U.S. Fish & Wildlife Service

Estimation of Sockeye Salmon Escapement in Mortensens Creek, Izembek National Wildlife Refuge, 2006; and 2001 to 2006 Run Comparisons

Alaska Fisheries Data Series Number 2007-7

Anchorage Fish and Wildlife Field Office
Anchorage, Alaska

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Jeffry L. Anderson and Cheryl A. Dion

Abstract

A fixed picket weir and underwater video monitoring station was operated on Mortensens Creek from 18 June to 16 September 2006. Sockeye salmon *Oncorhynchus nerka* were the most abundant species counted through the weir (N = 14,788) followed by coho salmon *O. kisutch* (N = 5,003) and Dolly Varden *Salvelinus malma* (N = 890). Most sockeye salmon passed the weir at night during the high tide cycle. The weir was removed prior to the peak coho salmon run in 2006 because of budget constraints; therefore, our estimate is a minimum number. Sockeye salmon sampled at the weir were predominantly male (53%) and age 1.3 fish comprised 67% of the run. Female sockeye salmon sampled at the weir ranged in length from 504 to 581 mm and males ranged from 526 to 626 mm. Age, sex, and length data were not collected from coho salmon in 2006 because we were unable to sample the entire run. In 2006 we compared counts from motion-triggered video files to counts made by reviewing continuously recorded video files; counts were nearly identical. Motion detection functioned well except for times of high fish passage (> 300 fish/h) when small breaks in recording made it difficult to accurately count fish; continuously recorded video files were used to enumerate escapement during times of high fish passage. From 2001 to 2006, sockeye salmon escapement at the Mortensens Creek weir ranged from 4,268 to 21,703 (mean = 11,664) and coho salmon escapement ranged from 3,836 to 8,184 (mean = 5,478). The sex ratio of sockeye salmon varied over the years of the project, but no trends were apparent; age composition for sockeye salmon was similar over all years with age 1.3 predominant. Mean lengths of sockeye salmon were similar over all years of the project. Coho salmon sex composition also varied over project years without any apparent trends and age 2.1 fish were predominant each year. Mean lengths of coho salmon appeared to decline in 2004 and 2005, but we did not measure length in 2006 and did not determine if this trend continued. Sockeye and coho salmon populations in Mortensens Creek can continue to support harvest by all user groups at current levels, although the commercial fishery has the potential to overharvest this small sockeye salmon run.

Introduction

Subsistence harvest of salmon is important to residents of the villages of Cold Bay and King Cove, and residents of the two villages harvest about 4,700 sockeye *Oncorhynchus nerka* and 3,000 coho *O. kisutch* salmon each year (2000 to 2004 averages; Tschersich 2006). The outlet of Mortensens Creek is one of the few areas where sockeye and coho salmon are available for harvest by subsistence users from King Cove and Cold Bay. In 1999, escapement of sockeye salmon in Mortensens Creek was estimated to be 3,600 fish and an estimated 1,378 sockeye salmon were harvested in the subsistence and commercial fisheries (Shaul and Dinnocenzo

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2000). About 30% of the subsistence harvest of sockeye salmon was taken by Alaska residents living outside of Cold Bay and King Cove. Also in 1999, 279 coho salmon were harvested in the commercial and subsistence fisheries (Shaul and Dinnocenzo 2000). Management of both species was based on aerial surveys of escapements, but effectiveness of these surveys was limited by dark stream bottoms, turbid water, and inclement weather. An escapement goal for Mortensens Creek of 3,200 to 6,400 has been established for sockeye salmon, but currently there is no goal for coho salmon (Nelson and Lloyd 2001).

The Alaska Department of Fish and Game (ADFG) was concerned that the lack of an in-season estimate of sockeye and coho salmon escapement into Mortensens Creek could jeopardize the continued health of these runs, as well as limit opportunities for subsistence and sport fishing (Arnold Shaul, ADFG, personal communication). Additionally, King Cove residents were concerned about sport fishing effects on coho salmon. Although specific sport harvest data are not available for Mortensens Creek, the ADFG estimated an average sport harvest of 671 coho salmon from 1996 to 1998 in the Cold Bay area, which includes Russell and Mortensens creeks (Howe et al. 1997, Howe et. al. 1998, and Howe et al. 1999).

In 2001, the King Salmon Fish and Wildlife Field Office (KSFO) received funding from the U.S. Fish and Wildlife Service (USFWS) Office of Subsistence Management to address these concerns. Beginning in January 2007, the KSFO has become the Fisheries Branch of the Anchorage Fish and Wildlife Field Office. The KSFO operated a fish counting weir on Mortensens Creek to estimate escapement of sockeye and coho salmon. Project objectives were to:

1. Enumerate daily passage of sockeye and coho salmon through a weir on Mortensens Creek;
2. Describe the run-timing of sockeye and coho salmon through the weir;
3. Estimate the sex and age compositions of sockeye and coho salmon such that simultaneous 90% confidence intervals have a maximum width of 0.20;
4. Estimate the mean length of sockeye and coho salmon by sex and age;
5. Determine if the sockeye and coho salmon returns to Mortensens Creek are adequate to allow subsistence fishing; and
6. Determine if the sockeye and coho salmon returns to Mortensens Creek are adequate to allow sport fishing.

The USFWS is responsible for management of subsistence fisheries occurring in Mortensens Creek and prior to 2006 was also responsible for management of subsistence fisheries in Mortensens Lagoon. The ADFG manages commercial and sport fisheries in Mortensens Creek and Lagoon, and beginning in 2006 is also responsible for managing subsistence fisheries in Mortensens Lagoon. Subsistence fishing in Mortensens Creek and Lagoon requires a permit issued by the ADFG, and current regulations limit subsistence harvest in Mortensens Lagoon to 50 salmon per permit (5 AAC 01.423).

This report provides results from the 2006 field season, and also provides an overall project summary and run comparisons for sockeye and coho salmon, 2001 to 2006. Detailed information on previous years can be found in the individual annual reports (Whitton 2002 and 2003; Cornum et al. 2004; Dion 2005; Hildreth and Dion 2006).

Study Area

Mortensens Creek is located on the southwestern tip of the Alaska Peninsula near the town of Cold Bay, Alaska, approximately 1,050 km southwest of Anchorage (Figure 1). Climate in the area is characterized by high winds, moderate temperatures, protracted cloud cover, and frequent precipitation (USFWS 1985). The drainage area of the Mortensens Creek watershed is approximately 18 km^2, and consists of numerous springs and ponds, several small tributaries, and a shallow (< 2 m) 112-ha lake. Mortensens Creek is a low gradient tundra stream with stable stream banks, with a riparian area composed primarily of grasses and forbs. Turbidity in Mortensens Creek is relatively high, and can be aggravated by high winds which frequently churn up the substrate of the lake. Mortensens Creek discharges into Mortensens Lagoon, which feeds into the North Pacific Ocean via Cold Bay. Mortensens Lagoon is a shallow tidal area of approximately 2 km^2, and is sheltered by two sand spits where it enters Cold Bay. Migrating salmon often stage in Mortensens Lagoon and enter Mortensens Creek when tide and wind conditions are optimal.

Mortensens Creek supports spawning populations of sockeye salmon, coho salmon, and Dolly Varden *Salvelinus malma*; chum *O. keta* and pink *O. gorbuscha* salmon are also present, but in limited numbers. Bering cisco *Coregonus laurettae*, sculpin *Cottus* spp., and starry flounder *Platichthys stellatus* have also been observed in Mortensens Creek, but abundance of these species is unknown.

Methods

Escapement Monitoring

The KSFO installed and operated a fish counting weir on Mortensens Creek from 18 June to 16 September 2006. We were unable to keep the weir in place for the duration of the coho salmon run (mid October) because the funding commitment for the project ended on 30 September and all project equipment needed to be removed from the field and returned to King Salmon prior to that date. The weir panels were constructed of 2-m long aluminum pickets with 2-cm spacing between each picket. Each weir panel had a minimum of three cross pieces that were welded to the pickets to provide rigidity. Weir panels were supported by fence posts and an 8-mm diameter galvanized aircraft cable stretched across the stream. The supporting cable was anchored to the stream banks using “dead men” buried vertically at a depth that allowed the cable to be suspended under tension just above the water surface. Weir panels were placed across the channel, connected together and to the supporting cable with plastic cable ties, and the continuous panel was tilted downstream in relation to stream flow to shunt debris to the water surface, thereby maintaining free-flow of water through the pickets. A permeable textile cloth was placed under the weir to prevent undercutting. A fyke was installed in the weir, leading to an upstream migrant live trap. The entire weir was inspected and cleaned daily and maintained as necessary to ensure integrity.

An underwater video monitoring system was incorporated into the weir to facilitate fish passage and reduce the number of fish handled. The system included an underwater camera, camera box, video monitoring chute, lights, and digital video recorders (DVR). Anderson et al. (2006) provides details of the video monitoring system design and components. The video monitoring system was operated 24 h/d to allow unimpeded fish passage. Except for fish sampled in the live trap, all fish passage at the Mortensens Creek weir was enumerated with the video monitoring system in 2006.

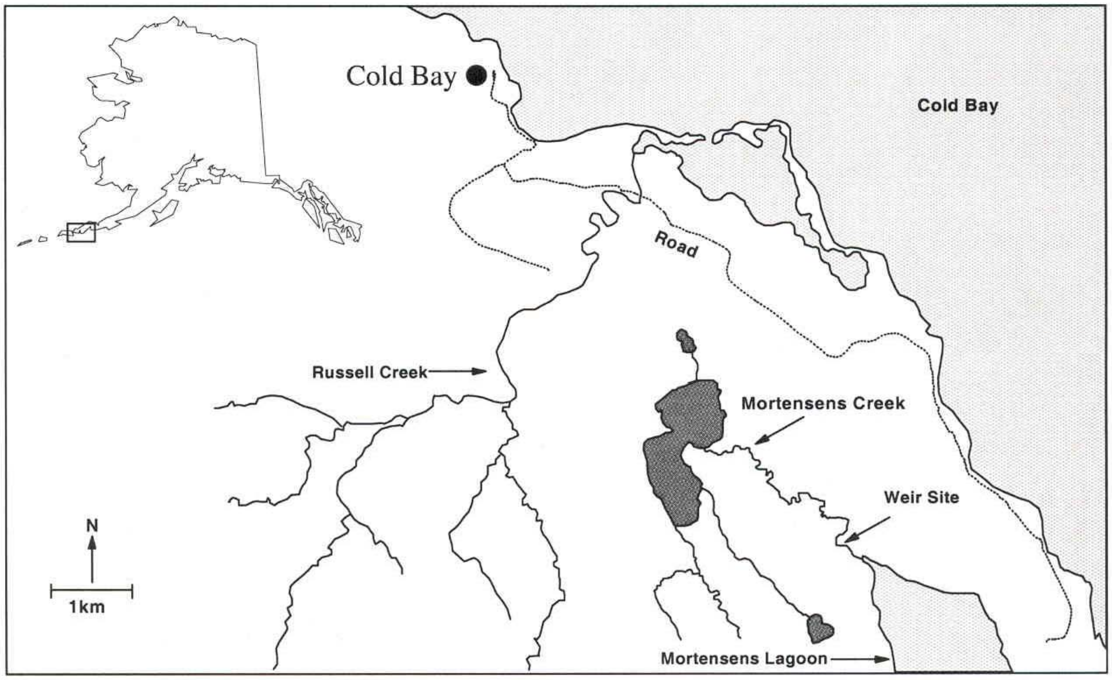

Figure 1. Mortensens Creek weir location, southwest Alaska.

