Fishery Data Series No. 93-56

Assessment of the 1992 Return of Steelhead to the Karluk River, Alaska

by

Robert N. Begich

December 1993

Alaska Department of Fish and Game

Division of Sport Fish

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ABSTRACT

Beginning August 15, 1992, commercial set gillnet and purse seine catches from selected waters along the southwest side of Kodiak Island were sampled for the incidental harvest of steelhead *Oncorhynchus mykiss*. One hundred thirty-eight steelhead were observed in a sample of 123,412 harvested Pacific salmon *Oncorhynchus*. Combined set gillnet and purse seine fisheries harvested and sold an estimated 331 steelhead. In addition, 86 steelhead were harvested for personal use and 79 released from the set gillnet fishery. The total estimated incidental commercial catch of steelhead from waters included in the Karluk study area between August 15 and September 30 was 496 fish.

Sport and subsistence fisheries harvested an estimated 40 and 804 steelhead, respectively, from the 1992 return year.

The estimated abundance of spawning steelhead for the entire Karluk River drainage in the spring of 1993 was 7,026 fish (standard error = 308). Most of the spawning population was composed of initial spawners (87%), followed by repeat (12%) and multi-repeat (1%) spawners. Mean length for female initial and repeat spawners was larger (635 millimeters and 702 millimeters, respectively) than for males (618 millimeters and 600 millimeters, respectively). Multi-repeat spawners were observed only in females (774 millimeters).

Spawning survival of steelhead was estimated at 58%. Spawning survival was similar between sexes (females 55% and males 50%). Survival of male initial (49%) and repeat (57%) spawners was also similar. Survival of females was not different among spawning histories (initial 56%, repeat 44%, and multi-repeat 50%).

KEY WORDS: steelhead, *Oncorhynchus mykiss*, purse seine, set gillnet, kelts, statistical area, Kodiak Island, Karluk River, Portage area, harvest, abundance estimate, survival, initial spawners, repeat spawners, multi-repeat spawners.

INTRODUCTION

The Karluk River contains the largest known steelhead *Oncorhynchus mykiss* population on Kodiak Island. From its source at the outlet of Karluk Lake, it flows approximately 35.2 km (22 mi) to its terminus at Karluk Lagoon and the North Pacific Ocean (Figure 1). Adult steelhead begin immigrating during late August and may continue immigrating through the winter months. Steelhead overwinter, spawn and emigrate to sea as kelts from May through July.

Karluk River steelhead are harvested in several fisheries. Adults are targeted in the Karluk River by sport anglers from September through November. In addition, adult steelhead are harvested in subsistence fisheries conducted by residents of Karluk Village during June through September and Larsen Bay during October through April. The autumn steelhead migration coincides with the return of coho salmon *Oncorhynchus kisutch* and late-run sockeye salmon *O. nerka* to the Karluk River. When commercial purse seine vessels and set gillnet operators target these salmon stocks, steelhead are incidentally harvested in nearshore marine waters along the southwest portion of Kodiak Island. Emigrant kelts (postspawners) are harvested in commercial fisheries in these same waters during June. Additionally, Karluk steelhead are incidentally harvested by commercial gear in nearshore marine waters along the Pacific side of the Alaska Peninsula.

Counts of postspawner steelhead obtained at the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries Management and Development weir, located at Karluk Lagoon since 1976, have ranged from 210 to 4,226 (Figure 2). The average annual kelt count was 2,385 from 1981 through 1985 and 566 per year from 1986 through 1990. This apparent decline of Karluk River steelhead created concern about overexploitation. However from 1991 through 1993, emigration has averaged 2,814 kelts including a record count 4,226 kelts in 1993.

In August of 1991, a study was initiated to assess stock status of adult steelhead returning to and overwintering in the Karluk River. Estimated parameters included incidental commercial harvest of steelhead from marine waters near the Karluk River, sport and subsistence harvests within the Karluk River, and the number of spawning steelhead in the Karluk River from a single return year (Begich 1992).

This report is part of a continuing study to assess the stock status of adult steelhead returning, overwintering and spawning at the Karluk River. The study objectives for the 1992 return are listed below.

Fishing Mortality:

1. Estimate the number of steelhead retained for personal use and the number released by commercial setnetters operating between West Point and Rocky Point from August 15 through September 30, 1992.

