WENATCHEE RIVER SALMON ESCAPEMENT ESTIMATES USING VIDEO TAPE TECHNOLOGY IN 1989

Technical Report 90-4

Douglas R. Hatch
Matthew Schwartzberg

May 23, 1990

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INTRODUCTION

The Wenatchee River Salmon Escapement Estimation Project conducted by the Columbia River Inter-Tribal Fish Commission (CRITFC) is a part of the U.S.-Canada Pacific Salmon Treaty spawning escapement monitoring program (Pacific Salmon Treaty 1985). The purpose of this study is to determine the feasibility of recording fish passage at the Tumwater Dam observation window using a video camera and time-lapse video cassette recorder. The video tape procedure employed will permit a variance to be determined and a bound placed on the escapement estimate through multiple readings of tapes. Bounded estimates are not typically generated from one-time visual fish counts. Video count technology is also beneficial at small projects because it is relatively inexpensive, in terms of personnel time, compared to round-the-clock visual monitoring.

Our specific objectives for this project in 1989 were to estimate escapement at Tumwater Dam for spring and summer chinook salmon (*Oncorhynchus tshawytscha*) sockeye salmon (*O. nerka*) and steelhead salmon (*O. mykiss*) and to determine if video tape recording speed affects accuracy of fish counts.

METHODS

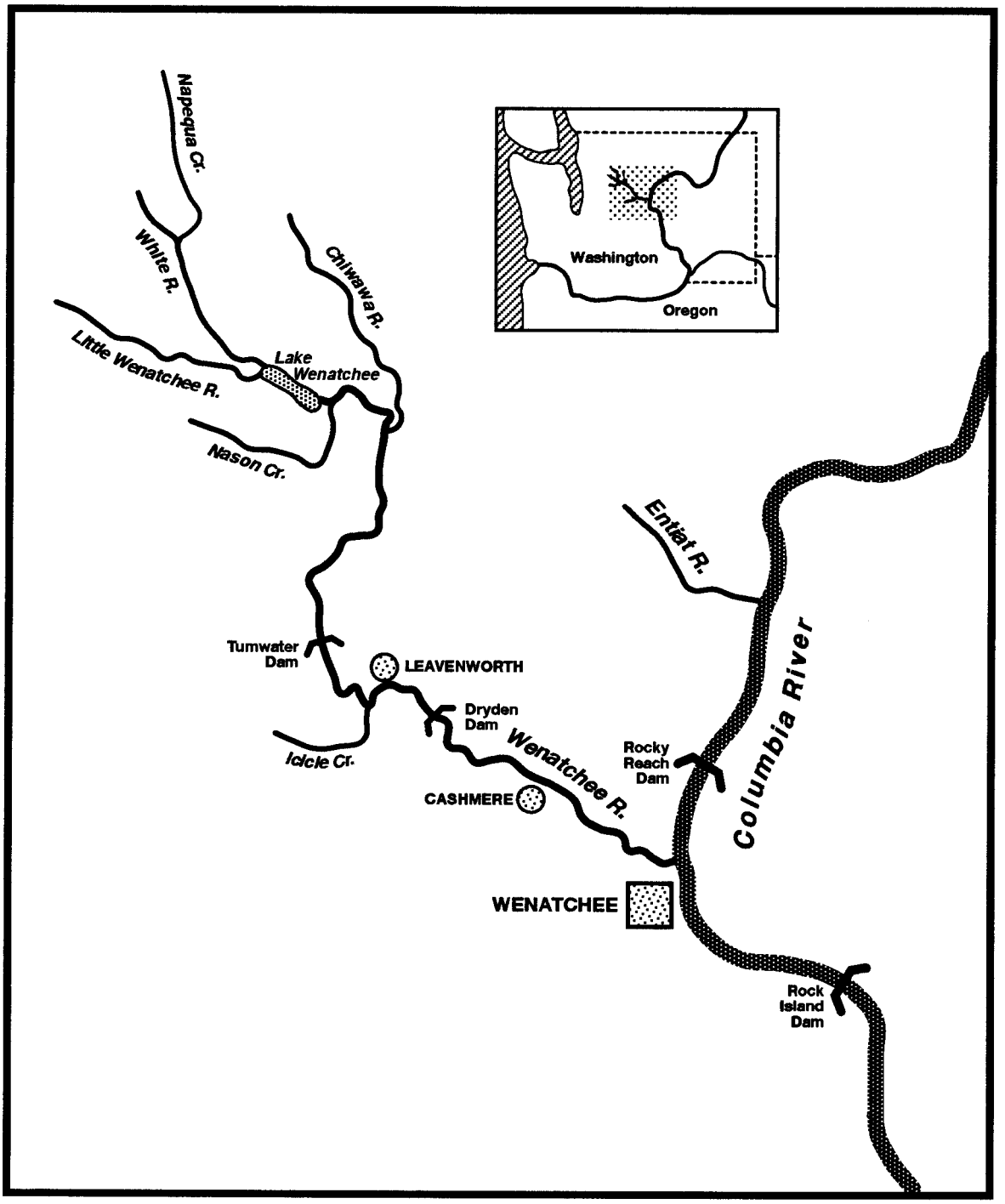
Tumwater Dam is located at river kilometer (rkm) 52 on the Wenatchee River, Washington (Figure 1). Tumwater Dam is 7 m high and 122 m long and was built by The Great Northern Railroad in 1907. It was the first hydroelectric dam constructed in the Pacific Northwest and was originally built with an adult fish passage facility. The dam provided electric power to railroad locomotives passing through the 4.4 km Old Cascade Tunnel. Puget Sound Power and Light leased the dam in 1929 and Public Utility District Number 1 of Chelan County (Chelan PUD) purchased the facility in 1957. Diesel locomotives replaced the electric locomotives in the 1950s and, by 1956, the Tumwater Dam hydroelectric generating facilities were dismantled. Fish passage facilities were redesigned and a 2.3 x 1.8 m fish viewing window was constructed in 1987 and, in 1988, a fish trap was added. A single fish ladder exists at Tumwater Dam and the dam is otherwise impassable to upstream salmon migration.

