WENATCHEE RIVER SALMON ESCAPEMENT ESTIMATES USING VIDEO TAPE TECHNOLOGY IN 1992

Technical Report 93-5

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Andrew Wand
Matthew Schwartzberg

March 26, 1993

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ABSTRACT

Accurate determination of escapement is necessary for fish stock status analysis. In an effort to devise a more accurate salmon escapement estimation technique, a time-lapse video tape recording system was installed and operated from 11 May, 1992 through 11 September, 1992, in the fish counting station at Tumwater Dam on the Wenatchee River. This was a continuation of studies conducted annually since 1989.

In 1992, Wenatchee River salmon escapement above Tumwater Dam was estimated to be 20,026 and 3,802 for sockeye *Oncorhynchus nerka* and chinook salmon *O. tshawytscha*, respectively. Salmon migatory timing estimates have remained similar from 1989 through 1992. The mean dates of passage for salmon in 1992 were 21 July (SD = 10.0) for sockeye, and 9 July (SD = 22.0) for chinook. Nighttime sockeye salmon passage estimates accounted for 6.2% of the run. That percentage is similar to estimates made in prevous years at Tumwater Dam and at Bonneville Dam in 1973 and 1974.

Estimating salmon escapement using time-lapse video technology has been successful at Tumwater Dam on the Wenatchee River, Washington. Our findings indicate that by implementing video counting at other locations where salmon passage is monitored, fish count accuracy would likely increase because nighttime passage could be monitored with little additional effort. Also, individual specimen identification would be more precise, and a permanent record of fish passage events would be created.

ACKNOWLEDGEMENTS

We thank the following individuals for their assistance with this project: Jeff Fryer and Phil Mundy of the Columbia River Inter-Tribal Fish Commission; Steve Hays and Dick Nason of Public Utility District Number 1 of Chelan County; John Easterbrooks and Larrie LaVoy of the Washington Department of Fisheries; Tom Ruehle of the National Marine Fisheries Service; Mike Kane of Natapoc Resource Services. Additionally, we thank Northwest Marine Technology for providing the fluorescent polymer tagging equipment used in 1992.

This report is the result of research funded by U.S. Government (Bureau of Indian Affairs, Department of Interior) Contract No. P00C1409445 for implementation of the U.S.-Canada Pacific Salmon Treaty.

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INTRODUCTION

Accurately estimating escapement of salmon is critically important to permit analysis of stock status. In the Columbia Basin, the Northwest Power Planning Council has established a management goal of doubling fish runs (NPPC 1987). Accurate adult salmon counts in natal streams are essential to judging the success of strategies designed to increase stock abundances. Toward this goal, the Columbia River Inter-Tribal Fish Commission has been developing the use of time-lapse video technology for salmon escapement estimation.

The use of video technology as a tool for monitoring biological systems is becoming increasingly popular. For example, Irvine et al. (1991) recently developed a video-based method for counting fish captured in a trap. The feasibility of estimating salmon escapement using underwater video has been investigated (Hatch et al. 1991, 1992a; Pippy et al. 1993).

The Columbia River Inter-Tribal Fish Commission has, over the past four years, developed a salmon escapement estimation program utilizing time-lapse video technology at Tumwater Dam, Washington (Hatch and Schwartzberg 1990,1991; Hatch et al. 1992b) and at Lower Granite Dam, Washington (Hatch et al. 1993). Previous work has investigated the effects of several reviewers on count precision in video estimates (Hatch and Schwartzberg 1991), the effect of different recording speeds on fish counts (Hatch and Schwartzberg 1990), the probability of capturing a particular fish on video tape as it passed a viewing window (Hatch et al. 1993) and the magnitude of nighttime fish passage (Hatch and Schwartzberg 1990, 1991; Hatch et al. 1992a, 1992b, 1993).

The current study continues to estimate Wenatchee River escapement, and to document nighttime fish passage. Additionally, we investigated the feasibility of detecting fluorescent polymers tags, injected in the adipose eyelid of adult sockeye salmon, using video technology. A hatchery stock supplementation program has been implemented in the Wenatchee River since 1989 (Hays 1992). Most proposed methods for evaluation of this project are based on a mark-recapture procedure. Passive interrogation of fluorescent polymer tags using a video camera may provide an accurate project evaluation tool.

The project objectives in 1992 were:

1. To estimate sockeye *Oncorhynchus nerka* and chinook salmon *O. tshawytscha* escapement using time-lapse video at Tumwater Dam on the Wenatchee River;
2. To document sockeye and chinook salmon migratory timing at Tumwater Dam in 1992, and compare with estimates made in 1989, 1990, and 1991;
3. To test the ability of a video system to detect fluorescent polymer tags injected in the adipose eyelid of adult sockeye salmon as they pass the fish ladder viewing window at Tumwater Dam.

