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EFFORT AND CATCH STATISTICS FOR THE CHINOOK SALMON *(Oncorhynchus tshawytscha)* SPORT FISHERY IN THE LOWER NUSHAGAK RIVER, 1986

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ABSTRACT

A roving creel survey was conducted on the lower Nushagak River from 16 June through 14 July to estimate sport fishing effort and harvest of chinook salmon (*Oncorhynchus tshawytscha* Walbaum). Over 120 anglers were interviewed during the 29-day sample period to estimate angling effort in hours and catch and harvest rate in fish per hour. An estimated 9,410 angler hours were expended on the lower Nushagak River which resulted in 2,505 chinook salmon landed of which 1,780 (71 percent) were harvested. Seasonal catch rates between guided (0.31 fish per hour) and unguided anglers (0.10 fish per hour) were significantly different ($p = 0.05$). Age 1.3 chinook salmon dominated the harvest (71 percent). Mean length and weight of the harvest was 778 millimeters and 8.4 kilograms, respectively. At present, levels of sport fishing effort and harvest constitute the smallest utilization of all user groups (less than 2 percent).

KEY WORDS: chinook salmon, *Oncorhynchus tshawytscha*, sport harvest, sport effort, creel survey, Nushagak River

INTRODUCTION

The Nushagak River, located on the western side of Bristol Bay (Figure 1), is the largest producer of all Pacific salmon (*Oncorhynchus* spp.) species except sockeye salmon (*O. nerka* Walbaum) in Bristol Bay. A sport fishery that targets primarily on chinook salmon (*O. tshawytscha* Walbaum) occurs mainly in the lower reach of the river between Black Point and the village of Portage Creek. This stretch of the river is 19.3 km long, about 300 m wide, moderately silty, and influenced by tides. Access to the area is primarily by boat from Dillingham or by float-equipped aircraft. Anglers may also use wheel-equipped aircraft to land on gravel bars or at a public airstrip servicing the village of Portage Creek and then walk to the river.

During the period 1977-1986, the Nushagak River chinook salmon run averaged 238,000 fish (Nelson 1987). Although the fish are not exceptionally large (average weight of commercially-caught fish is approximately 9.5 kg), discovery of this abundant resource and easy access have resulted in the rapid growth of the lower Nushagak River sport fishery. From 1982 through 1985, a voluntary questionnaire was distributed to the guides operating on the Nushagak River. These results indicate a growing interest in the lower Nushagak River chinook salmon sport fishery (Minard and Morstad 1985; and Brandt and Minard 1985).

In 1986, the Sport Fish Division of the Alaska Department of Fish and Game (ADF&G) began a creel survey of this sport fishery. Results from the survey will be used to increase our understanding of the chinook salmon sport fishery developing on the lower Nushagak River and to evaluate current management strategies and policies. The objective of this report is to present baseline statistics for the lower Nushagak River sport fishery in 1986, including estimates of: fishing effort, catch (fish landed), harvest (fish retained), and age, sex, size compositions. These data, in conjunction with other information from the commercial and subsistence fisheries and spawning escapement (Nelson 1987), provide

