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Estimation of Sockeye Salmon Escapement into McLees Lake, Unalaska Island, Alaska 2004

Alaska Fisheries Data Series Number 2005-4

King Salmon Fish and Wildlife Field Office
King Salmon, Alaska
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Michael R. Edwards

Abstract

The King Salmon Fish and Wildlife Field Office operated a fixed picket weir at the outlet of McLees Lake on Unalaska Island from 1 June to 26 July 2004. Three species of salmon were counted through the weir including 40,327 sockeye *Oncorhynchus nerka*, 3 chum *O. keta,* and 1 pink *O. gorbuscha* salmon. Peak weekly passage occurred from 13 June to 19 June when 12,416 sockeye salmon were counted through the weir. Seven age classes were identified from the 847 sockeye salmon sampled at the weir. Age class 1.2 was the most abundant, accounting for 53 % of the sample. Females comprised an estimated 43 % of sockeye salmon sampled in 2004.

Introduction

McLees Lake empties into Reese Bay on the north side of Unalaska Island approximately 12 miles NW of the city of Unalaska (Figure 1). This watershed provides important spawning and rearing habitat for sockeye salmon *Oncorhynchus nerka*. Subsistence users from Unalaska harvest adult sockeye salmon returning to McLees Lake in Reese Bay. The Reese Bay subsistence fishery accounts for approximately 88% of the annual salmon harvest for this community (Shaul and Dinnocenzo 2004). Prior to 2001, management of the fishery was limited to aerial surveys and harvest data to assess escapement.

The escapement of sockeye salmon to McLees Lake has been monitored using aerial survey counts since 1974 (Arnie Shaul, Alaska Department of Fish and Game, personal communication). Aerial surveys have generally been limited to one survey each year and have ranged from 300 - 34,000 fish (Appendix A). Aerial counts potentially serve as an index of abundance, but can be negatively influenced by several factors including time of survey, poor weather, lack of availability of suitable aircraft and variation among observers. No aerial surveys were conducted during some years because of one or more of these factors.

Subsistence harvest of sockeye salmon returning to McLees Lake has been monitored since 1985 with harvests ranging from 436 to 4,694 (Shaul and Dinnocenzo 2004). Since 1985, the number of subsistence permits issued for this fishery has steadily increased; the average number of permits issued from 2001-2003 was 220. Annual fluctuations in harvest have generally corresponded to the number of permits issued for the fishery. Since 1995, the average annual harvest has nearly doubled and the number of permits issued has nearly tripled from that observed from 1985-1994. These numbers suggest that sockeye salmon returning to McLees Lake have become increasingly important to the local subsistence fishery. Local residents and the Alaska Department of Fish and Game (ADFG) have expressed concerns that the lack of an escapement estimate for sockeye salmon into McLees Lake may jeopardize the health of the run, as well as future opportunities for subsistence fishing.

