State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

The 2007 Mill Creek video station steelhead and spring-run Chinook salmon counts

By
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Sacramento River Salmon and Steelhead Assessment Project
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SRSSAP Technical Report No. 08-1
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Cover Photo: View from the overhead camera at the 2007 Mill Creek video station showing spring-run Chinook salmon swimming through the passageway at noon.

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1/ This was a cooperative investigation between the California Department of Fish and Game (Department), and willing local landowners It was supported by funding from the Sport Fish Restoration Act Grant F-51-R-18 Project 57-(Department), and a CALFED Bay-Delta Ecosystem Restoration Program (ERP) grant.

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SUMMARY

This report provides results of a fish counting video station operated on Mill Creek in Tehama County California to count steelhead trout, *Oncorhynchus mykiss* and other fish species (e.g. Chinook salmon- *Oncorhynchus tshawytscha*, and Sacramento sucker- *Catostomus occidentalis*). The California Department of Fish and Game in cooperation with local landowners collaborated to operate the station using a partial weir and overhead video monitoring. A video camera suspended above Mill Creek was used in conjunction with a variable 8 foot to 16 foot opening in the weir that provided unrestricted passage to count (both up and downstream directions) migrating steelhead trout (steelhead) and other fish from 06 March 2007 through 18 June 2007.

An estimated 67 steelhead passed upstream and 145 steelhead passed downstream through the station during the March through June time period. Based on visual analysis, most of the downstream steelhead were kelts (post-spawn steelhead) returning to the mainstem Sacramento River and Pacific Ocean after their earlier upstream spawning migration and the completion of their spawning cycle. In addition, an estimated 1,060 spring-run Chinook salmon, *Oncorhynchus tshawytscha,* entered into Mill Creek in 2007 based on the video station counts.

Future use of the video station at this location in subsequent years could provide an annual estimate escapement of anadromous salmonid passage in Mill Creek. (Water in Mill Creek is used for agricultural diversions and fish passage data below Ward Dam. Data from real time monitoring at the video station could be of importance to water management decisions that facilitate the passage of spring-run Chinook and steelhead.)

Use of similar video stations may provide opportunities to easily monitor steelhead and spring-run salmon escapement in other Central Valley streams that have limited or no monitoring programs due to budget limitations, trespass concerns, lack of in-stream counting structures or inaccessible spawning areas.

INTRODUCTION

A video station was operated to monitor the passage of steelhead and other fish passage in Mill Creek (Tehama County, California), from 6 March through 18 June 2007. The station was constructed and operated cooperatively by the staff of the Sacramento River Salmon and Steelhead Assessment Project (SRSSAP) of the California Department of Fish and Game (Department) and SRSSAP personnel employed through a Department grant with the Pacific States Marine Fisheries Commission (PSMFC). The Mill Creek video station site (Figure 1) was located in the town of Los Molinos near the Sherwood Road Bridge about 1.8 miles upstream from the mouth of Mill Creek where it enters the Sacramento River. Unique to this video station was the fact that the SRSSAP-PSMFC Crew Leader, Mr. Matt Johnson, (co-author) is also a landowner on Mill Creek where the station was located.

Funding for this project was provided by Project 60 of the Department's Sport Fish Restoration Act (SFRA) Grant and by a grant from the CALFED Bay-Delta Ecosystem Restoration Program.

Objectives

- To determine if overhead video monitoring could be used as a viable technique to estimate anadromous salmonid escapement into Mill Creek.

- To obtain, for the first time in decades, an estimate of steelhead escapement into Mill Creek.

- Provide a beginning of baseline data on steelhead escapement that can be used to evaluate steelhead population trends in the Mill Creek watershed.

Background

Well-designed environmental monitoring programs are needed to provide information to guide sound decision-making processes for natural resource management in California's Central Valley. In the Mill Creek watershed of the upper Sacramento River, reliable resource monitoring information is important to guide decisions and evaluate actions associated with an ecologically important watershed. The Mill Creek watershed is home to two fish species listed under the Federal Endangered Species Act (FESA) as Threatened in the Central Valley of California, Central Valley steelhead and spring-run Chinook salmon, (also State listed as Threatened). Reliable data on steelhead and salmon escapement in Mill Creek is needed to interpret fishery responses to habitat restoration activities, water diversions, and provide information to fisheries managers, landowners, and others interested in the Mill Creek watershed. Establishing a sound methodology for estimating current steelhead population trends in Mill Creek is especially relevant as such

data has been unavailable since the discontinuation of a fish counting station on Mill Creek at the Clough Dam (an irrigation diversion dam at RM 5.8) in 1963.