METHODS

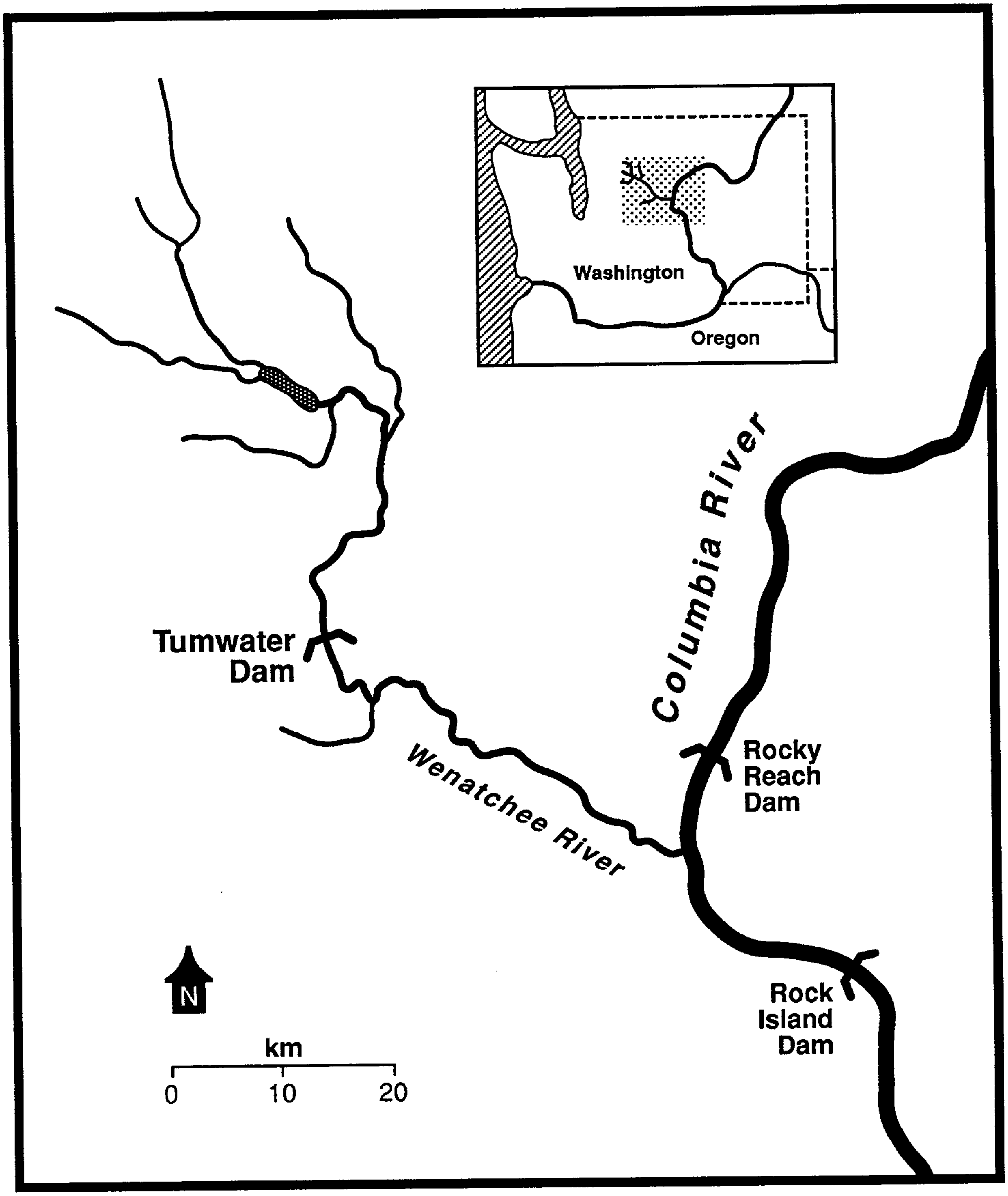
Study Area

Tumwater Dam is located at river kilometer (rkm) 52 on the Wenatchee River, Washington (Figure 1). Constructed in 1907 by the Great Northern Railroad, Tumwater Dam was the first hydroelectric dam built in the Pacific Northwest. It is 7 m high and 122 m long, and was built with an adult fish passage facility. This fish ladder allowed adult salmonid migration across what would otherwise have been an impassable barrier. By 1956, all electricity generating capabilities had been removed from Tumwater Dam. In 1987 and 1988, the fish ladder was redesigned, and a fish viewing window and trapping facilities were installed.

For this project, a video camera was placed on a tripod and aimed at the fish viewing window. Two time-lapse S-VHS video tape recorders (VTRs), set on 72 h recording speed, were connected to the camera in series, so that when the first VTR finished recording the second would immediately begin recording. In this manner, it was possible to record continuously for up to seven days without changing tapes. Ten 150-watt flood lights surrounded the fish viewing window to provide sufficient illumination for the video camera. The entire system was connected to a backup battery unit, in case of power failure (see Appendix 1 for a complete equipment list). The camera and VTRs were operated continuously from 11 May, 1992, through 11 September, 1992.

Several other agencies used Tumwater and Dryden (rkm 27) dams as sites for fish trapping associated with other research and management programs. These counts were collected and added to the daily video counts.