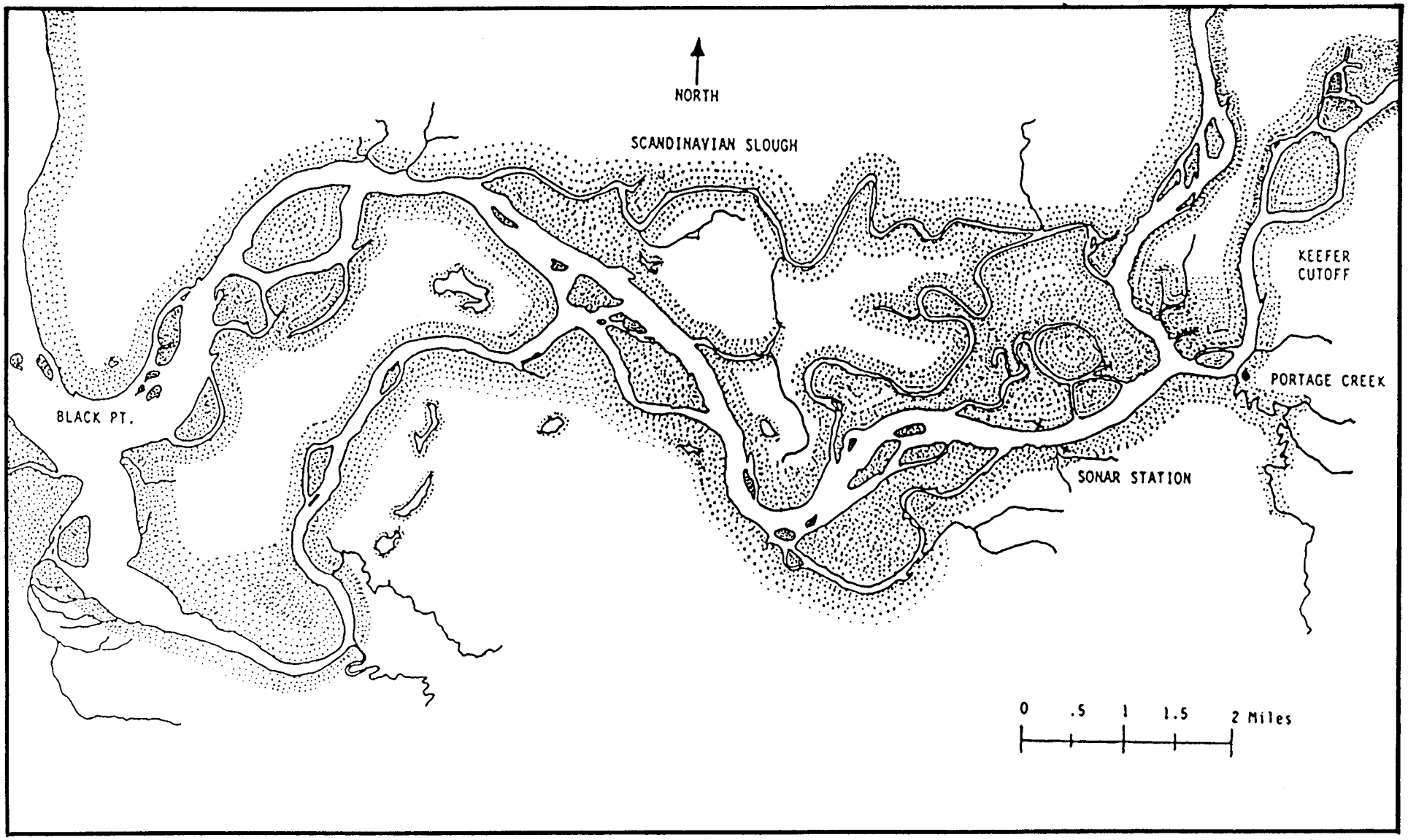

Figure 1. Lower Nushagak River, Bristol Bay, Alaska.

estimates for the total return of chinook salmon to the Nushagak River. Historical brood-year relationships and forecasts of return have been estimated by Minard and Meacham (1985).

METHODS

Anglers were permitted a daily harvest of five chinook salmon, of which two could be greater than 71 cm (28 inches) in 1986 (ADF&G 1986). No further regulatory restrictions were imposed during 1986.

Study Design

The study area consisted of the mainstem of the Nushagak River between Black Point and the village of Portage Creek (Figure 1). A roving creel survey (Neuhold and Lu 1957) using a stratified, random sampling design was used to count anglers, conduct angler interviews, and sample the sport harvest. Angler counts were used to estimate fishing effort in units of angler-hours. Angler interviews provided estimates of catch rates (fish per angler-hour).

Guided fishing accounts for the majority of the effort on the Nushagak River and typically occurs between the hours of 1000 to 1800. For the creel survey, the fishing day was considered 14 hours long (0700-2100). Each day was divided into four strata: (A) 0700-0959 hours; (B) 1000-1359 hours; (C) 1400-1759 hours; and (D) 1800-2100 hours.

Chinook salmon first enter the Nushagak River during mid- to late June and the majority of the run typically migrates through the lower section of river during a 2 week period. The run was temporally stratified into peak and non-peak periods for purposes of estimation. Non-peak periods were subjectively defined when chinook salmon were less abundant and angler-effort sparse. Peak periods were subjectively defined when the chinook salmon were abundant in the river. Angler-effort and harvest statistics were compiled separately for peak and non-peak periods.

Data Collection

Sampling effort was designed to fully utilize one creel survey technician working 37.5 hours each week. Approximately two-thirds of the sampling effort was allocated to daily strata B and C and the rest to strata A and D. Daily strata were randomly selected without replacement subject to the constraint that a maximum of two strata (A, B, C, or D) could be designated on a single day.

Each survey trip started at the upstream boundary of the survey area. A coin was tossed to determine if angler counts or angler interviews were to be conducted first. For an angler count, the technician drove a skiff through the fishery area at a near constant speed and counted all anglers actively fishing. The angler count was completed within 40 to 60 minutes of the start and was considered an instantaneous count (Neuhold and Lu 1957). It was not possible to differentiate between guided and non-guided anglers during the count.

