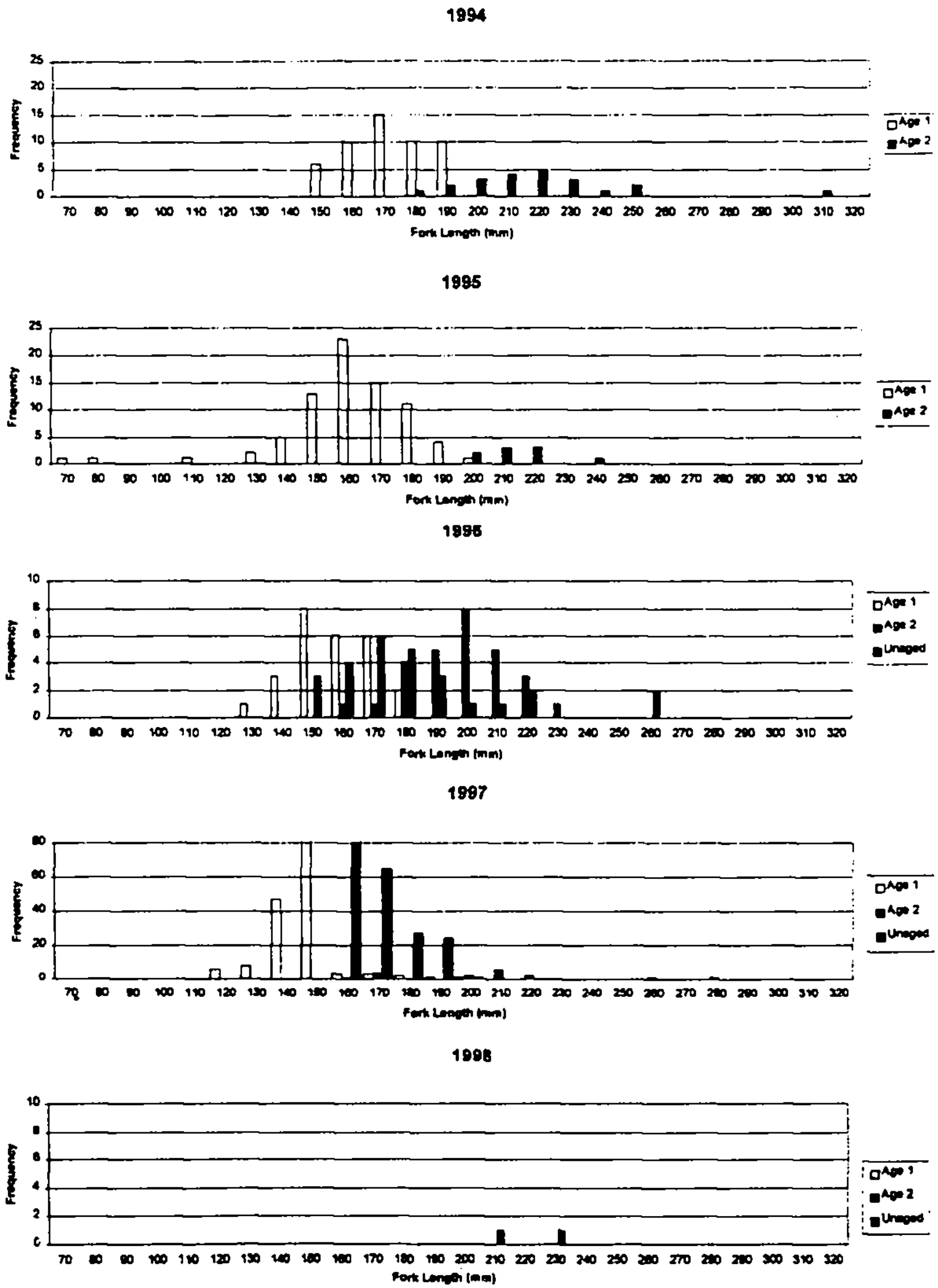


Figure 3-5 Length Frequency and Age Structure of Steelhead Smolt Captured at The Vern Freeman Diversion, 1994-1998.