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



Escapement Estimation

Video Based Estimate

Video tapes were reviewed by an experienced fish counter. Counting was performed on an editing VTR equipped with jog and shuttle controls for frame-specific viewing, and a 33 cm color monitor. At the time of recording, the VTRs imprinted a time and date *stamp* upon each frame of video tape, thereby providing the exact time that each fish on the tape passed through the viewing window. Using this feature, hourly counts were determined for each species. Hourly counts were also summed to provide daily counts for each species.

Inter-dam Based Estimate

For the purpose of comparison, a second, independent escapement estimate was calculated for sockeye salmon. This estimate was obtained by subtracting counts at Rocky Reach Dam (rkm 762) from counts at Rock Island Dam (rkm 730), giving an *inter-dam* count (CRITFC 1993). The Wenatchee River is the only major tributary entering the Columbia River between Rock Island and Rocky Reach dams (Figure 1), and sockeye salmon do not spawn in the Columbia River or in the lower Wenatchee River (Mullan 1986). Therefore, assuming that no mortality occurs between the two dams, all sockeye salmon that pass over Rock Island Dam but not Rocky Reach Dam will migrate past Tumwater Dam.

Migratory Timing

The average dates of migratory timing (Mundy 1982) and their associated standard deviations were calculated for sockeye and chinook salmon during migration passage at Tumwater Dam annually from 1989 through 1992.

Nighttime Fish Passage

Estimates of nighttime passage (fish passage between 2000 and 0400 hours) were made for sockeye and chinook salmon and steelhead at Tumwater Dam. Total counts for each species made between 2000 and 0400 hours were divided by their respective escapement estimates to calculate the percentage of the total count for each species that represented nighttime migration.

Fluorescent Polymer Tag Detection

Nineteen adult sockeye salmon were tagged to test the ability of the video system to detect fluorescent polymer tags. The sockeye salmon were trapped on 27 July, 1992 at Tumwater Dam, anesthetized with tricane methanesulfonate (MS222), adipose clipped, and injected with a small amount of fluorescent polymer in the adipose eyelid using a syringe with a 23 gauge hypodermic needle. Following recovery, the tagged fish were transported and released approximately 2 km downstream of Tumwater Dam. An additional video camera with a Tiffen 23 Å light red filter was focused on the fish ladder viewing window. The filter transmitted light between 5700 and 7000 Å wavelength, with peak transmission occurring between 6000 and 7000 Å. This additional camera and filter was used to enhance the possibility of detecting the fluorescent polymer tags. An additional light was also installed that produced 4000 Å wavelength light. This ultraviolet wavelength light caused the fluorescent polymer tag to emit 6400 Å light, thus aiding in its detection. When the video record (produced with the unfiltered camera) was reviewed, the dates and times of passage for all adipose clipped sockeye salmon were noted. The video tape record produced using the filter equiped camera was reviewed to determine if the fluorescent polymer tags could be detected on the previously located adipose-clipped sockeye salmon.

RESULTS

Escapement Estimation

Sockeye, adult and jack chinook salmon, and steelhead counts derived from video tape in 1992 were 16,756, 3,117, 86 and 251, respectively (Figure 2; Appendix 2). At Tumwater and Dryden dams, a number of fish were trapped and removed or bypassed around the video counting station. These fish included 3,270 sockeye salmon, 685 adult and 4 jack chinook salmon, and 17 steelhead. Total Wenatchee River escapement in 1992 was derived by combining video counts with counts of fish trapped and removed or bypassed around the video counting station. The total Wenatchee River escapement in 1992 was estimated as 20,026 sockeye salmon, 3,802 adult, and 90 jack chinook salmon. It was impossible to obtain a total escapement estimate for steelhead, since most steelhead passage occurs during periods when the video counting station is not operating (1 October through 31 April). However, a partial escapement of 268 steelhead was calculated.

The inter-dam based sockeye salmon escapement estimate for the Wenatchee River was 21,613 (Larrie Lavoy, personal communication). A comparision of Wenatchee River sockeye salmon escapement estimates made using inter-dam and video methods were similar (Figure 3).

Migratory Timing

The mean date of passage at Tumwater Dam was 21 July, 1992 and 9 July, 1992 for sockeye and adult chinook salmon. These are the earliest migration timing estimates that we have observed during the last four years of study (Table 1).

Figure 2. Wenatchee River sockeye and chinook salmon escapement in 1992 estimated by video tape count at Tumwater Dam.

