Alaska Fisheries Technical Report Number 69

Estimation of Coho Salmon Escapement in the Ugashik Lakes, Alaska Peninsula National Wildlife Refuge, Alaska, 2001-2003

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Key words: coho salmon, counting tower, escapement, run timing, subsistence, Ugashik lakes, Alaska Peninsula

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Alaska Fisheries Technical Report Number 69

Estimation of Coho Salmon Escapement in the Ugashik Lakes, Alaska Peninsula National Wildlife Refuge, Alaska, 2001-2003

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*Abstrac*t – Local subsistence users have expressed concern over the lack of in-season escapement information for coho salmon *Oncorhynchus kisutch* entering the Ugashik lakes. Escapement monitoring of coho salmon in the Ugashik Commercial Fishing District is from infrequent aerial surveys at the end of the season. The lack of in-season escapement information has lead to concerns of possible over harvest by the sport-fish user group. In 2000, the King Salmon Fish and Wildlife Field Office initiated a three-year counting tower project to estimate coho salmon escapement to address these concerns. Counting operations were conducted from mid-July to late-September each year using the standard Alaska Department of Fish and Game counting tower protocols. Escapement was estimated at 3,606 in 2001, 17,730 in 2002, and 28,212 in 2003. A total of 297 coho salmon were sampled for age, sex, and length data. Three age classes were identified; age class 2.1 was the most abundant each year, followed by age 1.1, and age 3.1. Mid-eye to fork lengths (mm) ranged from 465 to 687 in 2001, 452 to 663 in 2002, and 471 to 697 in 2003. Mean length at age varied between years and was largest for all age classes in 2003.

Introduction

Coho salmon *Oncorhynchus kisutch* is an important subsistence species for the residents of Ugashik and Pilot Point (Wright et al. 1985). A significant portion of the coho salmon harvested by local subsistence users are reported to be taken from the Ugashik lakes, located within the Alaska Peninsula National Wildlife Refuge (Wright et al. 1985). In-season salmon escapement monitoring in the Ugashik Commercial Management District is focused mainly on sockeye salmon *Oncorhynchus nerka.* The Alaska Department of Fish and Game (ADFG) monitors the catch and harvest of coho salmon from commercial, subsistence, and sport fishing.

However, this information is compiled after the subsistence fishery is over and therefore, does not provide an estimate of in-season run strength. Historically, in-season management of coho salmon was based on catch per effort indices from the commercial fishery (Keith Weiland, ADFG, personal communication) and seasonal escapement indexed post-season from a single aerial survey (Glick et al. 2000). The current ten-year average commercial harvest of coho salmon in the Ugashik District is 10,909 fish, however, recent commercial harvest has declined considerably; the 2000 to 2002 average harvest was 903 fish (Morstad et al. 2003). From 1992 to 2001 subsistence harvest in the District has averaged 395 fish (Morstad et al. 2003), while sport fish harvest has averaged 472 fish (Craig Schwanke, ADFG, personal communication).

The need for an in-season escapement estimate was demonstrated during the 2000 fishing season when ADFG Sport Fish received numerous phone calls demanding regulatory action because of poor coho salmon fishing success by sport anglers (Dan Dunaway, ADFG, personal communication). Concerns of a lack of coho salmon were also voiced by the subsistence fishery users outside of the Conservation Unit boundary (anonymous Ugashik Village subsistence fisher, personal communication). Because commercial fishing success was in the acceptable range early in the season (Keith Weiland, ADFG, personal communication) no action was taken to close the fisheries. Subsistence users are concerned that the lack of an in-season estimate of coho salmon escapement may allow the sport fishery to over harvest the population. Representatives from Ugashik Traditional Village, Bristol Bay Native Association (BBNA), and King Salmon Fish and Wildlife Field Office (KSFO) discussed solutions to the lack of escapement information for coho salmon and the subsistence versus sport fishing conflict. An agreement was reached that the first step toward resolving the conflict would be to obtain an accurate estimate of escapement. The parties agreed that the best way to evaluate escapement would be to extend the operation of the ADFG sockeye salmon counting tower through the coho salmon season.

In-season escapement information could have improved the decision making process and provided better conservation security for the coho salmon population. Also, an in-season estimate of escapement would ensure that a sufficient number of coho salmon is available for subsistence harvest. An accurate post-season escapement estimate may diminish concerns about over-harvest and will help in resolving the conflict between subsistence and sport users. The information provided by this project will aid the Bristol Bay Regional Advisory Council and the Federal Subsistence Board in evaluating regulatory proposals regarding management of coho salmon stocks in the Ugashik lakes drainage. The specific objectives for the project were:

1. Estimate daily and seasonal escapement of coho salmon in the Ugashik lakes.
2. Estimate the age and sex compositions of coho salmon such that simultaneous 90% confidence intervals have a maximum width of 0.20.
3. Estimate the mean length of coho salmon by age and sex.

Study Area

The Ugashik lakes are located within the Alaska Peninsula National Wildlife Refuge, about 120 km southwest of King Salmon, Alaska on the Alaska Peninsula. The Ugashik lakes system is comprised of an upper lake and lower lake that are joined by a short channel called the Ugashik Narrows (Figure 1). The upper lake has a mean depth of 28.6 m, a maximum depth of 150 m and a surface area of 199.4 km^2. The lower lake has a mean depth of 35.7 m, a maximum depth of 120 m and a surface area of 182.3 km^2 (Edmundson and Todd 2000).

Most of the tributaries that feed the upper and lower lakes originate in the Aleutian Range that bounds the lakes to the east. Terrestrial habitat bordering the lakes to the west is a combination of lowland tundra and numerous small lakes and ponds. The climate of the area is described as polar maritime with mild temperatures, high winds, and frequent precipitation (USFWS 1985).

The lakes support populations of five species of Pacific Salmon, sockeye and coho salmon are the most abundant (Edwards and Larson 2002; Sands et al. 2002). Resident freshwater species documented in the Ugashik lakes are: Arctic grayling *Thymallus arcticus*, Dolly Varden *Salvelinus malma*, Arctic char *Salvelinus alpinus*, lake trout *Salvelinus namaycush*, northern pike *Esox lucius*, round whitefish *Prosopium cylindraceum*, (Mecklenburg et al. 2002). Fieldwork in 2003 documented the presence of pygmy whitefish *Prosopium coulterii*, a species believed to be present in the Ugashik lakes but previously undocumented (Miranda Plumb, USFWS, personal communication).