Age 1+ smolts comprised 68.0 and 82.2 percent of the outmigrants in 1994 and 1995, respectively, but only 51.2 percent in 1996. The remaining fish were Age 2+, except for the two Age 3+ smolt, one of which was captured in 1994 and the other in 1997. The evidence suggests that young steelhead in the Santa Clara River system rarely rear for three years prior to emigrating. The proportion of smolts of each age captured in 1997 could not be determined because of the limited number of scales we were able to collect. However, they were likely dominated by Age 1 smolt as well, as the age distribution in 1994 through 1996 suggests that most of the fish in the 160 to 179 mm size range would be Age 1.

3.3.1.2 Emigration Timing

In 1994, 1996, and 1997 the first smolt were captured at the diversion in the middle of March, half of the smolt had been observed between April 1 and April 15, and the migration was nearly complete by early May (Figure 3-6). In 1995, smolt were first captured at the diversion in late April (although three parr were captured earlier), 50 percent had been captured by about May 8, and the last smolt was captured on June 18. The emigration period lasted five weeks in 1996, eight weeks in 1994, and nine weeks in 1995 and 1997. The central 80 percent of migrants were captured over a three to six week period.

The peak of emigration (largest number of smolt in a one week period) was the second week of April in 1994 and 1996, the fourth week of April in 1997, and the first week of May in 1995 (Table 3-4). These differences are likely the result of environmental conditions in the tributaries that controlled the number of smolt produced and the timing of the emigration. While the delay in 1995 was likely due to cooler than normal water temperatures delaying growth and thus emigration, the delay in 1997 was likely the result of the lack of a triggering cue related to flows. Flows are one of the emigration cues for smolting steelhead (Shapovolov and Taft 1954).

3.3.1.3 Other Species

Arroyo chub, prickly sculpin and Santa Ana sucker were the most common resident species captured at the Vern Freeman Diversion in all years (Table 3-6). Threespine stickleback, bullhead and green sunfish were captured in low numbers in most years. Owens sucker, largemouth bass, mosquito fish and channel catfish were also captured at the Vern Freeman.

