WENATCHEE RIVER SALMON ESCAPEMENT ESTIMATES USING VIDEO TAPE TECHNOLOGY IN 1994

Technical Report 95-3

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March 30, 1995

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ABSTRACT

Accurate determination of escapement is necessary for analysis of the status of important fish stocks. In an effort to evaluate and develop more accurate Pacific salmon escapement estimation techniques, a time-lapse video recording system and a computerized counting system were tested. The time-lapse video tape recording system was installed and operated from 11 May 1994 through 29 September 1994 in the fish counting station at Tumwater Dam on the Wenatchee River. This was a continuation of studies conducted annually since 1989. The automated counting system was installed and operated from 22 August 1994 to 14 September 1994.

In 1994, Wenatchee River salmon escapement above Tumwater Dam was estimated to be 7,595 sockeye salmon *Oncorhynchus nerka* and 1,882 chinook salmon *O. tshawytscha*. Salmon migratory timing estimates have remained similar from 1989 through 1992. The mean dates of passage for salmon in 1994 were 24 July (SD=10.3) for sockeye, and 19 July (SD=12.5) for chinook salmon. Nighttime (2100 to 0500) sockeye salmon passage estimates accounted for 10.6% of the run. That percentage is slightly higher than estimates made in previous 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

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Accurately estimating escapement of salmon is critically important to permit analysis of stock status. In the Columbia River Basin, the Northwest Power Planning Council has established a management goal of doubling anadromous 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 and documenting the use of time-lapse video (Hatch et al. 1994a) and other innovate technologies for salmon escapement estimation.

Since initially reporting of the use of video technology as a tool for monitoring Pacific salmon fish ladder passage (Hatch and Schwartzberg 1990), we have noted an increase in the use of such systems for salmon. For example, Irvine et al. (1991) reported a video-based method for counting fish captured in a trap. Several systems have been installed at the U.S. Army Corp of Engineers' (COE) operated mainstem Columbia River hydroprojects, as a result of requests for more complete monitoring at these locations (NMFS 1994). Operators of other Columbia River hydroprojects have instituted the use of video as the primary or only fish ladder count system and have reported substantial improvements over previously employed methods (S. Hays Chelan County PUD, personal communication). Systems are now routinely used to enumerate adult fish migrating through streams in British Columbia, Alaska, and Michigan.

The Columbia River Inter-Tribal Fish Commission has, over the past six 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. 1994b). Additional work investigated the effects of several reviewers on count precision in video estimates (Hatch and Schwartzberg 1991), the effect of different video 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 at various sites (Hatch and Schwartzberg 1990, 1991; Hatch et al. 1992a, 1992b, 1993). The possibility of detecting very small fluorescent polymer tags in migrating adult sockeye salmon *Oncorhynchus nerka* was also investigated (Hatch et al. 1993).

The current study continues to estimate Wenatchee River salmon escapement and to document relevant migration statistics. Additionally in 1994, we estimated the return of sockeye salmon propagated from the Lake Wenatchee net pen project (Hays 1992), based on observations of missing adipose fins and we tested more advanced videotape analysis techniques. These techniques included using a computer to reduce or *edit* the total amount of videotape that must be reviewed to precisely count passing fish and the use of *machine vision* to automatically count passing fish. The machine vision system analyzed approximately seven video frames per second for the presence of salmon sized fish, the direction of fish movement, and entrance and exit position of fish. Based on this data the system documented fish ladder passage and wrote the data to a database file on the computers hard disk.

The project objectives in 1994 were to:

1. Estimate sockeye and chinook salmon *O. tshawytscha* escapement using time-lapse video at Tumwater Dam on the Wenatchee River;
2. Document sockeye and chinook salmon migratory timing, and diel passage at Tumwater Dam in 1994, and compare with estimates made in past years;
3. Test the precision of fish counts made at Tumwater Dam using a computerized videotape editing procedure that reduces the total amount of video that an individual must review; and,
4. Test the implementation of a machine vision fish counting system.

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 originally built with a simple 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.

In 1994 we installed a video camera on a tripod aimed at the fish viewing window. Two time-lapse, SVHS video tape recorders (VTRs), were set on a recording speed of 72 h(recording one field every 0.66 seconds), and connected to the camera. Recording was made in series, so that when the first VTR finished recording, the second VTR would immediately begin recording. In this manner, it was possible to record continuously for up to seven days without changing tapes. Ten 90-watt halagen 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 A for a complete equipment list). The camera and VTRs were operated continuously from 11 May 1994, through 29 September 1994.

Several fisheries management agencies used Tumwater Dam as a site for fish trapping associated with other research and management programs. When the trap is operated all fish bypass the counting window. Therefore, counts of fish that