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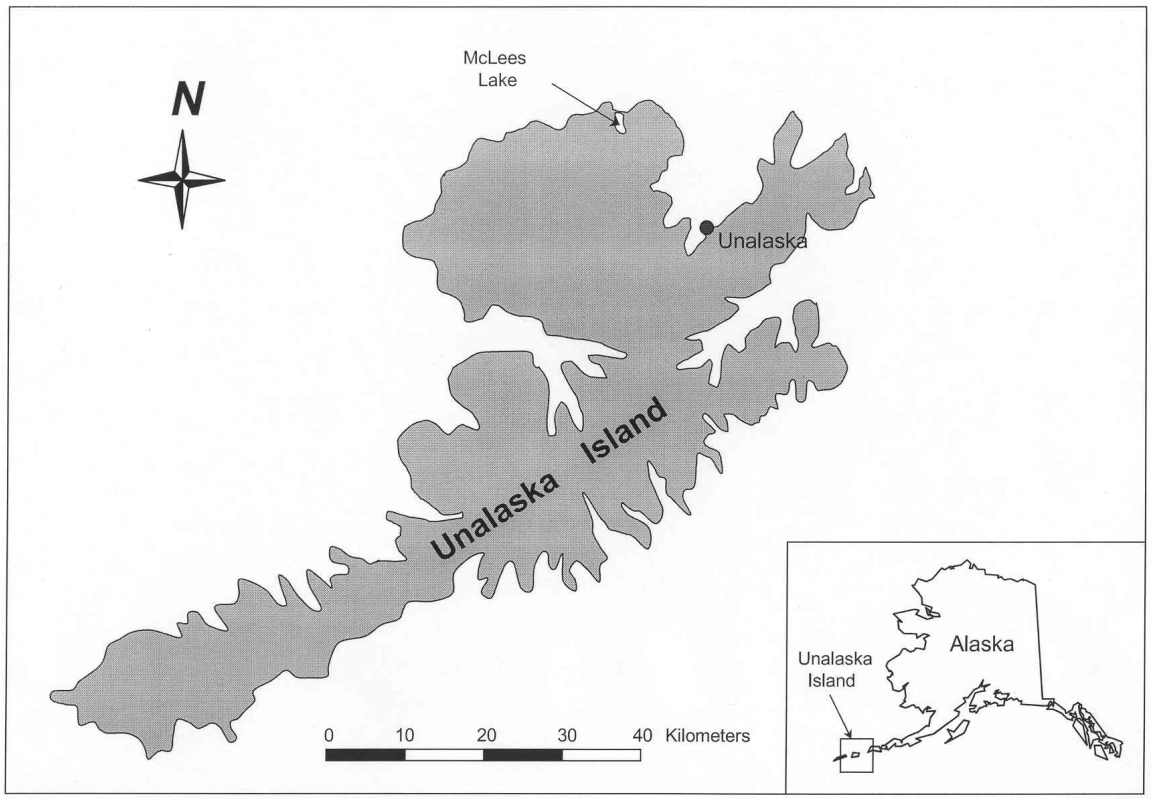

Figure 1. Map of Unalaska Island showing the location of McLees Lake, Alaska Maritime National Wildlife Refuge.

These concerns prompted the Kodiak/Aleutian Federal Regional Subsistence Advisory Council to identify an escapement-monitoring project on McLees Lake as a high priority. To address these concerns, the Kenai Fish and Wildlife Field Office and the Qawalangin Tribe of Unalaska entered into a partnership agreement to monitor the sockeye salmon return to McLees Lake beginning in 2003.

In 2002, the Alaska Region Fisheries Program realigned areas of responsibility of the Kenai and King Salmon field offices; this resulted in the King Salmon Field Office (KSFO) assuming responsibility for projects in the Aleutian Islands Area. Since the Kenai Office had received funding for the McLees Lake project through 2003, it was agreed that the Kenai Office would complete the 2003 field season. In 2004, KSFO received funding to operate the McLees Lake project through 2006.

Specific objectives of the project were to:

1. Enumerate the daily passage of sockeye salmon through the weir.
2. Describe the run-timing, or proportional daily passage, of sockeye salmon through the weir.
3. Estimate the sex and age composition of sockeye salmon such that simultaneous 90% confidence intervals have a maximum width of 0.20
4. Estimate the mean length of sockeye salmon by sex and age.

Gates and Palmer (2004) summarized the 2003 season and compared escapements observed during the first three years of weir operations. This report summarizes findings during the 2004 season.

Methods

Escapement Monitoring

A flexible picket weir spanning 21 m was installed at the outlet of McLees Lake and operated from June 1 to July 26, 2004. Weir pickets were constructed from 13 mm electrical metal conduit. Picket spacing ranged from 3.5 cm for panels in shallow water near each stream bank to 2.2 cm on panels near the middle of the McLees Lake outlet channel. All pickets were 1.5 m long and strung together with 3-mm aircraft cable to make panels 3 m long. A spanning cable (6-mm aircraft) was strung bank-to-bank and pulled tight about 0.3 m above the surface of the water. The weir panels were leaned against the cable, which was supported with two wooden tripods evenly spaced across the channel and fence posts approximately every 3 meters. A combination trap box/counting chute was placed on the upstream side of the weir to capture fish for sampling and to pass adult salmon for identification and counting. The weir and trap box were inspected daily and maintained as needed to ensure integrity. A staff gauge was installed 4 m downstream of the weir to measure daily water levels. Water temperatures were monitored in the outlet channel with a Hobo® temperature logger.