The Wenatchee River video fish counting experiment at Tumwater Dam included one video camera and tripod, two time-lapse video cassette recorders (VCR), a bank of flood lights within the viewing room, and a backup power supply (for complete equipment specifications see Appendix 1). A video camera was placed on a tripod and aimed at the fish viewing window. The camera was connected to two time-lapse VCRs. Each VCR operated at a different time-lapse recording speed. The camera and VCRs were operated continuously from 15 May, 1989, through 30 September, 1989. Tapes were changed in both VCRs at least every 48 hours. Initial images were very dark and, consequently, additional lighting was added in the viewing room in mid-July 1989. The entire recording system was attached to a battery backup unit designed to supply power to the system during potential power failures.

Escapement Estimation

An individual with experience in visual fish identification and counting at The Dalles and John Day dams reviewed Tumwater video tapes to determine fish counts by species. Viewing of tapes was done with a 33 cm color monitor connected to a VCR equipped with jog and shuttle controls that permitted frame-by-frame viewing. Each frame of video tape was marked by the recording VCR with the date and time of the

Figure 1. Map of the Wenatchee River Basin showing location of Tumwater and Dryden dams.



recording allowing enumeration of counts by time units. Fish images were identified by species and hourly counts recorded. Hourly counts were summed to provide daily totals and composite escapement estimates. Migratory timing, mean passage date, and variance were estimated for each species (Mundy 1982).

The fish trapping facilities, constructed at Tumwater Dam in 1988, were used in several independent research projects in 1989. With the fish trap in use, the fish viewing window was bypassed. In 1989, sockeye and summer chinook salmon trapped at Tumwater Dam, and those fish incidently collected as a result of trapping efforts, were not recorded by video. Consequently, records of these operations were obtained and used to augment daily video totals. Dryden Dam located downstream from Tumwater Dam at rkm 27 on the Wenatchee River also has a fish trapping facility primarily used in 1989 to trap summer chinook salmon. Fish that were removed from the river at the Dryden trap were also included in escapement estimates.

Recording Speed Tests

The equipment used in this study provided a choice of time-lapse *recording modes*. The recording mode is the number of recording hours (time-lapse) that may be placed on one T120 minute video tape. We wished to test whether recording speeds affected the relative accuracy of video fish counts. A slower recording speed required less frequent tape changes but recorded fewer frames per second. We wished to test whether such a slow speed might create problems in fish detection and identification. The test devised utilized two VCRs, both recording simultaneously from the same camera. Each VCR operated at a different time-lapse recording mode. One VCR recorded in 48 hour mode providing 1.25 frames per second while the second machine recorded in 72 hour mode providing 0.83 frames per second. Normal speed recording (2 hour mode) provides 30 frames per second recordings.

The complete seasonal record of Tumwater Dam fish counts contained two sets (48 and 72 hour recording modes) of 66 tapes each. Each recorded time interval was referred to as a *tape period*. From these 66 tape periods, four were randomly selected containing 168 recorded hours from eleven different calendar recording dates. Video tapes from the selected periods were viewed by a single individual. Fish images from 48 hour and 72 hour modes were identified and counted by species and tallied by

recorded hour. Fish count differences from both recording modes were tested using between-recorded-hour pairs and also between-recorded-date pairs. Paired difference variables (for sockeye, chinook, and both species combined) were tested for normality using Lilliefors Test (Lilliefors 1967). Paired 't' and Wilcoxon tests were used to test recording mode differences.