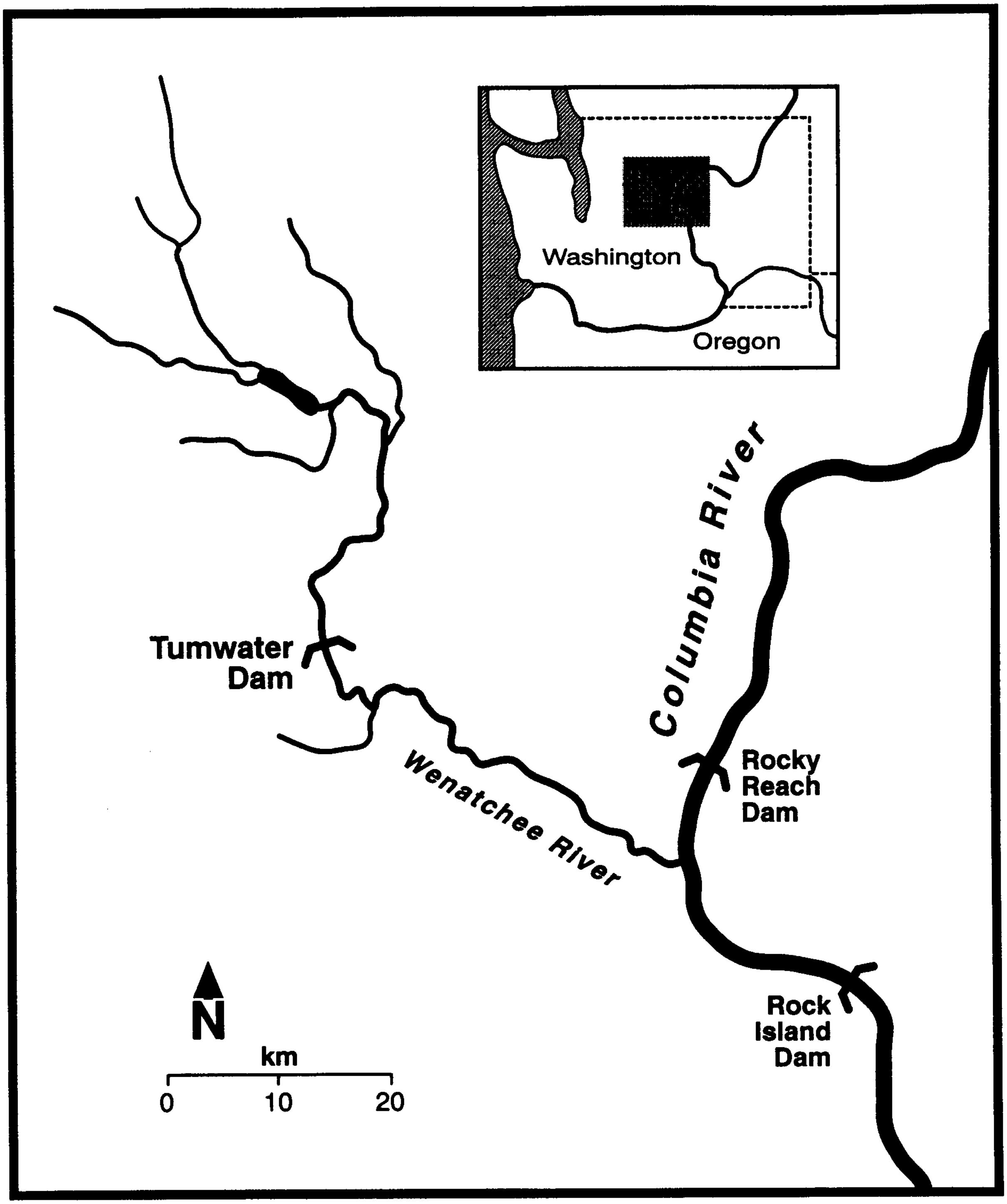


Figure 1. Map of the Wenatchee River Basin showing the location of Tumwater, Rock Island, and Rocky Reach dams.

were diverted through the fish trap were obtained and added to the daily video counts.

Escapement Estimation

Video-Based Estimate

Video tapes were reviewed by an experienced fish counter using 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 the time and date 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. Escapement estimates were based on the sum of video counts and counts of fish diverted through the fish trap. In 1994, the video system did not function on 7 days because of equipment malfunctions. For these periods, , fish counts were imputed by averaging fish counts for the previous day and the day following any malfunction. These counts were added to the escapement estimates for each stock.

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 1994). 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 three count locations, all sockeye salmon that pass over Rock Island Dam but not Rocky Reach Dam will migrate past Tumwater Dam

Migratory Timing and other Passage Statistics

The average dates of migratory timing and their associated standard deviations were calculated for sockeye and chinook salmon during migration passage at Tumwater Dam annually from 1989 through 1994, based on review of videotape records (Mundy 1982).

Estimates of nighttime passage (fish passage between 2100 and 0500 hours) were made for sockeye and chinook salmon and steelhead at Tumwater Dam. Total counts for each species made between 2100 and 0500 hours were divided by their respective escapement estimates to calculate the percentage of the total count for each species that represented nighttime migration.

Test of the Computerized Videotape Editing Procedure

The computerized videotape editing system automatically scans a recorded source tape and dubs all frames containing fish images onto another second edited tape. The second tape is then available for review by individuals using editing VTRs in the same manner that we have described for source tape review. An equipment list for the videotape editing system is located in Appendix (A).

Detection Procedure

Custom software that we wrote detected fish images by measuring changes in luminance values (pixel brightness ranging from 0 to 255) between consecutive frames. For each frame, 6 vertical columns were digitized, and the luminance value of each pixel in the column was measured. Columns were 1 pixel wide by 360 pixels high, giving a total of 2,160 sampled pixels per frame. The resulting luminance values were broken into subsets of 15 pixels and averaged, yielding 144 values for each frame. These values were used to compare consecutive frames, and if any of the 144 values differed by more than a preset threshold (in this case

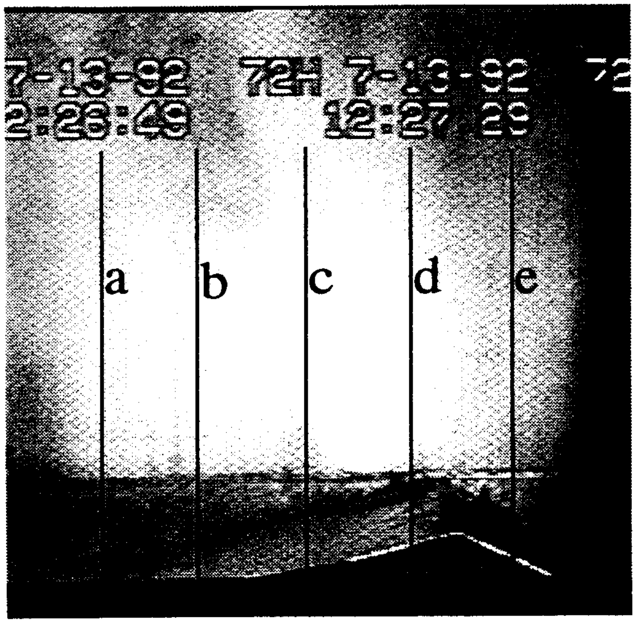
25, or 10% of the total range of luminance values), fish images were assumed to be present on the current frame of videotape (Figure 2).

