U.S. Fish and Wildlife Service

Estimation of sockeye salmon escapement into McLees Lake, Unalaska Island, Alaska, 2005

Alaska Fisheries Data Series Number 2005-16

King Salmon Fish and Wildlife Field Office
King Salmon, Alaska
December 2005

The Alaska Region Fisheries Program of the U.S. Fish and Wildlife Service conducts fisheries monitoring and population assessment studies throughout many areas of Alaska. Dedicated professional staff located in Anchorage, Juneau, Fairbanks, Kenai, and King Salmon Fish and Wildlife Offices and the Anchorage Conservation Genetics Laboratory serve as the core of the Program's fisheries management study efforts. Administrative and technical support is provided by staff in the Anchorage Regional Office. Our program works closely with the Alaska Department of Fish and Game and other partners to conserve and restore Alaska's fish populations and aquatic habitats. Additional information about the Fisheries Program and work conducted by our field offices can be obtained at:

http://alaska.fws.gov/fisheries/index.htm

The Alaska Region Fisheries Program reports its study findings through two regional publication series. The **Alaska Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency databases. The **Alaska Fisheries Technical Reports** publishes scientific findings from single and multi-year studies that have undergone more extensive peer review and statistical testing. Additionally, some study results are published in a variety of professional fisheries journals.

Alaska Fisheries Data Series Number 2005-16, December 2005
U.S. Fish and Wildlife Service

Estimation of Sockeye Salmon Escapement into McLees Lake, Unalaska Island, Alaska, 2005

Michael R. Edwards and Derek R. Hildreth

Abstract

The King Salmon Fish and Wildlife Field Office operated a fixed picket weir at the outlet of McLees Lake on Unalaska Island from 29 May to 26 July 2005. Three species of salmon were counted through the weir including 12,097 sockeye *Oncorhynchus nerka*, 1 chum *O. keta,* and 3 pink *O. gorbuscha* salmon. Peak daily passage occurred on 13 June when 919 sockeye salmon were counted through the weir, and peak weekly passage occurred from 19 June to 25 June when 3,727 sockeye salmon were counted. Six hundred and seventy-six sockeye salmon were sampled for age, sex, and length analysis. Of this sample, 89 (13%) scales were unreadable. Five age classes were identified from the 587 readable scales obtained from sockeye salmon sampled at the weir. Age class 1.3 was the most abundant, accounting for 88 % of the sample. Females comprised an estimated 38 % of sockeye salmon sampled in 2005.

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 (Shaul and Dinnocenzo 2004). 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

Authors: Mike Edwards and Derek Hildreth are fishery biologists with the U.S. Fish and Wildlife Service. The authors can be contacted at King Salmon Fish and Wildlife Field Office, PO Box 277, King Salmon, Alaska 99613; or Mike_Edwards@fws.gov and Derek_Hildreth@fws.gov.