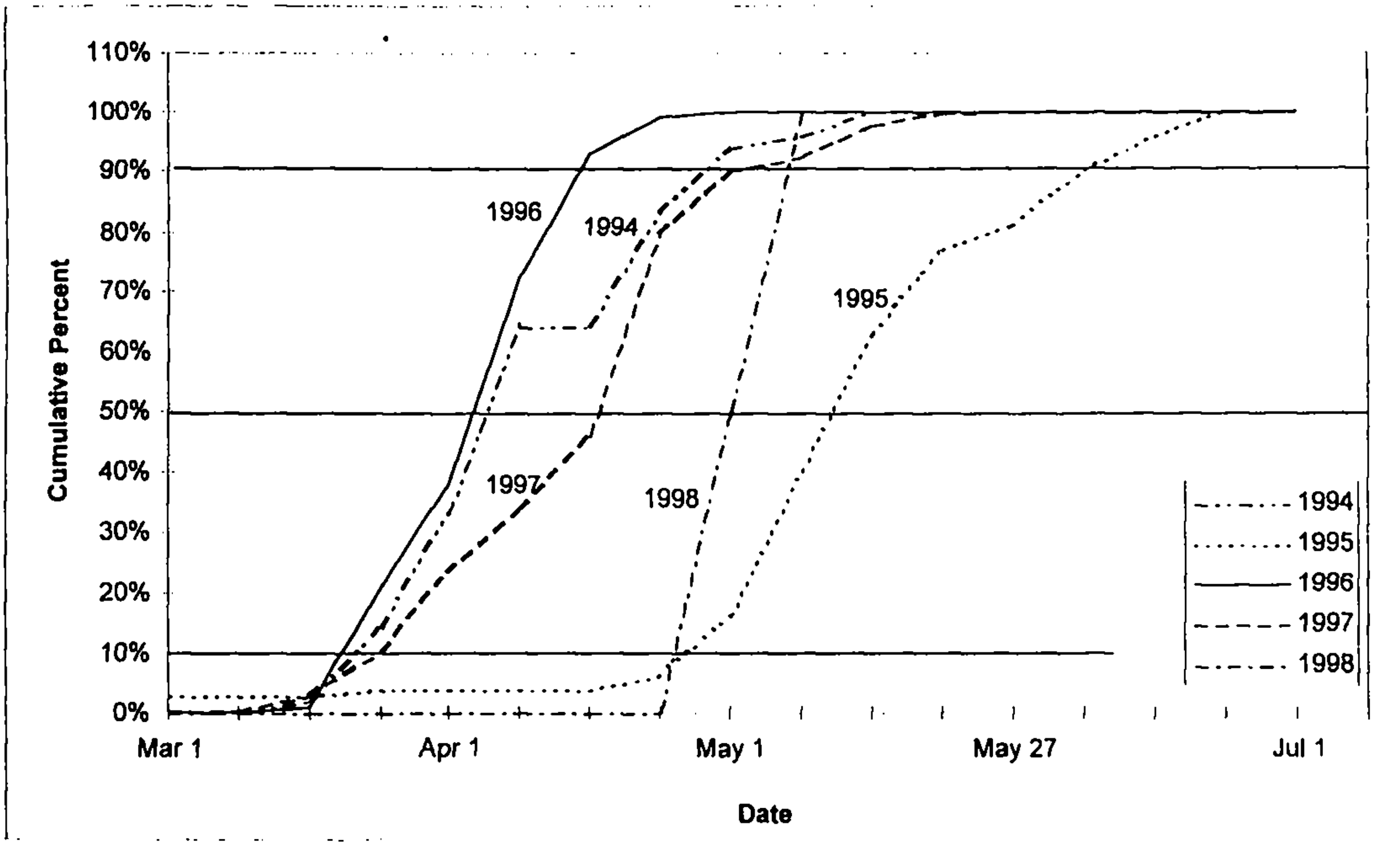


Figure 3-6 Cumulative Frequency of Smolt Captured in the Downstream Trap, 1994 – 1998.

4.0 DISCUSSION

4.1 1998 MONITORING

1998 was atypical of most years covered by this monitoring in several respects. First, the upstream migrant trap was not operated, so we do not know if any steelhead migrated upstream. Second, the downstream monitoring program started late, after the date when over 50 percent of the migrants had been caught in most other years. Third, because 1998 was an extremely wet year, the diversion spilled over 2,500 cfs from February through May, and less than 15 percent of the total flow of the river was diverted and trapped. Therefore, it is likely that the majority of smolt passed over the dam rather than entering the diversion where they would be trapped. In addition, the fish ladder was operated throughout most of the migration season with its auxiliary water supply going. The ladder requires 40 cfs, and the intake for the auxiliary water supply is in the forebay and has a capacity of 100 cfs. Smolt entering the forebay could have exited through the auxiliary water supply, as well as through the fish bypass (which typically has flows of less than 5 cfs passing through it). This would further reduce the efficiency of the trap in sampling the outmigration. It is therefore difficult to draw any firm conclusions from the small number of smolt captured in 1998. The small number is most likely the result of decreased likelihood that smolt would be trapped.

It is possible that the low number of smolt captured could also have been partially the result of poor rearing conditions in 1997. 1997 had greater than the median rainfall, but the rainfall all occurred early in the season, prior to the primary migration season. This resulted in low flows on the mainstem during the spring and summer months. The tributary streams, where rearing occurs, also likely experienced low flows. 1997 was also unusually warm and thus water temperatures were likely higher throughout the summer. This combination of factors may have resulted in poor summer rearing conditions in the tributary streams, which may have contributed to low survival in the tributaries and low number of outmigrating smolt captured in 1998.

The circumstances in 1998 make meaningful interpretation of the results of that year's sampling problematic. There could have been fewer smolt produced in the tributary streams, but it is more likely that the trapping effort was less successful because of the unusually high flows. The remainder of this discussion will focus on integration of the entire study period.

4.2 ADULT STEELHEAD

Adult steelhead were captured in the upstream trap during three of the four years upstream migrant trapping was conducted, indicating that adult steelhead can find and successfully utilize the fish ladder for passage over the diversion dam. One adult steelhead was captured in the fish ladder in 1994 and another was caught in 1995. Two adults were collected in 1996 and no adult steelhead were captured in the fish ladder in 1997. Upstream migrant trapping was not conducted during the 1998 water-year per a request by CDFG. All four adult fish were captured in the upstream trap during the month of March. The four adult steelhead captured ranged in length from 263 to 635 mm FL and in age from two to four years.