Two hours were allocated for conducting angler interviews during strata A and D and 3 hours were allocated for angler interviews during strata B and C. All interviews were of individual anglers and were not party interviews. The creel survey technician attempted to contact about 25% of the available anglers so that the number of anglers interviewed was proportional to the angler effort during the sampled time (Neuhold and Lu 1957; DiConstanzo 1956). Anglers were randomly selected throughout the fishing area. For each angler contacted, the creel survey technician recorded the number of hours fished, the number of fish in the angler's possession by species, the number of fish released by species, and whether the angler was guided or not guided.

Completed-trip information was collected from voluntary report forms given to interviewed anglers. The voluntary report form requested the time fishing started and ended, the catch by species, and the number of fish retained. Anglers were asked to mail the postage paid forms to the Dillingham ADF&G office.

Harvested chinook salmon encountered during the creel survey were measured for mid-eye to fork-of-tail length to the nearest millimeter and the sex recorded. Three scales were removed from the preferred area[1] and mounted on a gummed card.

Data Analyses

The mean number of anglers per count was calculated for each peak and non-peak period by:

$$\bar{X} = (1/N) \sum_{i=1}^{4} N_i \bar{x}_i,$$

where;

$\bar{X}$ = the mean number of anglers per count for a period,

$\bar{x}_i$ = the mean number of anglers per count for stratum i,

N = the total number of hours in a period, and

N_i = the total number of hours in stratum i.

The variance of the mean number of anglers per count was calculated as follows (Jessen 1978):

$$\hat{V}(\bar{X}) = (1/N^2) \sum_{i=1}^{4} N_i^2 [s_i^2/n_i],$$

[1] The left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (Clutter and Whitesel 1956).

where;

N and N_i are defined as above, and

n_i = the total number of angler counts in stratum i, and

s_i^2 = the sample variance of $\bar{x}_i$ for stratum i.

The total number of angler-hours (E_T) in each period was estimated as follows:

$$\hat{E}_T = N\bar{X} = \sum_{i=1}^{4} N_i \bar{x}_i.$$

The variance for the estimate of total angler-hours was calculated as follows:

$$\hat{V}(E_T) = N^2 \hat{V}(\bar{X}).$$

The total number of angler-hours for the season was estimated by summing the estimates of total angler-hours for the peak and non-peak periods. Because these are independent estimates, the total variance is the sum of the individual variances.

Catch per unit effort (CPUE) for species i during a period (peak or non-peak) was estimated by:

$$CPUE_i = \sum_{j=1}^{m} c_{ij} / \sum_{j=1}^{m} f_j$$

where:

m = the number of anglers interviewed during the period,

c_{ij} = the catch (either number harvested or total number caught) of species i by angler j, and

f_j = the effort (number of hours) expended by angler j.

The variance of mean effort per angler was estimated using a two-stage sample design with days representing the first-stage sample units and anglers the second-stage sample units (Von Geldern and Tomlinson 1973). On a given sample day, the number of second-stage units available was unknown. The variance of mean effort was estimated as follows (Sukhatme et al. 1984):

$$V(\bar{f}) = [1 - (d/D)]\, s_B^2/d + (\sum_{k=1}^{D} s_{Wk}^2/m)/dD,$$

where;

d = the number of days sampled during the period,

D = the number of days in the period,

s^2_{Wk} = the sample variance of effort for anglers interviewed during day k, and

s^2_B = the between-day variance of angler effort.

The between-day variance, s^2_B, was estimated as follows:

$$s^2_B = [\sum_{k=1}^{D} (\bar{f}_k - \bar{f})^2]/(d-1),$$

where $\bar{f}_k$ = the mean effort by anglers interviewed during day k.

The mean harvest and variances for or catch of a species were estimated identically to effort by substituting the corresponding harvest or catch quantities for effort (f).

The variance of $CPUE_i$ was calculated using the approximation for the variance of the quotient of two random variables (Jessen 1978):

$$\hat{V}(CPUE_i) = (\bar{c}_i/\bar{f}_i)^2 \ (s^2_c/\bar{c}^2 + s^2_f/\bar{f}^2 - 2rs_c s_f/\overline{cf})$$

where;

$\bar{c}_i$ = the mean catch of species i by anglers interviewed during a period,

$\bar{f}_i$ = the mean number of hours fished by anglers interviewed during a period,

s^2_c = the two-stage variance estimate for of $\bar{c}_i$,

s^2_f = the two-stage variance estimate for $\bar{e}_i$, and

r = the correlation between the c_{ij} and f_j.