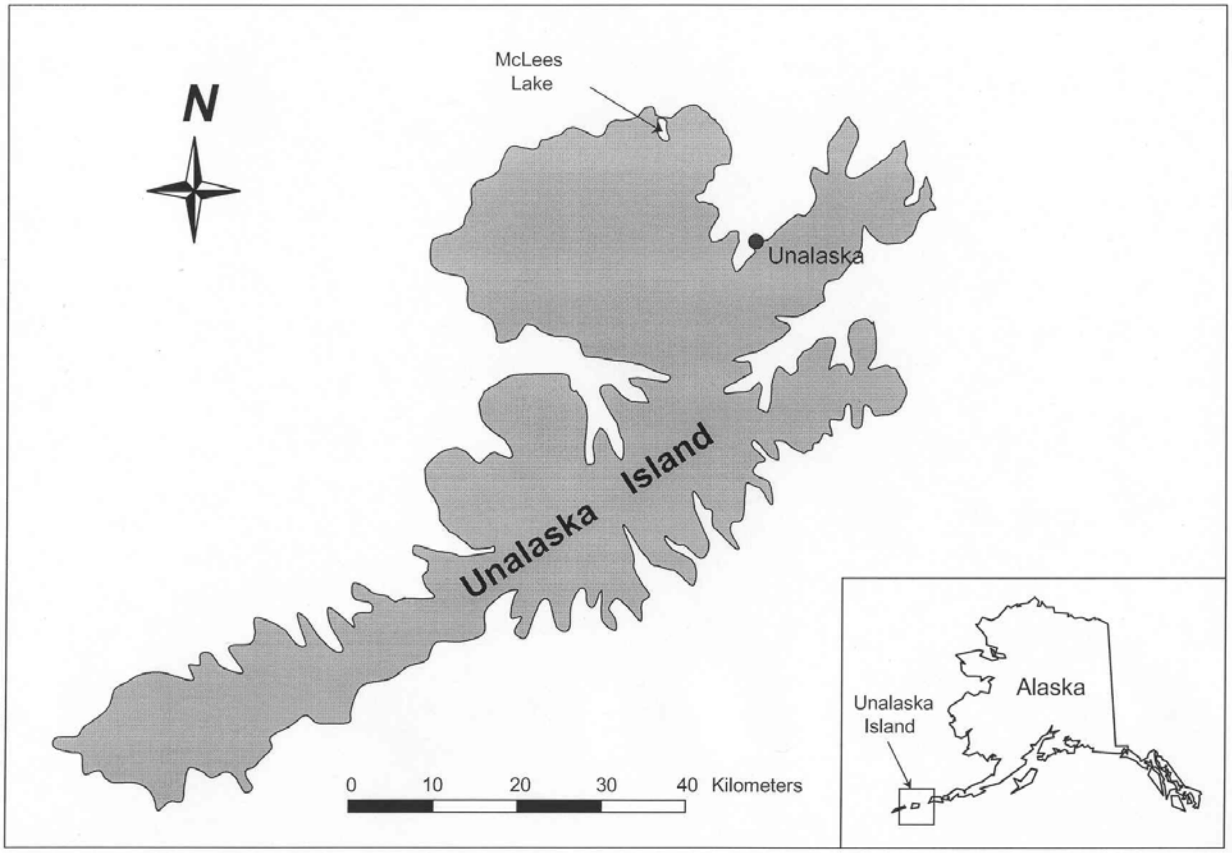


Figure 1. Map of Unalaska Island showing the location of McLees Lake, Alaska Maritime National Wildlife Refuge.

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.

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 2001.

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 Fish and Wildlife 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, and
4. Estimate the mean length of sockeye salmon by sex and age.

Gates and Palmer (2004) and Edwards (2005) have summarized past weir results. This report summarizes findings of the 2005 season.

Methods

Escapement Monitoring

A flexible picket weir spanning 21 m was installed at the outlet of McLees Lake and operated from 29 May to 26 July, 2005. Weir pickets were composed of metal, electrical conduit with a 1.3 cm inside diameter. 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 are 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 m. To prevent fish from squeezing between the weir pickets, plastic snow fencing (3 m by 1 m with 2.2 cm square mesh) was attached on the downstream side of the two weir panels adjacent to the entrance to the trap box. A trap box was constructed on the upstream side of the weir to facilitate sampling fish and passing adult salmon through the weir. The weir and trap box were inspected daily and maintained as needed to ensure integrity. Stage height was measured in the morning and evening from a staff gauge located in the outlet channel, and water temperatures were recorded with a Hobo® temperature logger (Appendix B).

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 estimated 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.

Table 1. Strata used for analysis of McLees Lake weir sockeye salmon ASL data, 2005.

Stratum	Start Date	End Date
1	29 May	11 June
2	12 June	18 June
3	19 June	25 June
4	26 June	2 July
5	3 July	9 July
6	10 July	16 July
7	17 July	26 July

Sample data were recorded on all-weather 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.