Fish were passed and counted intermittently between 0700 and 2400 hours each day. The duration of each counting session varied depending on the intensity of fish passage through the weir. Daily escapement counts were relayed to KSFO via satellite phone and the KSFO reported escapement information to the ADFG in Cold Bay (via E-mail) to support in-season management of the Reese Bay subsistence fishery.

Age, Sex, and Length Data

Data on sockeye salmon age, sex, and length (ASL) were collected using a temporally stratified sampling design (Cochran 1977), with statistical weeks defining strata (Table 1). Weekly sample size goals were determined from the work of Bromaghin (1993) who proposes that with 4 groups (2 dominate ages + 2 sexes) in the population, a sample size of 121 is needed to obtain the level of precision stated in objective #3. The predicted sample size of 121 was adjusted to 135 to account for 10% of the scale samples being unreadable. When the weekly sampling goal was unattainable because of low numbers, the crew attempted to sample 20% of the weekly escapement. Samples were dispersed throughout the week and taken periodically during the day. To avoid potential bias caused by the selection or capture of individual fish, all fish within the trap were sampled, even if the target number of fish was exceeded.

Sockeye salmon were measured from mid-eye to fork-of-caudal-fin to the nearest millimeter and sex was determined by observing external characteristics. One scale was collected from the preferred area on the left side of each fish sampled (Jearld 1983). Salmon ages are reported according to the European method where the number of winters the fish spent in fresh water and in the ocean is separated by a decimal (Koo 1962). Fish with scales that could not be aged were not included in the ASL analysis.

Sample data were recorded on all-weather age, sex; length (ASL) field forms and transferred to ASL mark-sense forms provided by ADFG. Salmon scales were cleaned and properly affixed to gummed scale cards. Mark-sense forms and scale cards were completed according to ADFG procedures (Murphy 2000). Scale samples were pressed and age determination analysis conducted by ADFG.

Table 1. Strata used for analysis of McLees Lake weir biological data, 2004.

Stratum	Date
1	1-Jun - 5-Jun
2	6-Jun – 12-Jun
3	13-Jun – 19-Jun
4	20-Jun – 26-Jun
5	27-Jun – 3-Jul
6	4-Jul – 10-Jul
7	11-Jul – 17-Jul
8	18-Jul – 26-Jul

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 fish passing the weir that are of sex *j* and age *k* was estimated by:

$$\hat{p}_{jkm} = \frac{n_{jkm}}{n_{++m}}$$

where n_{jkm} denotes the number of fish 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_{++m} denotes the total number of fish sampled in stratum m, summing over sex and age. The variance of $\hat{p}_{jkm}$ was estimated by:

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

where N_{++m} denotes the total number of sockeye salmon passing the weir in stratum *m*. The number of sockeye salmon of sex *j* and age *k* passing the weir in stratum *m* was estimated by:

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

with estimated variance

$$\hat{v}\left(\hat{N}_{jkm}\right) = N_{++m}^{2}\hat{v}\left(\hat{p}_{jkm}\right).$$

Estimated proportions by sex and age for the entire period of weir operation was computed as weighted sums of the stratum estimates, i.e.,

$$\hat{p}_{jk} = \sum_{m}\left(\frac{N_{++m}}{N_{+++}}\right)\hat{p}_{jkm},$$

with estimated variance

$$\hat{v}\left(\hat{p}_{jk}\right) = \sum_{m}\left(\frac{N_{++m}}{N_{+++}}\right)^{2}\hat{v}\left(\hat{p}_{jkm}\right).$$