Two DVR were used in 2006 to test the effectiveness of the motion detection system. One DVR recorded full quality (30 frames/s) fish passage 24 h/d and the date, time, and percent of remaining hard disk space were digitally encoded as a date time stamp on the video file. The second DVR was set to record full quality (30 frames/s) motion-triggered video files. Motion detection recording in the second DVR was activated in response to a moving object causing a change in the brightness in user-defined detection zones with user-defined trigger sensitivity. The second DVR was configured to record a 3-s pre-event in a memory buffer so the recorder could access and record the video that preceded each motion-triggered event. Motion-triggered video files were set to record for 10 s, but video footage would continue to record as long as fish were activating the motion detection. For a single fish passing directly through the video monitoring chute, 13 s of video were recorded (3-s pre-event plus a 10-s motion-triggered event). The date, time, file number, and percent of remaining hard disk space were digitally encoded as a date-time stamp on each video file.

Effectiveness of motion detection was assessed by comparing hourly fish counts tallied from reviewing a constant recording of the selected hour of fish passage on the first DVR to counts tallied by reviewing motion-triggered video files recorded on the second DVR during the same hour. Count comparison hours were initially selected randomly each day, but were later selected randomly within the high tide cycle to increase the probability of selecting hours of high fish passage. Differences between motion detection and constant recording counts were investigated with scatter plots, a sign test (Zar 1996), and correlation analysis. Results were considered significant at $P < 0.05$.

Fish counts were made by reviewing either motion-triggered video files or the constant recording of fish passage. When reviewing motion-triggered video files, we used the time/date search function of the DVR to retrieve the first file to review. The "Play" button was pressed and the recorded file would play back on the monitor. The DVR had numerous file review features that assisted in identification and counting of passing fish. The image could be played forwards or backwards at various speeds, or paused and zoomed to assist in counting or species identification. Video files were reviewed sequentially until all fish passing through the video monitoring chute were identified and counted. Reviewing the constant recording of fish passage was similar to above, except only one continuous video file was reviewed.

Beginning in mid July when sockeye salmon started passing the weir in large numbers, fish counts were tallied every hour and the associated tide cycle (high or low) was recorded. These data were used to calculate hourly passage rates and to correlate fish passage with time of day and tide cycle. We also recorded wind speed and staff height throughout the course of the field season to investigate the effects of wind and tides on fish migration in Mortensens Creek.

Power to operate the video equipment was provided by a combination of two solar panel arrays, two wind generators, and a 12-V DC battery bank. A 3,000-W gasoline-powered generator and 75-A battery charger were also used as a backup power source when solar and wind energy did not meet our needs.

Age, Sex, and Length Data

We collected sockeye salmon age, sex, and length (ASL) data using a temporally stratified sampling design (Cochran 1977) with statistical weeks defining strata. Samples were collected uniformly throughout the week (Sunday through Saturday). To avoid potential bias caused by the selection or capture of individual fish, all target species within the live trap were included in the sample even if the sample size goal for a species was exceeded. Although weir passage was stratified into statistical weeks a priori, strata for the analysis of sockeye salmon biological data at the Mortensens Creek weir were modified following the field season to represent actual weir passage (Table 1).

Samples for ASL data were collected using a dip net to remove fish from the live trap at least once daily or more often as the number of fish moving through the weir increased. Adult salmon were measured to the nearest mm (mid-eye to tail fork) and the sex of the fish was determined from secondary characteristics. One scale from each sockeye salmon was removed from the preferred area on the left side of the fish (Jearld 1983), cleaned, and mounted on gummed scale cards. Sockeye salmon scales were pressed and aged following the field season by ADFG personnel. Salmon ages are reported according to the European method described by Jearld (1983) and Mosher (1968), where the number of winters the fish spent in fresh water and in the ocean is separated by a decimal. Fish with scales that could not be aged were not included in the age analyses. Non-target fishes captured in the live trap were identified to species, enumerated, and released above the weir. Fish were not allowed to hold downstream of the weir. If this occurred, the live trap was closed and the video monitoring chute was opened to facilitate upstream passage.

Maximum weekly sample size goals for sockeye salmon were established such that simultaneous 90% interval estimates of age composition for each week have maximum widths of 0.20 based on a multinomial sampling model (Bromaghin 1993). The weekly sample size determined from Bromaghin (1993) was n = 121 based on four age categories, and was increased to 142 to account for the expected number of unreadable scales (about 15% in past years). For some weeks, the sample size goal was expected to be a substantial fraction of the sockeye salmon passage. Therefore, during weeks of low passage when the maximum sample size goal could not

Table 1. Strata (time periods) used for analysis of sockeye salmon biological data at Mortensens Creek, 2006.

Stratum	Dates
1	18 Jun – 15 Jul
2	16 – 22 Jul
3	23 – 29 Jul
4	30 Jul – 5 Aug
5	6 – 12 Aug
6	13 – 19 Aug
7	20 – 26 Aug
8	27 Aug – 2 Sep
9	3 – 16 Sep

be practically obtained, about 20% of the weekly escapement was sampled. This was sufficient to describe the age composition and reduce the number of fish handled at the weir. For sample size determination, major age categories (1.2, 1.3, 2.2, and 2.3) were defined from previous work (Whitton 2002 and 2003; Cornum et al. 2004; Dion 2005).

Characteristics of sockeye salmon passing through the weir were estimated using standard stratified random sampling estimators (Cochran 1977). Within a given stratum *m*, the proportion of species *i* passing the weir that are of sex *j* and age *k* (p_{ijkm}) was estimated as

$$\hat{p}_{ijkm} = \frac{n_{ijkm}}{n_{i++m}},$$

where n_{ijkm} denotes the number of fish of species *i*, sex *j*, and age *k* sampled during stratum *m* and a subscript of "+" represents summation over all possible values of the corresponding variable, e.g., n_{i++m} denotes the total number of fish of species *i* sampled in stratum *m*. The variance of $\hat{p}_{ijkm}$ was estimated as

$$\hat{v}(\hat{p}_{ijkm}) = \left(1 - \frac{n_{i++m}}{N_{i++m}}\right)\frac{\hat{p}_{ijkm}\left(1 - \hat{p}_{ijkm}\right)}{n_{i++m} - 1},$$

where N_{i++m} denotes the total number of species *i* fish passing the weir in stratum *m*. The estimated number of fish of species *i*, sex *j*, age *k* passing the weir in stratum *m* ($\hat{N}_{ijkm}$) was

$$\hat{N}_{ijkm} = N_{i++m}\,\hat{p}_{ijkm},$$

with estimated variance

$$\hat{v}(\hat{N}_{ijkm}) = N_{i++m}^2 \hat{v}(\hat{p}_{ijkm}).$$

Estimates of proportions for the entire period of weir operation were computed as weighted sums of the stratum estimates, i.e.,

$$\hat{p}_{ijk} = \sum_m \left(\frac{N_{i++m}}{N_{i+++}} \right) \hat{p}_{ijkm},$$

and

$$\hat{v}\left(\hat{p}_{ijk}\right) = \sum_m \left(\frac{N_{i++m}}{N_{i+++}} \right)^2 \hat{v}\left(\hat{p}_{ijkm}\right).$$

The total number of fish in a species, sex, and age category passing the weir during the entire period of operation was estimated as

$$\hat{N}_{ijk} = \sum_m \hat{N}_{ijkm},$$

with estimated variance

$$\hat{v}\left(\hat{N}_{ijk}\right) = \sum_m \hat{v}\left(\hat{N}_{ijkm}\right).$$

If the length of fish of species *i*, sex *j*, and age *k* sampled in stratum *m* is denoted x_{ijkm}, the sample mean length of fish of species *i*, sex *j*, and age *k* within stratum *m* was calculated as

$$\bar{x}_{ijkm} = \frac{\sum x_{ijkm}}{n_{ijkm}},$$

with corresponding sample variance s_{ijkm}^2

$$s_{ijkm}^2 = \left(1 - \frac{n_{ijkm}}{\hat{N}_{ijkm}} \right) \frac{\sum \left(x_{ijkm} - \bar{x}_{ijkm} \right)^2}{n_{ijkm} - 1}.$$

The mean length of all fish of species *i*, sex *j*, and age *k* ($\hat{\bar{x}}_{ijk}$) was estimated as a weighted sum of the stratum means, i.e.,

$$\hat{\bar{x}}_{ijk} = \sum_m \left(\frac{\hat{N}_{ijkm}}{\hat{N}_{ijk}} \right) \bar{x}_{ijkm}.$$

An approximate estimator of the variance of $\hat{\bar{x}}_{ijk}$ was obtained using the delta method (Seber 1982),

$$\hat{v}\left(\hat{\bar{x}}_{ijk}\right) = \sum_{m} \left\{ \hat{v}\left(\hat{N}_{ijkm}\right) \left[\frac{x_{ijkm}}{\sum_{x} \hat{N}_{ijkx}} - \sum_{y} \frac{\hat{N}_{ijky}}{\left(\sum_{x} \hat{N}_{ijkx}\right)^2} x_{ijky} \right]^2 + \left(\frac{\hat{N}_{ijkm}}{\sum_{x} \hat{N}_{ijkx}} \right)^2 s_{ijkm}^2 \right\}.$$

Results

Escapement Monitoring

An estimated 14,788 sockeye salmon migrated past the Mortensens Creek weir in 2006 (Table 2). Peak sockeye salmon passage occurred over a three day period from 8 to 10 August when over 6,600 fish passed the weir (Figure 2; Appendix A). In general, most sockeye salmon passed the Mortensens Creek weir at night during the high tide cycle (Figure 3). Sockeye salmon were first observed at the weir on 21 June and some were still passing the site on the last day the weir was operated (16 September). It is unlikely that many sockeye salmon entered Mortensens Creek prior to weir installation on 18 June or after the weir was removed on 17 September. Sockeye salmon passage rates at the Mortensens Creek weir averaged 17 fish/h over the course of the season (range 0 to 1,043).