Characteristics of 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* ($\hat{p}_{jkm}$) 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

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

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* (N_{jkm}) 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 (p_{ijk}) for the entire period of weir operation was computed as weighted sums of the stratum estimates

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

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 in a sex and age category (N_{jk}) 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 the r^{th} fish of sex j and age k sampled in stratum m is denoted x_{jkmr}, the mean length of all such fish (μ_{jkm}) was estimated by

$$\hat{\mu}_{jkm} = \left(\frac{1}{n_{jkm}}\right)\sum_{r}x_{jkmr},$$

with corresponding variance estimator

$$\hat{v}\left(\hat{\mu}_{jkm}\right) = \left(1-\frac{n_{jkm}}{\hat{N}_{jkm}}\right)\frac{\sum_{r}\left(x_{jkmr}-\hat{\mu}_{jkm}\right)^{2}}{n_{jkm}\left(n_{jkm}-1\right)}.$$

The mean length of all sockeye salmon of sex i and age j (μ_{jk}) was estimated as a weighted sum of the stratum estimates

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

An approximate estimator of the variance of $\hat{\mu}_{jk}$ was obtained using the delta method (Seber 1982) by

$$\hat{v}(\hat{\mu}_{jk}) = \sum_m \left\{ \hat{v}(\hat{N}_{jkm}) \left[\frac{\hat{\mu}_{jkm}}{\sum_x \hat{N}_{jkx}} - \sum_y \frac{\hat{N}_{jky}\,\hat{\mu}_{jky}}{\left(\sum_x \hat{N}_{jkx}\right)^2} \right]^2 + \left(\frac{\hat{N}_{jkm}}{\sum_x \hat{N}_{jkx}} \right)^2 \hat{v}(\hat{\mu}_{jkm}) \right\}.$$

Results

Escapement Monitoring

In 2005, operation of the McLees Lake weir began on 29 May and continued uninterrupted through 26 July. During this time, 12,097 sockeye, 1 chum *O. keta*, and 3 pink *O. gorbuscha* salmon were counted through the weir. Sockeye salmon were passed through the weir on 50 (87.7%) of the 57 days of operation (Figure 2). Peak daily passage occurred on 13 June when 919 sockeye salmon were passed through the weir (Appendix C), and peak weekly passage occurred from 19 June to 25 June when 3,727 sockeye salmon were counted (Table 2).

Age, Sex, and Length Data

Six hundred and seventy-six sockeye salmon were sampled for ASL analysis. Of this sample, 89 (13%) scales were unreadable. Five age groups were identified from the scale samples; ages 1.3 (88%) and 1.2 (8%) accounted for 96% of the run (Table 3). Ages 1.4 (n = 5) and 2.4 (n = 4) were the least abundant ages, accounting for less than two percent of the run. Approximately 38% of the sockeye salmon escapement was female (Table 2). Lengths of sockeye salmon sampled ranged from 432 to 596 mm for females and from 488 to 623 mm for males (Table 4, Figure 3).

Table 2. Sample size, sex composition, and escapement by stratum for sockeye salmon passing the McLees Lake weir, 2005.

Stratum	*n*	Female	Male	SE	Escapement
1	75	52	48	4.8	247
2	121	37	63	4.3	3,305
3	121	36	64	4.3	3,727
4	124	42	58	4.4	3,220
5	122	40	60	4.1	841
6	40	38	63	7.2	307
7	73	27	73	4.8	450
Total	676	38	62	2.2	12,097