Methods

Escapement Estimate

Counts of coho salmon at the Ugashik tower site were made using the same equipment, location, and procedures that the ADFG Commercial Fisheries Division uses to estimate sockeye salmon escapement in the drainage (ADFG 1984). Escapement is estimated by expanding 10-minute counts of fish passage (upstream and downstream) made every hour of the calendar day from each riverbank. The 10-minute counts are multiplied by an expansion factor of six to estimate passage for each hour. A negative estimate is possible if the number of fish counted moving downstream exceeds the number counted moving upstream. The 24 hourly estimates from each bank are then summed to provide daily passage estimates. A light-colored metal panel was anchored to the river bottom to provide a contrasting background for optimal fish identification. Technicians used polarized sunglasses to reduce surface glare and enhance counting ability. Artificial lights were used to obtain counts during the night.

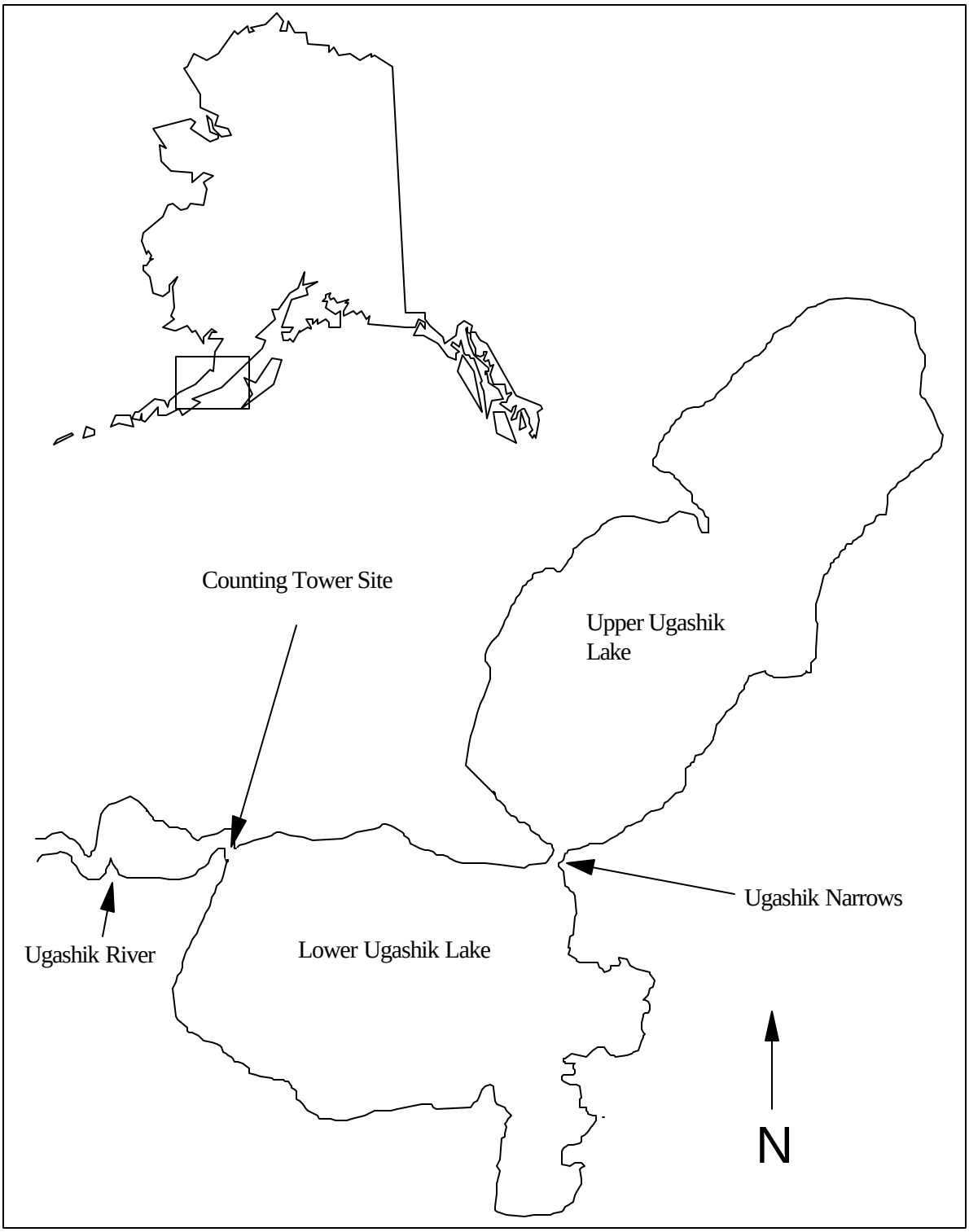

Figure 1. Location of coho salmon counting tower site on the Ugashik River, Alaska Peninsula National Wildlife Refuge, 2001-2003.

Age, Sex, and Length Data

A beach seine (30.5 m long, 3.1 m deep, and 7.6 cm stretch mesh) was used to capture salmon for collecting age, sex, and length (ASL) data. We estimated that we would need to sample 138 fish per week to meet the objectives outlined in the study plan, based on the methods of Bromaghin (1993). In 2001, seining was conducted five to six times per week throughout the season at several locations near the counting tower; it was difficult to capture coho salmon and sampling objectives were only met by pooling all samples into a single stratum. Results of the 2001 ASL data indicated the Ugashik lakes coho salmon run was dominated by a single age class, which was similar to that observed for other Bristol Bay stocks. Stratification was not necessary because of the uniformity of age structure. Therefore, we recalculated the sampling objective, which became a goal of 61 samples for the season. This sampling scheme was used in 2002 and 2003. The new sampling scheme for 2002 and 2003 used the methods of Bromaghin (1993), where estimates of $\hat{p}$ for both age and sex were calculated using the same equation (Karen Hyer, Office of Subsistence Management, personal communication);

$$\hat{p} = \frac{n_i}{n}, \text{ where } i = \text{age or sex.}$$

A sample size for age composition estimates was calculated for three simultaneous multinomial probabilities based on the age data collected in 2001. A sample size for sex composition estimates was calculated for two binomial probabilities base on the sex data from 2001. The largest sample size (n = 61) was used as the new sampling objective. All calculations used estimates of d_i and alpha as outlined in Bromaghin (1993).

$$n = \left(\frac{z^2_{(1-(\alpha_i/2))}}{2d_i^2} \right) \left[p_i(1-p_i) - 2d_i^2 + \sqrt{p_i^2(1-p_i)^2 - d_i^2\left[4p_i(1-p_i)-1\right]} \right]$$

where $d_i = 0.10$, $\alpha_i = 0.10$, and $z = \frac{x_i - m}{s}$.