An estimated 5,003 coho salmon, 138 pink salmon, 25 chum salmon, and 890 Dolly Varden passed the Mortensens Creek weir in 2006 (Figure 2; Appendix A). Coho salmon were first observed at the weir on 23 August, and a peak count of 2,092 fish occurred on 7 September. Although counts dropped considerably after this date, we do not know how much of the coho salmon run occurred after the weir was removed on 17 September. Starry flounder (n = 108), Bering cisco (n = 4), and sculpin (not counted) were also observed at the Mortensens Creek weir in 2006. Underwater video was used to count almost all fish passage at the Mortensens Creek weir in 2006. The only time fish did not pass through the video monitoring chute was when we needed to collect fish for biological samples in the live trap.

Thirty-seven hours were selected to compare paired counts from motion detection files and continuous recordings of fish passage in 2006 (Figure 4; Appendix B). Paired counts were identical for total numbers and individual species tallies for all but six of the selected hours. For five hours in which total counts differed, the maximum difference was only one fish. For the sixth hour in which total counts differed, a pink salmon was misidentified as a sockeye salmon during the continuous recording count, while the overall total fish count was the same for both methods. For the other five hours in which total counts differed: 1) a starry flounder was observed during review of the motion detection files, but was not observed during review of the continuous recording; 2) a sculpin was observed during continuous recording review that was bit recorded in the motion detection file; 3) one additional sockeye salmon was counted during the continuous recording review than was counted during the motion detection file review; 4) one additional sockeye salmon was counted during the motion detection file review than during the continuous recording review; and 5) one Dolly Varden was counted during the continuous recording review that was not recorded in the motion detection file until only its tail was visible and species identification was not possible. Counts from both methods were highly correlated (r = 0.99; P < 0.001) and a sign test did not detect a difference between the number of positive and

Table 2. Annual escapement estimates of Pacific salmon and Dolly Varden at the Mortensens Creek weir, 2001 to 2006. NC = not counted.

	Species				
Year	Sockeye Salmon	Coho Salmon	Chum Salmon	Pink Salmon	Dolly Varden
2001[a]	4,268	5,279	21	15	NC
2002[b]	5,205	6,406	55	16	NC
2003[c]	16,804	8,184	18	40	NC
2004[d]	7,215	3,836	13	22	289
2005[e]	21,703	4,162	13	164	153
2006	14,788	5,003	25	138	890

[a] Whitton (2002)
[b] Whitton (2003)
[c] Cornum et al. (2004)
[d] Dion (2005)
[e] Hildreth and Dion (2006)

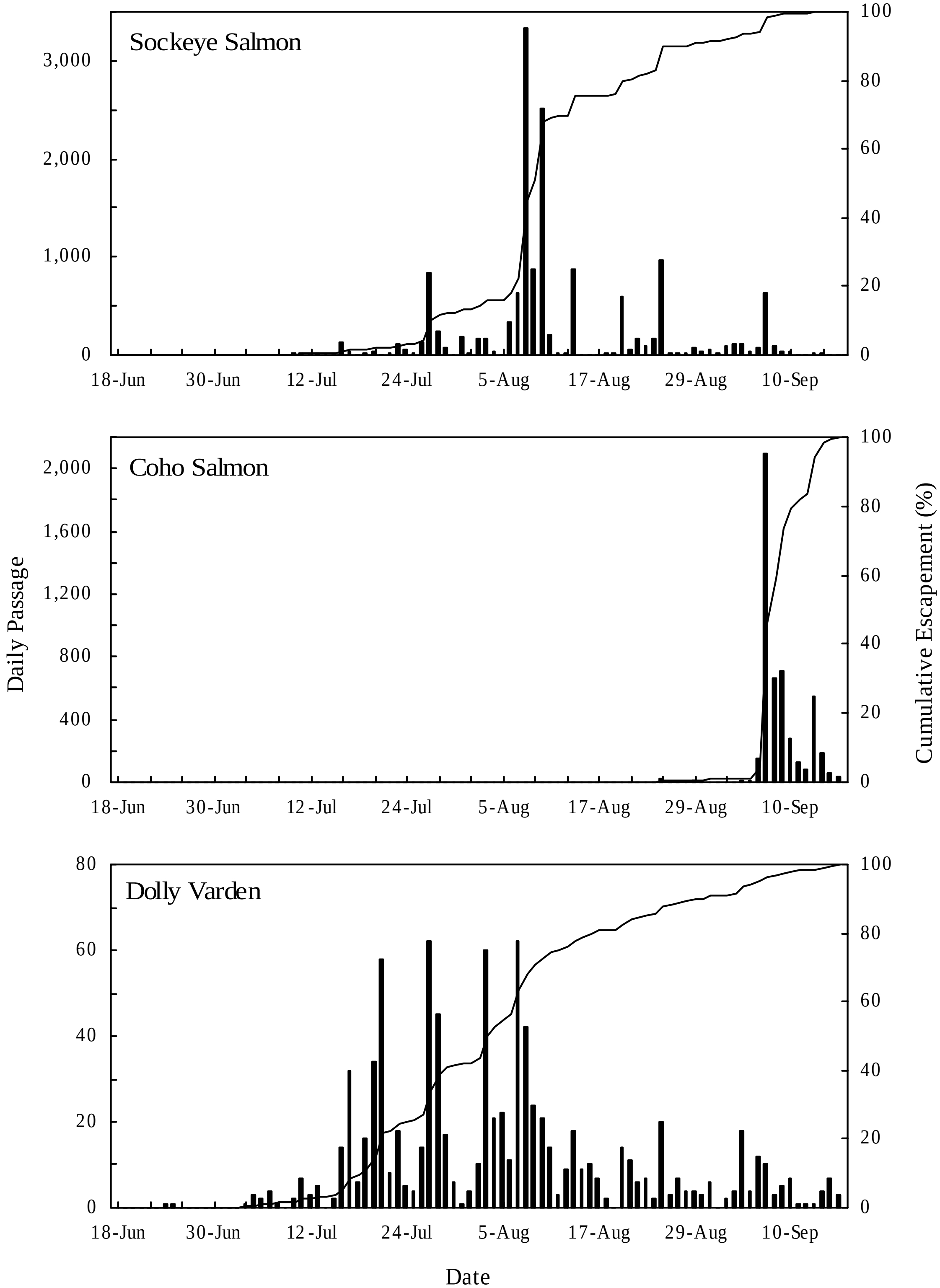

Figure 2. Daily passage (bars) and cumulative escapement (line) of sockeye salmon, coho salmon, and Dolly Varden at the Mortensens Creek weir, 2006.

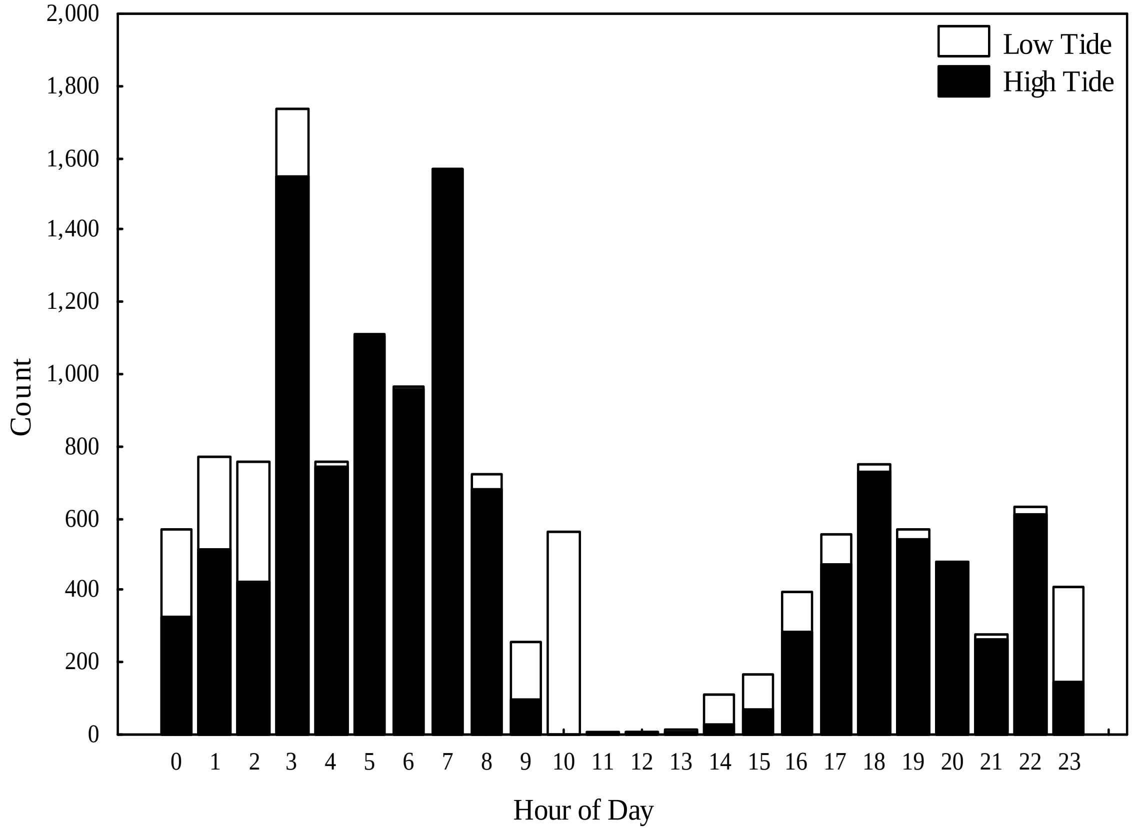

Figure 3. Sockeye salmon passage by hour of day and tide state (high or low) at the Mortensens Creek weir, 2006.