The catch (or harvest) of species i was estimated by:

$$C_i = E_T CPUE_i.$$

The variance of the catch was estimated using Goodman's (1960) formula for the variance of the product of two independent random variables, which is:

$$V(\hat{C}_i) = [\hat{E}_T^2 \, V(CPUE_i)] + [CPUE_i^2 \, V(\hat{E}_T)] - [V(\hat{E}_T) \, V(CPUE_i)].$$

Total catch and its variance were estimated for the peak and non-peak periods and summed to estimate the total season catch. The same procedures were followed in estimating total harvest of each species.

The assumptions necessary for these analyses were:

1. Incomplete-trip angler interviews provided an unbiased estimate of completed-trip angler CPUE.

2. Interviewed anglers were representative of the total angler population and anglers were interviewed in proportion to their abundance.

3. No significant fishing effort occurred between 2100 hours and 0700 hours.

4. The catch and effort are normally distributed random variables.

5. Catch rate and duration of fishing trip are independent (DiConstanzo 1956).

The age composition of chinook salmon harvested by the sport fishery was calculated from all legible scales collected during the creel survey. The proportional age composition of the chinook salmon harvest was estimated. Letting p_h equal the estimated proportion of age group h, the variance of p_h was estimated using the normal approximation to the binomial (Schaeffer et al. 1979):

$$V(\hat{p}_h) = \hat{p}_h(1-\hat{p}_h)/n_T-1),$$

where n_T is the number of chinook salmon scales read.

Mean length at age by sex and its variance were estimated using standard normal procedures. Mean length (mm) and weight (kg) were calculated by age group for all chinook salmon sampled.

RESULTS

The creel survey on the lower Nushagak River was conducted during the period 16 June to 14 July. The peak period was defined from 23 June to 6 July (period two). Two non-peak periods were identified, one from 16 to 22 June (period one) and one from 7 to 14 July (period three).

Effort

Mean angler counts were 9.1, 39.3, and 6.8 for periods one, two, and three, respectively (Appendix Table 1 and Table 1). Total effort was

Table 1. Estimated effort (angler-hours) by period for the lower Nushagak river sport fishery, 1986.

Dates	Number Of Interviews	Number Of Days Possible	Number Of Days Sampled	Anglers Per Count	Effort				Relative Precision
					Ang-Hrs	Std Err	95 % C. I.		
Period 1									
6/16-6/22	20	7	6	9.1	894	405	101 -	1,688	88.7%
Period 2									
6/23-7/6	95	14	14	39.3	7,754	941	5,910 -	9,598	23.8%
Period 3									
7/7-7/14	8	8	5	6.8	762	429	0 -	1,602	110.3%
Total									
6/16-7/14	123	29	25		9,410	1,110	7,233 -	11,586	23.1%

estimated to be 9,410 angler-hours. Most of the fishing effort (7,754 angler-hours or 82%) occurred during period two. Interviewed anglers who had completed their fishing trip (N = 33) averaged 6.4 hours per trip. Variability in this estimate is high (standard error = 2.3).

Catch Rate

Catch rates for chinook salmon varied substantially over the course of the fishery (Appendix Table 2 and Table 2). Peak daily harvest rate of chinook salmon was 0.51 fish per hour on 24 June and peak catch rate was 0.54 chinook salmon per hour on 25 June (Appendix Table 2). Although catch rates showed substantial variation, chinook salmon harvest rates were similar for all three periods (Table 2). The only other species with significant harvest rates were chum salmon (*O. keta*) and northern pike (*Esox lucius*).

Catch and Harvest

An estimated 2,505 chinook salmon were caught (landed) of which 1,780 (71%) were harvested (Table 3). The largest catch (2,184) and harvest (1,478) of chinook salmon occurred during period two (23 June - 7 July). Most of the catch and release fishing occurred during the peak period when chinook salmon were most abundant. The estimated catch and harvest of chum salmon were 450 and 354, respectively.

Although guided and unguided effort and catch could not be estimated separately, estimates of catch and harvest rates were possible (Table 4). Daily catch rates of guided and unguided anglers were compared with a sign test (Conover 1980). Guided anglers caught fish at a significantly greater rate (p = 0.05) than did unguided anglers. Harvest rates, however, were not significantly different.

Size, Sex, and Age Sampling

Fifty-six percent of the sampled chinook salmon (n=41) were males (Table 5). The sample was dominated by age 1.3 (71%) and age 1.4 (15%) fish. Lengths and weight by age and sex are also presented in Table 5.