RESULTS

Sockeye Escapement

Video tape records, after analysis and enumeration, provided a partial escapement estimate of 20,077 sockeye salmon at Tumwater Dam in 1989. Sockeye trapped and not enumerated in video records included 1,698 trapped at Tumwater Dam and 282 at Dryden Dam. Thus, the combination of counts produced a minimum 1989 Wenatchee River sockeye salmon escapement estimate of 22,057. The majority of passage occurred between 7 July, and 10 August, 1989 (Figure 2). The mean passage date was 25 July, 1989 and the variance was 52.

Chinook Escapement

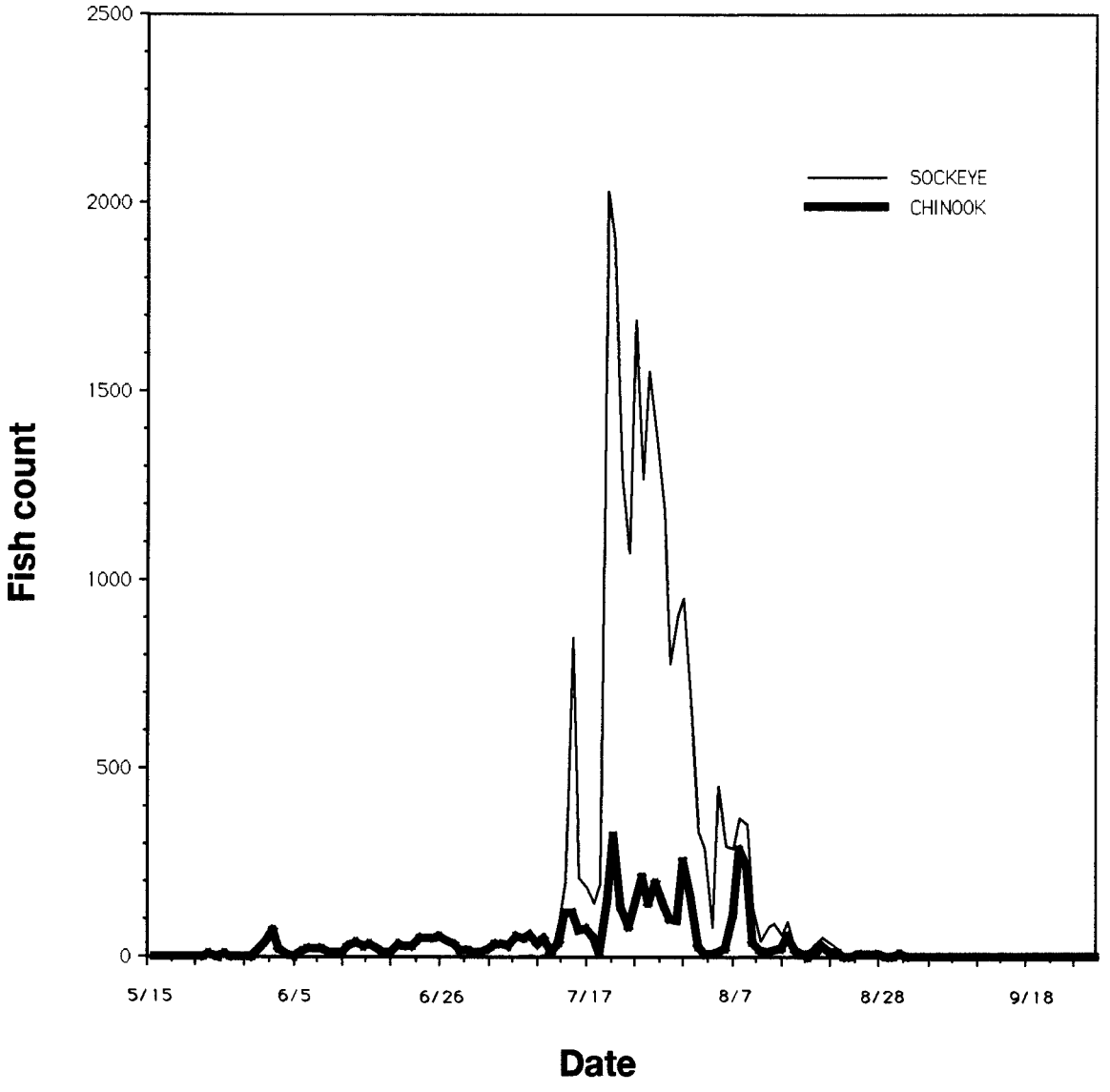
Video tape records after analysis and enumeration, provided a partial escapement estimate of 4,610 adult chinook salmon at the Tumwater Dam in 1989. Chinook trapped and not enumerated in video records included 89 trapped at Tumwater Dam and 215 at Dryden Dam. Thus, the combination of counts produced a minimum 1989 Wenatchee River adult chinook salmon escapement estimate of 4,914. The majority of passage occurred between 30 May, and 21 August, 1989 (Figure 2). The mean passage date was 18 July, 1989 and the variance was 352.