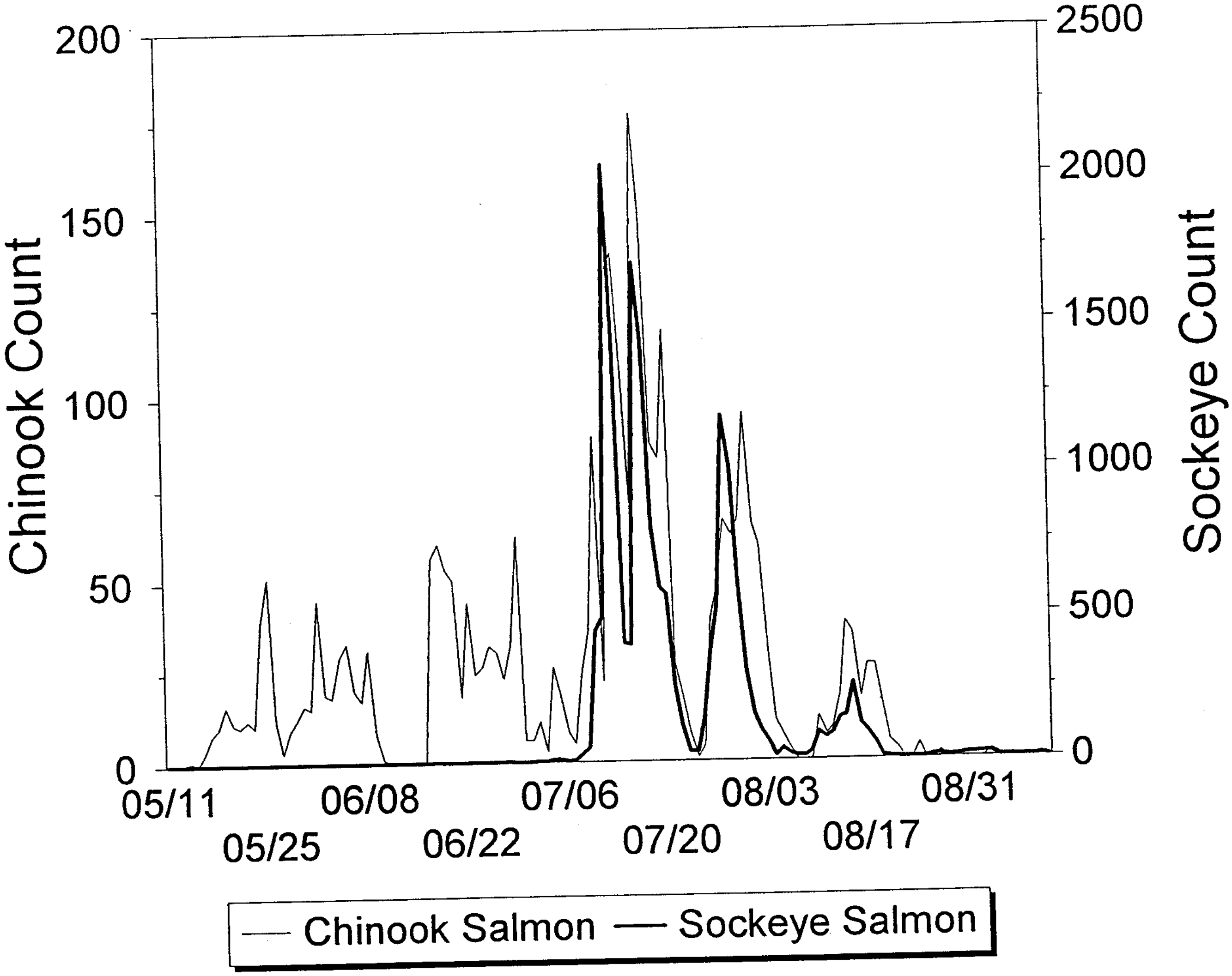
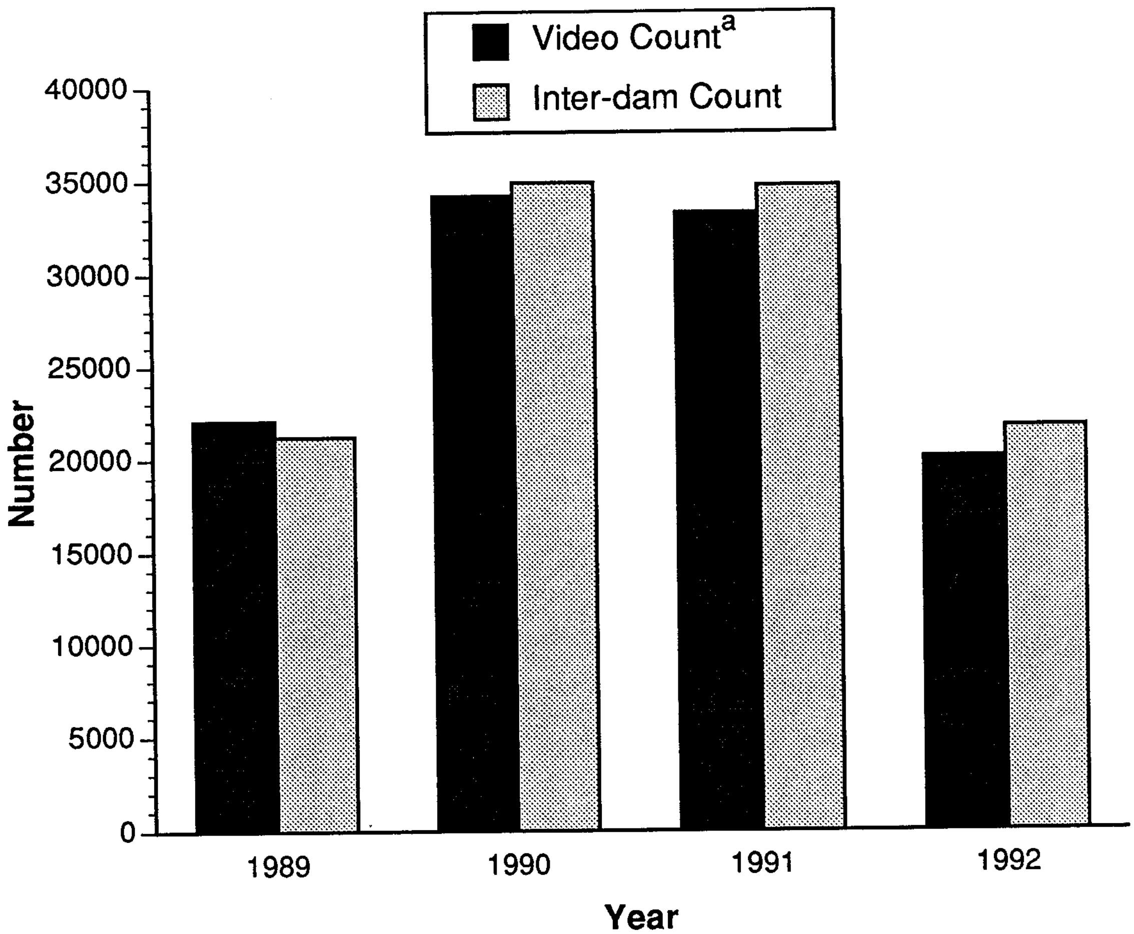