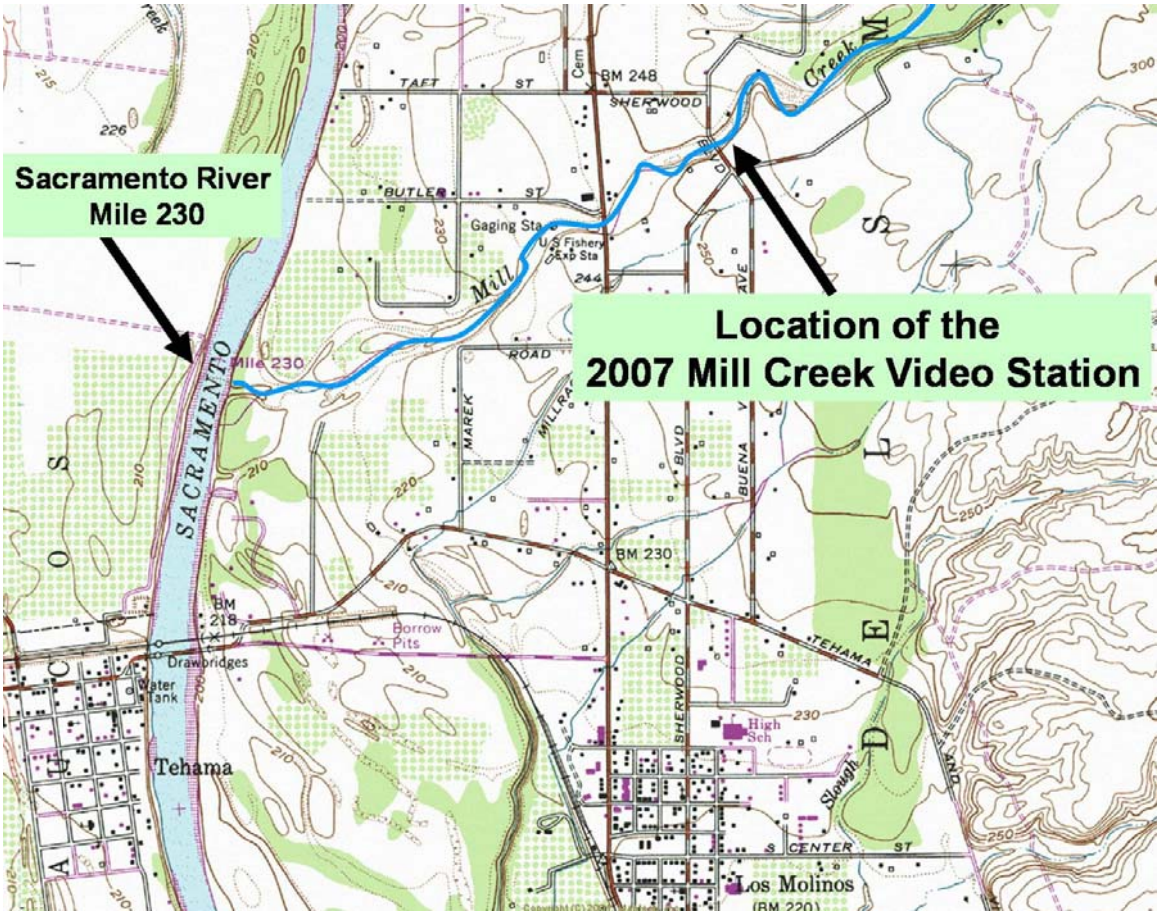

Figure 1. Map of the location of the 2007 Mill Creek Video Station site near the Sherwood Blvd. bridge in Los Molinos, CA.

The Department has not systematically monitored steelhead escapement into Mill Creek since the spring of 1963. The current ESA Threatened status of steelhead in the Central Valley ESU (Evolutionarily Significant Unit) makes the operation of facilities such as weirs and fish traps problematic due to the concerns raised in the permitting process associated with the stress and/or mortality of listed fish stocks at such facilities. Attempts by the SRSSAP staff since 2001 to make any estimates, (other than presence/absence observations) of Mill Creek steelhead by snorkel counts for adults and redds during the winter and spring have proven difficult due to periodic high flows associated with rain events and the natural turbidity of Mill Creek during snowmelt periods.

Table 1 provides a summary of the reported annual Mill Creek fall and spring-run Chinook and steelhead escapement into Mill Creek from 1953 to present. From 1953 to 1963 a fish trap operated at the Clough Dam, (destroyed in a flood in 1997), provided annual escapement estimates for fall and spring-run Chinook and steelhead. Since 1963,

no steelhead population estimates have been made, while fall and spring-run Chinook population estimates have been conducted most years using a variety of methodologies including carcass surveys, snorkel counts, and redd counts.

Table 1. Summary of the annual reported fall and spring-run Chinook, and steelhead escapement numbers into Mill Creek from 1953 to 2007. (source: Department's Grand Tab file)

Year	Fall-run Chinook	Spring-run Chinook	Steelhead	Year	Fall-run Chinook	Spring-run Chinook	Steelhead
1952	16,000	n/a	n/a	**1980**	320	500	n/a
1953	10,000	n/a	n/a	**1981**	1,020	n/a	n/a
1954	7,000	1,789	715	**1982**	1,290	700	n/a
1955	3,000	2,967	1,492	**1983**	200	n/a	n/a
1956	896	2,233	1,213	**1984**	5,800	191	n/a
1957	5,316	1,203	1,443	**1985**	3,840	121	n/a
1958	4,340	2,212	1,301	**1986**	574	291	n/a
1959	837	1,580	790	**1987**	282	90	n/a
1960	940	2,368	417	**1988**	1,487	572	n/a
1961	1,689	1,245	742	**1989**	1,565	563	n/a
1962	4,384	1,692	1,222	**1990**	n/a	844	n/a
1963	1,286	1,315	2,269	**1991**	n/a	319	n/a
1964	450	1,539	n/a	**1992**	999	237	n/a
1965	150	n/a	n/a	**1993**	1,975	61	n/a
1966	500	n/a	n/a	**1994**	1,081	723	n/a
1967	500	n/a	n/a	**1995**	n/a	320	n/a
1968	750	n/a	n/a	**1996**	n/a	253	n/a
1969	1,700	n/a	n/a	**1997**	478	202	n/a
1970	690	1,500	n/a	**1998**	546	424	n/a
1971	980	1,000	n/a	**1999**	n/a	560	n/a
1972	631	500	n/a	**2000**	n/a	544	n/a
1973	420	1,700	n/a	**2001**	n/a	1,100	n/a
1974	944	1,500	n/a	**2002**	2,611	1,594	n/a
1975	1,208	3,500	n/a	**2003**	2,426	1,426	n/a
1976	245	n/a	n/a	**2004**	1,192	998	n/a
1977	318	460	n/a	**2005**	2,426	1,150	n/a
1978	300	925	n/a	**2006**	1,403	1,002	n/a
1979	810	n/a	n/a	**2007**	796	920	n/a

The video station data gathered in 2007 represents a new method for estimating anadromous fish populations and determining run-timing in Mill Creek. A Similar video station has been successful in monitoring adult fall-run Chinook escapement in Battle Creek since 2003, and replaced the traditional carcass survey on that creek. Additionally, a new video station on Cow Creek was operated in the fall of 2006 and two other new stations were planned for Bear and Cottonwood Creek(s) in the fall of 2007.