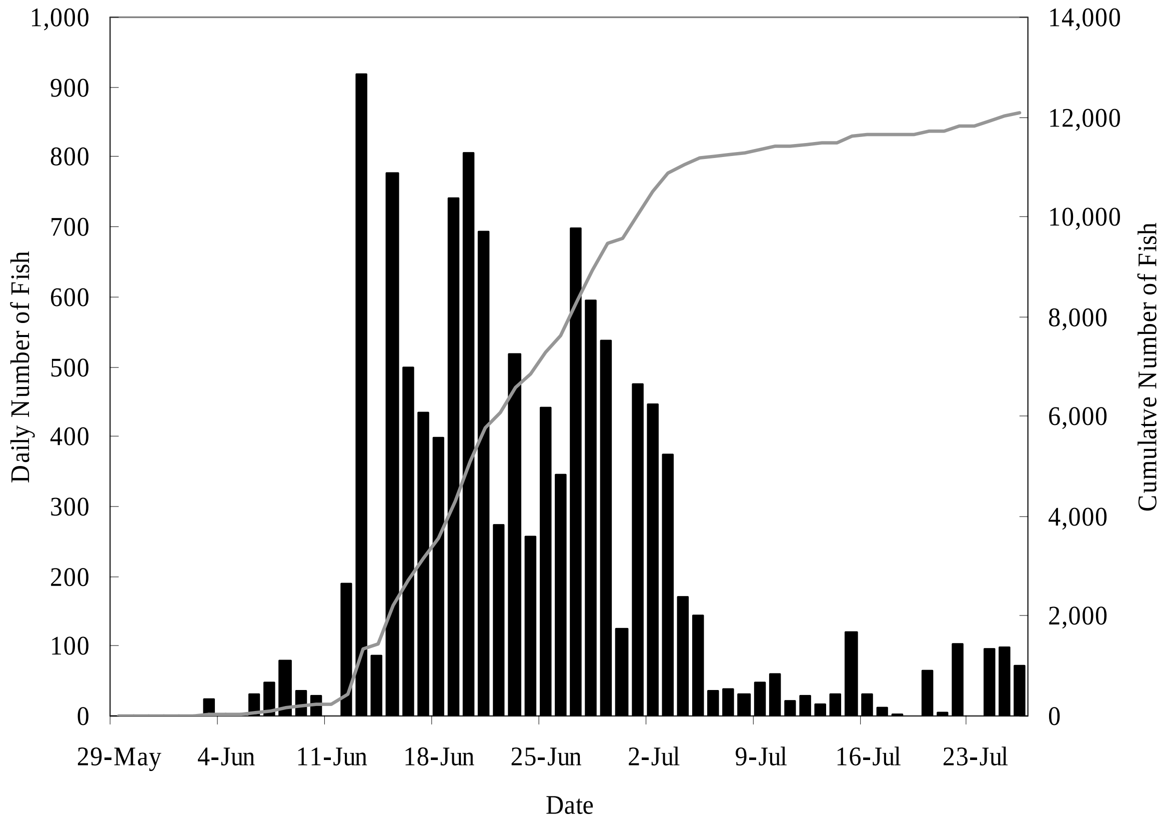


Figure 2. Daily (bars) and cumulative (line) weir passage of sockeye salmon entering McLees Lake, 2005.

Table 3. Age composition, SE, and sample size of sockeye salmon sampled at the McLees Lake weir, 2005.

	Age Class				
	1.2	1.3	1.4	2.3	2.4
			Stratum 1		
%	9	85	2	5	0
SE	3.1	3.8	1.3	2.2	0.0
n	6	56	1	3	0
			Stratum 2		
%	9	88	1	2	1
SE	2.7	3.2	0.9	1.3	0.9
n	9	91	1	2	1
			Stratum 3		
%	10	88	2	1	0
SE	2.7	3.0	1.2	0.9	0.0
n	11	101	2	1	0
			Stratum 4		
%	7	89	1	2	1
SE	2.5	3.0	0.9	1.3	0.9
n	8	97	1	2	1
			Stratum 5		
%	7	89	0	4	1
SE	2.3	2.9	0.0	1.7	0.9
n	7	94	0	4	1
			Stratum 6		
%	6	88	0	6	0
SE	4.0	5.5	0.0	4.0	0.0
n	2	29	0	2	0
			Stratum 7		
%	9	89	0	0	2
SE	3.7	4.0	0.0	0.0	1.7
n	5	48	0	0	1
			Total		
%	8	88	1	2	1
SE	1.3	1.5	0.5	0.6	0.4
n	48	516	5	14	4

Table 4. Mean length (mm), SE, range, and sample size by age class of sockeye salmon sampled at McLees Lake, 2005.