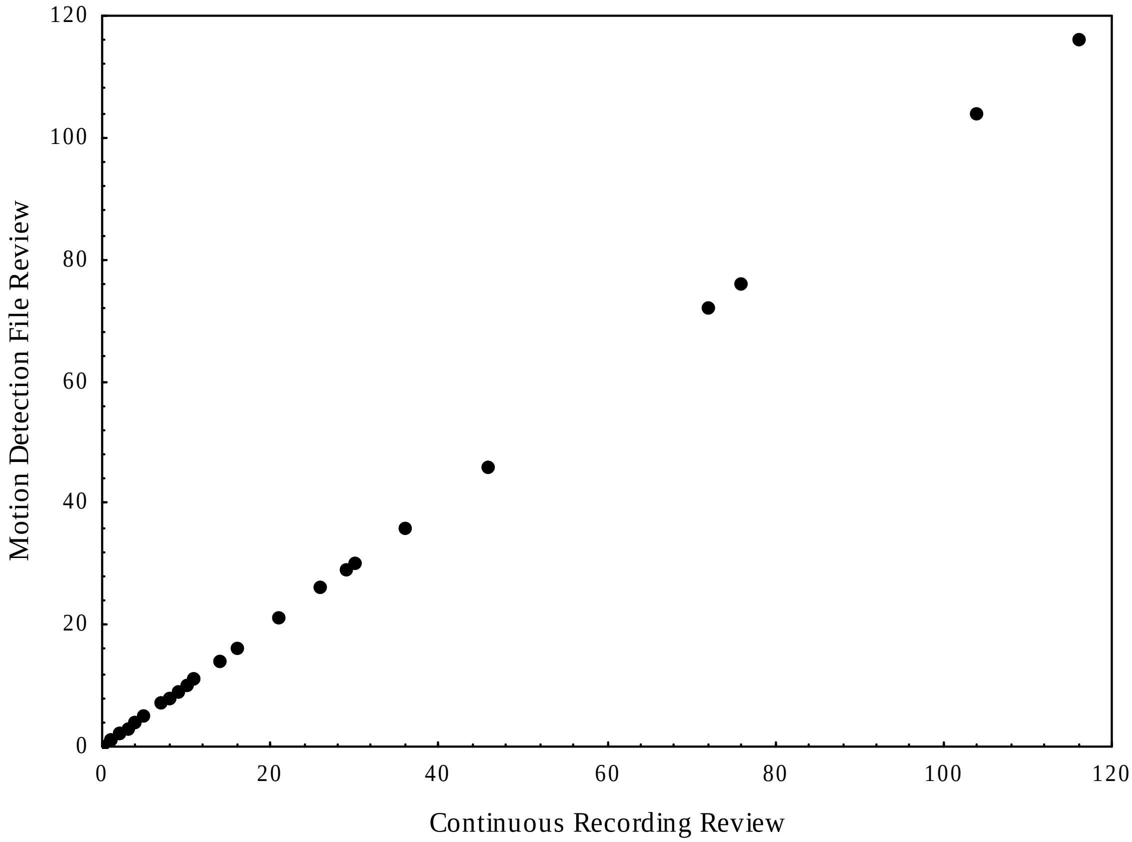

Figure 4. Comparison of fish counts obtained using a review of continuous recorded fish passage and motion detection files at Mortensens Creek, 2006.

negative differences between data pairs (Z = 0.00; P = 1.00). Fish passage rates for the selected hours averaged 19 fish/hr (range 0 to 116). For seven of the selected hours, no fish were observed with either method. Our random sampling of hours to compare did not include passage rates greater than 150 fish/h. However, we do not believe our sampling was biased because passage rates higher than 150 fish/h were only observed in 2% of all hours sampled and represented only 8% of all non-zero fish passage hours (Figure 5).

The crew used review of continuous recordings to enumerate and identify fish during high passage rates (> 300 fish/h) because motion detection was not adequate for accurate counts. During high fish passage rates (> 300 fish/h), motion detection files did not record constantly and 1- to 2-s breaks in the recording made counting difficult as the crew was uncertain whether the tail of a fish seen exiting the field of view at the beginning of a file was the same fish that they had already counted entering the field of view from the previous file. Also, reviewing motion detection files during high passage rates did not provide any time savings benefits compared to time-lapse review since motion detection files essentially recorded constantly. Fish passage rates only exceeded 300 fish/h on ten occasions in 2006.

The use of motion detection files to enumerate passage was also affected by localized water conditions in 2006. Strong incoming tides combined with high winds caused extreme reductions in visibility on some occasions. The combination of strong tides and winds churned up mud in Mortensens Lagoon and caused visibility to be almost totally obscured for up to 5 min and to be

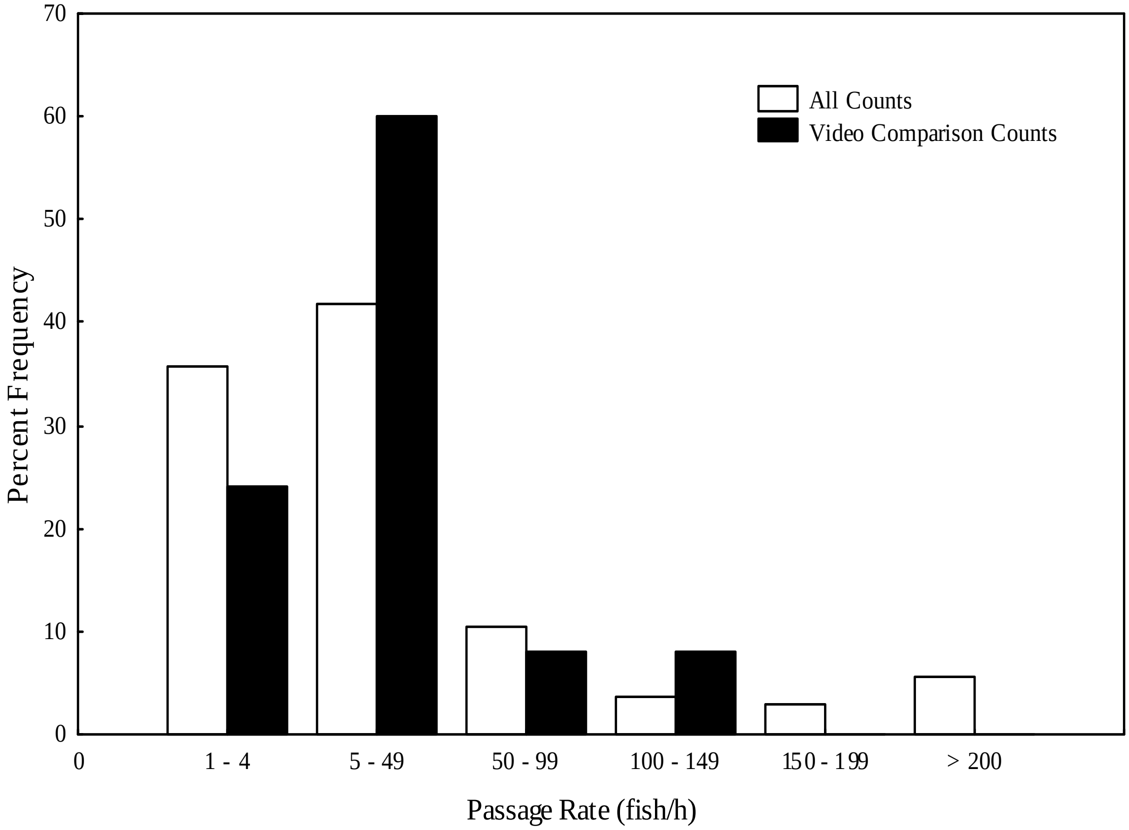

Figure 5. Histogram of non-zero passage rates of sockeye salmon at Mortensens Creek weir, 2006. Total non-zero hours counted were *n* = 25 for video comparison counts and *n* = 308 for all other counts.

noticeably poor for up to 15 min. Motion detection was not functional during these times, although review of continuous recordings was still possible. The crew was not able to adjust the motion detection sensitivity to trigger alarm recording when fish passed during these conditions.

Motion detection functionality was also affected later in the season by dirty glass in the camera box. Because of minor alterations to the video monitoring chute, necessary to correct intermittent fish passage problems, the crew was no longer able to clean the glass without completely disassembling the chute. Although the crew was able to adjust the motion detection sensitivity, fish would sometimes not trigger an alarm until they had almost completely passed through the field of view and review of motion detection files was not as efficient as when the glass was clean.

Age, Sex, and Length Data

Age, sex, and length data were collected from 814 sockeye salmon from 27 June to 11 September. Eleven age classes were identified from scale samples in 2006, although only three age classes (1.2, 1.3, and 2.3) accounted for over 93% of the sample. Over all strata, age 1.3 fish comprised the majority of the run (67%, Table 3); ages 1.2 (8%) and 2.3 (18%) sockeye salmon were also abundant. Scales were unreadable or regenerated for 141 (17%) samples. Over all strata in 2006, 47% of the sockeye salmon sampled were females (Table 4). Sex composition varied by sample period and ranged from 42% females in stratum 2 to 60% females in strata 1

Table 3. Estimated age composition (%) of sockeye salmon by stratum in Mortensens Creek, 2006. Data are only presented for age classes comprising more than 2% of the sample.

	Age		
	1.2	1.3	2.3
		Stratum 1	
%	0	57	43
SE (%)	--	19.2	19.2
n	0	4	3
		Stratum 2	
%	4	70	23
SE (%)	2.2	5.4	4.9
n	2	40	13
		Stratum 3	
%	5	74	17
SE (%)	1.9	3.7	3.2
n	7	96	22
		Stratum 4	
%	6	67	23
SE (%)	2.2	4.3	3.9
n	6	66	23
		Stratum 5	
%	8	74	14
SE (%)	2.5	3.9	3.1
n	10	91	17
		Stratum 6	
%	6	47	29
SE (%)	5.8	12.4	11.3
n	1	8	5
		Stratum 7	
%	6	58	30
SE (%)	2.0	4.0	3.7
n	9	82	42
		Stratum 8	
%	12	57	19
SE (%)	4.7	7.2	5.7
n	5	24	8
		Stratum 9	
%	20	51	15
SE (%)	5.2	6.4	4.6
n	12	30	9
		Total	
%	8	67	18
SE (%)	1.5	2.4	2.0
n	52	441	142

Table 4. Estimated sex composition, sample size, and escapement of sockeye salmon by stratum in Mortensens Creek, 2006.