The data from the Battle Creek video station allowed biologists to compare the results of a carcass mark-recapture study and hatchery counts to the video station results (Killam, 2006). Over a three-year period the counts from the two independent methods were

similar enough to give fisheries biologists the confidence to halt the labor intensive carcass survey, (since 2006 the video station was the only method used on Battle Creek). As a result of the success in Battle Creek the video station methodology was accepted by the Department and other agencies (i.e. U.S. Fish and Wildlife Service, National Marine Fisheries Service) as a suitable tool for use in other watersheds.

In 2006 a study to assess the possibility of using sonar acoustic devices to estimate salmon escapement in Mill Creek was conducted in the same location, (Johnson, et. al. 2006). This study compared two acoustic methods (DIDSON-dual-frequency identification sonar, and split-beam systems) and determined that the DIDSON system performed well in collecting salmon passage data during the study period from 29 March to 23 June. Flows in Mill Creek in 2006 were higher than average and the DIDSON system was capable of collecting data even when the creek was turbid (Johnson et. al. 2006). Based on the success of the DIDSON system in 2006, and the video station methodology in recent years, it was thought (by the authors) that a combination of the overhead video and the DIDSON system would provide an ideal means of monitoring steelhead in Mill Creek. A plan to operate the video station was developed and approved in early 2007 and a site was chosen soon afterwards.

In February of 2007 a survey of Mill Creek was made to choose a site for the video station. The site just upstream of the Sherwood Road Bridge that was used for the acoustic monitoring fit all the criteria for a video station. These criteria included:

1. Limited public access to avoid vandalism and poaching opportunities.
2. A nearby power supply to run the station's VCR's and cameras.
3. Near the mouth of Mill Creek so that all/most salmonids would travel above the site.
4. Landowner permission to construct and access (daily) the video station site.
5. Suitable stream geology to place the weir (shallow with even stream bottom).

It was hoped that simultaneous fish passage monitoring from the acoustic and video systems could be accomplished in 2007, but unfortunately the funding for the acoustic monitoring project was not available in 2007. It was decided that the operation of the video station alone would provide valuable information and it was installed as planned.

Assembly of the station began in early March of 2007 after landowner cooperation at the Mill Creek site was obtained. The site was located approximately 1.8-miles upstream of the mouth of the Sacramento River (Figure 1). Personnel from the Department and PSMFC accomplished station set-up, maintenance, tape changes, tape reading, and station removal.

METHODS and MATERIALS

The video station equipment consists of two component groups, these included:

- Power supply(s), camera, lights, and video cassette recorders (VCR's).

- Weir, camera support cables VCR lock box and the fish passage plates on the stream bed.

Each of these components required different skills and abilities to construct and assemble. The use of commonly available retail equipment avoided contracting out any of the work to construct the station. We were able to draw on the experience and backgrounds of current SRSSAP personnel to construct and operate the station.

Power Supply and Camera System

One criteria of the Mill Creek Video Station was that it be located near a conventional power supply. The Mill Creek station did not have sufficient funding to purchase solar panels and related equipment similar to the remote Battle Creek station, so it was necessary to select a site with existing power. Mr. Johnson provided access to 120 volt household AC power via extension cord to the VCR lock box. The lock box (see Figure 2) was a modified stand up freezer that was purchased from an appliance store's salvage yard. Modifications to the freezer included vent holes, removing all refrigerant plumbing lines, and welding on a sturdy mechanism to allow secure locking of the freezer.

A back-up power supply was constructed to provide power for a 1-2 day period should a power outage occur in the regular power supply. The backup power supply consisted of 4 six-volt "golf cart type" batteries linked to provide a 12volt DC power supply to a conventional computer battery backup system. The original batteries from the 300 watt APC brand Uninterruptible Power Supply (UPS) were removed and the larger golf-cart batteries were connected giving a much greater power reserve if the grid power failed. All of the stations electronics were routed through the UPS to ensure continual video coverage in the event of a power failure.

We selected a monochrome (black and white) camera (PC88WR) that provided good images in various lighting conditions. The low cost ($115 from supercircuits.com) camera was vastly superior over other more expensive cameras in low-light situations (Killam 2006). The weatherproof PC88WR camera was attached to a "camera" box that contained remote lighting and other wiring hookups (visible in Figure 3).

The camera box was suspended over Mill Creek at a height of about 15-feet (4.6 m) from the water's surface using a cable system constructed of 1/4-inch (6.3 mm) galvanized steel cables. The cable system consisted of two main cables that were linked together with two cross members holding the camera box, and is shown in Figure 3. The two main cables, about 150-feet (45.7 m) each, were stretched across the creek and anchored in three trees. The purpose of the cross segments was to pull the main cables together and stabilize the camera platform. This design helped to minimize side-to-side sway which allowed fish counting in all wind conditions. Tightening of the main cables was accomplished with a mechanical "come-along". The end of the main cable closest to the VCR-battery box was designed to allow easy movement up and down with the come-along. In this manner the camera was raised and lowered if an adjustment to lighting, or camera cleaning was required.

Figure 2. Photo of the modified freezer used to house the VCR's, batteries, monitor, and other electronic components of the 2007 Mill Creek video station.

The camera box was attached by ropes to the cross cables which reduced vibrations caused by wind. Power cords and camera co-axial cable were zip-tied to a one-half inch polypropylene rope that was strung from one of the two main cables. This rope was used so that the steel cable was never allowed to contact directly the co-axial camera or power cords, preventing wear and possible breakage of the power or camera wiring.