	Age Class				
Length	1.2	1.3	1.4	2.3	2.4
			Female		
Mean	483	540	-	549	-
SE	9.9	8.4	-	9.9	-
Min	432	476	-	533	549
Max	523	596	-	570	-
n	22	199	0	6	1
			Male		
Mean	501	562	570	569	571
SE	14.8	9.4	9.7	8.6	-
Min	448	448	544	554	560
Max	576	623	604	587	608
n	26	317	5	8	3
			All Fish		
Mean	492	554	570	565	562
SE	13.0	10.5	9.7	7.3	-
Min	432	448	544	533	549
Max	576	623	604	587	608
n	48	516	5	14	4

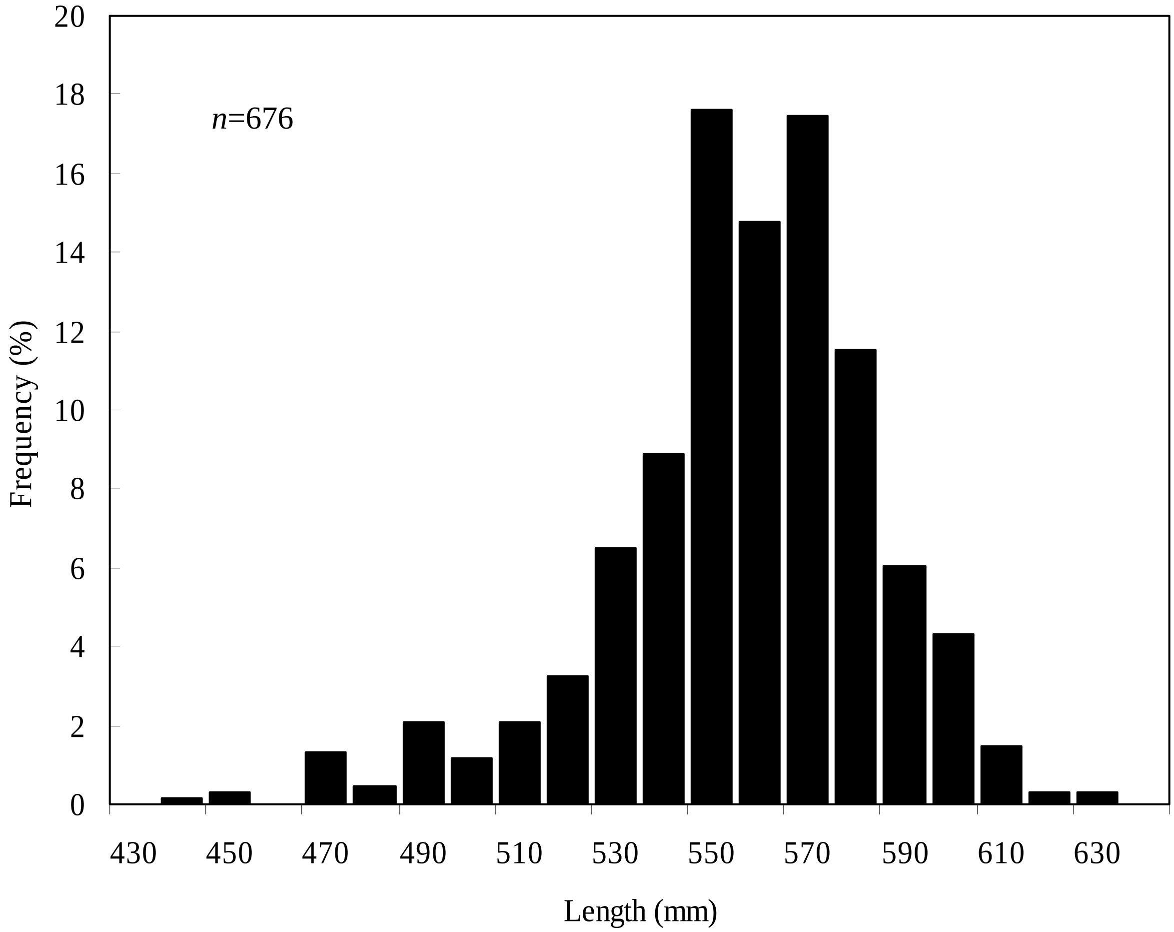


Figure 3. Length frequency distribution of sockeye salmon sampled at the McLees Lake weir, 2005.