Coho salmon mid-eye-to-fork of the tail length (MEF) was measured to the nearest millimeter, and sex was determined by observing external characteristics (Mecklenburg et al. 2002). Three to four scale samples were collected from the preferred area (Jearld 1983) on each coho salmon sampled. Scales were cleaned and mounted on gum cards for making scale impressions. Scale impressions were made on clear acetate with a laboratory press. Fish ages were determined from scale impressions by two researchers indenpendently, and any conflicting age determinations were re-analyzed jointly until both researchers agreed on an age determination. Age designations are expressed in the European fashion (Koo 1962), where numerals preceding the decimal denote freshwater annuli, and numerals following the decimal refer to the marine annuli.

Chi-square analysis was used to compare age and sex frequencies between years (StatSoft, Inc. 2004). Kolmogorov-Smirnov paired tests (Sokal and Rohlf 1981) were used to compare cumulative length frequency distributions between years. One-way analysis of variance (ANOVA) and a Tukey multiple comparison test were used to compare mean lengths between years (Minitab Inc. 2003). Residual analysis (Neter et al. 1996) was used to test the assumptions of the ANOVA model. Significance was declared at $p < 0.05$ for all statistical tests.

Results

Escapement Estimate

Tower operations began late-July and continued through late-September of each year. Coho salmon spawning escapement estimates were 3,606 in 2001, 17,730 in 2002, and 28,212 in 2003 (Appendices A, B, and C). Dates of highest daily escapement varied between years, occurring on 16 September in 2001 (n = 534), 25 August in 2002 (n = 1,494), and 9 September in 2003 (n = 3,588) (Figure 2). The earliest date coho salmon were counted was 25 July 2003 and the latest was 28 September 2001. Over 90% of the estimated escapement had occurred by 16 September in 2001, and by 15 September in 2002 and 2003 (Figure 3). Negative daily escapement estimates (i.e., more coho salmon counted moving downstream than upstream) occurred each year, the most in 2003 (n = 3; Appendices A, B, and C). Escapement estimates for other species of Pacific salmon observed were calculated each year, sockeye salmon were the most abundant in all years (Appendices A, B, and C).

Age, Sex, and Length Data

During the three years of study, 297 coho salmon were captured and released to collect ASL data. We were able to determine the age of 256 of these coho salmon, and three age classes (1.1, 2.1, and 3.1) were identified. Most coho salmon sampled were age 2.1, accounting for over 70% of the sample each year (Table 1). Age 1.1 coho salmon was the next most abundant age class, accounting for at least 10% of the sample each year, while age 3.1 coho salmon was the least abundant age class, accounting for 5% or less of the sample each year. Chi-square analysis indicated a significant difference in age class frequencies between years ($X^2 = 10.05$; df = 4; P = 0.03). Male coho salmon were more abundant than female coho salmon in 2001 (61 % of sample) and 2002 (60 % of sample), but slightly less abundant than female coho salmon in 2003 (49 % of sample) (Table 2).