The total number of sockeye salmon of sex *j* and age *k* passing the weir during the entire period of operation was estimated by:

$$\hat{N}_{jk} = \sum_{m}\hat{N}_{jkm},$$

with estimated variance

$$\hat{v}\left(\hat{N}_{jk}\right) = \sum_{m}\hat{v}\left(\hat{N}_{jkm}\right).$$

If the length of each sockeye salmon of sex *j* and age *k* sampled in stratum *m* is denoted x_{jkm}, the mean length of all such fish was estimated by:

$$\bar{x}_{jkm} = \left(\frac{1}{n_{jkm}}\right)\sum x_{jkm},$$

with corresponding variance estimator

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

The mean length of all sockeye salmon of sex *i* and age *j* was estimated as a weighted sum of the stratum estimates, i.e.,

$$\bar{x}_{jk} = \sum_{m}\left(\frac{\hat{N}_{jkm}}{\hat{N}_{jk}}\right)\bar{x}_{jkm}.$$

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

$$\hat{v}\left(\bar{x}_{jk}\right) = \sum_{m}\left\{\hat{v}\left(\hat{N}_{jkm}\right)\left[\frac{\bar{x}_{jkm}}{\sum_{x}\hat{N}_{jkx}}-\sum_{y}\frac{\hat{N}_{jky}\bar{x}_{jky}}{\left(\sum_{x}\hat{N}_{jkx}\right)^{2}}\right]^{2}+\left(\frac{\hat{N}_{jkm}}{\sum_{x}\hat{N}_{jkx}}\right)^{2}\hat{v}\left(\bar{x}_{jkm}\right)\right\}.$$

Results

Escapement Monitoring

Operation of the McLees Lake weir began on 1 June and continued uninterrupted through 26 July. In 2004, 40,327 sockeye, 3 chum *Oncorhynchus keta*, and 1 pink *O. gorbuscha* salmon were counted through the weir. Peak weekly passage of 12,416 sockeye salmon occurred in stratum 3. The next highest escapement of 11,576 sockeye salmon took place in stratum 5 (Figure 2). Sockeye salmon were passed through the weir every day of operation except for July 13, 14, 25, and 26. The peak daily passage occurred on 19 June when 6,488 sockeye salmon were passed through the weir (Appendix B).

Age, Sex, and Length Data

Nine hundred sixty-two sockeye salmon were sampled for ASL analysis. Of this sample, 115 (12%) scales were unreadable. Seven age groups were identified from the scale samples; ages 1.2 (54%) and 1.3 (32%) accounted for the majority of the run (Table 2). Ages 2.4 (n = 4), and 3.3 (n = 1) were the least abundant ages, accounting for less than one percent of the run. Approximately 43% of the 2004 sockeye salmon escapement was female (Table 3). Lengths of sockeye salmon sampled in 2004 ranged from 436 to 611 mm for females and from 455 to 638 mm for males (Table 4, Figure 3).

Discussion

Sockeye salmon escapement in 2004 was the lowest observed over the past three years, however, the 2004 escapement did surpassed the 1995 to 2000 (recent 6 year pre-weir data) average aerial count of 4,246 (Arnie Shaul, ADFG personal communication). Recent weir counts of sockeye salmon escapements into McLees Lake have documented a much higher level of escapement than historical aerial survey data. Due to the infrequency of aerial surveys and limited weir data; it is unclear if the 2001-2004 escapements are anomalies and the 2004 escapement is the onset of smaller returns to McLees Lake.

The majority of the 2004 run were age 1.2 fish; this was similar to the age composition observed in 2002 (Gates and Palmer 2004). The dominant age class of the McLees Lake run appears to alternate annually between ages 1.2 and 1.3. The 2004 sex composition was similar to that observed during the first three years of the weir project. Mean lengths of male sockeye salmon were larger than female mean lengths across all age groups and for the majority of fish sampled the more time spent in the marine habitat the larger the fish was at time of return.