The camera image was routed by co-axial (RG-6) cable to the station's VCR-lock box, which was located about 20 feet (6.1 m) from the creek, above the flood plain. All wiring was passed through conduit and buried underground to prevent vandalism and provide an appearance suitable for the existing private area where the station was located.

Figure 3. Photo of 2007 Mill Creek video station from the Sherwood Avenue Bridge. Photo is looking upstream and shows weir, open area with white bottom plates, hanging camera, and lights.

The image from the overhead camera was split into four VCR's. Three of the VCR's (Panasonic PV-V4624S) were programmed to sequentially record eight-hour periods, thereby providing 24-hours of continuous coverage each day. Video tapes were type T-160, set to record on extended play (EP) mode. A fourth "time-lapse VCR" was programmed to record 4-hours each day at the end of the third 8-hour cycle. The purpose of this VCR was to ensure complete coverage in the event the personnel servicing the video station did not arrive before the last of the three 8-hour VCR's had finished recording. A small TV monitor was used observe the image from the camera and to check the hookup of all VCR's for proper operation throughout the season.

A second camera was installed midway in the season in an underwater location in an attempt to identify the species of fish that were being observed. This camera was identical to the overhead camera but was housed in a plastic housing. The image from this camera was originally sent to a fifth VCR but the purchase of a "QS-29 quad processor" (Supercircuits.com) late in the season allowed both camera images to be merged into one image that was recorded on the three main daily 24-hour VCRs.

Lighting for the camera was provided by two compact outdoor fluorescent spotlights (16 watt EDXR-30-16; available at retail stores) which were mounted on the overhead cable system (visible in Figure 3). These outdoor spotlights use very little power compared to conventional spotlight bulbs, which was an important consideration for the video station. A photocell sensor, similar to those used on streetlights, was used to turn on the lights at dusk and turn them off at dawn.

Weir System

A weir was constructed to channel salmon into the camera's view without causing passage delay (Figures 3 and 4). The weir was constructed of ten-foot (3m) long steel $1^{1/8}$ inch O.D. (28mm) pipes which were welded to uprights with 3" (76mm) spaces between pipes. Some taller panels used $1^{1/4}$ inch EMT conduit on the inner cross members to lighten the overall weight of the finished panel. The 10-foot (3m) wide horizontal pipe panels were designed to fit the depth of Mill Creek at the station site (i.e. panels in shallow water had only 5 or 6 cross members while panels in deeper water had up to 12 cross members). The horizontal design and spacing between bars of the weir panels allowed smaller fish and most leaves and sticks to pass through the weir while preventing large fish from passing the weir unmonitored. Six weir panels configured in a slight "V" shape facing upstream to guide fish to the center opening (Figure 3) were secured in place using downstream angled braces that provided vertical support to each panel. The braces consisted of pipe similar to the panel pipe that slid through slightly larger "dog leg" pipe fittings that attached inside the top rail of each panel allowing the entire weir to be set-up without the addition of any difficult to remove t-post fence stakes into the stream bottom.

Two weir panels were added as upstream facing guidance panels along the fish passage opening to prevent fish from skirting around the ends of the weir (visible in Figure 4). These guidance panels were placed along the outside edges of the white bottom plates just under the water surface and resulted in most fish swimming upstream along the entire length of the plates allowing for easier counting compared to similar weirs without these guidance panels (e.g. Battle Creek in 2003, (Killam 2006)).

White colored high density polyethylene (HDPE) sheets were staked to the creek bottom to make the observation of passing salmon easier. Two overlapping ¼ inch by 4 by 8 feet (6mm x 1.2 m x 2.4 m) sheets were used to create a white background contrasting to the dark color of the passing fish, (Figures 3 and 4). These plates had ¾-inch (19mm) holes drilled around their perimeters to allow staking. Stakes were 24 inch concrete form stakes with a 2-inch (50mm) washer welded to their tops to secure the plates.
A measuring device was constructed to allow tape readers to approximate the length of passing fish. A flat metal square measuring 16-inches (406mm) wide allowed tape readers to estimate fish lengths by comparison, (visible in the cover photo at top).

Figure 4. Photo of 2007 Mill Creek video station. Photo is looking downstream and shows weir, open area with the narrow configuration of white bottom plates, and upstream facing guidance panels to ensure fish swim through the area of white bottom.

Two configurations of the white bottom plates were used in 2007 in Mill Creek. The first configuration used early in the season was 16 feet wide (4.9m) and 4 feet (1.2m) deep (seen in Figure 3). This configuration was used to maximize the opening in the creek to allow potential high rain and snow melt flows an opportunity to pass through the station without damaging the ability of the weir panels to restrict fish passage outside of the camera image. The second configuration of white plates was used after the risk of potential high flows was minimized following a very dry water year. The second configuration measured 8 feet (2.4m) wide by 8 feet (2.4m) deep (seen in Figure 4). This configuration allowed better visibility of fast moving fish by tape readers since the fish were over the white plates for a longer period.

Video Station Operation and Maintenance

The video station was checked once a day during operation. Daily activities included:

- Changing videotapes in the three daily VCR's.
- Checking power levels and normal operation of equipment (lights, VCRs, etc).
- Cleaning the weir and white plates of algae, and debris.
- Recording comments and time of visit in the station logbook.

Recorded videotapes (tapes) were brought to the Department's SRSSAP office in Red Bluff where they were stored until viewing. Tapes were viewed and a database of fish passage was compiled. After the staff from the SRSSAP completed the tape reading the tapes were rewound and stored for re-use in later years.