Whenever a fish image was detected, the computer was instructed to read the current time code from the VTR playing the source videotape. Time code is a signal written to a videotape which gives each video frame a unique number. By reading the time code from the VTR, it was possible to determine exactly where on the videotape each fish image was located. After the source tape was scanned, these time codes were used to automatically copy all sections of tape containing fish images to another tape (edited tape).

Comparison of Fish Counts

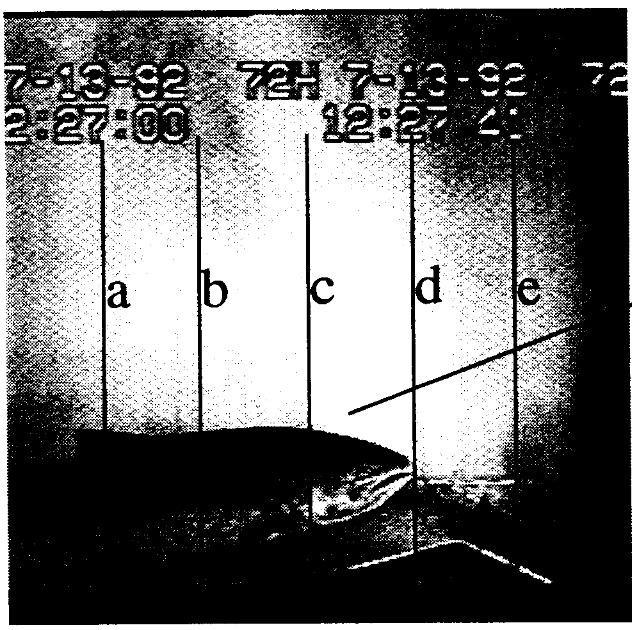
Edited videotapes made from source tapes recorded between 5 July 1994 and 21 September 1994, were reviewed by an experienced fish counter using previously detailed methods. Each fish image present was identified and enumerated by hour of passage. Hourly fish counts from edited videotapes were compared with fish counts from source videotapes using least squares linear regression (Mendenhall 1983). Hourly fish counts made from source videotapes were subtracted from counts made from edited tapes to produce a difference variable. The difference variable was evaluated to determine if the editing process introduced a bias to the fish counts.

Frame 1



Pixel values are measured on vertical lines (a-e) and compared between video frames.

Frame 2



This fish was detected because it changed the mean pixel value on three (lines a,b, and c) of the five vertical inspection lines.

Figure 2. Conceptual illustration of the computerized videotape editing algorithm.

Test the Implementation of a Machine Vision Fish Counting System

A machine vision fish counting system was installed at Tumwater Dam and evaluated for several weeks. The system consisted of a personal computer with an installed digital image processing frame grabber (Sharp GPB-1), and a timebase corrector. The video signal was routed from one of the VTRs into the timebase corrector and then into the computer via the frame grabber board.

Once a video frame was captured, an algorhym determined if a fish was present by comparing the luminance values of the frame with a background frame (a frame that was known to not contain fish images). If a fish image was not present, the system evaluated the next available frame. If a fish image was determined to be present, the fish image was isolated and tracked. As fish images exited a frame, the system recorded the event to a database. Fish that entered the window from the downstream side and tracked exiting to the upstream side were recorded as a positive number and fish that entered the window from the upstream side and tracked exiting to the downstream side were recorded as a negative number.

RESULTS

Escapement Estimation

Sockeye, adult and jack chinook salmon, and steelhead escapement estimates were based on counts from videotape, counts of fish that passed Tumwater Dam while the trap was in operation, and imputed counts when the video system was not functioning. Escapement estimates in 1994 were 7,595 (sockeye), 1,882 (adult chinook), 102 (jack chinook), and 94 (steelhead) (Figure 3, Appendix B). It should be noted that the steelhead count is not an accurate representation of escapement because the majority of steelhead pass Tumwater Dam when the video counting system is not operated. These fish included 751sockeye salmon, 398 adult and jack chinook salmon, and 4 steelhead that were deverted through the trap.

The inter-dam based sockeye salmon escapement estimate for the Wenatchee River was 7,988. A comparison of Wenatchee River sockeye salmon escapement estimates made using inter-dam and video methods were similar (Figure 4).

Adipose-clipped returns, as determined only from videotape analysis, were 413, 30, 7, and 12, for sockeye, adult chinook, jack chinook, and steelhead; respectively. Adipose-clipped fish represented an estimated 6.8% of the sockeye returns, 2.4% of the adult chinook returns, 8.5% of the jack chinook returns, and 14.6% of the steelhead returns.