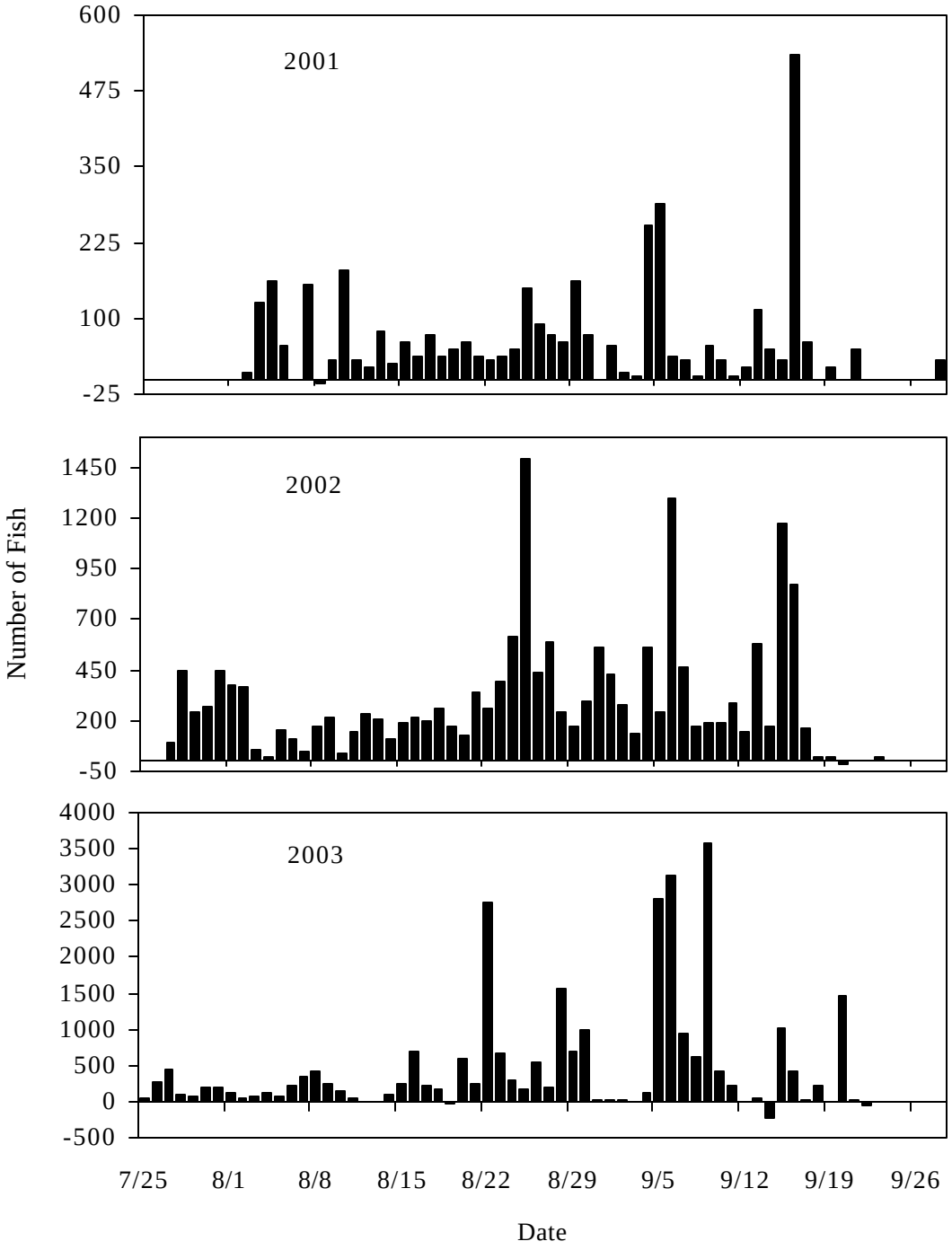

Figure 2. Daily counting tower estimates of coho salmon escapement into the Ugashik lakes, Alaska Peninsula National Wildlife Refuge 2001-2003.

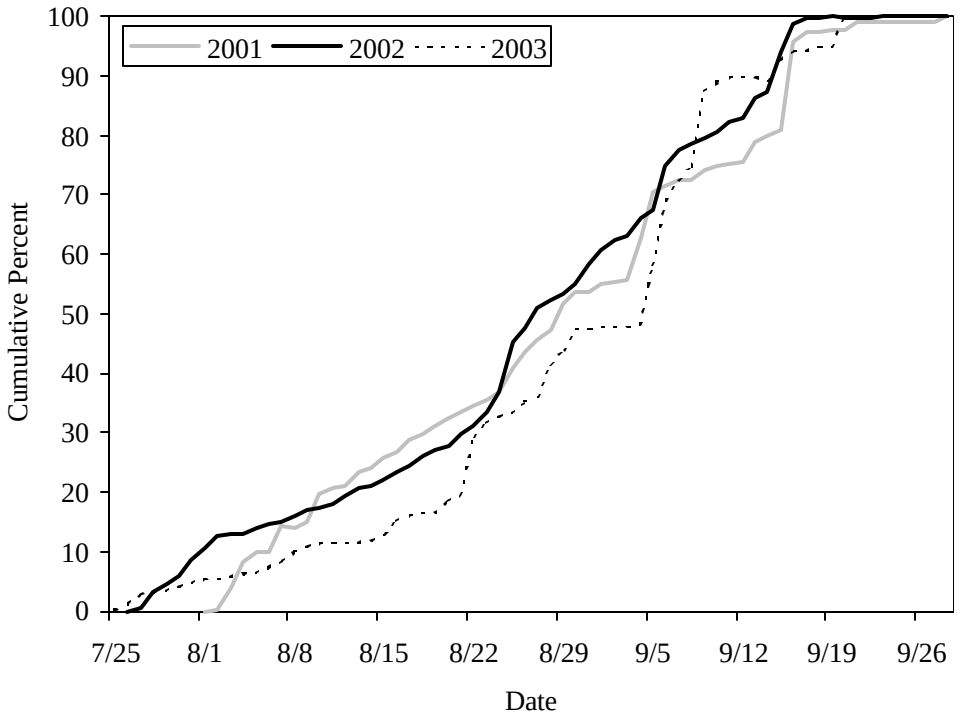

Figure 3. Cumulative count tower estimates of daily coho salmon escapement into the Ugashik lakes, Alaska Peninsula National Wildlife Refuge 2001-2003.

Table 1. Estimated age, mean mid-eye to fork length, and SE of coho salmon sampled in the Ugashik lakes, Alaska Peninsula National Wildlife Refuge, 2001 to 2003.

Age	n	Percent	SE	Mean length	SE
		2001			
1.1	14	10	0.03	571	14.05
2.1	122	87	0.03	591	4.23
3.1	5	3	0.02	618	22.52
		2002			
1.1	15	27	0.06	581	15.45
2.1	39	71	0.06	590	9.23
3.1	1	2	0.02	581	-
		2003			
1.1	9	15	0.04	618	6.01
2.1	48	80	0.05	615	5.65
3.1	3	5	0.02	616	2.84

Table 2. Estimated sex composition, mean mid-eye to fork length, and SE of coho salmon sampled in the Ugashik lakes, Alaska Peninsula National Wildlife Refuge, 2001 to 2003.

Sex	n	Percent	SE	Mean length	SE
			2001		
M	95	61	0.04	581	5.09
F	60	39	0.04	602	5.42
			2002		
M	40	60	0.06	572	9.84
F	26	40	0.06	598	8.76
			2003		
M	37	49	0.06	610	8.07
F	39	51	0.06	617	4.61

Coho salmon MEF ranged from 465 to 687 mm in 2001, 452 to 663 mm in 2002, and 471 to 697 mm in 2003 (Figure 4). Mean MEF at age varied between years and was largest for all age classes in 2003 (Table 1). Mean MEF of female coho salmon was greater than that of male coho salmon in all years (Table 2). The 2003 sample contained a greater proportion of coho salmon with MEF 620 mm or greater than did the 2001 and 2002 samples. The cumulative length frequency distributions for 2001 and 2002 were not significantly different ($D = 0.08$; $N_1 = 155$; $N_2 = 66$; $P = 0.89$) however, cumulative length frequencies between 2003 and all other years was significant ($D > 0.27$; $P < 0.01$) (Figure 5). One-way ANOVA revealed a significant difference between mean lengths for all years ($df = 294$; $F = 8.82$; $P < 0.0001$). Tukey's multiple means comparison indicated the 2003 mean MEF differed from the 2001 and 2002 lengths. A probability plot of the residuals showed that the normality assumption was reasonable and the ANOVA model was appropriate.