2. Estimate the number of steelhead harvested in the commercial purse seine fishery from West Point to Sturgeon Head, from August 15 to September 30, 1992, in selected commercial fishing district sections.

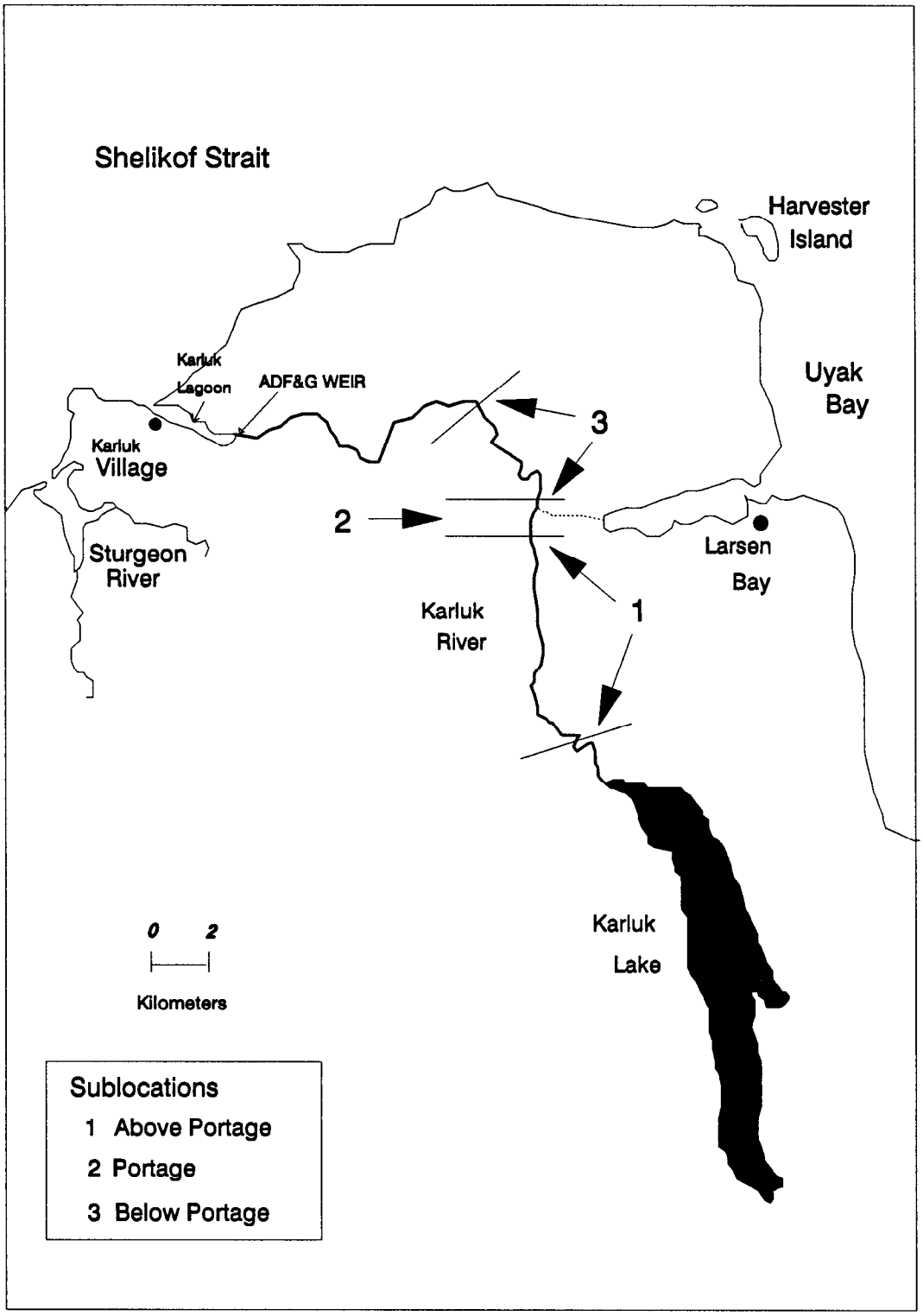

Figure 1. Map of the Karluk River freshwater study area sampling sublocations, Portage, Larsen Bay, weir and Karluk Village.