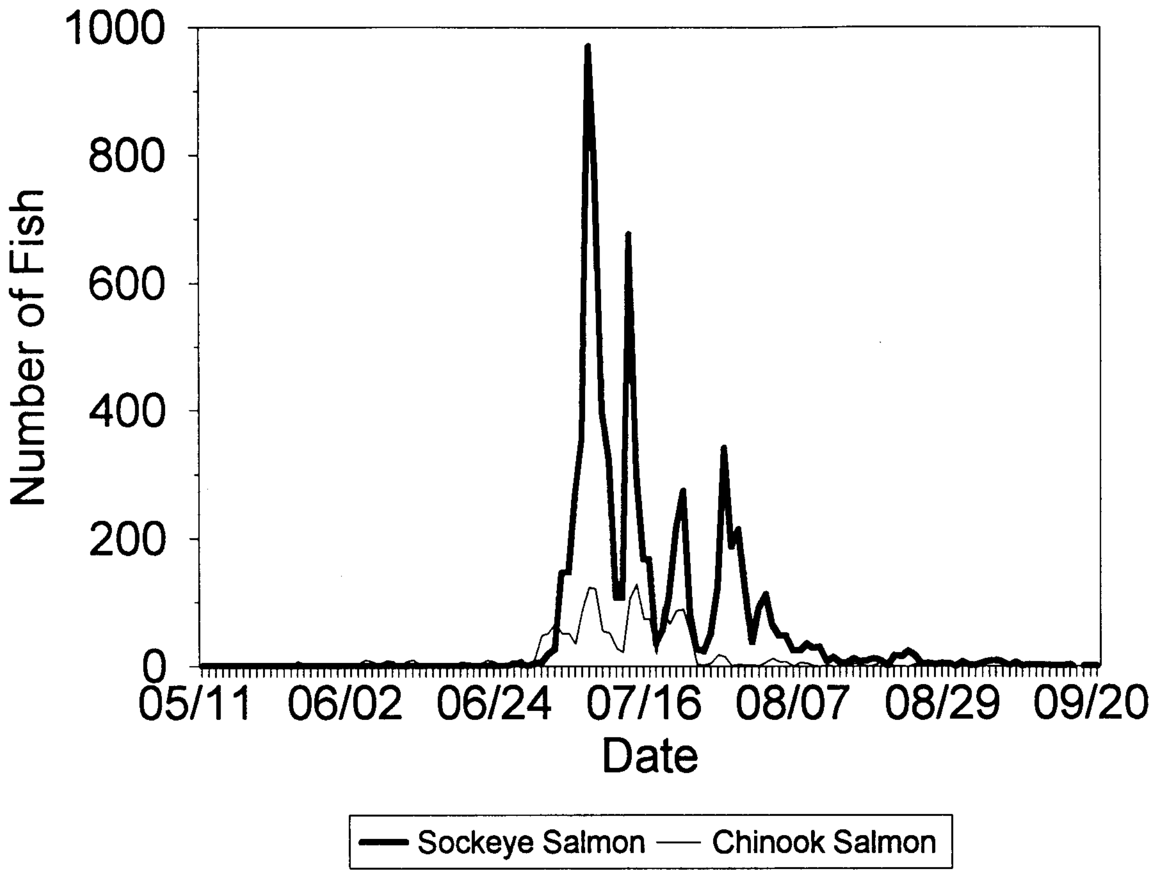


Figure 3. Wenatchee River sockeye and chinook salmon escapement in 1994, estimated using video tape analysis at Tumwater Dam.

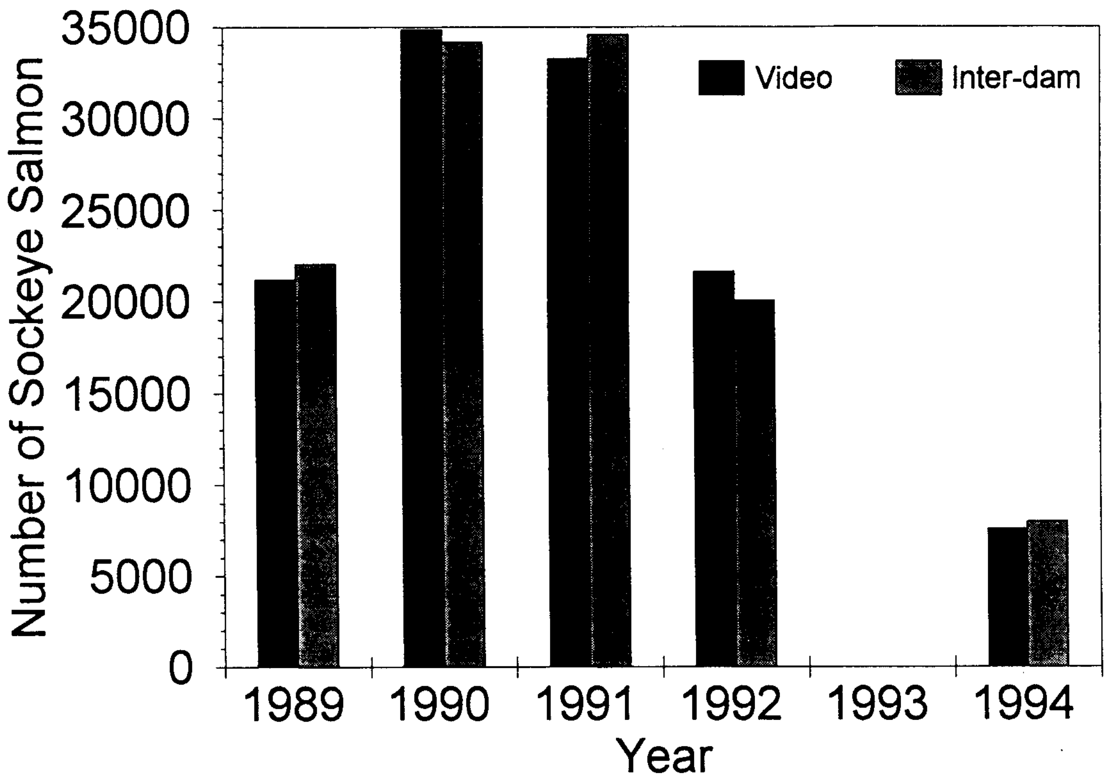


Figure 4. Comparison of sockeye salmon counts made video tape analysis at Tumwater Dam and those calculated from inter-dam based estimates, 1989 through 1994.

Migratory Timing and other Passage Statistics

The mean date of passage at Tumwater Dam was 24 July 1994 and 19 July 1994 for sockeye and adult chinook salmon (Table 1). The migration timings of adipose-clipped and nonclipped sockeye salmon was similar (Figure 5).

Over the entire 1994 migratory period, 803 sockeye salmon were video recorded migrating past Tumwater Dam between 2000 and 0500 hours (Figure 6). This represents 10.6% of the total Wenatchee River sockeye salmon escapement estimate. Nighttime migration observed for chinook salmon (Figure 6) and steelhead was 6.3% and 22.3%, respectively.

Test of the Computerized Videotape Editing Procedure

A total of 2,412 hours of possible fish passage was reviewed on source as well as edited videotapes. The mean hourly fish count from source videotape was 2.910 and 2.920 for edited videotape (Table 2). The maximum difference in any one hour was 7 fish, in that hour the count from the edited videotape was higher than the source tape. Least squares linear regression of fish counts from edited videotape as a function of fish counts from source tape yielded a nonsignificant difference ($p>0.05$) (Figure 7).