Discussion

Escapement Estimate

We believe our counting period each year encompassed most of the coho salmon run entering the Ugashik lakes. This assumption is supported by the distribution of our counts each season

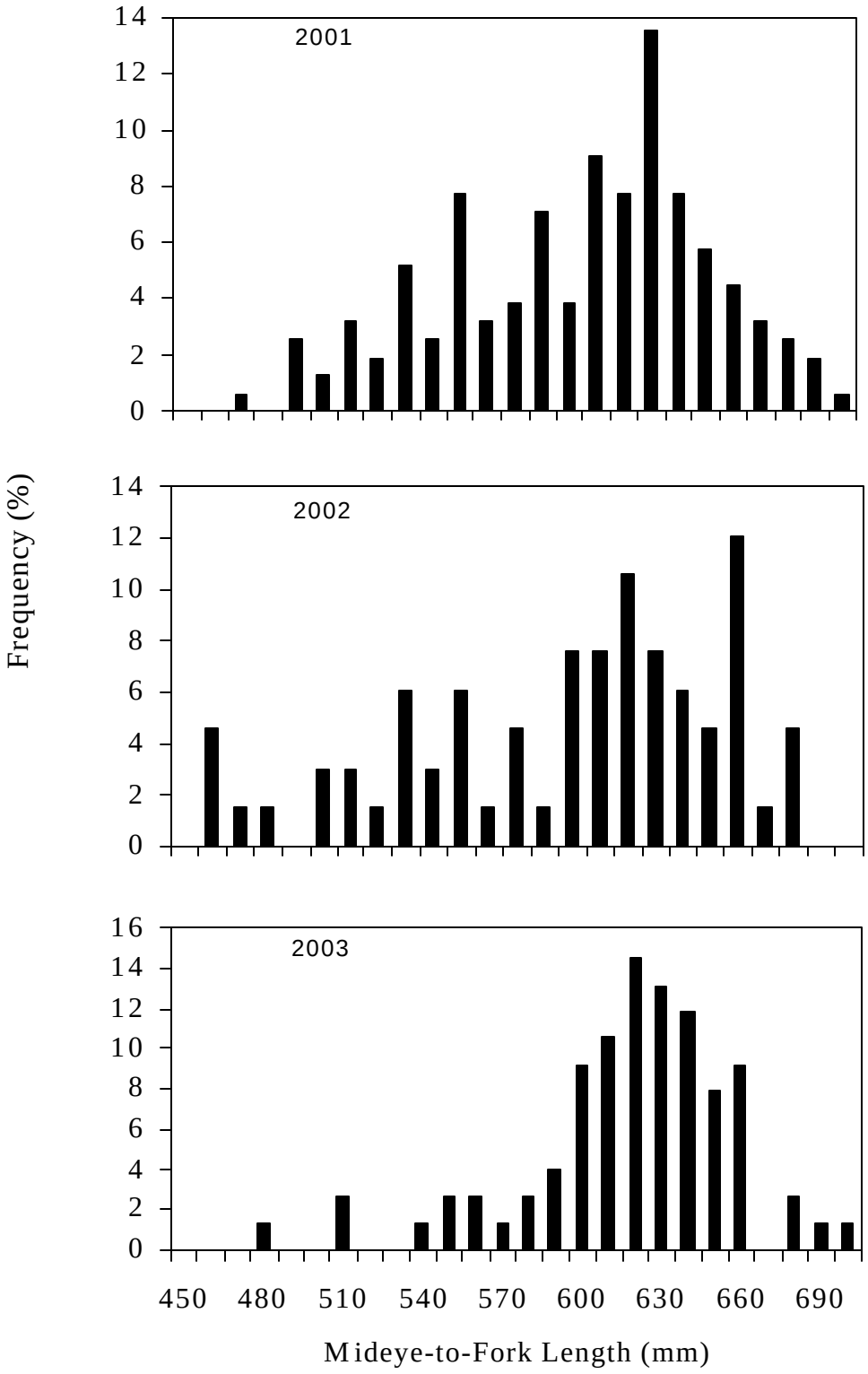

Figure 4. Length frequency distribution of coho salmon sampled in the Ugashik lakes, Alaska Peninsula National Wildlife Refuge 2001-2003.

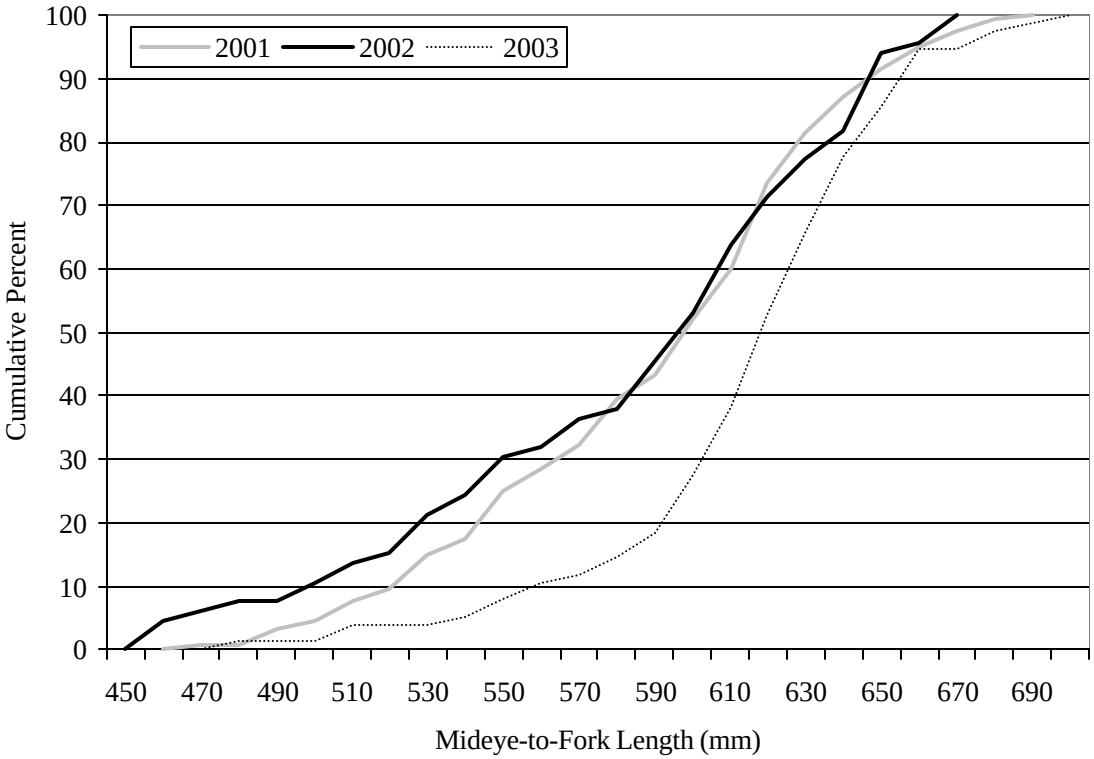

Figure 5. Cumulative length frequency distribution of coho salmon sampled in the Ugashik lakes, Alaska Peninsula National Wildlife Refuge 2001-2003.

and the absence of coho salmon during the time salmon were counted by the ADFG crew prior to our arrival. We counted few or no coho salmon during our last week of operations each year except for 2003. Studies from other Bristol Bay rivers, such as the Egegik (Russell 1996 and Weiland 1996) and Kulukak (Price and Larson 1999) rivers, also suggest that our study began early enough to monitor the beginning of the coho salmon run. However, neither of these studies were operated long enough to determine an end date of these runs to compare to our study.