DISCUSSION

Since 1982, the annual sport harvest of Nushagak River chinook salmon appears to have stabilized at approximately 2,000 fish (Table 6). This relatively stable harvest followed a period of increase which started in 1977 and continued through 1982. The trends in harvest are similar to trends in sport fishing effort (Figure 2). Rapid increases in sport fishing effort and harvest alarmed many local residents and resource managers who voiced concern about the potential impact of this relatively new fishery. Results of this and past years' studies indicate that at present sport fishing effort and harvest levels, the impact of the sport fishery on the lower Nushagak River is minor. Sport fishermen in 1986 harvested less than 2% of the total run and constitute the smallest utilization of all user groups (Figure 3). At current sport fishing effort and harvest levels, present management strategies, regulations, and bag limits appear satisfactory from a biological perspective.

Table 2. Catch per angler-hour for total catch (number landed) and harvest by species and time period for the lower Nushagak River sport fishery, 1986.

Species	Period Date	Catch Catch/Hr	Catch Std Err	Harvest Harvest/Hr	Harvest Std Err
Chinook Salmon	Period 1 6/16-6/22	0.1905	0.0127	0.1693	0.0118
	Period 2 6/23-7/6	0.2817	0.0036	0.1906	0.00295
	Period 3 7/7-7/14	0.1948	0.0442	0.1984	0.0494
Chum Salmon	Period 1 6/16-6/22	0.0000	0.0006	0.0000	0.0000
	Period 2 6/23-7/6	0.0580	0.0016	0.0456	0.0013
	Period 3 7/7-7/14	0.0000	0.0000	0.0000	0.0000
Northern Pike	Period 1 6/16-6/22	0.0212	0.0037	0.0212	0.0037
	Period 2 6/23-7/6	0.0041	0.0002	0.0041	0.0002
	Period 3 7/7-7/14	0.0000	0.0000	0.0000	0.0000

Table 3. Estimated total catch (number landed) and harvest of chinook salmon, chum salmon, and northern pike for the lower Nushagak River sport fishery, 1986.

		Catch				Harvest				
Species	Dates	Number	Std Err	95% CI	Rel. Pre.	Number	Std Err	95% CI	Rel. Pre.	Percent Harvested
Chinook Salmon	Period 1 6/16-6/22	170	78	18- 322	89.6%	151	69	15- 287	89.8%	88.8%
	Period 2 6/23-7/6	2,184	268	1,661-2,707	23.9%	1,478	181	1,124-1,832	24.0%	67.7%
	Period 3 7/7-7/14	151	89	0- 326	116.1%	151	151	0- 326	116.1%	100.0%
	Total 6/16-7/14	2,505	292	1,933-3,077	22.8%	1,780	213	1,362-2,198	23.5%	71.1%
Chum Salmon	Period 1 6/16-6/22	0	0	0 0		0	0	0 0		
	Period 2 6/23-7/6	450	56	340- 560	24.4%	354	44	267- 441	24.4%	78.7%
	Period 3 7/7-7/14	0	0	0- 0		0	0	0 0		
	Total 6/16-7/14	450	56	340- 560	24.4%	354	44	267- 441	24.4%	78.7%
Northern Pike	Period 1 6/16-6/22	19	9	1- 37	93.5%	19	9	1- 37	93.5%	100.0%
	Period 2 6/23-7/6	32	4	24- 40	25.3%	32	4	24- 40	25.3%	100.0%
	Period 3 7/7-7/14	0	0	0- 0		0	0	0 0		
	Total 6/16-7/14	51	10	31- 71	38.3%	51	10	31- 71	38.3%	100.0%

Table 4. Comparative catch and harvest rates (fish per angler-hour) of chinook salmon by guided and unguided anglers, lower Nushagak River, 1986.

Period	No. Interviews		Catch		Harvest	
Date	Guided	Unguided	Guided	Unguided	Guided	Unguided
Period 1						
6/16-6/22	13	7	0.1747	0.2793	0.1747	0.1397
Period 2						
6/23-7/6	71	18	0.3439	0.0797	0.2178	0.0797
Period 3						
7/7-7/14	7	0	0.2000	[1]	0.2000	[1]
Total	91	25	0.3073[2]	0.1046[2]	0.2093	0.0872

[1] Insufficient data

[2] Seasonal catch rates between guided and unguided anglers were significantly different ($p \leq 0.05$)

Table 5. Sex, age, length (mm), and weight (kg) compositions for chinook salmon sampled from the lower Nushagak River sport harvest, 1986.