Thirty-five chinook salmon jacks were counted and an additional 17 trapped at Tumwater Dam in 1989 yielded a total escapement estimate of 52.

Steelhead Escapement

Total steelhead escapement is estimated at 105, with 97 fish counted and 8 trapped. Steelhead salmon migrated over Tumwater Dam between 15 May and 30 August, 1989. The mean passage date was 22 July, 1989, and the variance was 1077.

Figure 2. Wenatchee River sockeye and chinook salmon escapement in 1989, estimated by video tape count at Tumwater Dam and including additional fish trapped at Dryden and Tumwater dams.



Recording Speed Tests

The paired difference variables between 48 and 72 hr recordings using sockeye, chinook, and counts of both species combined were tested for normality using Lilliefors Test. All paired difference variables (using paired recorded dates and paired recorded hours) were significantly different from normal ($p < 0.001$) and, as such, only nonparametric tests are reported.

No significant differences were found between counts from 48 and 72 hr recording speeds for sockeye, chinook, or combined species counts paired by recorded hour. Probability values from paired Wilcoxon tests were 0.286, 0.698, and 0.343 for sockeye, chinook, and combined species; respectively (Table 1, Figure 3). The maximum paired hour sockeye salmon count difference was 60 fish, representing a 23% difference. The maximum paired hour chinook salmon count difference was 5 fish, representing a 14% difference.

No significant differences were found between counts from 48 and 72 hr recording speeds for sockeye, chinook, or combined species counts paired by recorded date. Probability values from paired Wilcoxon tests were 0.476, 0.824, and 0.266 for sockeye, chinook and combined species; respectively (Table 1, Figure 4). The maximum paired date sockeye salmon count difference was 42 fish, representing a 6% difference. The maximum paired date chinook count difference was 17 fish, representing a 10% difference.

Night Migration

Between 2100 and 0500 hours, 1,354 sockeye were recorded in Tumwater Dam video counts (Figure 5). This represents 6.7% of the total Wenatchee River sockeye salmon escapement estimate. Night migration was also observed for chinook and steelhead salmon, with 8.6% and 12.4%, respectively, migrating over Tumwater Dam between 2100 and 0500 hours (Figure 5).

Table 1. Probability values from paired Wilcoxon tests on fish counts from 48 and 72 hour time-lapse video tape recording modes.

	Sample Size	Sockeye	Chinook	Combined
Paired by date	11	0.476	0.824	0.266
Paired by hour	168	0.286	0.698	0.343

Figure 3. Comparison of 48 and 72 hour time-lapse video tape recording modes using hourly sockeye and chinook salmon counts recorded at Tumwater Dam, 1989.