In 2003, a large number of coho salmon passed the tower site on 20 September, three days prior to termination of counts (Appendix C). Additionally, an aerial survey conducted on 21 September resulted in an estimate of 5,000 coho salmon below the counting tower site (Keith Weiland, ADFG, personal communication). Therefore, we believe our 2003 counts missed a portion of the escapement.

Based on coho salmon runs in the Becharof Lake system we expected coho salmon escapement in the Ugashik lakes to be in the range of 10,000 to 15,000 fish annually. Coho salmon runs in Becharof Lake have been documented between 7,000 and 24,000 (Russell

1996 and Weiland 1996). The Becharof system is similar in rearing and spawning habitat and geographically close to the Ugashik lakes. Our escapement estimates of 17,730 in 2002 and 28,212 in 2003 were similar or greater than our preseason expectations, while our estimate of 3,606 in 2001 was much less than expected. Based on catch per effort data from the Ugashik District sport fishery (Craig Schwanke, ADFG, personal communication), we think coho salmon escapement in 2001 was low and that our counts were representative of the actual abundance.

During the years of our study, aerial survey counts were 77% (2001), 8% (2002), and 44% (2003) of the tower estimate (Browning et al. 2002; Keith Weiland, ADFG, personal communication). The large variation between aerial counts and tower estimates suggests that aerial counts are not a reliable abundance index of coho salmon escapement in the Ugashik lakes. During studies on the Kulukak River in Bristol Bay, Price and Larson (1999) found aerial estimates were as likely to over as under estimate salmon escapement estimates derived from counting towers. Additionally, they reported the correlation between tower and aerial estimates was weakest for coho salmon.

Various sources of error are involved in estimating escapement from tower counts, including observer error, visibility, salmon passage variation within each hour, and the proportion of the run available to observers. Some of these sources of error can be examined using video technology (Irvine et al. 1991; Hiebert et al. 2000; Otis and Dickson 2001). Although counting towers have been shown to produce accurate escapement estimates of large salmon runs (Anderson 2000), this may not be true for runs of only a few thousand salmon. During our study, comments from local residents and the tower crew in 2001 led us to question the accuracy of tower counts in estimation coho salmon escapement in the Ugashik lakes. In 2002 we investigated the accuracy of tower estimates of coho salmon escapement in the Ugashik lakes using video recording equipment. Based upon examination of 152 hours of digital video and comparisons of video counts to corresponding tower counts, we found tower estimates to be approximately 12% less than corresponding video counts (Edwards 2004 in preparation). However, we feel that this level of accuracy would still make counting towers a useful method to estimate coho salmon escapement for our management needs.

Age, Sex, and Length Data

The age composition of the Ugashik coho salmon run was similar to that estimated for other Bristol Bay coho salmon runs (Russell 1996; Price and Larson 1999; West and Gray 2001). Age distributions were statistically different between years; however, age 2.1 fish were the most abundant age group in samples collected each year. Hetrick and Nemeth (2003) also observed variation in age for coho salmon runs to several streams on the Alaska Peninsula. Age composition differences between years appears to reflect the natural variation in age at time of return exhibited by coho salmon (Sandercock 1991).

Since we did not stratify our sampling design, we were unable to track the sex composition over time and are unable to say whether males were more abundant than females throughout the Ugashik lakes coho salmon run. Sandercock (1991) found some coho salmon runs in Alaska exhibit a greater abundance of males to females throughout the run. Since females tend to be larger than male, size selection by gill net fisheries could have influenced the sex composition observed in our escapement samples. However, commercial and subsistence fishing for coho salmon was limited during our study; the 2001-2002 average commercial harvest was less than 1000 coho salmon and the average subsistence was than 900 coho salmon (Morstad et al. 2003). The sex composition of the Ugashik coho salmon exhibited no significant difference between years of our study and does not appear to be skewed.

Coho salmon do not display a geographical trend in length throughout their range (e.g. southern stocks having larger individuals than northern stocks), and size at return is influenced by many variables (Sandercock 1991). During this study we observed a significant difference in coho salmon size between years and attribute this difference to varying oceanic growth conditions, since our sampling gear and techniques were the same throughout the study.

The 2001 to 2003 tower counts have provided a three-year view of coho salmon escapement into the Ugashik lakes. This will provide management and regulatory bodies with information to make informed decisions concerning subsistence issues within the Ugashik lakes. Additionally, age and length data obtained from this project provide baseline information that may be used to signal changes in production characteristics of this stock in the future.

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Appendix

Appendix A. Estimated daily and cumulative salmon escapement into the Ugashik lakes, Alaska Peninsula National Wildlife Refuge, 2001.