Sample Period: 6/16 - 7/14

	Age Class					
	1.2	1.3	2.2	1.4	1.5	Total
MALE		738	87	87	87	999
Percent		41.5%	4.9%	4.9%	4.9%	56.1%
Av Length		726	480	870	940	768
Std Error		20.1	0.0	0.0	0.0	18.6
Sample Size		17	2	2	2	23
Av Weight		6.9		11.0	14.0	8.7
Std Error		0.6		0	0	0.6
Sample Size		17		2	2	21
FEMALE	87	521		174		781
Percent	4.9%	29.3%		9.8%		43.9%
Av Length	560	682		885		791
Std Error	0.0	15.9		37.5		18.7
Sample Size	2	12		4		18
Av Weight	3.0	5.2		11.5		8.1
Std Error	0	0.3		1.2		0.6
Sample Size	2	12		4		18
BOTH SEXES	87	1,259	87	260	87	1,780
Percent	4.9%	70.7%	4.9%	14.6%	4.9%	100.0%
Av Length	560	708	480	880	940	778
Std Error	0.0	14.2	0.0	25.2	0.0	13.3
Sample Size	2	29	2	6	2	41
Av Weight	3.0	6.3		11.3	14.0	8.4
Std Error	0	0.4		0.8	0.0	0.4
Sample Size	2	29		6	2	39

Table 6. Harvest and escapement of chinook salmon returns to the Nushagak/ Mulchatna River drainage, 1977 - 1986.

Year	Harvest			Escapement	Total Run	Percent Sport
	Commerical	Subsistence	Sport			
1977	85,074	5,200	923	65,000	156,197	0.6%
1978	118,548	6,600	442	130,000	255,590	0.2%
1979	157,321	8,900	654	95,000	261,875	0.2%
1980	64,958	11,800	757	141,000	218,515	0.3%
1981	193,461	11,500	1,220	150,000	356,181	0.3%
1982	195,287	12,100	1,824	147,000	356,211	0.5%
1983	137,123	11,800	2,003	161,730	312,656	0.6%
1984	61,375	9,800	2,382	80,940	154,497	1.5%
1985	67,616	7,900	1,852	115,720	193,088	1.0%
1986	63,859	12,600	1,780	32,774	111,033	1.6%
Average	114,462	9,820	1,386	111,916	237,584	0.6%