		Sex			
Stratum	*n*	Female (%)	Male (%)	SE (%)	Escapement
1	10	60	40	15.1	69
2	65	42	58	5.3	256
3	159	43	57	3.7	1,458
4	120	50	50	4.1	582
5	145	46	54	4.1	7,919
6	25	60	40	9.9	935
7	172	51	49	3.7	2,084
8	49	55	45	6.6	298
9	69	43	57	5.8	1,187
Total	696	47	53	2.4	14,788

and 6. Lengths of sockeye salmon sampled in 2006 ranged from 427 to 581 mm for females, and from 420 to 626 mm for males (Table 5, Figure 6). In general, males were longer than females at a given age and the more winters a fish spent in the ocean, the larger its size.

Discussion

Sockeye salmon escapement in Mortensens Creek ranged from 4,268 to 21,703 over the six years of the project, and met or exceeded the ADFG escapement goal (3,200 to 6,400) every year (Table 2). Run timing past the Mortensens Creek weir was also variable over the duration of the project, with earlier run timing observed in 2002 and 2004 (Figure 7; Appendix C). The mean 50th percentile passage over the six year period was 7 August; run timing in 2002 and 2004 was about two weeks earlier than average (Appendix C). Commercial harvest of sockeye salmon outside Mortensens Lagoon exceeded escapement past the weir in 2002 and 2003, although some fish harvested may not have been destined to spawn in Mortensens Creek (Table 6). Subsistence harvest in Mortensens Lagoon was greatest in 2003 and 2004, but was less than 20% of the run in all years except 2000 and 2004 (Table 6). Residents of Cold Bay depend on subsistence harvest of sockeye salmon in Mortensens Lagoon more than other areas, while King Cove residents gather more subsistence sockeye salmon in places besides Mortensens Lagoon (Table 7). Less than 400 sockeye salmon were harvested in the sport fishery in 2002 (n = 104) and 2003 (n = 360) based on creel surveys (Whitton 2003; 2004). It appears that the sockeye salmon population in Mortensens Creek can be self-sustaining with current levels of subsistence and sport harvest, although the commercial fishery has the potential to overharvest this small run.

Table 5. Mean length (mm), SE, range, and sample size by sex and age taken from sockeye salmon at the Mortensens Creek weir, 2006. Data are only presented for age classes comprising more than 2% of the sample.

	Age		
	1.2	1.3	2.3
		Female	
Mean	504	545	545
SE	7	10	11
Minimum	485	427	501
Maximum	553	581	581
n	19	220	67
		Male	
Mean	526	576	574
SE	11	13	13
Minimum	420	483	509
Maximum	580	625	626
n	33	221	75
		Total	
Mean	520	561	560
SE	11	15	14
Minimum	420	427	501
Maximum	580	625	626
n	52	441	142

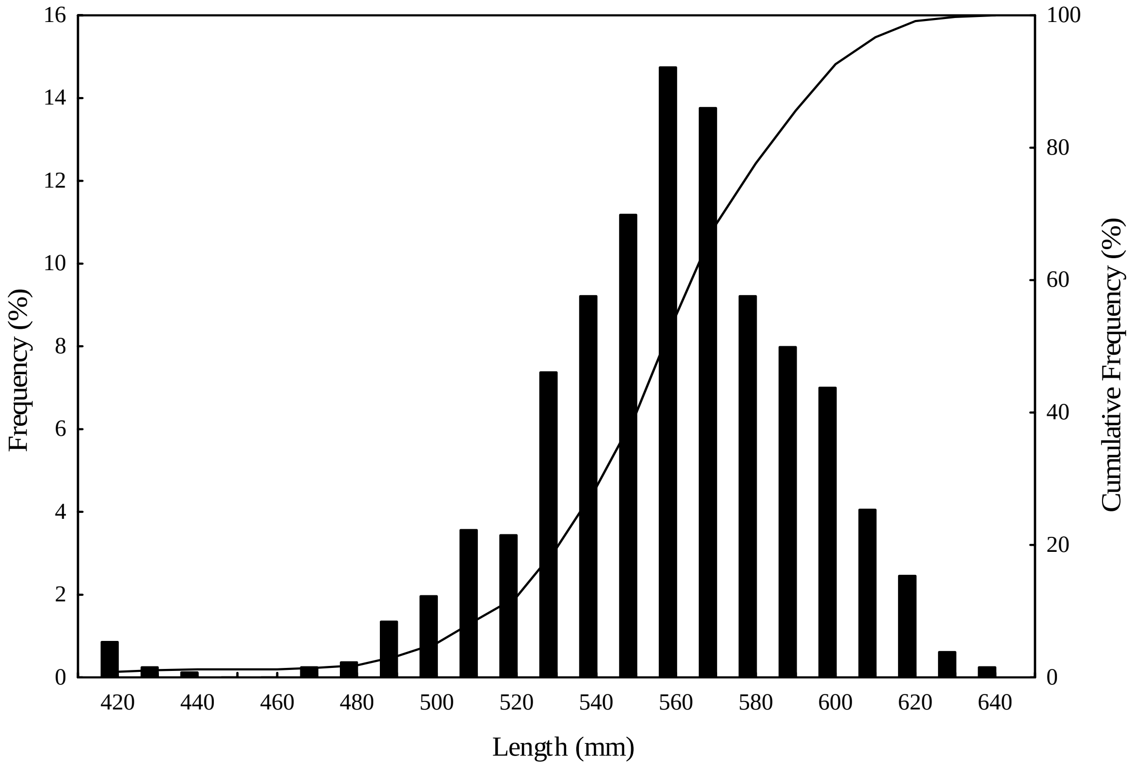

Figure 6. Length frequency distribution of sockeye salmon sampled at the Mortensens Creek weir, 2006.

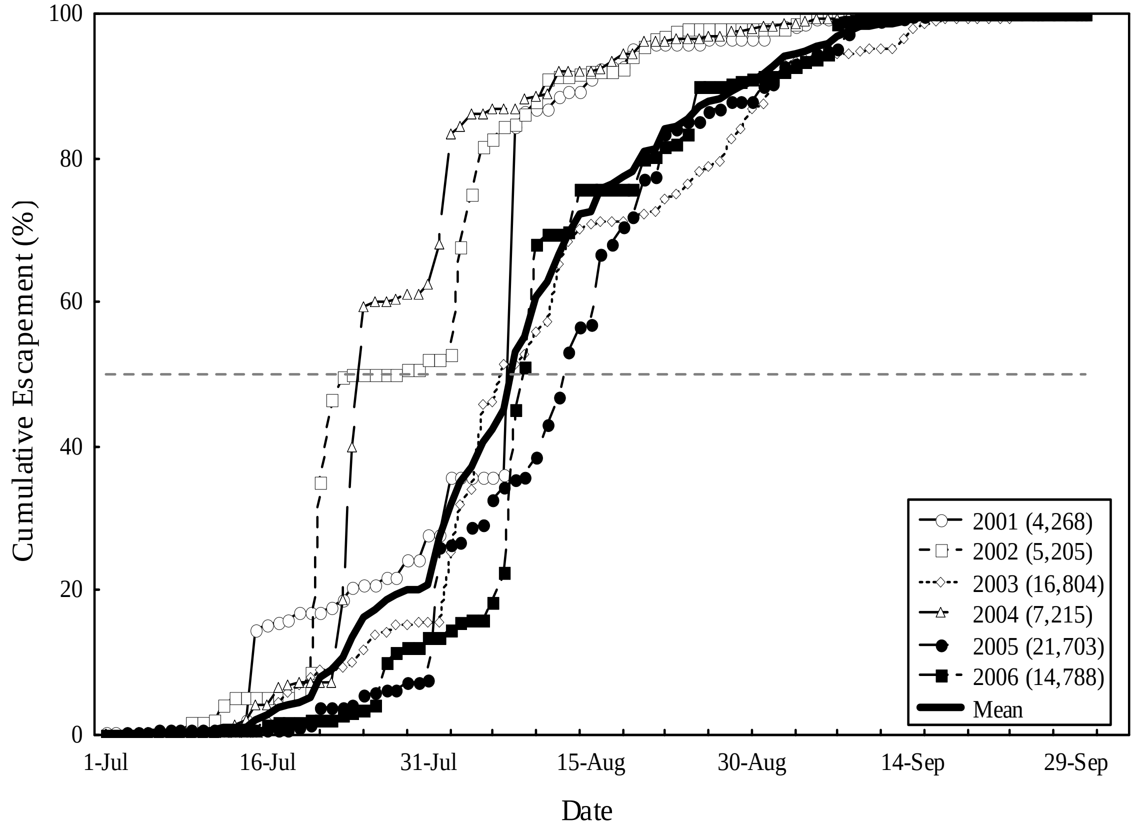

Figure 7. Cumulative escapement of sockeye salmon at the Mortensens Creek weir, 2001 to 2006. Total escapement numbers for each year are in parenthesis in legend.

Table 6. Subsistence and commercial harvest, and escapement of sockeye and coho salmon in Mortensens Lagoon, 2000 to 2005.

	Sockeye Salmon			Coho Salmon		
	Harvest			Harvest		
Year	Subsistence	Commercial	Escapement	Subsistence	Commercial	Escapement
2000[a]	844	665	3,800	291	88	--
2001[b]	918	2,254	4,268	87	0	5,279
2002[c]	811	18,872	5,205	77	0	6,406
2003[d]	1,817	16,998	16,804	434	0	8,184
2004[e]	1,623	3,962	7,215	146	50	3,836
2005[f]	992	2,252	21,703	81	0	4,162

[a] Harvest and escapement data from Shaul and Dinnocenzo (2001)
[b] Harvest data from Shaul and Dinnocenzo (2002)
[c] Harvest data from Shaul and Dinnocenzo (2003)
[d] Harvest data from Shaul and Dinnocenzo (2004)
[e] Harvest data from Shaul and Dinnocenzo (2005)
[f] Harvest data from Tschersich (2006)

Table 7. Sockeye salmon subsistence harvest by location for residents of Cold Bay and King Cove villages, 2000 to 2005.

	Cold Bay Residents			King Cove Residents		
	Harvest Area			Harvest Area		
Year	Mortensens	Other	Total	Mortensens	Other	Total
2000[a]	403	150	553	328	2,016	2,344
2001[b]	312	200	512	494	3,488	3,982
2002[c]	473	20	493	167	4,342	4,509
2003[d]	594	0	594	1,115	4,105	5,220
2004[e]	438	94	532	442	4,946	5,388
2005[f]	679	0	679	844	3,853	4,697

[a] Shaul and Dinnocenzo (2001)
[b] Shaul and Dinnocenzo (2002)
[c] Shaul and Dinnocenzo (2003)
[d] Shaul and Dinnocenzo (2004)
[e] Shaul and Dinnocenzo (2005)
[f] Tschersich (2006)

Age composition of sockeye salmon sampled at Mortensens Creek was consistent over the years except for 2004 (Table 8). Age 1.3 was the predominant age class of sockeye salmon observed at the weir, accounting for over two thirds of the run. In 2004, age 1.3 sockeye salmon were also dominant, but age 2.2 fish accounted for one fourth of the run; age 2.2 sockeye salmon were a minor component of the run in all other years. In all years except 2005, males were more common than females in Mortensens Creek (Table 8). Mean lengths of sockeye salmon by age varied over years (Table 9). Fish that spent three winters in the ocean were larger than fish that spent two winters in the ocean in all years regardless of the length of freshwater rearing.