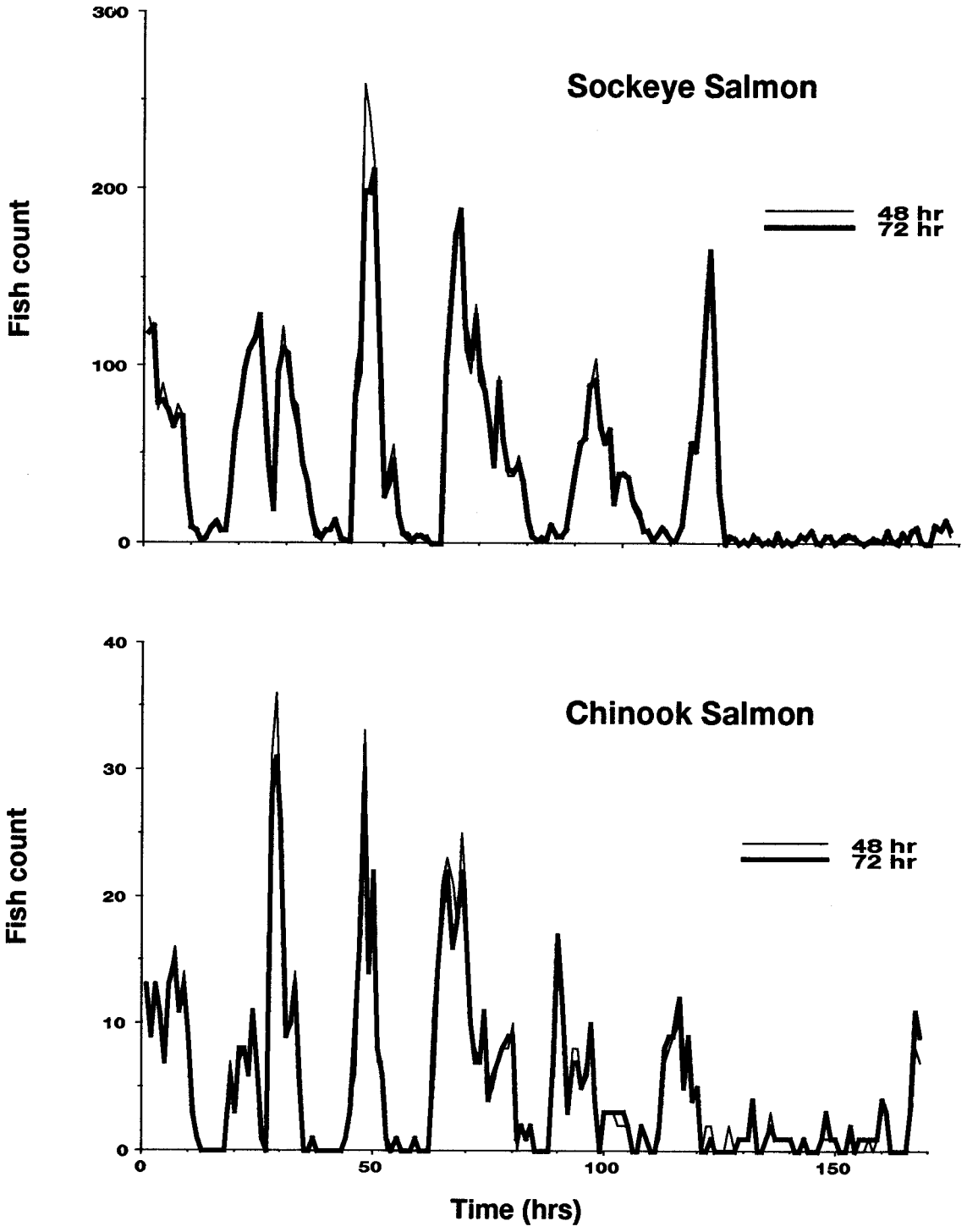


Figure 4. Comparison of 48 and 72 hour time-lapse video tape recording modes using daily sockeye and chinook salmon counts recorded at Tumwater Dam, 1989.