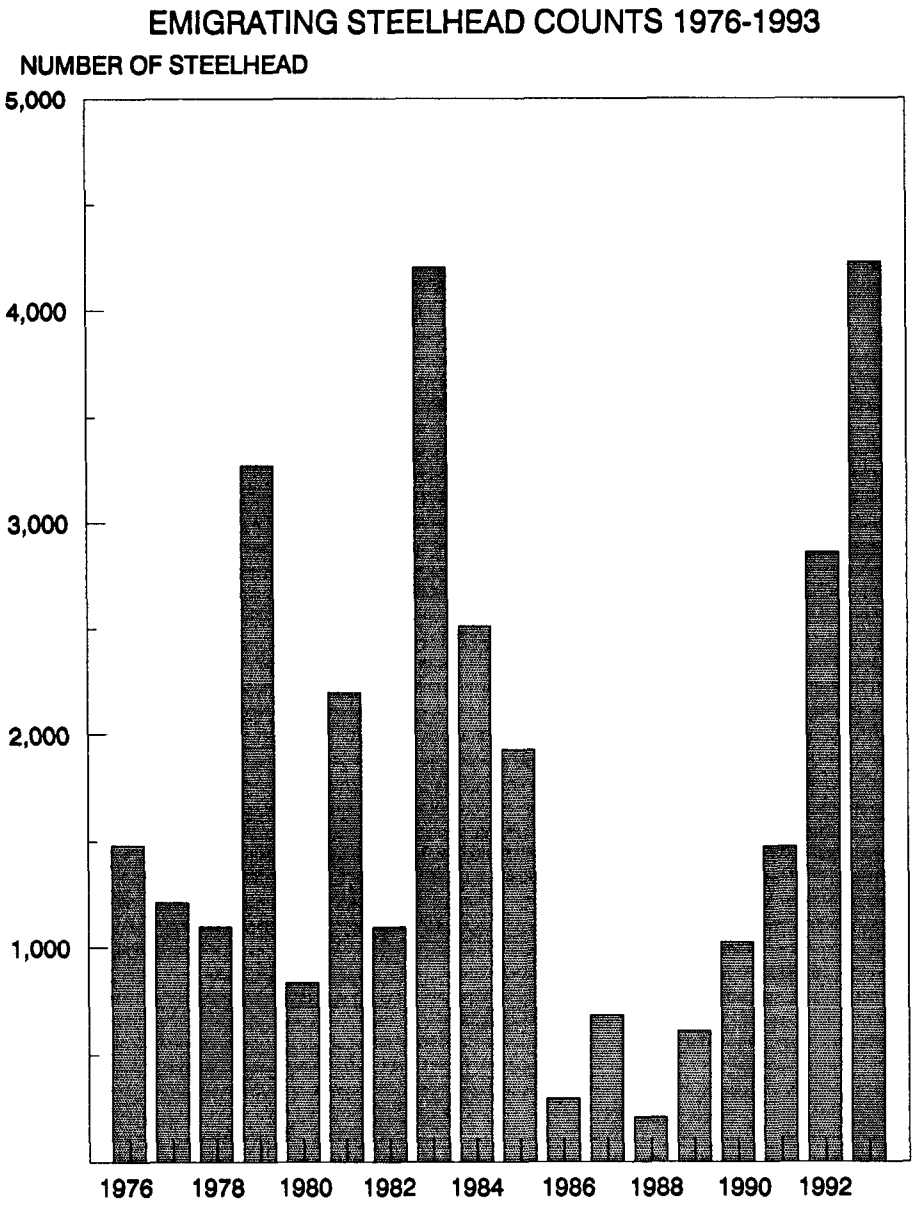

Figure 2. Historic emigrating steelhead counts obtained at the Division of Commercial Fisheries and Development weir, Karluk River, 1976 through 1993.

3. Estimate the number of steelhead sold in the commercial set gillnet fishery between West Point and Rocky Point from August 15 through September 30, 1992.

4. Estimate the age, sex, and length composition of steelhead and the number of repeat spawners of Karluk origin harvested in these commercial fisheries.

5. Census the number of steelhead harvested in the Karluk Village subsistence fishery and the Larsen Bay subsistence fishery during 1992.