Discussion

Sockeye salmon escapement in 2005 was the lowest observed over the past four years, however the 2005 escapement was almost three times greater than the 1995-2000 pre-weir average aerial count of 4,246 (Arnie Shaul, ADFG personal communication). Recent weir counts of sockeye salmon escapements into McLees Lake have documented much higher levels of escapement than historical aerial survey data. However, due to the infrequency of aerial surveys and limited years of weir data, it is unclear if the 2001-2004 escapements (range 40,327 to 101,793 fish) were abnormally large and the 2005 escapement signals a return to more normal smaller escapements to McLees Lake.

Most of the 2005 run was composed of age 1.3 sockeye salmon (88%), similar to the age composition observed in 2001 and 2003 (Gates and Palmer 2004). The dominant age class in McLees Lake appears to alternate between ages 1.2 in even years and 1.3 in odd years. The sex composition was skewed toward males, which is similar to the first four years of the weir project, although it was more pronounced than in previous years.

The desired level of precision in the sex and age composition was met (Appendix D) even though the number of unreadable scales exceeded 10%. Therefore, the sampling goal of 135 fish per stratum will be used again in 2006.

As in past years, the crew reported that a few sockeye salmon forced their way through weir panel spaces and some were being gilled in areas where snow fencing had not been used to fortify the weir pickets. To reduce the weir's impact on salmon migration, snow fencing will be installed on the entire downstream side of the weir panels in 2006.

Sockeye salmon escapements over the last five years have been highly variable. We recommended extending the study through at least 2009 to better define the escapement levels needed to maintain a productive run. This would give state and federal agencies nine years of total escapement data to establish escapement goals for the McLees Lake sockeye salmon run.

Acknowledgements

We thank Anderson Berry and Ryan Kniaziowski for their efforts in operating the McLees Lake weir. We also thank Sharon Livingston, environmental coordinator for the Qawalangin Tribe, for providing the local hire for this project. We also appreciate ADFG local manager Forest Bowers and staff efforts in transporting supplies and personnel from Dutch Harbor to the weir site and for providing bunkhouse space for the crew while in Dutch Harbor.

The U. S. Fish and Wildlife Service Office of Subsistence Management provided funding for this project through the Fisheries Resource Monitoring Program, project number FIS 04-403.

References

Bromaghin, J.F. 1993. Sample size determination for interval estimation of multinomial probabilities. The American Statistician 47: 203-206.

Cochran, W.G. 1977. Sampling techniques, 3rd edition. John Wiley and Sons, New York.

Edwards, M.R. 2005. Estimation of sockeye salmon escapement into McLees Lake, Unalaska Island, Alaska, 2004. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Report Number 2005-4, King Salmon, Alaska.

Gates, K.S. and D.E. Palmer. 2004. Estimation of sockeye salmon escapement into McLees Lake, Unalaska Island, Alaska, 2003. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Report Number 2004-1, Kenai, Alaska.

Jearld, A. 1983. Age determination. Pages 301-324 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