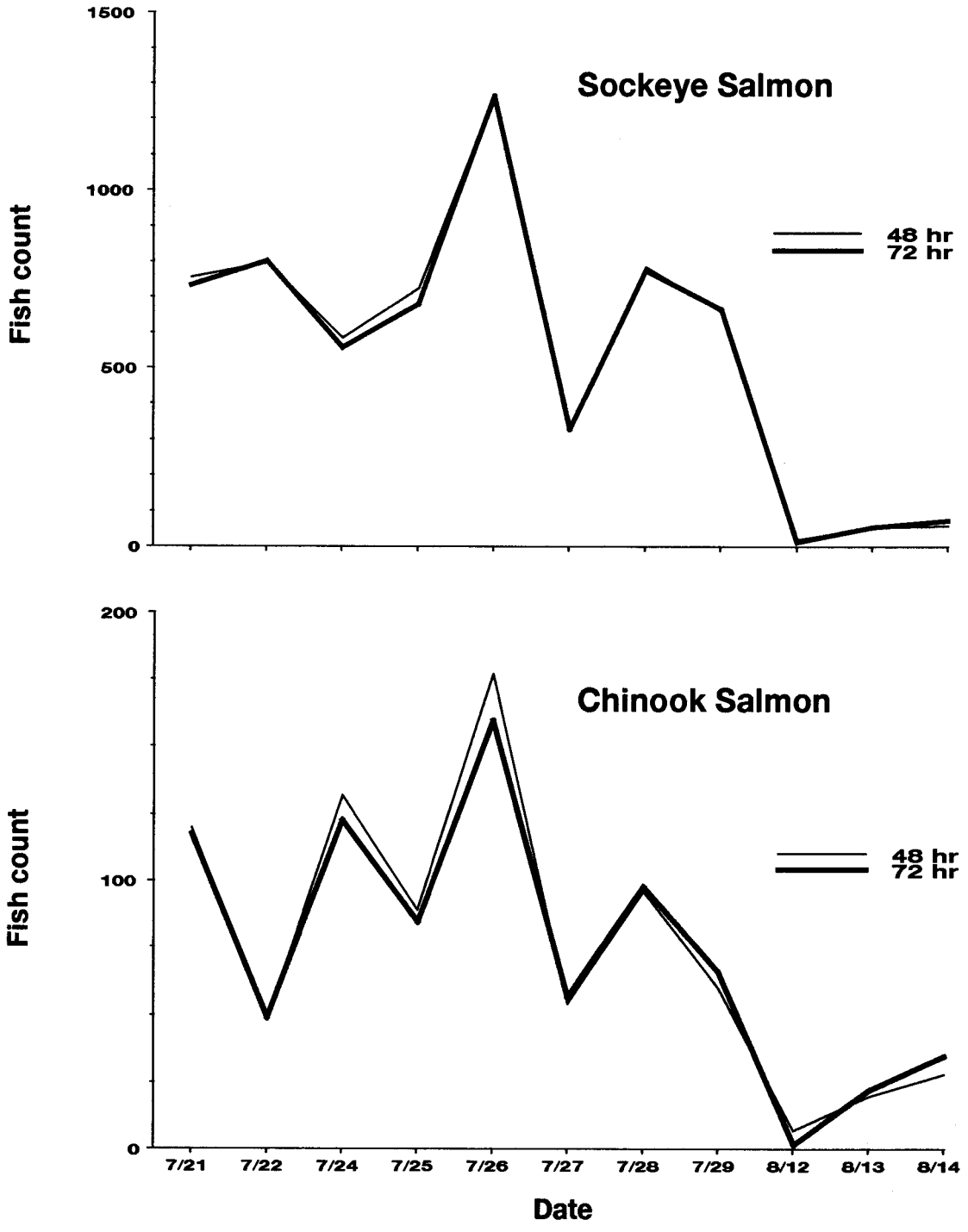
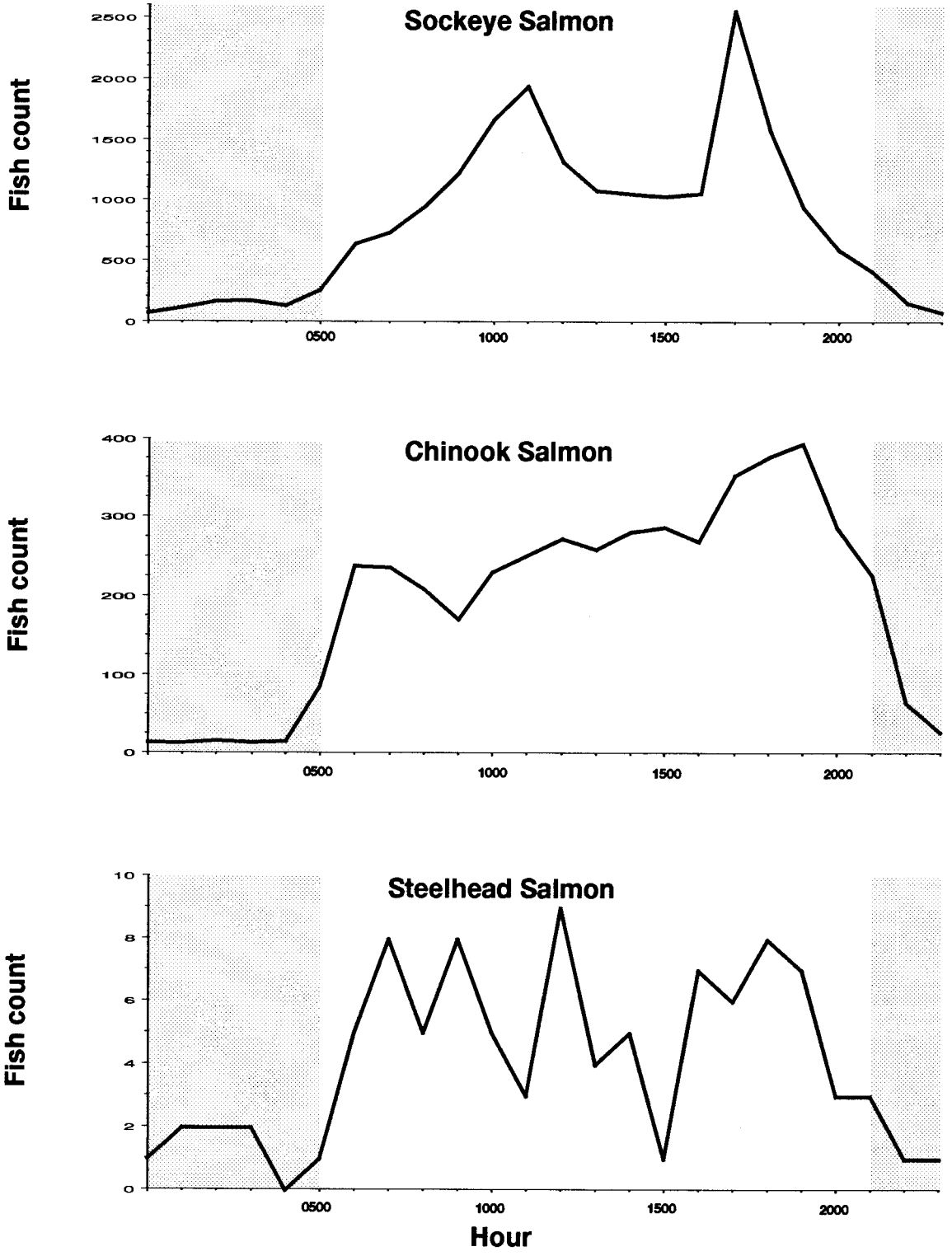


Figure 5. Total sockeye, chinook, and steelhead salmon counts as a function of time of day with approximate hours of darkness shaded[1], recorded at Tumwater Dam, 1989.