Tape Reading and Data Collection

The video tapes were "filtered" through a digital video recorder, (DVR). This DVR (Honeywell Fusion III) had the ability to reduce the amount of taped video footage by only recording those periods when there was motion detected in the area of the white plates (i.e. fish movement). The DVR significantly reduced the amount of labor required to analyze the data, as there were large blocks of time on each tape devoid of fish passage. This "filtered" data was then stored in the memory of the DVR and could be read using a monitor connected to the DVR or remotely from office desk-top computers with monitors linked to the DVR. Readers could turn out the lights in the room if desired for reading "night tapes" to allow for easier viewing. Passage data was recorded in one-half hour increments. Hand held tally counters were used to tally the number of fish going up and down through the weir passageway. Fish were counted as passing upstream once they exited the upper portion of the white bottom plates above the weir edges.

Fish categories on the data collection form included steelhead, salmon and other species. Fish counts were tallied for each of the 48 half-hour periods in each day. Analysis of historical trapping data at the Red Bluff Diversion Dam on the Sacramento River (SRSSAP, unpublished data) determined that almost all (99.8%) of the salmon in the Upper Sacramento River Basin are larger than 16-inches (406 mm). In addition, the Department considers any rainbow trout greater than 16-inches present in anadromous waters to be a steelhead form of *Oncorhynchus mykiss*. It was left to the reader's judgment to determine if fish greater than 16-inches (406 mm) were to be tallied as salmon or steelhead or some other species. Readers were instructed to provide comments on all small fish generally less than 24-inches (610 mm) that were counted on their datasheets. Most non-salmonid species in Mill Creek are less than 24 inches (610 mm) although some individual carp (*Cyprinus carpio)*, hardhead (*Mylopharodon conocephalus*), Sacramento pikeminnow (*Pytchoceilus grandis*), and Sacramento suckers (*Catostomus occidentalis*) may rarely obtain lengths greater than this in the watershed. Readers can typically differentiate (with experience) salmonids from these other species based on body form, shape and posture of pectoral fins, and swimming behavior.

An underwater camera (two different types) was added in an attempt to aid in fish identification by allowing readers an opportunity to see a fish from an underwater view if the fish swam near where the camera was placed at the side of the weir opening.

RESULTS and DISCUSSION

The Mill Creek video station was in operation for 105 days in 2007. The acquisition of recorded video data was nearly continuous during the 6 March through 18 June time period. Near drought conditions during the spring of 2007 prevented high flow events from compromising the weir or eliminating visibility. There was no loss of data due to high turbidity during the spring snowmelt period.

The 3 objectives of the station were successfully met. First, it was possible to use an overhead camera in combination with the partial weir to count anadromous salmonid escapement and collect run timing information for Mill Creek. Second, a partial count of steelhead immigration and subsequent emigration into the creek was made. Third, the beginning of a future database of steelhead migration and timing into the Mill Creek watershed was established.

The original intent in installing and operating the station was to gather information about the possibilities of using this type of station to count steelhead during their migrations into this and other tributaries of the Upper Sacramento River Basin (USRB). Mill Creek was well suited for this "test" because it is commonly known to have the worst visibility conditions of any of the Sacramento River tributaries during this time frame. Mill Creek originates in Lassen National Park and during the late winter/spring time frame can frequently experience periods of water visibility ranging from muddy to a milky green (snow melt from the Park). Some years this turbidity can last for weeks, and in other years the visibility can be quite good (clear) for most of the season. There were very few storm events in the winter-spring of 2007 and consequently the dry water year tended to favor the abilities of the overhead camera in counting fish.

Salmonid Counts

The final estimate of steelhead and spring-run Chinook salmon (salmon) that passed through the Mill Creek video station during the period from 6 March through 18 June in 2007 was **67** upstream steelhead, **145** downstream steelhead, (or kelts), and **1,060** spring-run Chinook salmon upstream. The passage data by date for the video station is presented in Table 2. Peak steelhead and salmon movement both occurred in early May. Of interest is that both upstream and downstream peak movements of steelhead occurred from 8 to 10 May. This may represent the presence of two runs of steelhead in Mill Creek. One run may be exiting the system while another is entering during this May period. Peak salmon passage occurred on 3-4 May and these days combined (259 fish) represented nearly 25% of the total passage observed, (note salmon passage, in contrast to steelhead data, in this report is always reported as the number of fish passing upstream of the station since salmon die after spawning and therefore do not normally pass downstream).

Table 3 presents the results of fish passage by half-hour periods. The table is useful in categorizing fish passage during the 24-hour cycle. Table 3 demonstrates that upstream

Table 2. Summary by date for daily passage of steelhead, spring-run Chinook salmon and for water temperature and flow at the 2007 Mill Creek video station.