Recommendations

The desired level of precision in the sex and age composition was met even though the number of unreadable scales exceeded 10%. Therefore, the sampling goal of 135 fish per stratum should be used again in 2005.

During the early run, sockeye salmon were gilled when they forced their heads between the weir pickets. The problem was resolved when the crew attached orange snow fencing on the downstream side of the two weir panels adjacent to the trap box entrance. For 2005, the picket spacing on all weir panels will be reduced to 2.2 cm and the orange snow fencing will be installed on the two panels adjacent to the trap box entrance.

Table 2. Age composition (%), SE, and sample size by stratum of sockeye salmon sampled at the McLees Lake weir, 2004.

	Age Class						
	1.2	1.3	1.4	2.2	2.3	2.4	3.3
				Stratum 1			
%	17	45	7	3	28	--	--
SE	4.2	5.6	2.8	2.0	5.1	--	--
n	10	27	4	2	17	0	0
				Stratum 2			
%	27	53	4	3	11	1	1
SE	4.2	4.7	1.8	1.6	3.0	0.9	0.9
n	29	57	4	3	12	1	1
				Stratum 3			
%	48	40	1	3	7	1	--
SE	4.6	4.5	0.8	1.7	2.3	0.8	--
n	57	47	1	4	8	1	0
				Stratum 4			
%	46	43	3	2	7	--	--
SE	4.7	4.7	1.5	1.2	2.4	--	--
n	51	48	3	2	8	0	0
				Stratum 5			
%	63	21	3	1	10	2	--
SE	4.5	3.7	1.7	0.9	2.8	1.2	--
n	74	24	4	1	12	2	0
				Stratum 6			
%	74	16	1	2	7	--	--
SE	4.0	3.4	0.9	1.2	2.4	--	--
n	84	18	1	2	8	0	0
				Stratum 7			
%	61	25	4	2	9	--	--
SE	4.5	4.0	1.7	1.2	2.6	--	--
n	69	28	4	2	10	0	0
				Stratum 8			
%	64	13	--	7	7	--	--
SE	4.1	3.2	--	2.3	2.3	--	--
n	79	14	0	7	7	0	0
				Total			
%	54	32	2	2	8	1	<1
SE	2.2	2.0	0.6	0.6	1.2	0.4	--
n	453	263	21	23	82	4	1

Table 3. Estimated sex composition, sample size, and escapement by stratum of sockeye salmon sampled at the McLees Lake weir, 2004.

Stratum	*n*	Female (%)	Male (%)	SE (%)	Escapement
1	60	38	62	5.5	235
2	107	39	61	4.6	1,670
3	118	42	58	4.5	12,416
4	112	42	58	4.7	7,880
5	117	42	58	4.6	11,576
6	113	55	45	4.6	1,985
7	113	52	48	4.6	3,107
8	107	43	57	4.6	1,458
Total	847	43	57	2.2	40,327