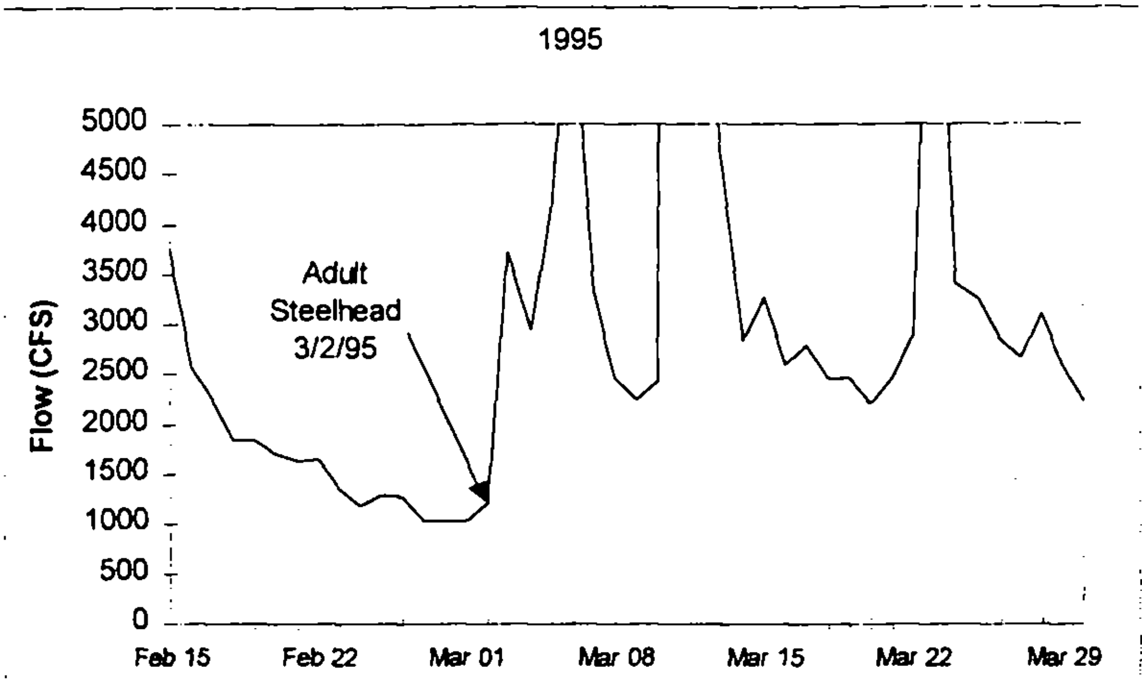
Adult steelhead have migrated through the lower Santa Clara River and ascended the fish ladder when streamflows below the diversion ranged from approximately 40 cfs to more than 1,000 cfs (Figure 4-1). In 1996, flow below the diversion was approximately 40 cfs (a result of the fish ladder release) on both days when steelhead were collected in the fish ladder and on one or more days preceding the day of capture. This suggests that adult steelhead (ranging in size from 263 to 437 mm FL) may be able to migrate upstream and ascend the fish ladder when flow in the river is limited to fish ladder releases. However, flows in the one to two-week period prior to the capture of each of these fish were quite high for a period of several days. Therefore, it is possible that these adults may have moved upstream during this high flow period and held over for some period of time prior to entering the fish ladder.

The 1995 data provide little insight regarding the lower range of flows at which steelhead can migrate upstream, as flow in the river was approximately 1,000 cfs in the days prior to the capture of the adult that year (Figure 4-1). However, the capture of this adult does indicate that steelhead can find the fish ladder entrance under conditions of relatively high flow. Unfortunately flow data below the Vern Freeman Diversion are not available for the 1994 water year because the USGS gage at Montalvo was out of service and UWCD did not record spillage from the dam in that year. Therefore, nothing can be said about the relation of flows to the capture of the single upstream migrant on March 31 of that year.