Date	Steelhead Up	Steelhead Down	Chinook Salmon	H2O (F°)	Flow-cfs	Date	Steelhead Up	Steelhead Down	Chinook Salmon	H2O (F°)	Flow-cfs
6-Mar	0	0	0	50	242	28-Apr	0	5	11	62	154
7-Mar	1	0	0	50	248	29-Apr	0	3	20	62	162
8-Mar	1	0	1	50	250	30-Apr	0	3	7	61	166
9-Mar	2	0	1	50	251	1-May	0	22	10	59	173
10-Mar	0	1	1	50	245	2-May	0	1	25	57	208
11-Mar	1	1	0	52	248	3-May	0	1	136	53	220
12-Mar	1	0	2	53	278	4-May	0	0	123	54	181
13-Mar	1	1	4	53	327	5-May	0	0	2	54	163
14-Mar	0	1	45	53	360	6-May	0	0	0	57	144
15-Mar	0	2	7	53	365	7-May	0	1	2	61	151
16-Mar	0	1	10	53	350	8-May	7	24	27	64	181
17-Mar	4	1	16	54	347	9-May	3	18	9	64	183
18-Mar	0	0	11	54	347	10-May	15	5	27	63	177
19-Mar	1	0	25	54	336	11-May	1	0	12	62	169
20-Mar	1	0	28	54	328	12-May	3	1	17	61	161
21-Mar	0	0	6	51	330	13-May	0	0	10	61	154
22-Mar	0	1	-1	50	284	14-May	0	0	10	62	147
23-Mar	0	0	4	52	262	15-May	0	0	15	63	144
24-Mar	0	0	4	54	261	16-May	0	0	11	64	148
25-Mar	0	0	53	56	267	17-May	15	0	8	65	148
26-Mar	0	0	68	54	276	18-May	0	0	1	64	146
27-Mar	0	3	9	50	320	19-May	0	2	5	64	144
28-Mar	0	0	4	48	247	20-May	0	0	12	64	141
29-Mar	0	0	3	50	202	21-May	0	0	3	63	136
30-Mar	0	0	4	52	176	22-May	0	0	2	61	124
31-Mar	0	0	5	54	168	23-May	0	0	4	62	114
1-Apr	0	0	9	55	173	24-May	0	0	1	64	104
2-Apr	2	0	0	55	166	25-May	0	1	1	65	104
3-Apr	0	1	1	54	154	26-May	0	0	2	66	109
4-Apr	0	0	6	56	145	27-May	0	0	8	67	118
5-Apr	0	0	5	56	142	28-May	0	0	1	67	109
6-Apr	0	0	4	58	143	29-May	0	0	0	67	103
7-Apr	0	4	58	60	157	30-May	0	0	1	68	99
8-Apr	0	11	23	58	155	31-May	0	0	2	69	100
9-Apr	0	6	2	58	155	1-Jun	0	0	0	70	103
10-Apr	0	1	2	55	149	2-Jun	0	0	0	70	109
11-Apr	0	4	3	54	143	3-Jun	0	0	1	69	105
12-Apr	0	0	10	52	147	4-Jun	0	0	1	68	94
13-Apr	0	0	3	53	127	5-Jun	0	1	0	65	94
14-Apr	0	0	7	54	130	6-Jun	0	0	1	62	98
15-Apr	0	1	20	53	135	7-Jun	0	0	3	62	84
16-Apr	0	0	2	54	115	8-Jun	0	0	0	64	74
17-Apr	0	1	0	55	108	9-Jun	0	0	0	65	68
18-Apr	0	0	-1	53	108	10-Jun	0	0	0	68	63
19-Apr	0	0	3	51	106	11-Jun	0	0	0	68	61
20-Apr	0	2	0	52	102	12-Jun	0	0	0	69	57
21-Apr	3	0	1	51	101	13-Jun	0	0	0	71	54
22-Apr	0	7	4	52	169	14-Jun	0	0	0	72	52
23-Apr	1	1	41	53	153	15-Jun	0	0	0	73	82
24-Apr	3	0	8	56	147	16-Jun	0	0	0	73	114
25-Apr	0	5	5	58	150	17-Jun	0	0	0	71	110
26-Apr	0	0	1	58	144	18-Jun	0	0	0	71	76
27-Apr	1	1	2	60	145	**Totals**	**67**	**145**	**1,060**	48°-73°	52 to 365

migrating steelhead show a preference for early morning movement compared to other times. The period from 01:30 to 02:30 represented 36%, (24 fish), of the total upstream steelhead movement. In comparison, the 14-hour period from 07:00 to 21:00 resulted in only 1.5%, (1 fish), of total passage. Movement of steelhead kelts downstream, however, did not exhibit such large contrast. The out-migrating steelhead seemed to prefer passing at any time except the 5-hour period from 15:00 to 20:00. Salmon passage occurred at all time periods but was highest at 02:00 (48 fish, 4.5%). Only a few salmon passed during the 14:30 through 19:30 period (25 fish, 2.4%). This data is useful in interpreting fish movement patterns that may have implications for irrigation strategies. Based on the data in Table 3, it appears that salmonids in Mill Creek are moving at all hours of the day but show a trend towards non-movement from 15:00 until 19:30.

Table 3. Summary of salmonid passage by time of day at the 2007 Mill Creek video station.

Time	Steelhead Up	Steelhead Down	Chinook Salmon	Time	Steelhead Up	Steelhead Down	Chinook Salmon
0:00	2	4	39	**12:00**	0	11	20
0:30	6	4	26	**12:30**	0	0	8
1:00	2	4	44	**13:00**	0	6	3
1:30	9	5	34	**13:30**	0	2	8
2:00	15	4	48	**14:00**	0	2	9
2:30	4	4	42	**14:30**	0	1	9
3:00	2	6	40	**15:00**	1	0	6
3:30	6	7	35	**15:30**	0	0	2
4:00	1	6	36	**16:00**	0	0	4
4:30	4	10	37	**16:30**	0	1	2
5:00	1	7	32	**17:00**	0	0	1
5:30	0	3	22	**17:30**	0	0	4
6:00	1	6	27	**18:00**	0	0	2
6:30	1	1	27	**18:30**	0	0	1
7:00	0	1	32	**19:00**	0	0	3
7:30	0	1	22	**19:30**	0	0	18
8:00	0	0	23	**20:00**	0	2	21
8:30	0	0	24	**20:30**	0	6	30
9:00	0	2	22	**21:00**	1	4	45
9:30	0	2	19	**21:30**	1	5	36
10:00	0	6	14	**22:00**	3	4	44
10:30	0	3	12	**22:30**	0	3	38
11:00	0	4	12	**23:00**	4	3	43
11:30	0	4	8	**23:30**	3	1	26

Table 4 provides the salmonid counts grouped by month and by Julian week. Table 4 demonstrates that the end of April into early May was the period of greatest fish passage for both up and downstream migrating steelhead and salmon. The data in Table 4 also reflect that the station was installed at the correct time for a nearly complete counting of salmon but was likely installed in the middle of steelhead migrations. This was not surprising as data collected on fish passage at the Clough Dam in the 1950's showed that the steelhead run began in late October (CDFG 1964). An objective of the 2007 Mill Creek video station was to determine **if** it was possible to collect data on steelhead. Future efforts (with proper funding) may include complete sampling of steelhead migrations but for 2007 we were satisfied with the steelhead information that we were able to collect.