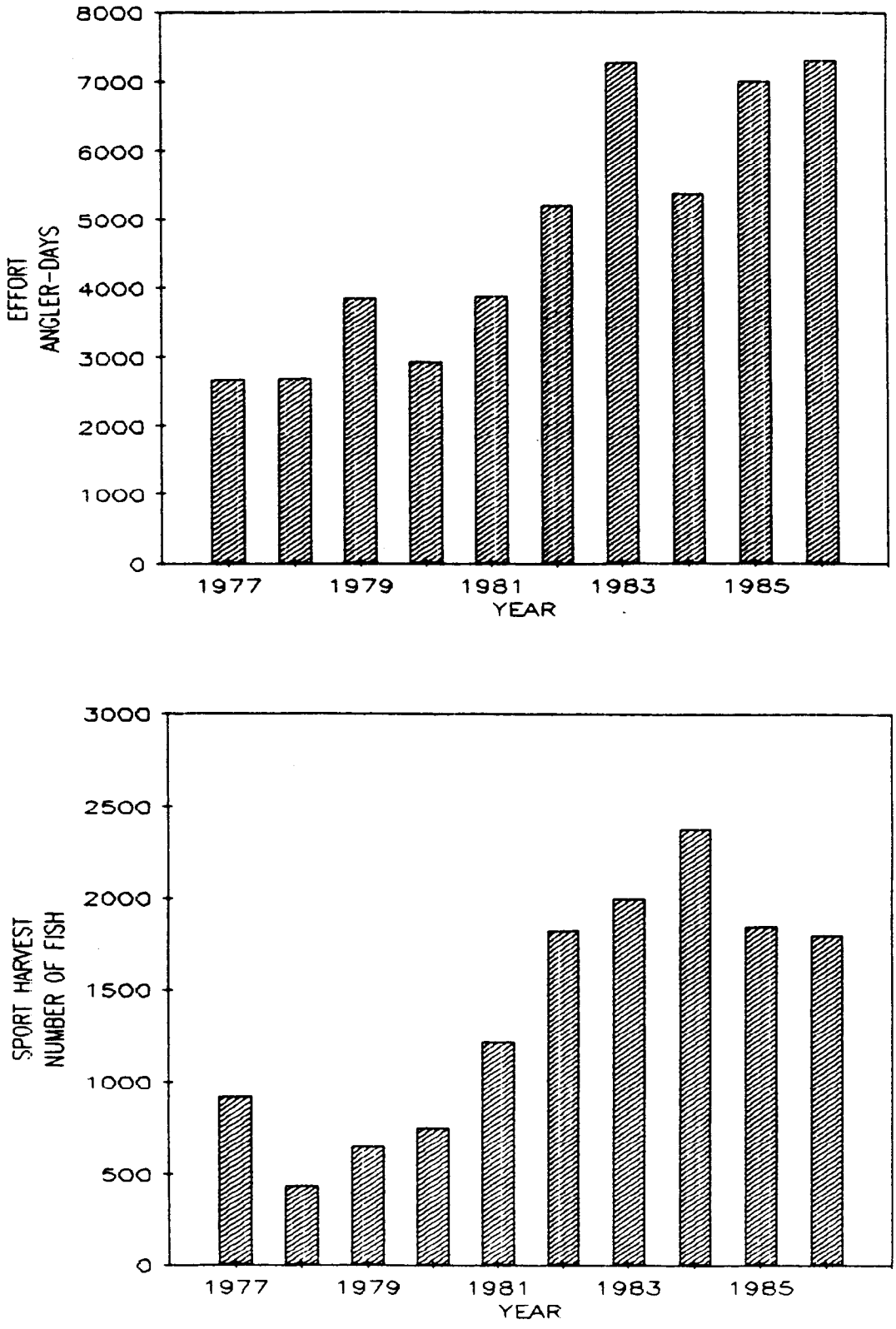

Figure 2. Sport fishing effort and sport harvest of chinook salmon for the Nushagak/Mulchatna River drainage, 1977-1986. Data for 1977-1985 are from ADF&G statewide harvest surveys (Mills 1985). Data for 1986 are from creel survey.