1. Shaded hours (2100 through 0500) correspond to times when visual in-person counts are not made at mainstem Columbia River hydroelectric projects.

DISCUSSION

Using Video Tape for Escapement Estimation

Using video tape technology to record fish passage at Tumwater Dam appears to be a feasible and accurate method for salmon escapement estimation. High quality video tape records of fish passage can be made using professional equipment with adequate lighting. Video taped fish counts are economical to produce. Total personnel time, including tape changing and image enumeration, is much less than that required by the more commonly employed technique of in-person visual fish counting. The mean amount of time required to view, identify, and count fish images from each 72 recorded hour tape was approximately 6 hours. Tape changing at Tumwater Dam was done every 48 hours but this time interval can be increased by using two VCRs operating consecutively and by using 160 minute video tapes instead of the standard 120 minute tapes. As a result of the decrease in personnel time required for video fish counting, accurate escapement estimates may be made economically feasible at remote sites such as Tumwater Dam. Accurate escapement estimates in near-headwater areas could make discrete stock management more feasible. This technique may also be applicable at larger projects, such as mainstem Columbia River dams. Another possible application of video counts could be to record night fish-passage at these projects to augument the visual in-person daytime counting program currently employed.

Escapement Estimates

The Wenatchee River enters the Columbia River upstream of Rock Island and downstream of Rocky Reach dams (Figure 1). By subtracting the in-person visual salmon counts made at Rock Island Dam from those made at Rocky Reach Dam an approximate Wenatchee River salmon escapement estimate can be derived (often referred to as an *interdam count*). These interdam counts were used as secondary escapement estimates to which we compared results from this video escapement estimation study.

The 1989 interdam sockeye count was 21,185 (CRITFC 1990). This count is relatively close to 22,057, our Wenatchee River sockeye salmon escapement estimate

derived from video counts. A possible explanation for the slightly higher Tumwater Dam video count may be the inclusion of night fish-passage counts in this study. As was previously discussed, night fish-passage is not monitored nor are visual fish counts adjusted accordingly at Columbia River dams.

Comparisons between video chinook counts and a secondary (interdam based) estimate required some adjustments to account for chinook escapement below Tumwater Dam that was not recorded in video tapes. Therefore, the 1989 interdam estimate was separated into spring and summer stocks (based on migratory date), adjusted to account for escapement to areas below Tumwater Dam, and then, because spring and summer chinook were not differential in video counts, recombined to allow comparison to video mixed stock estimates.

The 1989 interdam spring and summer chinook salmon counts (adults and jacks) were 7,522 and 13,656, respectively. The interdam spring chinook count, less estimated escapement and harvest in areas below Tumwater Dam, yielded a secondary estimate of 2,210. Spring chinook escapement and harvest downstream of Tumwater Dam included 5,312 estimated returns to Icicle Creek (personal communication, Larry LaVoy, Washington Department of Fisheries). The Icicle Creek return was, in turn, estimated to include 1,112 fish harvested in a sport fishery, 58 natural spawners, 1,463 harvested in a tribal fishery, and 2,679 that returned to Leavenworth National Fish Hatchery. The interdam summer chinook count, less estimated escapement in areas below Tumwater Dam, yielded a secondary estimate of 3,891. To estimate summer chinook escapement above and below Tumwater Dam, we factored the interdam summer chinook count of 13,656 by the estimated mean proportion (0.285) of summer chinook salmon that spawned above Tumwater Dam in 1987 and 1988. This estimated proportion is based on spawning ground surveys conducted in those two years (Fast 1987, 1988).

By combining adjusted 1989 interdam spring and summer chinook salmon escapement estimates, we derived a secondary total chinook estimate, at Tumwater Dam, of 6,101. The Tumwater Dam video escapement estimate for spring and summer chinook salmon was 4,914. Possible explanations for escapement estimate differences are multiple counting as a result of fallback at mainstem dams, a greater summer chinook escapement to areas below Tumwater Dam than was reflected in spawning ground surveys, and a higher escapement to Icicle Creek than was estimated.