Figure 3. **Comparison of sockeye salmon counts made using Tumwater Dam video tape analysis[a] and those calculated from inter-dam based estimates, 1989 through 1992.**



a. Video counts were augmented by the number of fish removed at the Tumwater Dam fish trap that were not recorded by the video system.

Table 1. **Average date and standard deviation of salmon migration at Tumwater Dam for 1989, 1990, 1991, and 1992.**

Sockeye

Year	Mean Date	S.D.
1989	7/25	7.2
1990	7/29	6.2
1991	8/04	5.2
1992	7/21	10.0

Chinook

Year	Mean Date	S.D.
1989	7/18	18.8
1990	7/24	16.9
1991	8/01	16.2
1992	7/09	22.0

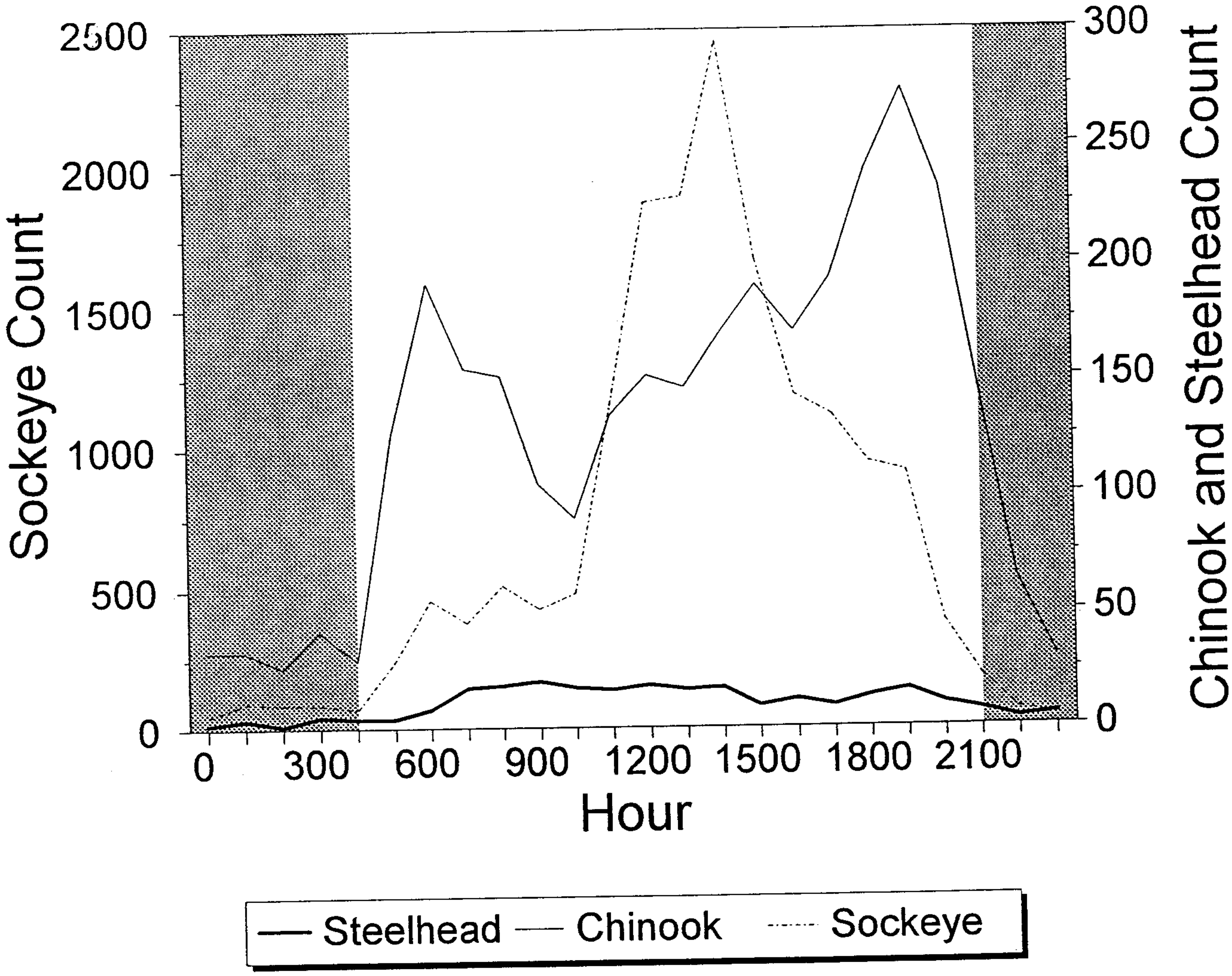
Nighttime Fish Passage

Over the entire 1992 migratory period, 1,036 sockeye salmon were video recorded migrating past Tumwater Dam between 2000 and 0400 hours (Figure 4). This represents 6.2% of the total Wenatchee River sockeye salmon escapement estimate. Nighttime migration observed for chinook salmon and steelhead was 20.3% and 16.3%, respectively (Figure 4).

Fluorescent Polymer Tag Detection

All 19 of the adipose-clipped, fluorescent polymer tagged sockeye salmon were interrogated on video tape in an attempt to determine tag detectability. All 19 tagged fish passed the viewing window within 24 h of being marked. We were unable to detect any of the fluorescent polymer tagged sockeye salmon using the standard video fish counting system or with the video system equipped with a red filter to enhance tag detection.