Coho salmon escapement in Mortensens Creek ranged from 3,836 to 8,184 over the six years of the project, although a complete count was not obtained in 2006 (Table 2). Run timing past the Mortensens Creek weir was consistent in all years except 2002, when the 50th percentile passage occurred about two weeks after the average for all other years (Figure 8; Appendix D). In most years, the majority of coho salmon passage in Mortensens Creek occurred in one or two large pulses of fish (Appendix D). Commercial and subsistence harvest of coho salmon outside Mortensens Lagoon has been minimal in recent years (Table 6), and sport harvest was less than 500 fish in 2002 (n = 140) and 2003 (n = 483) based on creel surveys (Whitton 2003; 2004). Current levels of harvest should have little impact on the coho salmon population in Mortensens Creek.

Age 2.1 coho salmon were the dominant age class in all years of sampling at Mortensens Creek, although age 1.1 fish comprised a greater percentage of the run in 2004 and 2005 compared to previous years (Table 10). We did not collect biological samples from coho salmon in 2006, so we do not know if this trend has continued. Males were more common than females at the weir

Table 8. Sockeye salmon sex and age composition (standard errors in parentheses) at the Mortensens Creek weir, 2001 to 2006. Data are only presented for age classes comprising more than 2% of the sample.

		Age (%)				
Year	% Female	0.3	1.2	1.3	2.2	2.3
2001[a]	42 (2.5)	3 (0.9)	16 (2.0)	67 (2.7)	4 (1.3)	7 (1.5)
2002[b]	47 (1.7)	1 (0.4)	17 (1.4)	73 (1.6)	3 (0.6)	6 (0.8)
2003[c]	44 (1.6)	2 (0.5)	20 (2.8)	69 (1.7)	3 (0.7)	9 (1.0)
2004[d]	38 (2.5)	2 (0.9)	23 (2.3)	35 (2.5)	25 (2.2)	13 (1.7)
2005[e]	54 (2.0)	4 (0.9)	11 (1.3)	66 (2.1)	2 (0.4)	17 (1.7)
2006	47 (2.4)	2 (0.7)	8 (1.5)	67 (2.4)	< 1	18 (2.0)

[a] Whitton (2002)
[b] Whitton (2003)
[c] Cornum et al. (2004)
[d] Dion (2005)
[e] Hildreth and Dion (2006)

Table 9. Sockeye salmon mean length (mm; SE in parenthesis) by age class at the Mortensens Creek weir, 2001 to 2006. Data are only presented for age classes comprising more than 2% of the sample.

	Age				
Year	0.3	1.2	1.3	2.2	2.3
2001[a]	580 (5)	536 (64)	577 (3)	529 (5)	578 (3)
2002[b]	575 (2)	519 (2)	585 (3)	521 (4)	577 (3)
2003[c]	560 (15)	534 (16)	571 (13)	532 (20)	569 (13)
2004[d]	551 (12)	509 (20)	569 (10)	511 (6)	559 (16)
2005[e]	572 (10)	523 (15)	567 (11)	516 (13)	573 (11)
2006	562 (9)	520 (11)	561 (15)	496 (26)	560 (14)

[a] Whitton (2002)
[b] Whitton (2003)
[c] Cornum et al. (2004)
[d] Dion (2005)
[e] Hildreth and Dion (2006)

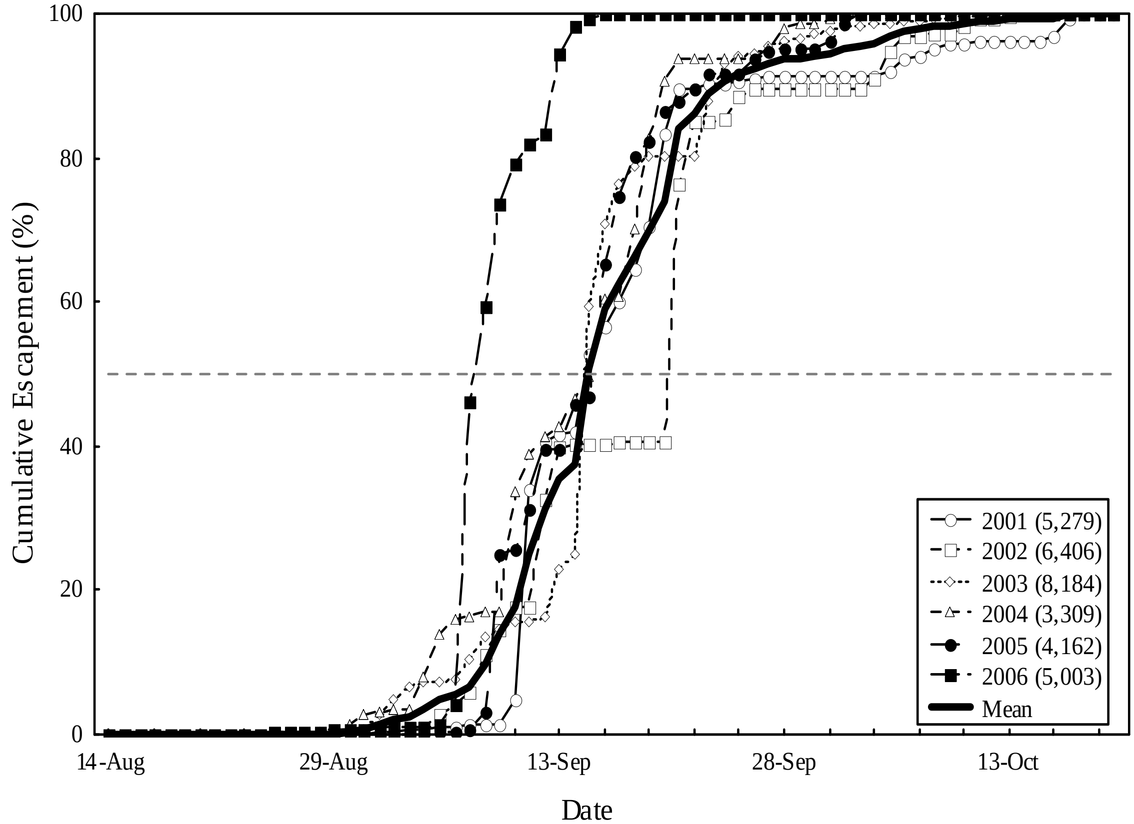

Figure 8. Cumulative escapement of coho salmon at the Mortensens Creek weir, 2001 to 2006. Total escapement numbers for each year are in parenthesis in legend. 2006 data were not used to determine mean.

Table 10. Coho salmon sex and age composition (standard errors in parentheses) at the Mortensens Creek weir, 2001 to 2005. Age and sex data were not collected for coho salmon in 2006. Data are only presented for age classes comprising more than 1% of the sample.

		Age (%)		
Year	% Female	1.1	2.1	3.1
2001[a]	40 (2.7)	14 (1.9)	82 (2.2)	4 (1.2)
2002[b]	45 (2.5)	11 (1.7)	83 (2.0)	6 (1.3)
2003[c]	50 (2.6)	19 (2.1)	70 (2.4)	8 (1.4)
2004[d]	51 (2.4)	34 (2.3)	63 (2.3)	2 (0.6)
2005[e]	45 (2.7)	43 (2.8)	53 (2.8)	4 (1.1)

[a] Whitton (2002)
[b] Whitton (2003)
[c] Cornum et al. (2004)
[d] Dion (2005)
[e] Hildreth and Dion (2006)

in all years except 2003 and 2004 (Table 10). Mean lengths of coho salmon by age were similar from 2001 to 2003, but fish were somewhat smaller in 2004 and 2005 regardless of age (Table 11). We did not measure lengths in 2006 to determine if this trend continued.

Although comparisons of motion detection files to continuous recording were nearly identical in 2006, no comparisons were done for hours of high fish passage. We have observed motion detection failures in other systems during higher fish passage rates (600 fish/h; Anderson et al. 2006), and motion detection file review at Mortensens Creek in 2006 was not effective at high passage rates (> 300 fish/h). Other motion detection systems designed specifically for video monitoring of fish passage have been used successfully. Hatch et al. (1998) developed a motion detection algorithm to detect the presence of fish on time-lapse video by comparing pixel luminance values between consecutive videotape frames. Counts of their source and edited video tapes were nearly identical, even during times of high fish passage (> 400 fish/d; Hatch et al. 1998). However, application of their technology has been problematic in some instances (Faurot and Kucera 2002), and other motion detection algorithms have also proven difficult to implement (Hetrick et al. 2004; Estensen and Cartusciello 2005). Passage rates at Mortensens Creek when the motion detection was not effective (> 300 fish/h) were well above the “high” fish passage density category (> 400 fish/d) described by Hatch et al. (1998). Except for passage rates > 300 fish/h, motion detection was capable of accurately monitoring fish passage at Mortensens Creek in 2006. However, potential bias of motion-triggered file review should be investigated at high fish passage rates.

A problem we have had with other video monitoring projects is erratic fish behavior at night, possibly a behavioral response to artificial white light (Anderson et al. 2006; Dion 2006). In some instances, fish would swim into the video monitoring chute and dart around rapidly passing upstream and downstream. On other occasions, erratic fish behavior in the video monitoring

Table 11. Coho salmon mean length (mm; SE in parenthesis) by age class at the Mortensens Creek weir, 2001 to 2005. Age and length data were not collected for coho salmon in 2006. Data are only presented for age classes comprising more than 1% of the sample.