4.3 Downstream Migration

The results of the five year monitoring study indicate that the downstream bypass facilities at the Vern Freeman Diversion do allow steelhead smolt, lamprey and other fish species to migrate downstream past the diversion without intervention. The design and operation of this facility allows steelhead smolt to reach the ocean during all years, either without intervention when there is continuous flow between the diversion and the estuary (as was the case in 1995 and 1998, and portions of 1996), or through trap and truck operations during periods when there is not continuous flow between the diversion and the estuary (portions of 1996 and most of 1997).

The total number of downstream-migrating steelhead smolt caught during the 5 year monitoring period was highly variable, ranging from a low of two during the 1998 monitoring year to a high of 414 during the 1997 monitoring year. These results are only indicative of the minimum number of smolts that migrated downstream, as the number of



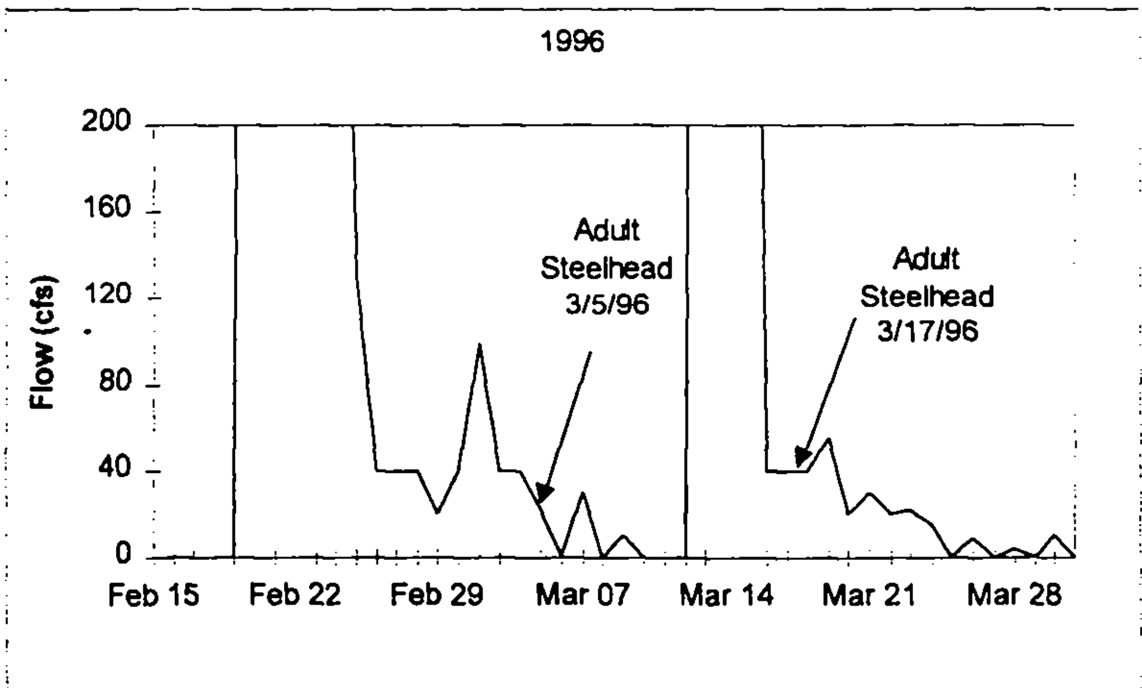


Figure 4-1 Flow Below the Vern Freeman Diversion Prior to Capture of Adult Steelhead in 1995 and 1996.

smolt produced during any given year is unknown. The variability in the number of smolt captured is likely due to a number of factors including the number of smolt produced in the upstream rearing areas, the flow regime of the tributaries, flow regime of the river, and the daily operation of the diversion relative to the outmigration. Because the number of smolt produced is unknown, it is also impossible to address how the number of smolt passing through the facilities relates to the proportion of the total river flow captured.

While it is likely that there is some relationship between the proportion of total flow diverted and the number of smolt caught, it is unlikely that this is a simple linear or proportional relationship. This relationship would be affected by the way in which the river approaches the diversion at different flow levels, the way fish behave as they approach the intake of the diversion, and how the diversion is being operated at that particular time (i.e. is the fish ladder operating, is the auxiliary water being used, is the flushing gate open, etc.).