Table 4. Summary by month and Julian week of salmonid passage at the 2007 Mill Creek video station.

Month		Steelhead Up	Steelhead Down	Chinook Salmon
March		13	12	310
April		10	56	257
May		44	76	487
June		0	1	6
Week	**Week Date**	**Steelhead Up**	**Steelhead Down**	**Chinook Salmon**
10	6-Mar	4	1	3
11	11-Mar	7	7	84
12	18-Mar	2	1	77
13	25-Mar	0	3	146
14	1-Apr	2	5	83
15	8-Apr	0	22	50
16	15-Apr	3	4	25
17	22-Apr	5	19	72
18	29-Apr	0	30	323
19	6-May	29	49	94
20	13-May	15	2	60
21	20-May	0	1	25
22	27-May	0	0	12
23	3-Jun	0	1	6
24	10-Jun	0	0	0

Flow and Temperature

Table 2 includes the water temperature and flows in Mill Creek during the period of station operation. The flows were relatively low compared to the previous year (Johnson, et. al. 2006) and the average water temperature for each date ranged from 48 degrees Fahrenheit (8.9 ^{o} Celsius) on 28 March to 73 degrees (22.8 C^{o}) on 15-16 June. Flows in the lower section of Mill Creek at the video station site are influenced by irrigation needs.

Flows at the video station site ranged from a high of 365 cubic feet per second (cfs) on 15 March to a low of 52 cfs on 14 June. These temperatures and flows were obtained via the internet (CDWR 2007) from the permanent stream gauge at Highway 99 Bridge (CA. Data Exchange Center Station (CDEC): MCH) just downstream of the video station site. A general comparison of the natural flow in Mill Creek to the post-irrigation flow can be made by subtracting the flow from the upper Mill Creek gauge (USGS 2007) (CDEC: MLM) that is just above the irrigation diversions to the MCH gauge that is below the major irrigation diversions.

Fish Identification

The data summarized in tables 2 through 4 suggests that a small run of steelhead ascended Mill Creek in the spring of 2007. However, due to the presence of other similar size and shaped fish species such as hardhead and Sacramento pikeminnow migrating through lower Mill Creek during the 6 March to 18 June time frame, there is some uncertainty associated with identification of steelhead. We were not able to correlate all the underwater camera images with the overhead image of these targets because of low light conditions and the tendency of some of these fish to swim up the side of the weir opening opposite of the underwater camera. This was the first time that video station tape readers were expected to be able to distinguish species other than the much larger salmon. The Clough Dam data set from the 1950's documents the presence of steelhead during the March to mid June time frame (CDFG 1964) but does not identify other species that may have been migrating during historical monitoring. Further monitoring and more efficient underwater cameras (now available) are required to determine if steelhead can be reliably distinguished from very similar shaped species.

Steelhead Kelts

The data summarized in tables 2 -4 detail the phenomenon of a previously un-monitored out migration of steelhead adults (kelts) from Mill Creek. Visual identification of these targets was very confident by all tape viewers, and we had positive identification and correlation with the underwater camera image. Steelhead appear to be long and slender on their migration downstream and move with rapid, deliberate movements, unlike other species that we commonly observed (e.g. Sacramento suckers). Figure 5 is an image of a steelhead kelt and a Chinook salmon captured by the overhead camera. The downstream migration of steelhead documented in our study likely represents the completion of spawning and out-migration of a run of steelhead that entered Mill Creek before the 6 March installation of the video station. Peak out-migration of these fish occurred during early May. Little or no data exists on steelhead out migration in Mill Creek. Typically traps and fish ladders are well suited for collecting upstream migrants but not downstream traveling fish, since most fish are not funneled into the typically narrow upstream opening of a fish ladder or trap. The weir at the video station was only a few inches (see Figure 3) above the surface of the water and had no provisions to prevent fish from jumping over it, but the weir itself was apparently enough of a barrier to steer at least some portion of the steelhead kelts (145 fish) through the counting area.

Figure 5. Image taken from Mill Creek overhead camera of steelhead kelt and Chinook salmon on 22 April, 2007 at 04:04 AM.

Other Species

The most abundant species observed during monitoring efforts was the Sacramento sucker. Large schools of these fish numbering in the hundreds could be viewed passing through the weir opening on a regular basis starting in early March and lasting into early May. These fish were seen feeding on the stream bottom alongside the area of the white plates and would linger in the camera view for long periods of time (see Figure 6). Pacific lamprey (*Lampetra tridentate*) were often seen in late April to early May going both up and downstream (see Figure 7). Other fish that were observed were large cyprinids thought to be either Sacramento pikeminnow or hardhead (impossible to distinguish between the two from camera image). Also observed frequently were bird species including: common merganser, mallard, great blue heron, great egret, and belted kingfisher. Mammals observed included beavers, and river otters.

Figure 6. Image of Sacramento suckers passing upstream at the Mill Creek 2007 video station.

Figure 7. Image of a Pacific lamprey passing upstream at the Mill Creek 2007 video station.

Chinook Salmon

The goal of the video station was to collect data on steelhead in Mill Creek. The video station also collected surprisingly complete information on the spring-run Chinook salmon population (see cover photo) entering Mill Creek for spawning purposes later in the year. The Department's SRSSAP staff conducts redd surveys each year, typically occurring in October, to estimate an index of the population of spring-run salmon in Mill Creek. Crews walk the known spawning areas counting the number of salmon redds observed over the entire spawning period. The total count of new redds observed is multiplied by two (a hypothesized one female to one male ratio for each redd) to determine the total population estimate (Killam and Harvey Arrison, 2006). In 2007 the spring-run estimate for Mill Creek was 920 (Table 1) and was based on the redd count survey. The Mill Creek video station reported a total spring-run salmon count of 1,060 (Table 2). The difference between these two estimates is only 140 fish. Given the length of time elapsed between the two counts (4-5 months) and the likely mortality (otters, poachers, disease, etc) suffered by the holding salmon over that time, the two estimates are quite similar. Having two independent counting methods is a useful management tool in determining the suitability of either method. Since both methods resulted in similar estimates, managers can have confidence that either method alone should result in an accurate population estimate. The success of the video station on Mill Creek in counting spring-run salmon opens up possibilities of future stations on other creeks with spring-run populations.