	Age		
Year	1.1	2.1	3.1
2001[a]	646 (5)	652 (4)	669 (4)
2002[b]	638 (4)	645 (3)	661 (4)
2003[c]	606 (35)	641 (23)	644 (18)
2004[d]	591 (24)	608 (20)	607 (24)
2005[e]	605 (21)	613 (23)	607 (26)

[a] Whitton (2002)
[b] Whitton (2003)
[c] Cornum et al. (2004)
[d] Dion (2005)
[e] Hildreth and Dion (2006)

chutes during darkness would cause almost constant recording of motion-triggered files, resulting in near constant recording. This erratic behavior made it difficult to get accurate counts (Anderson et al. 2006; Dion 2006). At Mortensens Creek in 2006, the crew did not observe erratic behavior at night in response to artificial light, and most sockeye salmon passage occurred at night (Figure 3). The crew did observe that fish tended to mill about and swim through the video monitoring chute in both directions during slack tides, day or night, but this behavior did not affect the counts in 2006. The strong tidal influence on fish passage at Mortensens Creek might mask any effects artificial light has on fish behavior.

Based on data collected from 2001 through 2005, the KSFO did not attempt to extend funding of the Mortensens Creek weir past 2006. Sockeye and coho salmon populations in Mortensens Creek can continue to support harvest by all user groups at current levels, although the commercial fishery for sockeye salmon has the potential to overharvest this small run.

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Appendix A. Daily and cumulative (%) escapement of sockeye salmon and coho salmon, and daily passage of pink salmon, chum salmon, and Dolly Varden at the Mortensens Creek weir, 2006.

	Sockeye Salmon		Coho Salmon		Chum Salmon	Pink Salmon	Dolly Varden
Date	Daily	Cum	Daily	Cum	Daily	Daily	Daily
18-Jun	0	0	0	0	0	0	0
19-Jun	0	0	0	0	0	0	0
20-Jun	0	0	0	0	0	0	0
21-Jun	1	0	0	0	0	0	0
22-Jun	0	0	0	0	0	0	0
23-Jun	0	0	0	0	0	0	0
24-Jun	1	0	0	0	0	0	1
25-Jun	0	0	0	0	0	0	1
26-Jun	0	0	0	0	0	0	0
27-Jun	1	0	0	0	0	0	0
28-Jun	1	0	0	0	0	0	0
29-Jun	0	0	0	0	0	0	0
30-Jun	0	0	0	0	0	0	0
1-Jul	0	0	0	0	0	0	0
2-Jul	0	0	0	0	0	0	0
3-Jul	1	0	0	0	0	0	0
4-Jul	2	0	0	0	0	0	1
5-Jul	2	0	0	0	0	0	3
6-Jul	5	0	0	0	0	0	2
7-Jul	0	0	0	0	0	0	4
8-Jul	0	0	0	0	0	0	1
9-Jul	6	0	0	0	0	0	0
10-Jul	10	0	0	0	0	0	2
11-Jul	11	0	0	0	0	0	7
12-Jul	7	0	0	0	0	0	3
13-Jul	21	0	0	0	1	0	5
14-Jul	0	0	0	0	0	0	0
15-Jul	0	0	0	0	0	0	2
16-Jul	126	1	0	0	0	0	14
17-Jul	38	2	0	0	0	0	32
18-Jul	3	2	0	0	0	0	6
19-Jul	16	2	0	0	0	0	16
20-Jul	44	2	0	0	0	0	34
21-Jul	5	2	0	0	0	0	58
22-Jul	24	2	0	0	0	0	8
23-Jul	104	3	0	0	0	0	18
24-Jul	50	3	0	0	0	0	5
25-Jul	19	3	0	0	0	0	4
26-Jul	134	4	0	0	0	0	14
27-Jul	833	10	0	0	0	1	62
28-Jul	239	12	0	0	0	0	45
29-Jul	79	12	0	0	0	0	17
30-Jul	2	12	0	0	0	0	6
31-Jul	194	13	0	0	0	0	1
1-Aug	20	14	0	0	0	0	4
2-Aug	161	15	0	0	0	0	10
3-Aug	171	16	0	0	0	0	60
4-Aug	32	16	0	0	0	0	21
5-Aug	2	16	0	0	0	0	22
6-Aug	341	18	0	0	0	0	11

Appendix A. Continued.

Date	Sockeye Salmon Daily	Sockeye Salmon Cum	Coho Salmon Daily	Coho Salmon Cum	Chum Salmon Daily	Pink Salmon Daily	Dolly Varden Daily
7-Aug	637	23	0	0	3	1	62
8-Aug	3,330	45	0	0	2	6	42
9-Aug	870	51	0	0	6	1	24
10-Aug	2,520	68	0	0	2	7	21
11-Aug	197	69	0	0	1	0	14
12-Aug	24	70	0	0	0	-1	3
13-Aug	16	70	0	0	0	0	9
14-Aug	871	76	0	0	1	3	18
15-Aug	9	76	0	0	0	0	9
16-Aug	3	76	0	0	0	0	10
17-Aug	0	76	0	0	0	0	7
18-Aug	12	76	0	0	0	-2	2
19-Aug	24	76	0	0	0	0	0
20-Aug	600	80	0	0	0	4	14
21-Aug	54	80	0	0	1	1	11
22-Aug	173	81	0	0	1	2	6
23-Aug	89	82	3	0	3	6	7
24-Aug	168	83	0	0	0	6	2
25-Aug	975	90	18	0	2	22	20
26-Aug	25	90	2	0	0	-2	3
27-Aug	13	90	1	0	0	-1	7
28-Aug	16	90	0	0	0	0	4
29-Aug	82	91	13	1	0	10	4
30-Aug	31	91	0	1	0	4	3
31-Aug	54	91	4	1	1	13	6
1-Sep	17	91	4	1	0	0	0
2-Sep	85	92	0	1	0	0	2
3-Sep	118	93	2	1	0	9	4
4-Sep	105	93	7	1	0	3	18
5-Sep	40	94	10	1	0	3	4
6-Sep	81	94	147	4	0	11	12
7-Sep	630	99	2,092	46	0	21	10
8-Sep	85	99	660	59	1	1	3
9-Sep	41	99	714	73	0	9	5
10-Sep	35	100	285	79	0	-4	7
11-Sep	8	100	131	82	0	-2	1
12-Sep	4	100	78	83	0	-2	1
13-Sep	22	100	551	94	0	4	1
14-Sep	13	100	190	98	0	2	4
15-Sep	4	100	55	99	0	2	7
16-Sep	1	100	36	100	0	0	3
Total:	**14,788**		**5,003**		**25**	**138**	**890**

Appendix B. Paired counts of fish passage from motion-triggered file review and continuous recording review at the Mortensens Creek weir, 2006. An asterisk (*) indicates that although total counts were identical, species were identified differently for the two methods.

Date	Start Time	End Time	Motion-triggered Count	Continuous Recording Count	Difference
7/11	00:00	01:00	1	0	1
7/11	22:30	23:30	0	0	0
7/14	21:00	22:00	0	0	0
7/14	10:00	11:00	0	0	0
7/16	20:00	21:00	14	15	1
7/20	02:00	03:00	4	4	0
7/20	13:00	14:00	0	0	0
7/25	23:00	00:00	1	1	0
7/25	09:00	10:00	2	2	0
7/25	07:00	08:00	11	11	0
8/1	17:00	18:00	8	8	0
8/1	14:00	15:00	0	0	0
8/1	04:00	05:00	0	0	0
8/2	05:00	07:00	1	1	0
8/2	19:00	20:00	0	0	0
8/2	22:00	23:00	116	116	0
8/3	12:00	13:00	29	29	0
8/12	00:00	01:00	16	15	1
8/22	04:00	05:00	30	31	1
8/24	17:00	18:00	3	3	0
8/25	05:00	06:00	104	104	0
8/29	00:00	01:00	2	2	0
8/29	23:00	00:00	8	8	0
8/31	00:00	01:00	9	9	0
8/31	01:00	02:00	21	21	*
9/1	01:00	02:00	5	5	0
9/3	02:00	03:00	36	36	0
9/4	00:00	01:00	76	76	0
9/6	01:00	02:00	72	72	0
9/6	18:00	19:00	10	10	0
9/8	07:00	08:00	7	8	1
9/9	09:00	10:00	46	46	0
9/10	08:00	09:00	4	4	0
9/12	09:00	10:00	2	2	0
9/14	09:00	10:00	26	26	0
9/15	08:00	09:00	9	9	0
9/16	08:00	09:00	11	11	0

Appendix C. Daily and cumulative (%) escapement of sockeye salmon at the Mortensens Creek weir, 2001 to 2006.

	2001		2002		2003		2004		2005		2006	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
1-Jul	11	0	0	0	0	0	1	0	0	0	0	0
2-Jul	6	0	0	0	0	0	2	0	1	0	0	0
3-Jul	0	0	0	0	0	0	0	0	51	0	1	0
4-Jul	0	0	0	0	1	0	14	0	32	0	2	0
5-Jul	0	0	0	0	0	0	9	0	25	1	2	0
6-Jul	0	0	0	0	0	0	0	0	50	1	5	0
7-Jul	0	0	0	0	1	0	3	0	0	1	0	0
8-Jul	2	0	8	0	0	0	1	0	18	1	0	0
9-Jul	0	0	73	2	0	0	0	0	2	1	6	0
10-Jul	0	0	0	2	1	0	3	0	0	1	10	0
11-Jul	0	0	18	2	87	1	0	0	3	1	11	0
12-Jul	0	0	125	4	1	1	20	1	1	1	7	0
13-Jul	1	0	45	5	6	1	41	1	0	1	21	0
14-Jul	64	2	0	5	4	1	49	2	0	1	0	0
15-Jul	535	15	0	5	3	1	164	4	0	1	0	0
16-Jul	27	15	0	5	232	2	0	4	0	1	126	1
17-Jul	20	16	0	5	403	4	179	7	0	1	38	2
18-Jul	17	16	0	5	248	6	12	7	0	1	3	2
19-Jul	37	17	30	6	155	7	29	7	35	1	16	2
20-Jul	4	17	153	9	209	8	0	7	115	2	44	2
21-Jul	1	17	1,373	35	150	9	0	7	479	4	5	2
22-Jul	31	18	603	47	19	9	2	7	27	4	24	2
23-Jul	51	19	154	50	83	10	836	19	0	4	104	3
24-Jul	69	21	11	50	88	10	1,527	40	31	4	50	3
25-Jul	13	21	2	50	289	12	1,389	59	350	6	19	3
26-Jul	1	21	0	50	376	14	55	60	83	6	134	4
27-Jul	42	22	1	50	12	14	1	60	41	6	833	10
28-Jul	4	22	8	50	204	15	22	60	1	6	239	12
29-Jul	104	24	25	51	13	15	41	61	220	7	79	12
30-Jul	3	24	9	51	15	15	9	61	51	7	2	12
31-Jul	148	28	68	52	1	15	105	63	74	8	194	13
1-Aug	1	28	4	52	12	16	404	68	3,989	26	20	14
2-Aug	331	36	41	53	1,662	25	1,087	83	86	27	161	15
3-Aug	3	36	766	68	1,072	32	90	84	5	27	171	16
4-Aug	0	36	389	75	380	34	122	86	467	29	32	16
5-Aug	1	36	345	82	1,995	46	0	86	113	29	2	16
6-Aug	3	36	49	83	52	46	42	87	706	33	341	18
7-Aug	13	36	83	84	868	51	7	87	406	34	637	23
8-Aug	2,057	84	28	85	0	51	1	87	204	35	3,330	45
9-Aug	92	87	62	86	223	53	96	88	89	36	870	51
10-Aug	10	87	107	88	540	56	15	88	644	39	2,520	68
11-Aug	8	87	158	91	234	57	24	89	949	43	197	69
12-Aug	74	89	11	91	1,312	65	238	92	807	47	24	70
13-Aug	19	89	6	91	555	68	0	92	1,405	53	16	70
14-Aug	2	89	12	92	306	70	0	92	717	57	871	76
15-Aug	84	91	15	92	99	71	0	92	76	57	9	76
16-Aug	56	92	4	92	34	71	25	92	2,105	67	3	76
17-Aug	10	93	10	92	19	71	64	93	317	68	0	76
18-Aug	2	93	12	92	16	71	94	95	537	71	12	76

Appendix C. Continued.