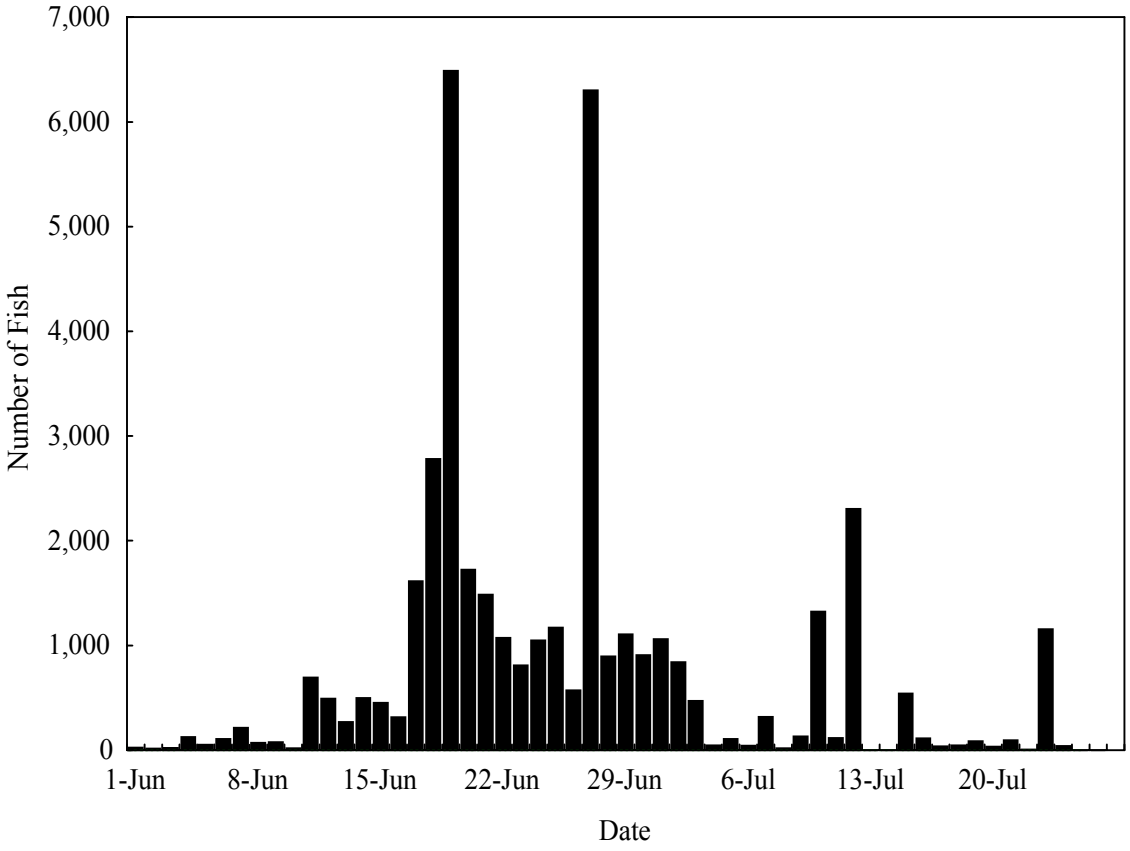

Figure 2. Daily weir passage of sockeye salmon entering McLees Lake 2004.

Table 4. Mean length (mm), SE, range, and sample size by age class of sockeye salmon sampled at the McLees Lake weir, 2004.

	Age Class						
Length	1.2	1.3	1.4	2.2	2.3	2.4	3.3
			Female				
Mean	491	549	572	501	541	--	--
SE	8.5	12.6	7.0	2.6	11.0	--	--
Min	436	468	494	470	479	--	--
Max	568	611	593	516	589	--	--
n	206	119	7	9	36	--	--
			Male				
Mean	515	573	602	509	575	587	570
SE	9.6	11.6	14.4	21.3	7.6	16.1	--
Min	455	472	536	460	485	562	--
Max	589	638	635	547	615	600	--
n	247	144	14	14	46	4	1
			Total				
Mean	505	563	593	506	557	590	570
SE	17.8	21.8	19.8	25.4	21.7	16.1	--
Min	436	468	494	460	479	562	--
Max	589	638	635	547	589	600	--
n	453	263	21	23	82	4	1