Tape Reading and Data Analysis

The 2007 Mill Creek video station estimate represents an almost complete count of fish passage for the period from 6 March to 18 June. Except for a lapse of video coverage due to a tape malfunction on 18 March (4 hours) and an approximate 3.5 hours total of short lapses (i.e. 15 minutes or less) during tape changing periods and equipment modifications, the entire period of 105 days was taped (no fish were added to the database due to these lapses). Readers reported that a combined 21.5 hours were difficult to read due to excessive turbidity, but that at no time was turbidity too excessive to be unable to distinguish and count passing fish.

The purchase of a Honeywell Fusion III Digital Video Recorder (DVR) allowed for a reduction in tape reading time requirements. The three daily tapes from the station were taken to the SRSSAP office and recorded simultaneously onto the hard drive of the DVR. The DVR was connected to 3 office VCR's allowing the recording of a 24-hour period to be finished in eight hours. The software design and motion detection capabilities of the DVR resulted in a significant (i.e. greater than 75% in some cases) reduction of the time it took to review tapes as compared to viewing them on a standard VCR.

The DVR software allowed multiple readers to view recorded video simultaneously. The software also allowed readers to view tapes without having to handle tapes or push buttons to rewind or fast forward to periods of fish passage. All previous tape reading

functions that were done on a VCR were now done within the framework of the DVR software and the click of a computer mouse. The DVR also allowed tapes to be recorded at a variety of motion detection sensitivities.

Tapes were generally recorded using conservative motion detection sensitivities that resulted in many recorded periods with no fish passage. Some periods were also recorded with both continuous (complete recording) and with motion detection and the two types compared to "test" if the motion detection settings were missing fish passage events. The more conservative motion detection settings were found to capture all of the fish passage events during periods of ideal visibility. Staff found that during periods of turbid water or periods with excessive light reflection from rain or wind events that the motion detection did not function well. These periods were subsequently recorded continuously and the entire period was reviewed for passage events.

Tape readers were all experienced SRSSAP crew members that have had prior experience on various fisheries surveys and video station tape reading. All readers were instructed to view taped periods at a moderately slow pace to avoid missing fish. When uncertain about a fish species using the overhead camera view the crew members noted the uncertainty in the comments section of the data sheet and tallied their "best guess" as to the fish's identification, and were encouraged to consult with other readers to attempt identification. In these cases if an underwater image was available it was viewed and a species was determined. In many cases an underwater image was not available, and as a result some larger cyprinids may have been tallied as steelhead and vice versa. However, given the experience of the readers and the cross checking with similar appearing fish with accompanying underwater images, these errors likely did not occur in any significant number.

The effectiveness of the underwater camera was limited due to the width of the weir opening that allowed fish to pass far from the camera and the limitations of the camera technology to see into the sometimes turbid water. We tested two types of underwater cameras. The first was a stock purchased underwater camera (model PC136UW1 B/W-supercircuits.com) that came complete with a housing and infrared LED (light emitting diodes) lights to illuminate the image at low light levels. This camera did not provide satisfactory images due to the narrow field of view (85^{o}) and reflection of the LED on particles in the water column at night. The second camera type was an identical camera to the overhead camera (PC88WR) that was housed in a watertight PVC housing. This camera performed much better but still was still limited by a narrow (70^{o}) field of view that reduced the chance of a good image being recorded for fast moving fish.

The first attempt of underwater filming occurred on 19 March. A fifth VCR was used to record the underwater image independent of the overhead camera. This resulted in difficulties for the tape readers in finding and sequencing the overhead fish passage image with the underwater image. The purchase of a quad processor (QS-29) in early May allowed the overhead and the underwater image to be merged into a single recorded image (picture in a picture (PIP) mode) that provided a full screen image from the overhead camera with a smaller PIP image of the underwater image off to the side of the

overhead image. This provided satisfactory results when fish swam within range of the camera during periods when the creek was clear. When the creek was slightly turbid however, the underwater image was typically poor unless the fish swam immediately adjacent to the camera. Neither underwater camera captured fish that were moving fast very well. A camera with a wider field of view (under development) is recommended for future efforts. As mentioned previously, a DIDSON camera system would have been very helpful during periods of turbid water.

There was not a significant quality control (QC) process integrated into the Mill Creek video station data. The project had no dedicated budget or staff assigned to it and relied solely on existing staff completing tape reading during periods when time allowed. Due to the start of other higher priority projects (winter-run Chinook carcass surveys) in May, crew members were instructed to ensure the highest possible alertness in tape reading by taking frequent breaks, avoiding distractions, and staying focused and alert. Since the station was designed to determine the possibilities of counting fish in Mill Creek, the numbers generated were not recognized as "official" estimates. As a result of this and the staffing concerns, a high quality single read of each period was deemed sufficient for efforts in 2007.

RECOMMENDATIONS

1. The video station proved to be a valuable and accurate tool in estimating salmonid escapement into Mill Creek. The installation of similar stations on waterways currently unmonitored in the Upper Sacramento River Basin should be investigated.

2. Year-round operation of the video station on Mill Creek should be considered to estimate the escapement and complete run-timing of steelhead, fall-run, and spring-run Chinook salmon.

3. The purchase of a Digital Video Recorder should be pursued to reduce the time and costs of reading tapes.

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