The large number of smolt captured in 1997 (relative to other study years) is likely because flow conditions were such that UWCD diverted all of the river flow during the entire outmigration period in that year. As such, it is likely that nearly all of the outmigrant steelhead were counted during this year. 1996 was a relatively dry year, but the diversion spilled four times between January and the end of March. The spills in February and March exceeded five hundred cfs for the first few days of each spill, which may have allowed many smolt to pass over the dam. However, no smolt were captured at the diversion until March 18, which was during the descending limb of the last spill event. Therefore it is unclear how many smolt may have passed over the dam during that year. 1995 was a wet year when the diversion began spilling on January 3, spilled over 1,000 cfs from January 24 through May 1, and continued spilling until June 9. During this year 111 smolt were captured, but is likely that many more smolt passed over the dam without being detected. 1998 was wetter than 1995 and only two smolt were captured. This is likely the result of the wet year, but may also be related to the late start for downstream sampling due to NMFS permitting requirements.

The smolt captured were predominately Age 1, but a substantial proportion (18 to 49 percent) of them were Age 2. Two Age 3 smolt were captured, indicating that while steelhead may rear this long prior to emigration, it is a relatively uncommon life history strategy in the Santa Clara.

Emigration generally begins in mid-March and continues through mid-May. The peak of emigration generally appears to occur during April. In 1995, a wet year, a few parr were captured as early as the last week of January, but the peak of emigration was in the early part of May. The latest any smolt was captured was June 18, 1995. The later smolt emigration in 1995 than in other years, may have been the result of the wet water year and cooler temperatures.

Shapovalov and Taft (1954) reported that downstream migration of smolts began earlier in low flow years compared to high flow years. This appears to be the case in the Santa Clara River, as well. During relatively low flow years (1994 and 1996), smolt outmigration began in mid-March, peaked in early-April, and was essentially completed by the second week of May. In 1995, a high flow year, the outmigration period essentially began in late-April, peaked in early-May, and continued into early-June. In 1998 we cannot really define a trend because of the low number of smolt captured, but those smolt were captured during late April and early May, indicating that the later wet year emigration pattern may hold here as well. 1997 was a normal year in terms of rainfall amount (although unusual in terms of rainfall timing). The timing of smolt emigration in 1997 was intermediate to that of the dry years and the wet years.

As can be seen in Figures 4-2 through 4-5, the frequency of smolt emigration increases as average seasonal flows fall off beginning in March (1996 and 1997 water years) and extending into May (1995 water year).

4.3.1 Origin of Smolt

Given the low number of anadromous adults observed returning to the Santa Clara River and their distribution over time it seems unlikely that the smolt produced could be the progeny of these anadromous returners alone. Rather it is most likely that the majority of smolt produced are the progeny of resident rainbow trout. Production of trout within the Santa Clara basin occurs mainly on Sespe Creek and Santa Paula Creek. Both of these streams have been heavily stocked with hatchery produced rainbow trout for many years, which has affected the genetics of these populations so that they are no longer purely southern California ESU steelhead/rainbow trout.

Genetic tests conducted on tissue samples collected in 1995 from smolt at the Vern Freeman Diversion indicates that a high proportion of the smolts had a Type 1 or Type 3 mtDNA genotypes (ENTRIX 1996). These genotypes are commonly associated with northern steelhead and hatchery-bred rainbow trout (Nielsen 1994). Approximately 40 percent of the smolt had either Type 5 or Type 8 mtDNA genotypes which are more indicative of the Southern California ESU. These results indicate that the steelhead/rainbow trout population within the Santa Clara Basin have been strongly influenced by the planting of hatchery fish within basin streams. This is supported by mtDNA data collected from Sespe (n=36), Santa Paula (n=41), and Piru (n=23) creeks (Nielsen 1994). These samples found the Type 8 genotype most indicative of Southern California ESU origin only in Sespe Creek, where it was found only in approximately 27 percent of the fish sampled. Only Type 1 and Type 3 genotypes were observed in Santa Paula and Piru Creeks, with the exception of a single Type 5 fish in Piru Creek.