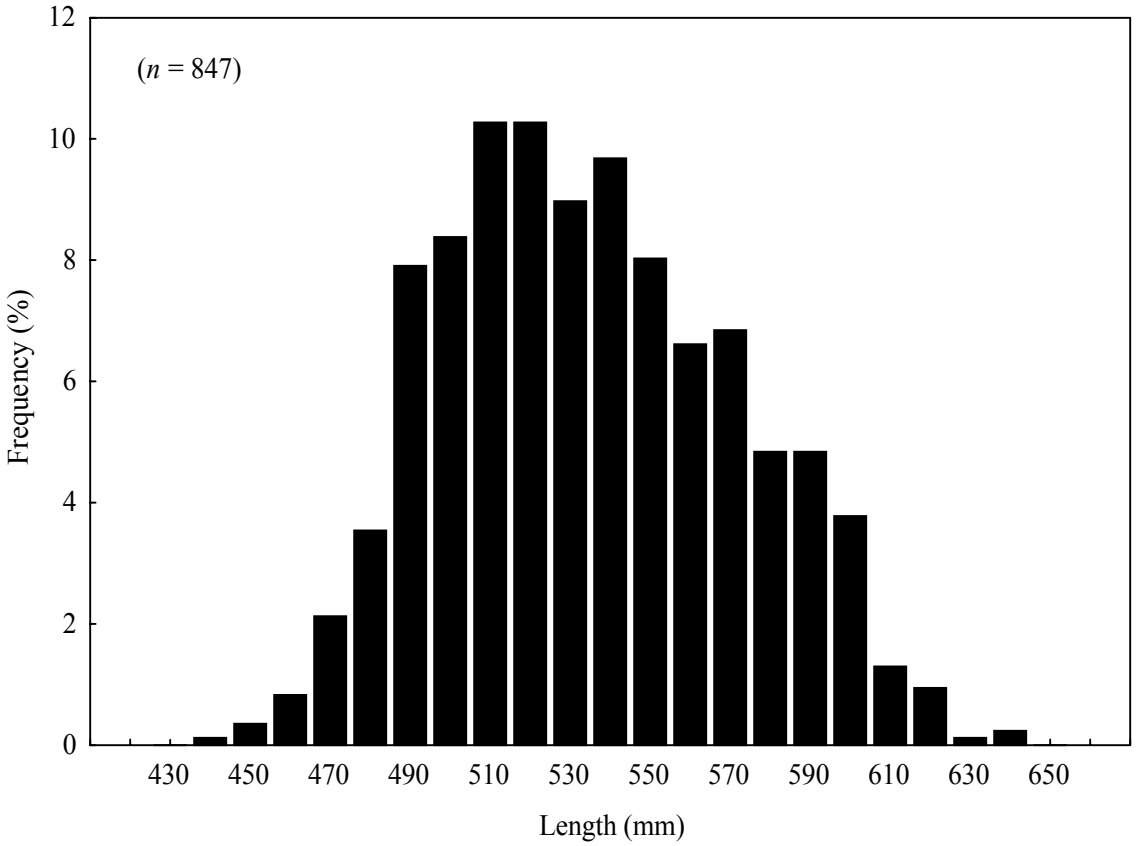

Figure 3. Length-frequency distribution of sockeye salmon sampled at the McLees Lake weir, 2004.