6. Estimate the number of steelhead harvested in the Karluk River sport fishery during 1992.

Spawning Population:

7. Estimate the number of spawning steelhead in the Karluk River during the spring of 1993.

8. Estimate the age, sex, and length composition of the spawning population.

9. Enumerate emigrating kelts through the Karluk River weir during spring, 1993.

10. Estimate the age, sex, and length composition of the population of emigrating kelts.

ESTIMATION OF STEELHEAD BYCATCH IN SELECTED COMMERCIAL FISHERIES

Methods

Commercial catches from waters of eight statistical areas between West Point and Sturgeon Head were sampled for the incidental harvest of steelhead (Figure 3). The sampling of these fisheries was based on the assumption that steelhead harvests are likely of Karluk origin. All eight statistical areas were open to commercial purse seine fishing. Three of these eight statistical areas are permanently closed to the harvest of salmon with set gillnet gear. These fisheries are managed for the return of sockeye salmon, chinook salmon *O. tshawytscha*, pink salmon *O. gorbuscha*, and coho salmon to the Karluk River by ADF&G Division of Commercial Fisheries Management and Development, Kodiak.

Commercial catch sampling occurred over a 6-week period and was divided into five strata in order to detect temporal changes:

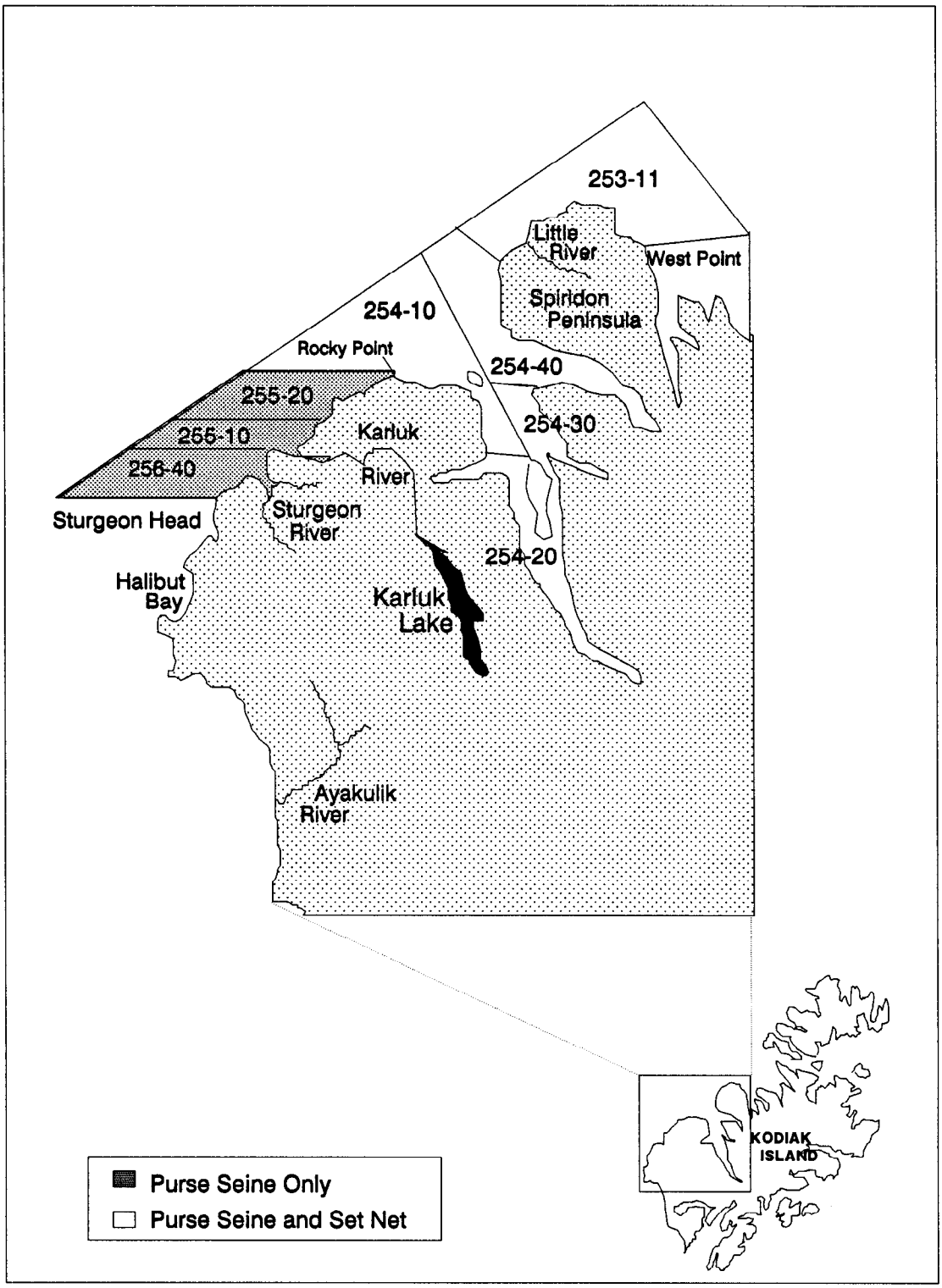

Figure 3. Map of marine study area and Karluk River, 1992.