By editing these videotapes the amount of tape that needed to be reviewed was reduced by 82.2%. Data compression rate per day ranged from 46.8% to 96.1% (Table 3). The total data compression would have been even higher if videotapes recorded in May and June (months with very low fish passage) had been used in the analysis.

Table 1. Mean date of passage and standard deviation for salmon migration at Tumwater Dam for 1989 through 1994.

Sockeye Salmon

Year	Mean Date of Passage	Standard Deviation
1989	7/25	7.2
1990	7/29	6.2
1991	8/04	5.2
1992	7/21	10.0
1993	not available	not available
1994	7/24	10.3

Chinook Salmon

Year	Mean Date of Passage	Standard Deviation
1989	7/18	18.8
1990	7/24	16.9
1991	8/01	16.2
1992	7/09	22.0
1993	not available	not available
1994	7/19	12.5

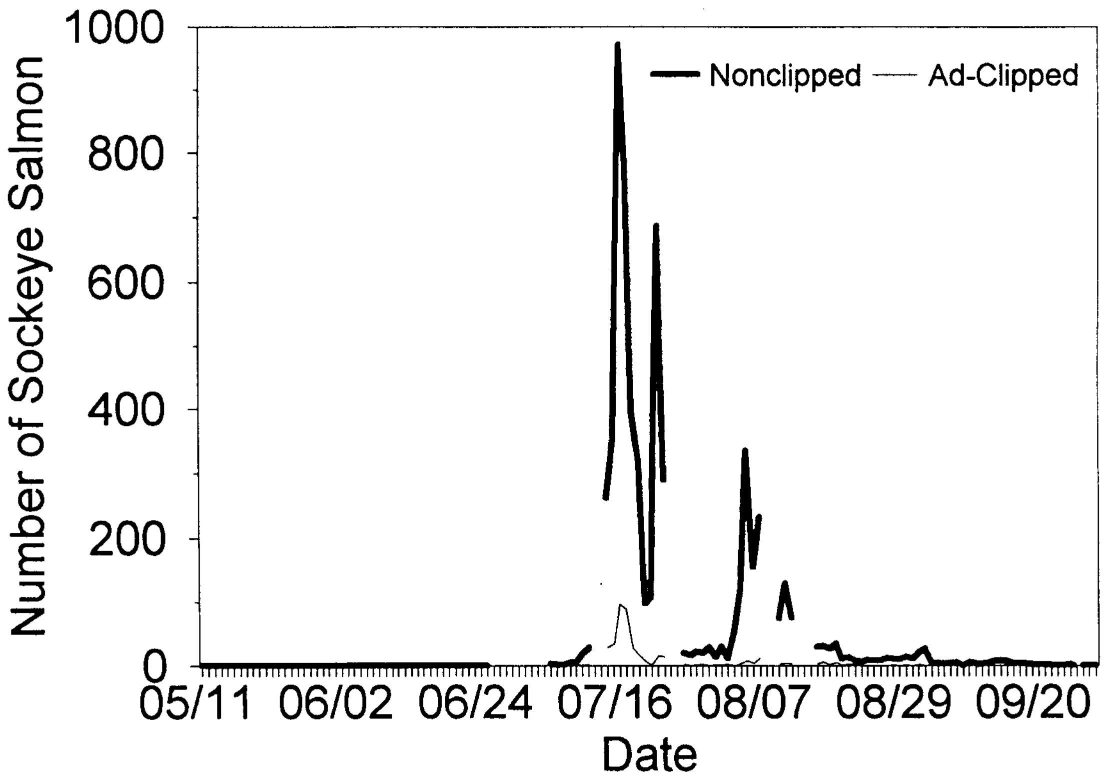


Figure 5. Migratory timing of wild (non-adipose clipped) and net pen reared (adipose clipped) sockeye salmon passing Tumwater Dam in 1994.