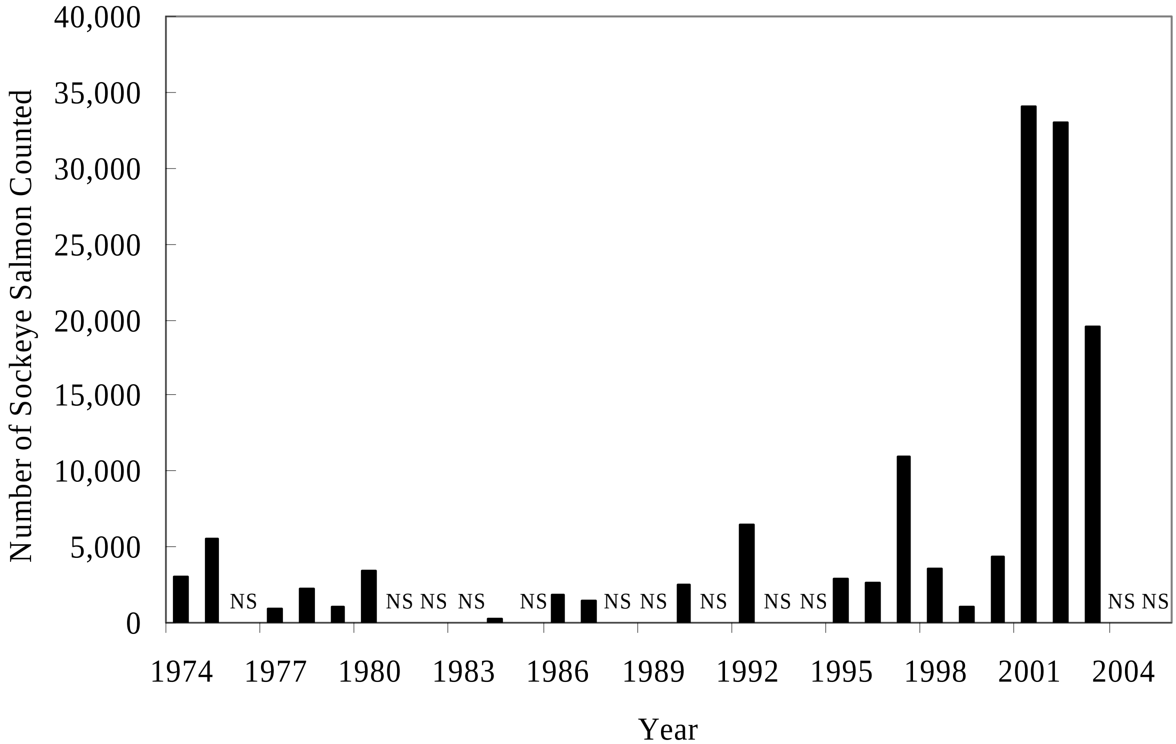
Koo, T.S.Y. 1962. Age determination in salmon. Pages 37-48 *in* T.S.Y. Koo, editor. Studies of Alaskan red salmon. University of Washington Press, Seattle, Washington.

Murphy, R.L. 2000. Alaska Peninsula salmon evaluation and escapement sampling operating procedures, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

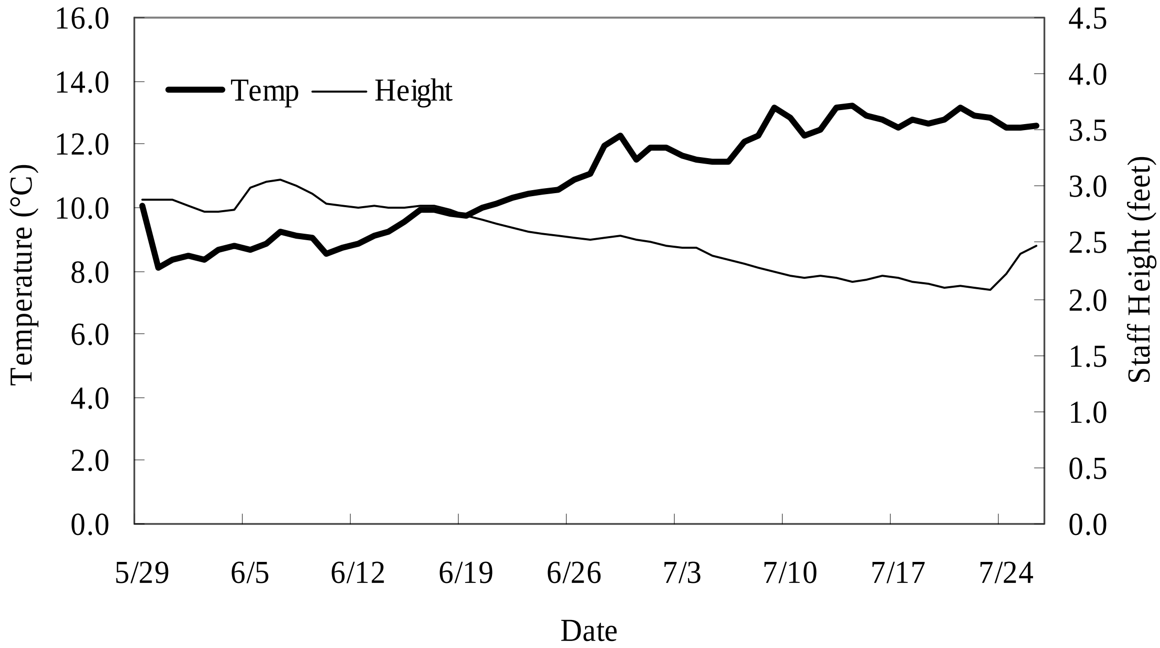
Seber, G.A.F. 1982. The Estimation of Animal Abundance and Related Parameters, 2nd edition. Maxmillan, New York.