Stratum	Date
1	8/15 - 8/31
2	9/01 - 9/07
3	9/08 - 9/14
4	9/15 - 9/21
5	9/22 - 9/30

Set Gillnet Fishery:

Prior to August 15, catch calendars were distributed to all set gillnet permit holders operating within the Karluk marine study area. The data voluntarily recorded on the calendar included: name of permit holder; permit number; and number of steelhead caught, retained and released by day. Calendar recipients were asked to mail the prepaid postage calendar to the Division of Sport Fish in Kodiak upon completion of fishing. Permit holders who did not return calendars were contacted by mail and asked to return calendars. This program was intended to provide data that would allow for the estimation of the number of steelhead retained and released by setnetters.

Since some permit holders failed to return their calendars, calendar returns were used to expand steelhead catches to the unreturned calendars. The total salmon harvest of permit holders who returned calendars was obtained by period from sales receipts (fish tickets). These data were used to estimate the ratio $(\hat{r})$ of steelhead retained or released to the number of salmon harvested for each stratum (h):

$$\hat{r} = \frac{\sum_{i=1}^{n} C_{si}}{\sum_{i=1}^{n} C_{oi}} \qquad (1)$$

where:

C_{si} = harvest or release of steelhead in net i,

C_{oi} = number of salmon in net i, and

n = number of returned calendars.

The total harvest $(\hat{C}_{ss})$ or release of steelhead in set gillnets by stratum was then estimated by:

$$\hat{C}_{ss} = \hat{r}\, C_{st} \qquad (2)$$

where:

C_{st} = total number of salmon in set gillnets in study area.

The variance of harvest or release was estimated for each stratum (h) by (Cochran 1977):

$$\hat{Var}(C_{ss}) = \frac{N^2(1-f)}{n\,(n-1)} \sum_{i=1}^{n} (C_{si} - \hat{rC}_{oi})^2 \qquad (3)$$

where:

N = total number of set gillnets in study area, and

f = finite population correction factor = n/N.

Estimates of harvest, release, and their variances were then summed over strata.

Tender-Sampled Set Gillnet and Purse Seine Fishery:

It was intended to estimate the number of steelhead sold by setnetters to tender vessels and delivered to canneries. Purse seine catches were to be sampled in the same manner. However, during 1992 industry logistics prohibited the separation of catches by gear types to accommodate this sampling methodology. Therefore, catches of both gear types were in aggregate at the time of sampling and were sampled on an opportunistic basis.

During off-loading, each fish in the catch was identified and sorted by species. Vessel operators were interviewed to obtain the number of steelhead sorted on the fishing grounds prior to sampling and included in the sample total. As many catches were sampled as possible during each sampling period.

Fish tickets from sampled deliveries provided the weight and number of salmon sold so that the ratio of steelhead to salmon could be computed as explained above. The number of salmon by gear type was also provided by fish tickets.

Steelhead observed in tender-sampled catches were measured from the tip-of-snout to the fork-of-tail (fork length) to the nearest millimeter and sexed. Four scales from the left side of the fish, two rows above the lateral line and on the diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, were taken for age determination (Paget 1920). Scales were mounted on gummed cards, pressed on acetate to make an impression and aged with a microfiche reader.

Scale analysis incorporated the methods of Mosher (1969), Jones (*Unpublished*) and Wallis (*Unpublished*). For example, an assigned age of 3.2s1s is an age-6 repeat spawner which: (1) spent 3 winters (years) in fresh water prior to smolt emigration, (2) returned to spawn in fresh water during its second year at sea, (3) returned to the sea, and (4) returned to spawn again the following spring. The letter "s" represents a freshwater immigration (spawning event) and numbers represent years between events. This represents a departure from the traditional method used for age assignment of fall immigrant steelhead

(Narver and Withler 1971). Utilizing these methods, the assigned age of this fish would have been 3.1ss.