Acknowledgements

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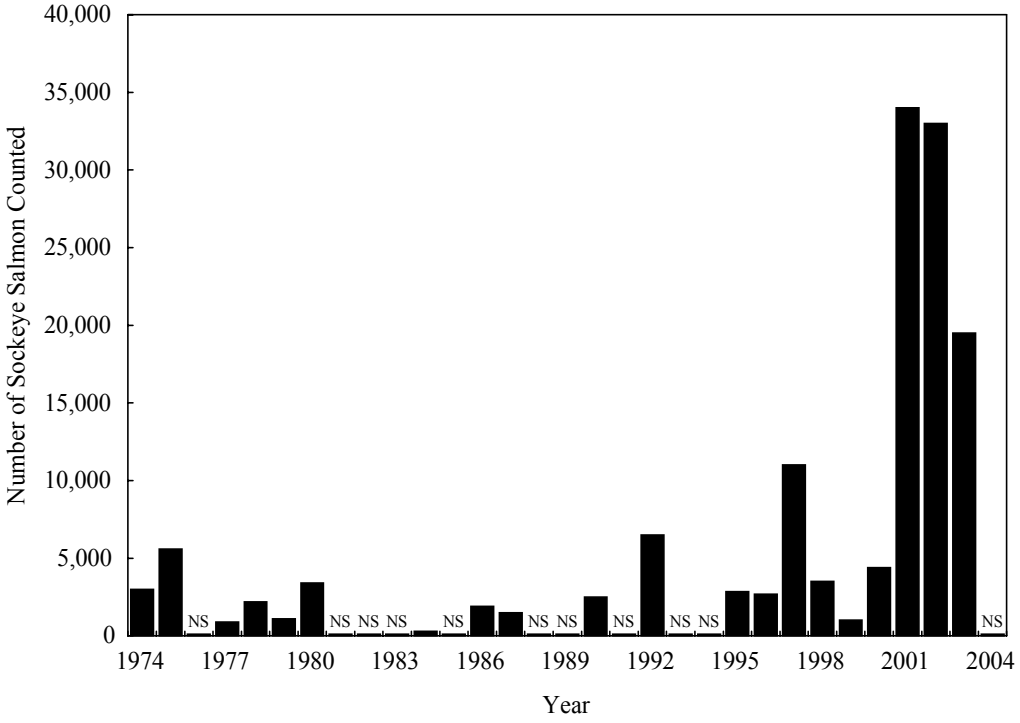
Appendix A. Aerial counts of sockeye salmon in McLees Lake 1974 – 2004. NS denotes no survey conducted. (Arnie Shaul, ADFG unpublished data).



Appendix B. Daily weir passage, number sampled, and cumulative count of sockeye salmon entering McLees Lake 2004.

Date	Count	Sampled	Daily Total	Cumulative Count
1-Jun	1	23	24	24
2-Jun	1	14	15	39
3-Jun	2	19	21	60
4-Jun	125	0	125	185
5-Jun	31	19	50	235
6-Jun	81	27	108	343
7-Jun	184	29	213	556
8-Jun	49	22	71	627
9-Jun	76	0	76	703
10-Jun	18	0	18	721
11-Jun	664	29	693	1,414
12-Jun	468	23	491	1,905
13-Jun	248	22	270	2,175
14-Jun	498	0	498	2,673
15-Jun	416	37	453	3,126
16-Jun	285	31	316	3,442
17-Jun	1,612	0	1,612	5,054
18-Jun	2,739	40	2,779	7,833
19-Jun	6,488	0	6,488	14,321
20-Jun	1,724	0	1,724	16,045
21-Jun	1,429	55	1,484	17,529
22-Jun	1,033	40	1,073	18,602
23-Jun	811	0	811	19,413
24-Jun	1,048	0	1,048	20,461
25-Jun	1,158	11	1,169	21,630
26-Jun	554	17	571	22,201
27-Jun	6,244	56	6,300	28,501
28-Jun	879	15	894	29,395
29-Jun	1,107	0	1,107	30,502
30-Jun	890	17	907	31,409
1-Jul	1,059	0	1,059	32,468
2-Jul	814	25	839	33,307
3-Jul	460	10	470	33,777
4-Jul	15	31	46	33,823
5-Jul	88	17	105	33,928

Appendix B continued.

Date	Count	Sampled	Daily Total	Cumulative Count
6-Jul	12	31	43	33,971
7-Jul	272	46	318	34,289
8-Jul	17	0	17	34,306
9-Jul	132	0	132	34,438
10-Jul	1,324	0	1,324	35,762
11-Jul	97	20	117	35,879
12-Jul	2,303	0	2,303	38,182
13-Jul	0	0	0	38,182
14-Jul	0	0	0	38,182
15-Jul	523	18	541	38,723
16-Jul	44	67	111	38,834
17-Jul	9	26	35	38,869
18-Jul	10	34	44	38,913
19-Jul	47	38	85	38,998
20-Jul	0	34	34	39,032
21-Jul	77	17	94	39,126
22-Jul	7	0	7	39,133
23-Jul	1,155	0	1,155	40,288
24-Jul	39	0	39	40,327
25-Jul	0	0	0	40,327
26-Jul	0	0	0	40,327