Shaul, A.R. and J.J. Dinnocenzo. 2004. Annual summary of the commercial and subsistence salmon fishery for the Alaska Peninsula, Aleutian Islands, and Atka-Amlia Islands Management Areas, 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K04-34. Kodiak, Alaska.

Appendix A. Aerial counts of sockeye salmon in McLees Lake, 1974 – 2005. NS denotes no survey conducted. (Arnie Shaul, ADFG unpublished data).



Appendix B. Staff Height and Temperature, McLees Lake, 2005.



Appendix C. Daily weir passage, number sampled, cumulative count and percentage of sockeye salmon entering McLees Lake, 2005.

Date	Sampled	Daily Count	Cumulative Count	Cumulative Percentage
29-May	0	0	0	0
30-May	0	0	0	0
30-May	0	0	0	0
31-May	0	1	1	0
1-Jun	0	0	1	0
2-Jun	0	0	1	0
3-Jun	0	24	25	0
4-Jun	0	0	25	0
5-Jun	0	0	25	0
6-Jun	0	31	56	0
7-Jun	10	48	104	1
8-Jun	15	79	183	2
9-Jun	27	35	218	2
10-Jun	23	29	247	2
11-Jun	0	0	247	2
12-Jun	0	190	437	4
13-Jun	33	919	1,356	11
14-Jun	19	87	1,443	12
15-Jun	27	776	2,219	18
16-Jun	37	500	2,719	22
17-Jun	5	435	3,154	26
18-Jun	0	398	3,552	29
19-Jun	29	740	4,292	35
20-Jun	40	806	5,098	42
21-Jun	0	692	5,790	48
22-Jun	26	273	6,063	50
23-Jun	26	518	6,581	54
24-Jun	0	256	6,837	57
25-Jun	0	442	7,279	60
26-Jun	34	345	7,624	63
27-Jun	29	699	8,323	69
28-Jun	30	594	8,917	74
29-Jun	0	536	9,453	78
30-Jun	0	125	9,578	79

Appendix C. Continued.

	Sampled	Daily Count	Cumulative Count	Cumulative Percentage
1-Jul	31	476	10,054	83
2-Jul	0	445	10,499	87
3-Jul	50	373	10,872	90
4-Jul	21	171	11,043	91
5-Jul	0	145	11,188	92
6-Jul	21	35	11,223	93
7-Jul	30	38	11,261	93
8-Jul	0	31	11,292	93
9-Jul	0	48	11,340	94
10-Jul	7	61	11,401	94
11-Jul	5	21	11,422	94
12-Jul	6	28	11,450	95
13-Jul	6	16	11,466	95
14-Jul	9	30	11,496	95
15-Jul	4	120	11,616	96
16-Jul	3	31	11,647	96
17-Jul	0	11	11,658	96
18-Jul	0	2	11,660	96
19-Jul	0	0	11,660	96
20-Jul	2	64	11,724	97
21-Jul	0	5	11,729	97
22-Jul	0	103	11,832	98
23-Jul	0	0	11,832	98
24-Jul	0	96	11,928	99
25-Jul	32	98	12,026	99
26-Jul	39	71	12,097	100

Appendix D. Standard Errors and Subsequent Derived Confidence Intervals (CI) for Age and Gender, McLees Lake, 2005.

Age Class	1.2	1.3	1.4	2.3	2.4	Gender
SE	1.3	1.5	0.5	0.6	0.4	2.2
n	48	516	5	14	4	676
CI	0.0221	0.0252	0.0109	0.0104	0.0086	0.0363