Figure 4. Composite sockeye and chinook salmon counts as a function of time of day with approximate hours of darkness shaded, recorded at Tumwater Dam in 1992.



DISCUSSION

The 1992 video-based sockeye salmon count at Tumwater Dam was within 7.5% of the inter-dam estimate. The inter-dam count is a gross approximation because the fish counting protocols differred between Rock Island (24 h) and Rocky Reach (16 h) dams. Therefore, this difference between inter-dam and video estimates, which is the greatest that we have observed in four years of study (Figure 3), may be somewhat artifical. Sockeye salmon condition was poorer in 1992 then in previous years at Tumwater Dam (Fryer and Schwartzberg 1993). This indicates that the Wenatchee stock may have suffered some measurable mortality between Rock Island and Tumwater dams, additionally affecting the inter-dam estimate.

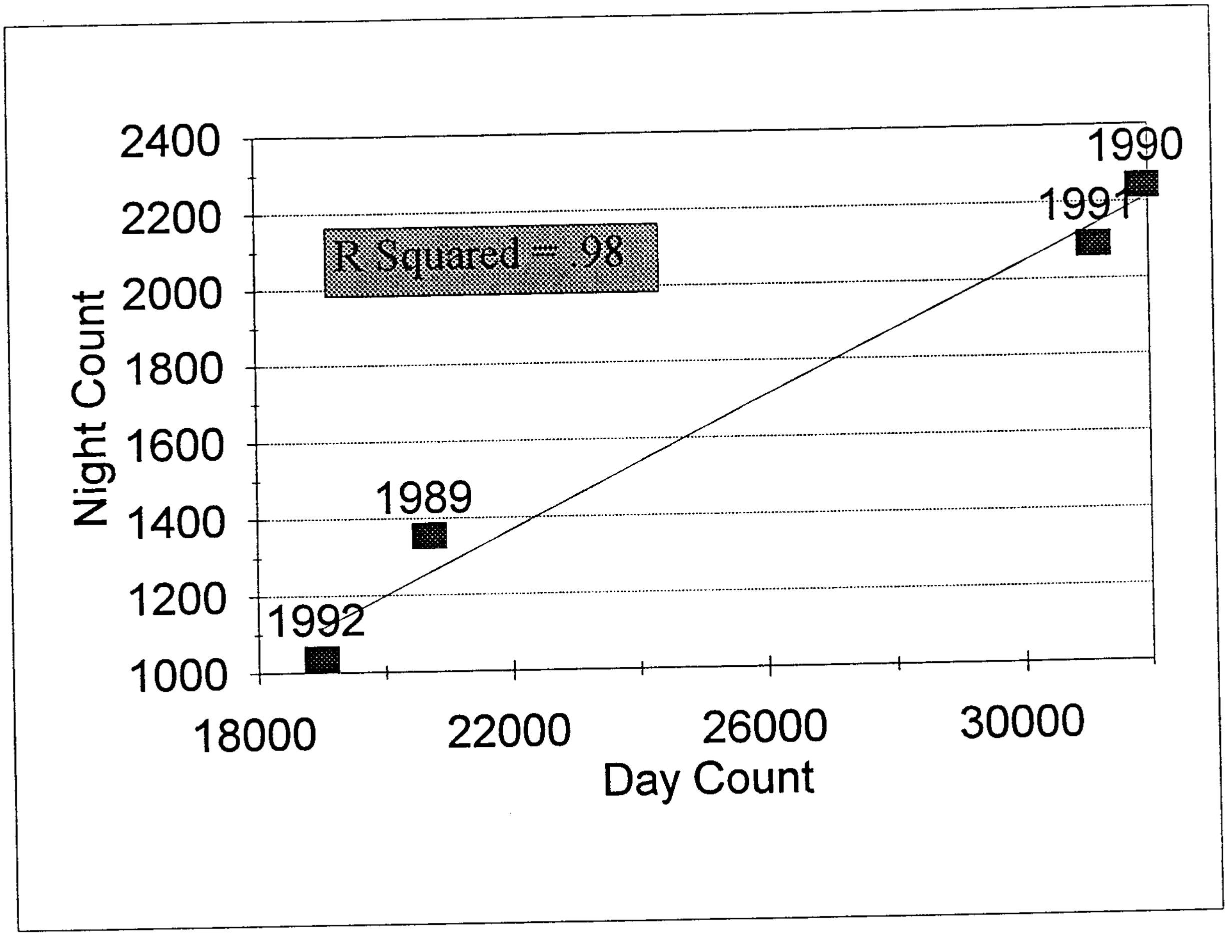
Both chinook and sockeye salmon migrations were the earliest that we have observed in the last four years. The mean date of passage for chinook salmon was approximately three weeks earlier in 1992 than in 1991. This is a general trend that was observed in the majority of the Mid-Columbia River area in 1992 (CRITFC 1993). Wenatchee stock sockeye salmon migrated earlier in 1992 as did the Okanogan stock sockeye salmon (Hatch et al. 1993). The Wenatchee River sockeye salmon migration had nearly twice the variability that has been measured in previous years.