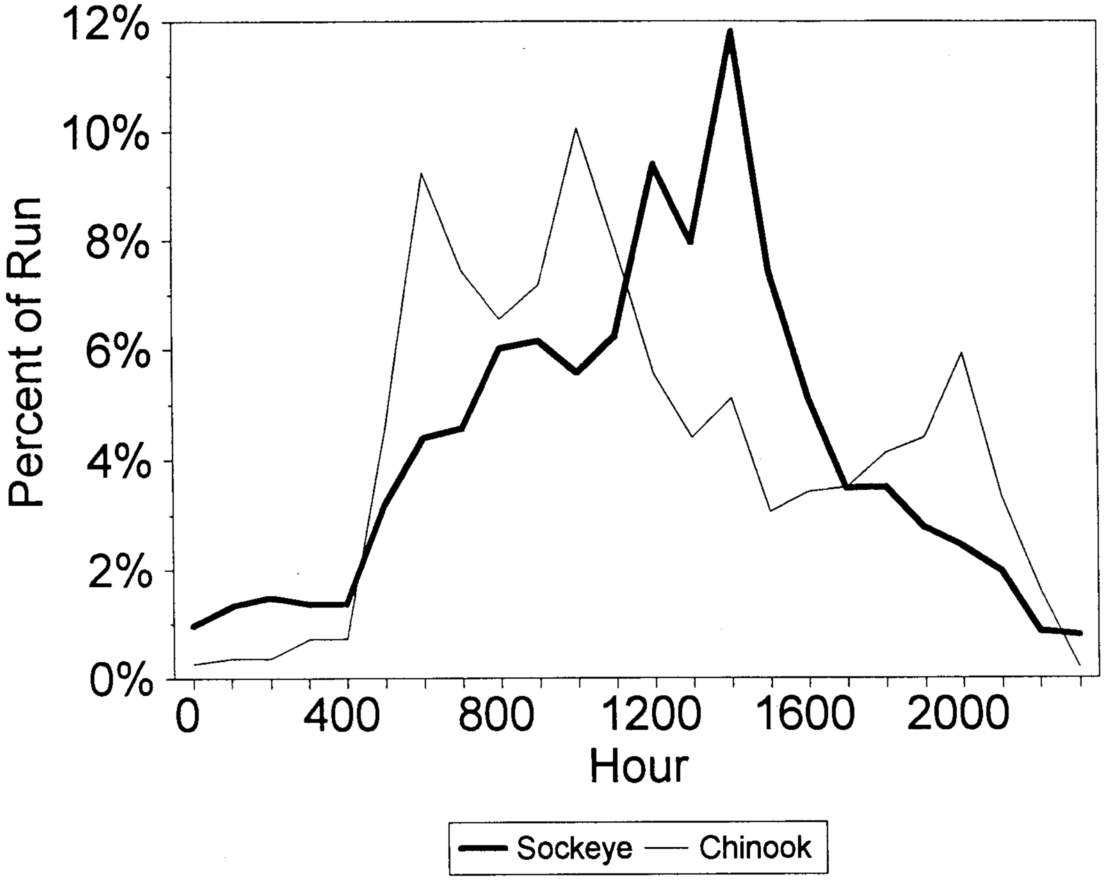


Figure 6. Percentage of sockeye and chinook salmon returns as a function of hour of the day at Tumwater Dam in 1994.

Table 2. Descriptive statistics of hourly fish counts derived from edited and source videotapes recorded at Tumwater Dam in 1994.

	Source Tape	Edited Tape	Differrence (Source-Edit)
n	2,412.000	2,412.000	2,412.000
Minimum	-1.000	0.000	-7.000
Maximum	168.000	163.000	6.000
Range	168.000	163.000	13.000
Mean	2.910	2.920	-0.010
Variance	139.821	139.414	0.217
Standard deviation	11.825	11.807	0.466
Standard error	0.241	0.240	0.009
C.V.	4.063	4.043	-44.924
Sum	7,019.000	7,044.000	-25.000

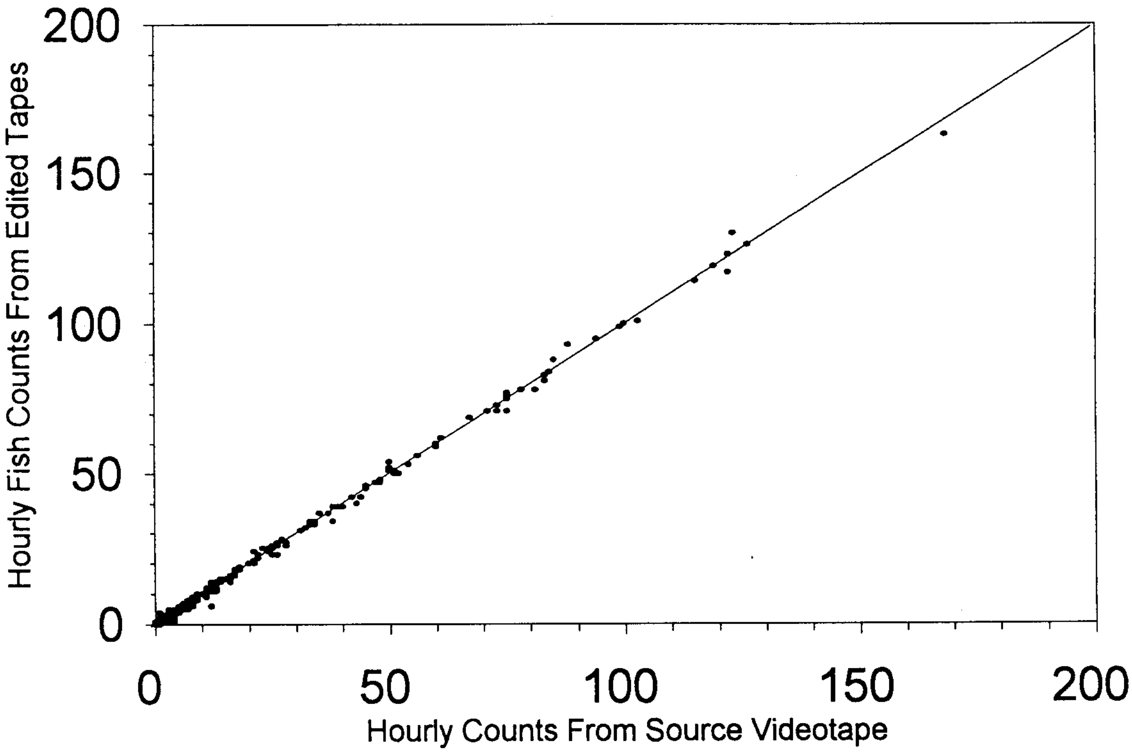


Figure 7. Hourly fish counts from edited videotapes as a function of fish counts from source tapes recorded at Tumwater Dam in 1994.

Table 3. Amount of time recorded on source tapes of fish passage and the corresponding times of edited tapes produced at Tumwater Dam in 1994. The compression rate was calculated by dividing the source tape time by the edited tape time.

Tape	Source Tape Time	Edited Tape Time	Compression Rate
1	02:00:18	00:31:00	74.2%
2	01:09:01	00:07:41	88.9%
3	02:02:54	00:28:27	76.9%
4	02:03:11	01:05:31	46.8%
5	01:43:32	00:39:41	61.7%
6	02:01:50	00:42:58	64.7%
7	02:02:13	00:19:27	84.1%
8	01:50:18	00:19:33	82.3%
9	02:02:42	00:17:47	85.5%
10	02:02:04	00:43:18	64.5%
11	01:19:11	00:29:10	63.2%
12	02:02:23	00:20:58	82.9%
13	01:20:56	00:10:07	87.5%
14	02:01:39	00:13:30	88.9%
15	01:45:15	00:08:45	91.7%
16	02:02:13	00:15:58	86.9%
17	01:50:40	00:14:55	86.5%
18	02:02:43	00:13:00	89.4%
19	02:01:12	00:06:27	94.7%
20	02:02:56	00:04:47	96.1%
21	01:48:46	00:09:03	91.7%
22	02:02:46	00:07:29	93.9%
23	01:51:18	00:08:05	92.7%
24	01:51:35	00:04:29	96.0%
Total	21:01:36	08:02:06	82.2%
Minimum	02:03:11	01:05:31	46.8%
Maximum	02:02:56	00:04:47	96.1%

Test the Implementation of a Machine Vision Fish Counting System

The machine vision fish counting system was installed for 54 days, beginning on 22 August 1994. Fish passage at the viewing window was very low during the installation which made calibration of the machine vision system difficult. Because we were unable to test the calibration of the machine vision system and very few fish passed the viewing area when the system was installed, accurate counts were not made.