Migratory Timing

In 1989, the mean date of sockeye migration was 25 July (Figure 2). Limited migratory timing data are available from past years when visual counts were made at Tumwater Dam. Between 1935 and 1973, fourteen (nonconsecutive) years of fish counts were made at Tumwater Dam using a glass bottom box placed in the fish ladder (personal communication, Steve Hays, Chelan PUD). During these years, the earliest mean passage date reported was 26 July (Mullan 1986).

In 1989, the mean date of the chinook salmon migration was 18 July (Figure 2). The only historic Tumwater Dam chinook migratory timing data available is French and Wahle (1959) which reports only migratory peaks and, therefore, is of little comparitive use (Mundy 1982). We will attempt to correlate migratory timing with biotic and abiotic factors in the future as the database produced by our studies is developed.

Recording Speed Tests

Paired Wilcoxon tests were used to determine whether significant differences existed between 48 and 72 hour recordings. All counts were made by the same individual. Data were paired by recorded date and by recorded hour. All tests were nonsignificant (Table 1) indicating that 72 and 48 hour recordings both produce similar results. These results indicate that, in future studies, the 72 hour recording mode should be employed to increase efficiency by extending tape change intervals.

Future Video Tape Research Topics

Video tape counts revealed 6.7% of the sockeye, 8.6% of the chinook, and 12.4% of the steelhead migtation at Tumwater Dam passed between 2100 and 0500 hours, times when fish counting at mainstem Columbia River hydoelectric projects does not occur (Figure 5). We believe further research should be conducted to determine if this same phenomenon is observable at other counting sites. If significant night passage is observed, dam counts should be adjusted to reflect these additional fish.

Among-viewer fish count differences will be tested using Tumwater Dam video fish count recordings in 1990. The experiment will employ a completely random factorial design. Factors to be tested will be fish density (number of fish per hour), species complexity (more than one species present), and viewer comparability. Equipment will include using two VCRs recording consecutively instead of simultaneously, as in 1989. T160 VHS tapes will be used instead of the standard T120 type. This will allow an eight day interval between tape changes (in 72 hour mode). A SVHS camera will be used instead of the VHS camera used in 1989. This camera has more scan lines which will increase picture quality. A higher resolution color monitor will be added to our viewing system which should also enhance picture quality. We are designing a control system to provide limited remote access to the Tumwater video equipment. This system would monitor whether equipment is functioning properly and also report malfunctions. The control system would operate over telephone circuits and allow remote activation of the VCRs using a touchtone telephone.

SUMMARY

1. Using video tape technology, we estimate 1989 total Wenatchee River sockeye, spring and summer chinook (including jacks), and steelhead salmon escapement at Tumwater Dam to be 22,057, 4966, and 105, respectively. These estimates were close to adjusted interdam Columbia River in-person visual fish counts.

2. We determined that, for a single viewer, fish counts (by species) from 48 hour and 72 hour time-lapse recorded video tapes did not differ significantly.

3. We outlined areas for future research including the estimation of night-time fish passage and comparison of video counts with in-person counts.

LITERATURE CITED

Fast, D. 1987. Spring and summer chinook spawning ground surveys—Yakima and Wenatchee Rivers. Yakima Indian Nation Fisheries Resource Management Technical Report, Toppenish, Washington.

Fast, D. 1988. Spring and summer chinook spawning ground surveys—Yakima and Wenatchee Rivers. Yakima Indian Nation Fisheries Resource Management Toppenish, Washington.

CRITFC. 1990. FISHCOUNT. Columbia River Basin computerized fish count database maintained by the Columbia River Inter-Tribal Fish Commission, Portland, Oregon.

French, R.R. and R.J. Wahle. 1959. Biology of chinook and blueback salmon and steelhead in the Wenatchee River system. United States Fish and Wildlife Service Special Scientific Report—Fisheries No. 304.

Lilliefors, H.W. 1967. On the Kolmogorov-Smirnov test for normality with mean and variance unknown. Journal of the American Statistical Association 64, 399-402.

Mullan, J.W. 1986. Determinants of sockeye salmon abundance in the Columbia River, 1800's-1982: a review and synthesis. United States Fish and Wildlife Service Biological Report 86(12).

Mundy, P.R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fisheries management. North American Journal of Fisheries Management 4:359-370.

Pacific Salmon Treaty. 1985. Treaty between the government of the United States of America and the government of Canada concerning Pacific salmon. Treaty document 99-2.

Appendix 1. Specifications of equipment used in the Wenatchee River Salmon Escapement Estimation Project.

Item	Number	Make	Model
Camera	1	Panasonic	WV-D500
Tripod	1	Bogen	3046
Time-lapseVCR	2	Panasonic	AG-6010s
Viewing VCR	1	Panasonic	AG-1950
Monitor	1	JVC	TM-13U
Video tape	140	Maxell	Professional / Industrial T120
Battery Backup	1	Tripp-lite	SB-200a
Lighting	8	Phillips	150 watt flood