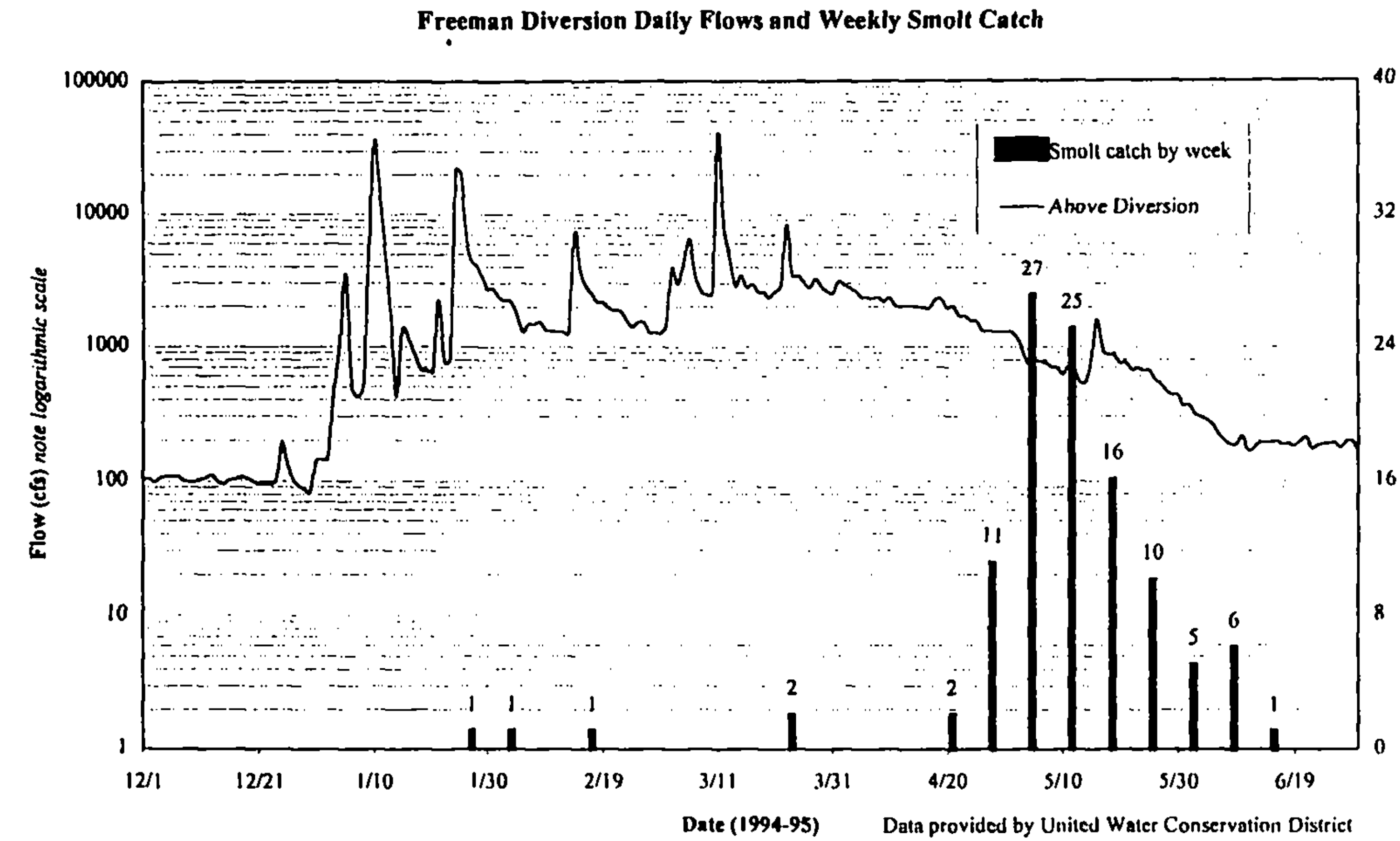


Figure 4-2 Smolt Capture in the Downstream Trap and Streamflow Above the Vern Freeman Diversion, 1995.