DISCUSSION

The sockeye salmon escapement estimate for the Wenatchee River made at Tumwater Dam was within 5% of the estimate calculated using the inter-dam method. The inter-dam estimate is probably an over-estimate because counting protocals differ between Rock Island (24 h per day) and Rocky Reach (16 h per day) faculities. This is continuing evidence of the validity of the video-based fish counting technique. Sockeye salmon abundance was the second lowest recorded in the last 35 years and the migration timing had an extended distribution (Figure 3). In the previous five years of video monitoring at Tumwater Dam, migration timing has been single-modal with the majority of passage occurring over a two week period. In 1994, the distribution extended over approximately a four week period. The cause of the change in migration timing distributation is unknown. The migatory timing distribution of net-pen reared sockeye salmon was similiar to wild fish (Figure 5).

Chinook salmon escapement was the lowest that we have estimated at Tumwater Dam since we began videotaping fish passage in 1989. The migatory timing of chinook was similiar to previous years, however.

Nighttime passage of sockeye salmon was higher in 1994 than in the previous six years. However, nighttime passage of chinook salmon was the lowest level that we have observed. These conflicting data make it difficult to infer a relationship between abiotic conditions and migratory behavior in 1994.

The videotape editing system proved to be an important tool to aid in the analysis of fish passage tapes. Fish counts made from both source and edited videotapes were similiar among the 2,412 hours tested. The large sample size made this a very sensitive test. The largest difference between counts in any particular hour was 7 fish. For that hour, more fish were counted on the edited videotape. Even during the hour with the greatest number of fish, the amount of videotape required to record the fish passage events was almost 50% less than the source version. Consequently, review time for that hour was approximately one half that of the source videotape. The greatest review time-savings was observed during periods with the lowest fish passage rates. The lowest fish passage rates generally occur during nighttime hours. This system could be employed at mainstem dams to edit nighttime fish passage tapes and permit documenting nighttime fish passage, thus making 24 hour monitoring at mainstem dams very cost effective.

As a result of logisitical problems, we were unable to adequately calibrate the machine vision fish counting system. The machine vision system was still installed and operated for several weeks, but the results were unsatifactory. We hope to thoroughly calibrate and evaluate the system in 1995.

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

Time-Lapse Recording Station

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	General Electric	90 watt halogen

Video-Tape Editing System

Item	Number	Make	Model
Video Tape Recorder	2	Panasonic	AG-7350
Digital Time-Base Corrector	1	FORA	FA-310
Monitor	1	Panasonic	CT-1383Y
Computer	1	Hewlett Packard	HP 486/33T Vectra
Frame Grabber Board	1	Sharp	GPB-1

Machine-Vision Fish Counting System

Item	Number	Make	Model
Computer	1	Hewlett Packard	HP 486/33T Vectra
Frame Grabber Board	1	Sharp	GPB-1

Appendix B. Daily and annual total fish passage estimates, and abundance of adipose clipped fish, at Tumwater Dam in 1994.

Date	Total Chinook Adult	Total Chinook Jack	Total Steelhead	Total Sockeye	Clipped Chinook Adult	Clipped Chinook Jack	Clipped Steelhead	Clipped Sockeye
05/11/94	0	0	0	0	0	0	0	0
05/12/94	0	0	0	0	0	0	0	0
05/13/94	0	0	0	0	0	0	0	0
05/14/94	0	0	0	0	0	0	0	0
05/15/94	0	0	0	0	0	0	0	0
05/16/94	0	0	0	0	0	0	0	0
05/17/94	0	0	0	0	0	0	0	0
05/18/94	0	0	0	0	0	0	0	0
05/19/94	0	0	0	0	0	0	0	0
05/20/94	0	0	0	0	0	0	0	0
05/21/94	0	0	1	0	0	0	0	0
05/22/94	0	0	0	0	0	0	0	0
05/23/94	1	0	2	0	0	0	1	0
05/24/94	2	0	0	0	0	0	0	0
05/25/94	8	0	0	0	1	0	0	0
05/26/94	4	0	1	0	0	0	0	0
05/27/94	1	0	0	0	0	0	0	0
05/28/94	2	0	0	0	1	0	0	0
05/29/94	0	0	0	0	0	0	0	0
05/30/94	0	0	0	0	0	0	0	0
05/31/94	3	0	0	0	1	0	0	0
06/01/94	5	0	0	0	0	0	0	0
06/02/94	5	0	0	0	1	0	0	0
06/03/94	4	0	0	0	1	0	0	0
06/04/94	10	0	1	0	3	0	0	0
06/05/94	7	0	2	0	4	0	0	0
06/06/94	3	0	1	0	0	0	0	0
06/07/94	8	0	0	0	2	0	0	0
06/08/94	8	0	0	0	2	0	0	0
06/09/94	1	0	0	0	0	0	0	0
06/10/94	7	0	0	0	2	0	0	0
06/11/94	10	0	0	0	2	0	0	0
06/12/94	3	0	0	0	1	0	0	0
06/13/94	5	1	1	0	0	0	0	0
06/14/94	1	0	0	0	1	0	0	0
06/15/94	3	0	0	0	1	0	0	0
06/16/94	2	0	0	0	0	0	0	0
06/17/94	1	0	0	0	0	0	0	0
06/18/94	7	0	0	0	2	0	0	0
06/19/94	6	0	0	0	1	0	0	0
06/20/94	5	0	0	0	0	0	0	0
06/21/94	4	0	0	0	0	0	0	0
06/22/94	9	0	0	0	0	0	0	0
06/23/94	7	0	0	0	1	0	0	0

Appendix B. Continued.