	Daily Escapement					Cumulative Escapement				
Date	sockeye	coho	chum	chinook	pink	sockeye	coho	chum	chinook	pink
July 26	4,416	0	0	6	72	4,416	0	0	6	72
27	3,096	0	0	18	-6	7,512	0	0	24	66
28	2,016	0	0	0	0	9,528	0	0	24	66
29	1,644	0	12	18	114	11,172	0	12	42	180
30	894	0	6	12	24	12,066	0	18	54	204
31	558	0	6	24	18	12,624	0	24	78	222
Aug. 1	900	0	-42	6	-12	13,524	0	-18	84	210
2	702	12	6	0	12	14,226	12	-12	84	222
3	1,662	126	18	6	42	15,888	138	6	90	264
4	906	162	78	12	84	16,794	300	84	102	348
5	900	54	30	-6	48	17,694	354	114	96	396
6	516	0	54	6	54	18,210	354	168	102	450
7	792	156	114	18	6	19,002	510	282	120	456
8	894	-6	150	-6	18	19,896	504	432	114	474
9	282	30	150	12	6	20,178	534	582	126	480
10	708	180	282	36	12	20,886	714	864	162	492
11	864	30	570	24	18	21,750	744	1,434	186	510
12	462	18	132	24	24	22,212	762	1,566	210	534
13	714	78	246	48	6	22,926	840	1,812	258	540
14	294	24	384	-12	24	23,220	864	2,196	246	564
15	72	60	234	18	12	23,292	924	2,430	264	576
16	534	36	222	30	42	23,826	960	2,652	294	618
17	186	72	258	6	12	24,012	1,032	2,910	300	630
18	414	36	492	18	24	24,426	1,068	3,402	318	654
19	-540	48	402	-6	-6	23,886	1,116	3,804	312	648
20	780	60	108	18	-18	24,666	1,176	3,912	330	630
21	594	36	156	12	0	25,260	1,212	4,068	342	630
22	1,092	30	120	0	0	26,352	1,242	4,188	342	630
23	-228	36	318	6	6	26,124	1,278	4,506	348	636
24	216	48	174	36	6	26,340	1,326	4,680	384	642
25	96	150	12	36	24	26,436	1,476	4,692	420	666
26	288	90	78	18	0	26,724	1,566	4,770	438	666
27	-174	72	-36	18	-18	26,550	1,638	4,734	456	648
28	144	60	54	6	0	26,694	1,698	4,788	462	648
29	216	162	36	-12	0	26,910	1,860	4,824	450	648
30	66	72	216	6	0	26,976	1,932	5,040	456	648
31	186	0	156	12	0	27,162	1,932	5,196	468	648
Sept. 1	84	54	96	-18	0	27,246	1,986	5,292	450	648
2	54	12	84	12	0	27,300	1,998	5,376	462	648
3	84	6	6	6	0	27,384	2,004	5,382	468	648
4	186	252	72	12	0	27,570	2,256	5,454	480	648
5	60	288	84	12	0	27,630	2,544	5,538	492	648
6	102	36	66	-6	0	27,732	2,580	5,604	486	648
7	42	30	48	0	0	27,774	2,610	5,652	486	648

Appendix A. Continued.

	Daily Escapement					Cumulative Escapement				
Date	sockeye	coho	chum	chinook	pink	sockeye	coho	chum	chinook	pink
Sept 8	12	6	12	0	-6	27,786	2,616	5,664	486	642
9	0	54	0	0	0	27,786	2,670	5,664	486	642
10	0	30	12	0	0	27,786	2,700	5,676	486	642
11	0	6	0	0	0	27,786	2,706	5,676	486	642
12	0	18	0	0	0	27,786	2,724	5,676	486	642
. 13	0	114	0	0	0	27,786	2,838	5,676	486	642
14	0	48	0	0	0	27,786	2,886	5,676	486	642
15	0	30	0	0	0	27,786	2,916	5,676	486	642
16	0	534	0	0	0	27,786	3,450	5,676	486	642
17	0	60	0	0	0	27,786	3,510	5,676	486	642
18	6	0	0	0	0	27,792	3,510	5,676	486	642
19	0	18	0	0	0	27,792	3,528	5,676	486	642
20	0	0	0	0	0	27,792	3,528	5,676	486	642
21	0	48	0	0	0	27,792	3,576	5,676	486	642
22	0	0	0	0	0	27,792	3,576	5,676	486	642
23	0	0	0	0	0	27,792	3,576	5,676	486	642
24	0	0	0	0	0	27,792	3,576	5,676	486	642
25	0	0	0	0	0	27,792	3,576	5,676	486	642
26	0	0	0	0	0	27,792	3,576	5,676	486	642
27	0	0	0	0	0	27,792	3,576	5,676	486	642
28	0	30	0	0	0	27,792	3,606	5,676	486	642

Appendix B. Estimated daily and cumulative salmon escapement into the Ugashik lakes, Alaska Peninsula National Wildlife Refuge, 2002.

	Daily Escapement					Cumulative Escapement				
Date	sockeye	coho	chum	chinook	pink	sockeye	coho	chum	chinook	pink
July 26	1,548	0	0	6	0	1,548	0	0	6	0
27	1,704	90	6	30	0	3,252	90	6	36	0
28	798	450	0	6	0	4,050	540	6	42	0
29	3,804	246	6	-18	42	7,854	786	12	24	42
30	2,838	270	12	18	108	10,692	1,056	24	42	150
31	1,746	444	12	12	204	12,438	1,500	36	54	354
Aug. 1	516	372	30	0	24	12,954	1,872	66	54	378
2	2,058	366	12	12	126	15,012	2,238	78	66	504
3	2,982	54	36	36	12	17,994	2,292	114	102	516
4	828	24	42	0	0	18,822	2,316	156	102	516
5	654	156	18	6	0	19,476	2,472	174	108	516
6	210	108	24	0	6	19,686	2,580	198	108	522
7	138	48	36	0	12	19,824	2,628	234	108	534
8	906	174	90	6	12	20,730	2,802	324	114	546
9	306	216	36	0	12	21,036	3,018	360	114	558
10	-474	36	18	0	0	20,562	3,054	378	114	558
11	402	144	96	0	0	20,964	3,198	474	114	558
12	96	234	66	0	0	21,060	3,432	540	114	558
13	132	204	24	6	6	21,192	3,636	564	120	564
14	18	114	72	0	12	21,210	3,750	636	120	576
15	18	186	60	0	6	21,228	3,936	696	120	582
16	12	216	102	0	24	21,240	4,152	798	120	606
17	0	198	12	12	24	21,240	4,350	810	132	630
18	6	264	6	0	12	21,246	4,614	816	132	642
19	0	174	12	0	18	21,246	4,788	828	132	660
20	0	126	0	0	12	21,246	4,914	828	132	672
21	0	336	0	0	6	21,246	5,250	828	132	678
22	0	264	0	0	0	21,246	5,514	828	132	678
23	0	390	6	0	6	21,246	5,904	834	132	684
24	0	618	12	0	0	21,246	6,522	846	132	684
25	6	1,494	6	0	0	21,252	8,016	852	132	684
26	0	438	42	0	0	21,252	8,454	894	132	684
27	0	588	0	0	12	21,252	9,042	894	132	696
28	0	240	6	0	6	21,252	9,282	900	132	702
29	0	174	0	0	6	21,252	9,456	900	132	708
30	0	300	0	0	0	21,252	9,756	900	132	708
31	0	564	0	0	0	21,252	10,320	900	132	708
Sept. 1	0	432	0	0	0	21,252	10,752	900	132	708
2	0	282	0	0	0	21,252	11,034	900	132	708
3	0	138	0	0	0	21,252	11,172	900	132	708
4	0	564	0	0	0	21,252	11,736	900	132	708
5	0	246	0	0	0	21,252	11,982	900	132	708
6	0	1,296	0	0	0	21,252	13,278	900	132	708
7	0	468	0	0	6	21,252	13,746	900	132	714
8	18	168	0	0	0	21,270	13,914	900	132	714
9	0	186	0	0	0	21,270	14,100	900	132	714