Nighttime sockeye salmon passage has remained similar over the last four years, ranging from 6.2% to 6.7% (Hatch and Schwartzberg 1990, 1991; Hatch et al. 1992). These nighttime passage estimates are slightly lower than those calculated at Rock Island Dam (6.0% to 9.0%) in 1991 and at Priest Rapids Dam (9.2%) in 1992 (Larrie Lavoy, personal communication). Calvin (1975) reported nighttime sockeye salmon passage as 5.0% to 5.1% of the run at Bonneville Dam in 1973 and 1974. A significant ($p<0.001$) relationship between total nighttime counts and daytime counts is apparent (Figure 5). This regression could be used to correct daytime-only counts that are made at several counting stations.

Nighttime chinook salmon passage has shown much more variability over the last four years with estimates ranging from 7.7% to 20.3% (Hatch and Schwartzberg 1990, 1991; Hatch et al. 1992b). It is unclear why nighttime chinook salmon passage increased to such a high level this year. However, relatively high rates of nighttime passage were reported at other locations in 1992. Nighttime fall chinook salmon passage at Lower Granite Dam in 1992 was 11.7% (Hatch et al. 1993) and ranged between 4.8% and 8.4% at The Dalles Dam in 1973 through 1974 (Calvin 1975). It seems apparent that with the increasing importance of fish counts at Columbia River Basin passage facilities, efforts should be made to account for fish movement at all times of the day. Counts should either be adjusted to account for nighttime passage or, preferably, complete 24 h monitoring should be employed. We believe that video could be utilitized for making 24 h fish counts at nearly all existing fish counting locations.

Although our video equipment was of high quality (S-VHS), the resolution was not adequate for reliable detection of fluorescent polymer tags injected in the adipose eyelid of adult sockeye salmon. The pupil of the average sockeye salmon on video tape is represented with approximately 5 to 7 pixels. Therefore, an injection of the fluorescent polymer would have to be at least 3 to 4 mm in diameter to be detectable on video tape. The standard injection produces a tag of approximately 4 mm by <1 mm size. Since fish passage on video tape can be reviewed on a frame by frame basis and each fish image inspected for marks, it would be desirable to develop an external tag that would be detectable on video tape. In the Wenatchee system, it would permit scientists to evaluate the effectiveness of the hatchery-based sockeye salmon program in terms of adult run composition. In the future, we may experiment with the detectability of various external tags on video tape.

Figure 5. Total nighttime sockeye salmon counts as a function of total daytime counts from Tumwater Dam on the Wenatchee River in 1989 through 1992.



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

Item	Number	Make	Model
Camera	1	Panasonic	WV-D5100
Tripod	1	Bogen	3046
Time-lapse VTR	2	Panasonic	AG-7620
Reviewing VTR	1	Panasonic	AG-1960
Monitor	1	Panasonic	CT-1382Y
Battery Backup	1	Tripp-lite	SB-200a
LIghting	10	Philips	150 watt flood

Appendix 2. Daily 1992 fish counts[1].