Date	Total Chinook Adult	Total Chinook Jack	Total Steelhead	Total Sockeye	Clipped Chinook Adult	Clipped Chinook Jack	Clipped Steelhead	Clipped Sockeye
06/24/94	3	0	0	0	0	0	0	0
06/25/94	1	0	0	0	0	0	0	0
06/26/94	0	0	0	0	0	0	0	0
06/27/94	0	0	0	0	0	0	0	0
06/28/94	0	0	0	0	0	0	0	0
06/29/94	0	0	0	0	0	0	0	0
06/30/94	0	0	0	0	0	0	0	0
07/01/94	0	0	0	0	0	0	0	0
07/02/94	0	0	0	0	0	0	0	0
07/03/94	0	0	0	0	0	0	0	0
07/04/94	0	0	0	0	0	0	0	0
07/05/94	7	0	0	4	0	0	0	0
07/06/94	11	0	1	2	0	0	0	0
07/07/94	0	0	0	0	0	0	0	0
07/08/94	12	0	1	4	0	0	0	0
07/09/94	48	5	0	6	0	1	0	0
07/10/94	51	25	1	19	1	0	1	1
07/11/94	67	18	2	27	0	2	0	2
07/12/94	51	9	2	146	0	0	0	0
07/13/94	51	9	2	146	0	0	0	0
07/14/94	35	0	2	265	0	0	0	30
07/15/94	88	17	4	356	0	2	0	35
07/16/94	123	2	0	969	0	0	0	97
07/17/94	121	0	0	780	0	0	0	89
07/18/94	55	1	0	397	0	0	0	28
07/19/94	52	3	3	322	0	0	0	16
07/20/94	28	0	0	106	0	0	0	7
07/21/94	22	0	1	107	0	0	0	1
07/22/94	105	3	3	675	0	0	0	16
07/23/94	128	2	3	300	0	0	0	14
07/24/94	74	1	2	167	0	0	0	0
07/25/94	74	1	2	167	0	0	0	0
07/26/94	19	0	0	35	0	0	0	2
07/27/94	93	0	2	58	1	1	0	0
07/28/94	66	1	2	110	0	0	1	1
07/29/94	87	0	1	215	0	0	0	2
07/30/94	89	0	1	274	0	0	0	0
07/31/94	48	0	0	81	0	0	0	1
08/01/94	3	0	0	26	0	0	0	1
08/02/94	2	0	0	23	0	0	0	2
08/03/94	5	0	1	51	0	0	0	0
08/04/94	18	3	1	124	1	1	1	4
08/05/94	15	0	1	341	0	0	0	8
08/06/94	1	0	5	187	0	0	0	4

Appendix B. Continued.

Date	Total Chinook Adult	Total Chinook Jack	Total Steelhead	Total Sockeye	Clipped Chinook Adult	Clipped Chinook Jack	Clipped Steelhead	Clipped Sockeye
08/07/94	3	0	2	214	0	0	2	13
08/08/94	3	0	2	125	0	0	0	0
08/09/94	2	0	2	37	0	0	0	0
08/10/94	1	0	0	93	0	0	0	3
08/11/94	7	0	1	112	0	0	0	4
08/12/94	13	0	1	64	0	0	1	3
08/13/94	7	0	1	47	0	0	0	0
08/14/94	7	0	1	47	0	0	0	0
08/15/94	0	0	0	24	0	0	0	0
08/16/94	6	0	2	24	0	0	0	3
08/17/94	5	0	0	35	0	0	0	6
08/18/94	1	0	2	28	0	0	0	2
08/19/94	0	0	1	30	0	0	0	5
08/20/94	2	0	0	8	0	0	0	1
08/21/94	0	0	0	14	0	0	0	2
08/22/94	1	0	1	6	0	0	0	2
08/23/94	1	0	1	5	0	0	0	0
08/24/94	4	0	0	12	0	0	0	0
08/25/94	3	1	0	7	0	0	0	0
08/26/94	0	0	2	9	0	0	1	0
08/27/94	2	0	0	12	0	0	0	0
08/28/94	6	0	1	9	0	0	0	1
08/29/94	1	0	0	1	0	0	0	0
08/30/94	1	0	0	17	0	0	0	1
08/31/94	1	0	1	15	0	0	0	0
09/01/94	0	0	0	24	0	0	0	2
09/02/94	4	0	0	17	0	0	0	0
09/03/94	0	0	2	4	0	0	0	1
09/04/94	0	0	0	5	0	0	0	0
09/05/94	0	0	1	2	0	0	0	0
09/06/94	0	0	0	5	0	0	0	0
09/07/94	1	0	0	4	0	0	0	0
09/08/94	0	0	1	0	0	0	1	0
09/09/94	0	0	1	7	0	0	0	0
09/10/94	0	0	0	2	0	0	0	0
09/11/94	0	0	3	1	0	0	0	0
09/12/94	0	0	0	5	0	0	0	1
09/13/94	0	0	0	8	0	0	1	0
09/14/94	0	0	1	9	0	0	0	0
09/15/94	0	0	1	6	0	0	0	1
09/16/94	1	0	0	1	0	0	0	0
09/17/94	3	0	1	6	0	0	0	0
09/18/94	0	0	4	0	0	0	0	1
09/19/94	0	0	1	2	0	0	0	0

Appendix B. Continued.

Date	Total Chinook Adult	Total Chinook Jack	Total Steelhead	Total Sockeye	Clipped Chinook Adult	Clipped Chinook Jack	Clipped Steelhead	Clipped Sockeye
09/20/94	0	0	1	1	0	0	0	0
09/21/94	2	0	0	1	0	0	0	0
09/22/94	0	0	0	1	0	0	0	0
09/23/94	0	0	1	0	0	0	0	0
09/24/94	0	0	1	0	0	0	0	0
09/25/94	1	0	1	2	0	0	0	0
09/26/94	0	0	0	-2	0	0	0	0
09/27/94	0	0	3	0	0	0	2	0
09/28/94	0	0	0	0	0	0	0	0
09/29/94	0	0	0	0	0	0	0	0
Total	**1882**	**102**	**94**	**7595**	**30**	**7**	**12**	**413**