Appendix B. Continued

	Daily Escapement					Cumulative Escapement				
Date	sockeye	coho	chum	chinook	pink	sockeye	coho	chum	chinook	pink
Sept 10	0	192	0	0	0	21,270	14,292	900	132	714
11	0	288	0	0	0	21,270	14,580	900	132	714
. 14	0	174	0	0	0	21,270	15,474	900	132	714
15	0	1,176	12	0	0	21,270	16,650	912	132	714
16	0	876	0	0	0	21,270	17,526	912	132	714
17	0	162	0	0	0	21,270	17,688	912	132	714
18	0	18	0	0	0	21,270	17,706	912	132	714
19	0	18	0	0	0	21,270	17,724	912	132	714
20	0	-18	0	0	0	21,270	17,706	912	132	714
21	0	0	0	0	0	21,270	17,706	912	132	714
22	0	0	0	0	0	21,270	17,706	912	132	714
23	0	18	0	0	0	21,270	17,724	912	132	714
24	0	6	0	0	0	21,270	17,730	912	132	714

Appendix C. Estimated daily and cumulative salmon escapement into the Ugashik lakes, Alaska Peninsula National Wildlife Refuge, 2003.

	Daily Escapement					Cumulative Escapement				
Date	sockeye	coho	chum	chinook	pink	sockeye	coho	chum	chinook	pink
July 25	1,566	54	0	0	6	1,566	54	0	0	6
26	3,912	282	6	0	0	5,478	336	6	0	6
27	2,796	456	18	0	0	8,274	792	24	0	6
28	1,374	96	0	0	6	9,648	888	24	0	12
29	876	78	6	12	0	10,524	966	30	12	12
30	360	204	0	0	0	10,884	1,170	30	12	12
31	864	198	6	0	0	11,748	1,368	36	12	12
Aug. 1	468	120	12	6	0	12,216	1,488	48	18	12
2	456	54	0	0	0	12,672	1,542	48	18	12
3	1,182	84	30	0	0	13,854	1,626	78	18	12
4	408	132	0	0	24	14,262	1,758	78	18	36
5	48	66	6	0	0	14,310	1,824	84	18	36
6	168	222	42	6	12	14,478	2,046	126	24	48
7	144	354	48	6	0	14,622	2,400	174	30	48
8	96	408	54	0	0	14,718	2,808	228	30	48
9	72	252	90	0	0	14,790	3,060	318	30	48
10	6	144	30	6	0	14,796	3,204	348	36	48
11	0	42	12	0	0	14,796	3,246	360	36	48
12	0	0	12	0	0	14,796	3,246	372	36	48
13	0	0	18	0	0	14,796	3,246	390	36	48
14	0	108	24	0	0	14,796	3,354	414	36	48
15	0	246	18	0	12	14,796	3,600	432	36	60
16	0	684	18	0	0	14,796	4,284	450	36	60
17	0	228	6	0	0	14,796	4,512	456	36	60
18	0	174	0	0	0	14,796	4,686	456	36	60
19	0	-36	0	0	0	14,796	4,650	456	36	60
20	0	594	24	0	12	14,796	5,244	480	36	72
21	0	240	6	0	0	14,796	5,484	486	36	72
22	0	2,766	6	0	0	14,796	8,250	492	36	72
23	0	660	0	0	0	14,796	8,910	492	36	72
24	0	306	0	0	0	14,796	9,216	492	36	72
25	0	180	0	0	0	14,796	9,396	492	36	72
26	0	540	30	0	0	14,796	9,936	522	36	72
27	0	198	12	0	0	14,796	10,134	534	36	72
28	0	1,560	24	0	6	14,796	11,694	558	36	78
29	0	690	0	0	0	14,796	12,384	558	36	78
30	0	1,002	18	0	0	14,796	13,386	576	36	78
31	0	30	18	0	0	14,796	13,416	594	36	78
Sept. 1	0	12	6	0	6	14,796	13,428	600	36	84

Appendix C. Continued

	Daily Escapement					Cumulative Escapement				
Date	sockeye	coho	chum	chinook	pink	sockeye	coho	chum	chinook	pink
Sept 2	0	12	6	0	6	14,796	13,440	606	36	90
3	0	6	0	0	0	14,796	13,446	606	36	90
. 4	0	120	0	0	0	14,796	13,566	606	36	90
5	0	2,802	0	0	0	14,796	16,368	606	36	90
6	0	3,138	12	0	0	14,796	19,506	618	36	90
7	0	954	0	0	0	14,796	20,460	618	36	90
8	0	618	6	0	0	14,796	21,078	624	36	90
9	0	3,588	0	0	0	14,796	24,666	624	36	90
10	0	420	6	0	0	14,796	25,086	630	36	90
11	0	228	0	0	0	14,796	25,314	630	36	90
12	0	-6	0	0	0	14,796	25,308	630	36	90
13	0	42	0	0	0	14,796	25,350	630	36	90
14	0	-222	0	0	0	14,796	25,128	630	36	90
15	0	1,008	0	0	0	14,796	26,136	630	36	90
16	0	408	0	0	0	14,796	26,544	630	36	90
17	0	12	0	0	0	14,796	26,556	630	36	90
18	0	216	0	0	0	14,796	26,772	630	36	90
19	0	6	0	0	0	14,796	26,778	630	36	90
20	0	1,470	0	0	0	14,796	28,248	630	36	90
21	0	12	0	0	0	14,796	28,260	630	36	90
22	0	-48	0	0	0	14,796	28,212	630	36	90
23	0	0	0	0	0	14,796	28,212	630	36	90