Date	Sockeye	Adult Chinook	Jack Chinook	Steelhead
5/11/1992	0	0	0	0
5/12/1992	0	0	0	1
5/13/1992	0	0	0	0
5/14/1992	0	1	0	3
5/15/1992	0	0	0	4
5/16/1992	0	3	0	0
5/17/1992	0	8	0	1
5/18/1992	0	10	0	1
5/19/1992	0	16	0	0
5/20/1992	0	11	0	3
5/21/1992	0	10	0	0
5/22/1992	0	12	0	1
5/23/1992	0	10	2	0
5/24/1992	0	39	0	0
5/25/1992	0	51	0	0
5/26/1992	0	12	0	0
5/27/1992	0	3	0	0
5/28/1992	0	9	0	0
5/29/1992	0	12	0	0
5/30/1992	0	16	0	0
5/31/1992	0	15	1	0
6/01/1992	0	45	0	0
6/02/1992	0	19	0	1
6/03/1992	0	18	0	0
6/04/1992	0	29	0	0
6/05/1992	0	33	0	2
6/06/1992	0	20	2	1
6/07/1992	0	17	0	3
6/08/1992	0	31	0	4
6/09/1992	0	8	1	1
6/10/1992	0	1	0	0
6/11/1992	0	0	0	0
6/12/1992	0	0	0	0
6/13/1992	0	0	0	0
6/14/1992	0	0	0	0
6/15/1992	0	0	0	0
6/16/1992	0	0	0	0
6/17/1992	1	56	1	1
6/18/1992	1	60	1	4
6/19/1992	0	53	3	3
6/20/1992	0	50	0	2
6/21/1992	0	18	2	3

[1]Doesn't include fish trapped for hatchery broodstock collection program.

Appendix 2. Continued.

Date	Sockeye	Adult Chinook	Jack Chinook	Steelhead
6/22/1992	0	44	0	4
6/23/1992	0	24	1	2
6/24/1992	0	26	1	2
6/25/1992	0	32	2	4
6/26/1992	0	30	0	2
6/27/1992	2	23	1	3
6/28/1992	3	32	0	1
6/29/1992	0	62	0	2
6/30/1992	0	6	0	3
7/01/1992	2	6	0	3
7/02/1992	3	11	0	2
7/03/1992	3	3	0	0
7/04/1992	8	26	0	1
7/05/1992	8	18	0	0
7/06/1992	1	8	1	2
7/07/1992	7	5	0	1
7/08/1992	26	24	0	2
7/09/1992	49	36	2	2
7/10/1992	447	89	0	1
7/11/1992	502	22	0	4
7/12/1992	2038	134	3	3
7/13/1992	1436	139	0	2
7/14/1992	407	106	0	1
7/15/1992	400	71	0	7
7/16/1992	1704	177	5	5
7/17/1992	1435	150	12	5
7/18/1992	811	87	0	2
7/19/1992	597	83	0	2
7/20/1992	573	118	2	8
7/21/1992	257	27	0	3
7/22/1992	115	18	0	2
7/23/1992	32	8	0	0
7/24/1992	31	1	0	4
7/25/1992	142	4	1	4
7/26/1992	374	39	1	3
7/27/1992	535	48	2	3
7/28/1992	1178	66	3	5
7/29/1992	997	62	3	4
7/30/1992	601	66	0	4
7/31/1992	311	95	1	5
8/01/1992	159	65	2	1
8/02/1992	104	59	0	3
8/03/1992	63	30	0	0
8/04/1992	15	11	1	0
8/05/1992	39	7	1	0
8/06/1992	21	3	0	0

Appendix 2. Continued.

Date	Sockeye	Adult Chinook	Jack Chinook	Steelhead
8/07/1992	12	0	4	3
8/08/1992	12	0	6	2
8/09/1992	28	0	3	0
8/10/1992	93	12	1	4
8/11/1992	76	7	1	1
8/12/1992	90	9	5	6
8/13/1992	141	18	1	5
8/14/1992	151	38	4	4
8/15/1992	260	35	0	6
8/16/1992	119	17	0	12
8/17/1992	96	26	0	3
8/18/1992	58	26	0	8
8/19/1992	11	15	0	4
8/20/1992	6	5	0	1
8/21/1992	6	3	0	1
8/22/1992	2	0	0	0
8/23/1992	3	0	0	2
8/24/1992	1	4	0	0
8/25/1992	3	0	0	0
8/26/1992	11	0	0	0
8/27/1992	13	2	0	0
8/28/1992	7	0	0	2
8/29/1992	9	0	0	3
8/30/1992	11	0	0	1
8/31/1992	16	0	0	7
9/01/1992	15	0	0	4
9/02/1992	17	0	0	0
9/03/1992	18	2	1	4
9/04/1992	6	1	0	1
9/05/1992	4	0	0	3
9/06/1992	5	0	0	0
9/07/1992	1	0	0	0
9/08/1992	5	0	0	1
9/09/1992	4	0	0	1
9/10/1992	7	0	2	3
9/11/1992	1	0	0	3
Total	**16756**	**3117**	**86**	**251**