	2001		2002		2003		2004		2005		2006	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
19-Aug	108	95	84	94	81	72	0	95	298	72	24	76
20-Aug	18	96	79	96	49	72	120	96	1,087	77	600	80
21-Aug	1	96	48	96	63	72	0	96	144	78	54	80
22-Aug	7	96	31	97	310	74	5	96	1,255	83	173	81
23-Aug	3	96	32	98	129	75	9	96	153	84	89	82
24-Aug	0	96	10	98	248	77	0	96	235	85	168	83
25-Aug	0	96	4	98	267	78	0	96	9	85	975	90
26-Aug	21	96	0	98	119	79	33	97	308	87	25	90
27-Aug	5	97	1	98	143	80	4	97	21	87	13	90
28-Aug	4	97	2	98	502	83	41	98	215	88	16	90
29-Aug	1	97	2	98	251	84	6	98	27	88	82	91
30-Aug	0	97	3	98	435	87	14	98	5	88	31	91
31-Aug	0	97	0	98	149	88	26	98	436	90	54	91
1-Sep	60	98	0	98	519	91	18	98	116	90	17	91
2-Sep	3	98	0	98	416	93	7	98	497	93	85	92
3-Sep	10	98	34	99	56	94	0	98	48	93	118	93
4-Sep	16	99	41	100	32	94	34	99	115	93	105	93
5-Sep	22	99	2	100	54	94	28	99	198	94	40	94
6-Sep	4	99	5	100	47	94	1	99	74	95	81	94
7-Sep	8	100	4	100	6	94	5	99	71	95	630	99
8-Sep	14	100	5	100	17	94	10	100	497	97	85	99
9-Sep	2	100	3	100	45	95	0	100	339	99	41	99
10-Sep	4	100	0	100	64	95	17	100	7	99	35	100
11-Sep	0	100	0	100	12	95	4	100	45	99	8	100
12-Sep	0	100	1	100	21	95	2	100	59	99	4	100
13-Sep	0	100	0	100	204	97	0	100	0	99	22	100
14-Sep	0	100	0	100	262	98	0	100	40	100	13	100
15-Sep	0	100	0	100	66	98	0	100	5	100	4	100
16-Sep	0	100	0	100	80	99	2	100	50	100	1	100
17-Sep	0	100	0	100	52	99	0	100	25	100	0	100
18-Sep	0	100	0	100	14	99	1	100	4	100	0	100
19-Sep	0	100	0	100	1	99	2	100	3	100	0	100
20-Sep	0	100	0	100	5	99	0	100	3	100	0	100
21-Sep	0	100	1	100	0	99	0	100	0	100	0	100
22-Sep	0	100	0	100	4	99	0	100	0	100	0	100
23-Sep	0	100	0	100	10	99	0	100	0	100	0	100
24-Sep	0	100	0	100	33	100	0	100	0	100	0	100
25-Sep	0	100	0	100	14	100	0	100	0	100	0	100
26-Sep	0	100	0	100	15	100	2	100	0	100	0	100
27-Sep	0	100	0	100	6	100	0	100	0	100	0	100
28-Sep	0	100	0	100	0	100	0	100	1	100	0	100
29-Sep	0	100	0	100	0	100	0	100	1	100	0	100
30-Sep	0	100	0	100	2	100	0	100	0	100	0	100
Total:	**4,268**		**5,205**		**16,804**		**7,215**		**21,703**		**14,788**	

Appendix D. Daily and cumulative (%) escapement of coho salmon at the Mortensens Creek weir, 2001 to 2006.

	2001		2002		2003		2004		2005		2006	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
10-Aug	0	0	0	0	0	0	0	0	0	0	0	0
11-Aug	0	0	0	0	0	0	0	0	0	0	0	0
12-Aug	0	0	0	0	0	0	0	0	0	0	0	0
13-Aug	0	0	0	0	0	0	0	0	0	0	0	0
14-Aug	0	0	0	0	1	0	0	0	0	0	0	0
15-Aug	0	0	0	0	0	0	0	0	0	0	0	0
16-Aug	0	0	0	0	0	0	0	0	0	0	0	0
17-Aug	0	0	0	0	0	0	0	0	0	0	0	0
18-Aug	0	0	0	0	0	0	0	0	0	0	0	0
19-Aug	0	0	0	0	0	0	0	0	0	0	0	0
20-Aug	0	0	0	0	0	0	0	0	0	0	0	0
21-Aug	1	0	1	0	0	0	0	0	0	0	0	0
22-Aug	2	0	0	0	0	0	0	0	0	0	0	0
23-Aug	0	0	0	0	0	0	2	0	0	0	3	0
24-Aug	0	0	2	0	3	0	0	0	1	0	0	0
25-Aug	0	0	0	0	1	0	0	0	0	0	18	0
26-Aug	0	0	0	0	6	0	0	0	1	0	2	0
27-Aug	0	0	0	0	4	0	0	0	0	0	1	0
28-Aug	0	0	0	0	5	0	0	0	0	0	0	0
29-Aug	5	0	1	0	6	0	0	0	0	0	14	1
30-Aug	0	0	0	0	21	1	46	1	0	0	0	1
31-Aug	0	0	0	0	8	1	42	3	0	0	4	1
1-Sep	3	0	0	0	161	3	19	3	0	0	4	1
2-Sep	8	0	0	0	174	5	2	3	3	0	0	1
3-Sep	14	1	1	0	152	7	0	3	0	0	1	1
4-Sep	11	1	71	1	42	7	150	8	2	0	7	1
5-Sep	6	1	96	3	22	7	203	14	2	0	10	1
6-Sep	7	1	96	4	18	8	62	16	13	1	147	4
7-Sep	8	1	100	6	226	10	19	16	2	1	2,092	46
8-Sep	14	1	354	11	266	14	19	17	111	3	660	59
9-Sep	0	1	202	14	88	15	3	17	900	25	714	73
10-Sep	180	5	208	18	71	16	551	34	36	26	285	79
11-Sep	1,535	34	8	18	4	16	172	39	228	31	131	82
12-Sep	343	40	962	33	55	16	79	41	346	40	78	83
13-Sep	55	42	446	40	531	23	44	43	4	40	551	94
14-Sep	29	42	35	40	170	25	122	46	260	46	190	98
15-Sep	565	53	0	40	2,826	59	105	50	42	47	55	99
16-Sep	211	57	8	40	950	71	358	60	771	65	36	100
17-Sep	173	60	2	40	444	76	13	61	385	75	0	100
18-Sep	236	65	0	40	198	79	306	70	236	80	0	100
19-Sep	317	71	3	41	105	80	415	83	86	82	0	100
20-Sep	685	84	14	41	5	80	268	91	167	86	0	100
21-Sep	313	89	2,286	76	0	80	98	94	55	88	0	100
22-Sep	17	90	548	85	9	80	0	94	80	90	0	100
23-Sep	24	90	3	85	609	88	0	94	84	92	0	100
24-Sep	13	90	29	85	434	93	0	94	1	92	0	100
25-Sep	4	91	194	89	74	94	0	94	1	92	0	100
26-Sep	18	91	61	89	49	95	6	94	88	94	0	100
27-Sep	16	91	5	90	73	95	45	95	48	95	0	100

Appendix D. Continued.

	2001		2002		2003		2004		2005		2006	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
28-Sep	2	91	2	90	71	96	87	98	13	95	0	100
29-Sep	0	91	1	90	14	96	28	99	0	95	0	100
30-Sep	5	91	0	90	72	97	0	99	1	95	0	100
1-Oct	4	91	2	90	31	98	17	99	36	96	0	100
2-Oct	0	91	0	90	43	98	0	99	103	99	0	100
3-Oct	0	91	0	90	6	98	24	100	56	100	0	100
4-Oct	5	91	93	91	16	99	4	100	0	100	0	100
5-Oct	35	92	230	95	12	99	0	100	0	100	0	100
6-Oct	80	94	138	97	16	99	0	100	0	100	0	100
7-Oct	26	94	7	97	10	99	0	100	0	100	0	100
8-Oct	50	95	17	97	23	99	0	100	0	100	0	100
9-Oct	36	96	1	97	11	99	0	100	0	100	0	100
10-Oct	11	96	78	98	18	100	0	100	0	100	0	100
11-Oct	11	96	63	99	11	100	0	100	0	100	0	100
12-Oct	2	96	2	99	16	100	0	100	0	100	0	100
13-Oct	0	96	18	100	3	100	0	100	0	100	0	100
14-Oct	3	96	16	100	0	100	0	100	0	100	0	100
15-Oct	1	96	1	100	0	100	0	100	0	100	0	100
16-Oct	37	97	0	100	0	100	0	100	0	100	0	100
17-Oct	115	99	0	100	0	100	0	100	0	100	0	100
18-Oct	36	100	0	100	0	100	0	100	0	100	0	100
19-Oct	5	100	1	100	0	100	0	100	0	100	0	100
20-Oct	2	100	0	100	0	100	0	100	0	100	0	100
Total:	**5,279**		**6,406**		**8,184**		**3,836**		**4,162**		**5,003**	