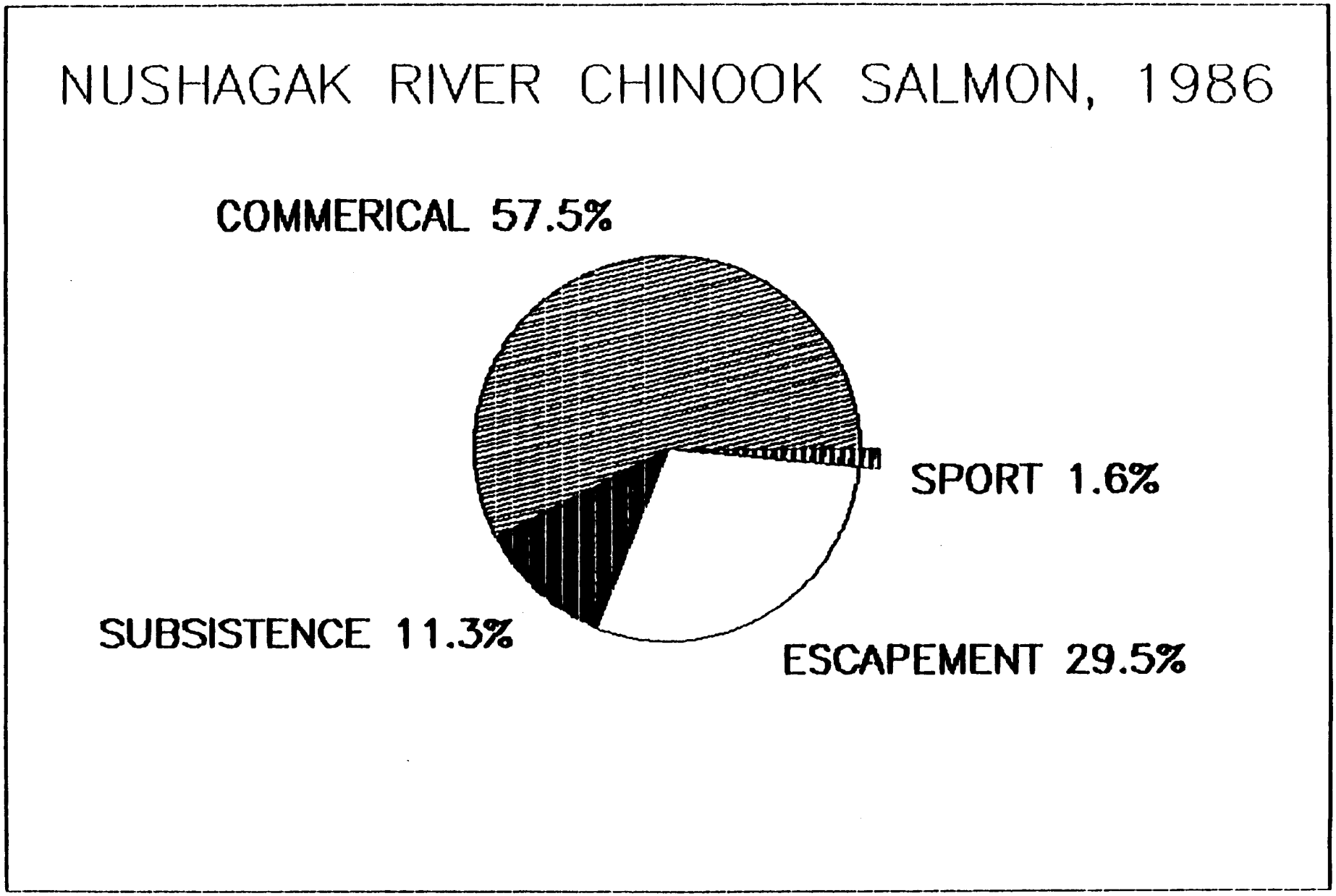

Figure 3. Total run of Nushagak River chinook salmon by major fishing components, 1986.

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APPENDIX

Appendix Table 1. Angler counts for the lower Nushagak River sport fishery, 1987.

	Period			
Date	A	B	C	D
16-Jun		1		
17-Jun			1	
18-Jun	0			2
19-Jun			17	
20-Jun			11	
21-Jun			34	
22-Jun				
23-Jun		28		0
24-Jun		13		
25-Jun	1		86	
26-Jun			70	
27-Jun		88		31
28-Jun		47	72	
29-Jun		97		
30-Jun		86		
01-Jul	8			
02-Jul		25		
03-Jul	2			
04-Jul		22		
05-Jul		28		
06-Jul	3			
07-Jul	0			
08-Jul				
09-Jul				
10-Jul		18		
11-Jul		14		
12-Jul	0			
13-Jul				
14-Jul		2		

Appendix Table 2. Summary of daily harvest (HPUE) and catch (CPUE) rates for chinook salmon from angler interviews in the lower Nushagak River sport fishery, 1986.

		Effort		Harvest			Catch		
Date	WD/WE[1]	N	Mean	Std Err	Mean	Std Err	HPUE	Mean	Std Err	CPUE
616	Wd	2	0.500	0.00000	0.000	0.00000	0.000	0.000	0.00000	0.000
619	Wd	5	4.300	1.33791	0.600	0.24495	0.140	0.600	0.24495	0.140
620	Wd	7	1.607	0.23053	0.143	0.14286	0.089	0.286	0.18443	0.178
621	We	6	2.248	1.22191	0.667	0.33333	0.297	0.667	0.33333	0.297
623	Wd	4	1.063	0.35904	0.000	0.00000	0.000	0.000	0.00000	0.000
624	Wd	5	1.182	0.51864	0.600	0.40000	0.508	0.600	0.40000	0.508
625	Wd	8	4.375	0.41993	1.750	0.36596	0.400	2.375	0.56497	0.543
626	Wd	10	4.475	0.79096	1.000	0.36515	0.223	1.300	0.49554	0.291
627	Wd	18	2.349	0.54895	0.278	0.10863	0.118	0.778	0.34825	0.331
628	We	13	3.250	0.68172	0.385	0.24122	0.118	0.462	0.24325	0.142
629	We	8	1.531	0.41306	0.375	0.18298	0.245	0.625	0.26305	0.408
630	Wd	8	1.906	0.26700	0.375	0.26305	0.197	0.500	0.32733	0.262
701	Wd	3	0.557	0.24127	0.000	0.00000	0.000	0.000	0.00000	0.000
702	Wd	4	1.500	0.35355	0.000	0.00000	0.000	0.000	0.00000	0.000
704	We	6	2.083	0.37454	0.167	0.16667	0.080	0.167	0.16667	0.080
705	We	8	2.406	0.67800	0.250	0.25000	0.104	0.375	0.26305	0.156
710	Wd	4	1.270	0.46141	0.250	0.25000	0.197	0.250	0.25000	0.197
711	Wd	2	1.000	0.00000	0.500	0.50000	0.500	0.500	0.50000	0.500
714	Wd	2	1.500	0.50000	0.000	0.00000	0.000	0.000	0.00000	0.000

[1] WD = Monday through Friday
WE = Saturday through Sunday