Scales without a legible spawning check were defined as fish that were initial or first time spawners. Fish with one previous spawning check legible on the scale impression were defined as repeat or second time spawners. Multi-repeat spawners were fish with at least two previous spawning checks legible on the scale impression.

Results

Calendars were sent to 58 set gillnet permit holders operating within the Karluk study area. Thirteen calendars were returned. From August 15 to September 30, sampled permit holders retained 17 and released 15 steelhead (Table 1). During the same period, these same permit holders harvested 25,448 of the 129,801 salmon harvested by set gillnet gear from the Karluk study area (19.6%). The estimated retention of steelhead by set gillnet permit holders was 86 steelhead. An additional 79 fish were released.

From August 15 to September 30, 329,134 salmon were harvested within the Karluk study area (Table 2); 129,801 by set gillnet and 199,333 by purse seine. A total of 138 steelhead were observed in the tender sample of 123,412 salmon or 37.5% of the total harvest. The sample total included 83,016 set gillnet captured salmon and 40,396 purse seine captured salmon. Total estimated bycatch that was sold of combined gear was 331 (Table 2).

The total steelhead bycatch for the set gillnet (calendar returns) decreased from August 15 to September 21 (Table 1). The estimated ratio of steelhead-to-salmon was lowest during the first two strata and then increased during the remaining strata for the tender-sampled commercial catch (Table 2). No tagged steelhead were recovered from the tender sampled commercial harvest and no tags were voluntarily returned by setnetters during 1992 (Begich 1992).

Harvest was highest in statistical area 254-20 where 18% of the total salmon harvest occurred (Table 3). The estimated total catch of steelhead was greatest in statistical area 253-11; 20 retained and 53 released (Tables 3 and 4). No calendars were returned from statistical area 254-30; however this section only accounted for 4% of the total set gillnet harvest of salmon.

Of 79 steelhead observed in tender-sampled set gillnet and purse seine catches, 52% were females (Table 5). Initial spawners dominated both sexes. Multi-repeat spawners were observed only in females. Only one repeat spawning male was observed. The mean length of females was 650 mm FL and of males was 575 mm FL (Table 6, Appendix A1).

ESTIMATION OF STEELHEAD HARVEST IN THE KARLUK RIVER SUBSISTENCE FISHERIES

Methods

Karluk River steelhead are a component of subsistence fisheries of both Karluk Village and Larsen Bay. Karluk Village residents fish with beach seines within Karluk Lagoon during the later part of May through September. Fishing effort increases with the influx and concentrations of immigrant sockeye and

Table 1. Estimated retention and release of steelhead from commercial set gillnets near the Karluk River, August 15 through September 30, 1992. Obtained from catch calendar survey.

			Steelhead Retained					Steelhead Released				
Stratum	Total Salmon Harvested[a]	Sample Size[b]	Steelhead Retained[c]	Ratio of Steelhead to Salmon	Estimated Steelhead Retained	SE	Relative Precision[d]	Steelhead Released[c]	Ratio of Steelhead to Salmon	Estimated Steelhead Released	SE	Relative Precision[d]
8/15-8/31	71,112	8,436	5	0.000592	42	6.9	32%	6	0.000711	51	12.4	47%
9/01-9/07	37,421	9,180	8	0.000871	33	16.6	99%	2	0.000218	8	3.8	92%
9/08-9/14	14,375	5,423	4	0.000736	11	7.5	132%	4	0.000736	11	7.5	132%
9/15-9/21	6,893	2,409	0		0			3	0.001245	9	4.6	100%
9/22-9/30	0	0										
Total	129,801	25,448	17		86	20.9	47%	15		79	15.6	33%

[a] From fish tickets.

[b] Salmon harvest of permit holders who returned calendars.

[c] From calendars.

[d] Relative precision of 95% confidence interval.

Table 2. Estimated harvest of steelhead from combined set gillnet and purse seine catches near the Karluk River, August 15 through September 30, 1992.

Stratum	Salmon Harvested[a]	Sample Size[b]	Steelhead Observed	Ratio of Steelhead to Salmon	Estimated Steelhead Harvested	SE	Relative Precision[c]
8/15-8/31	210,026	74,257	23	0.00030	65	12.9	39%
9/01-9/07	71,454	29,487	44	0.00149	107	15.7	29%
9/08-9/14	32,728	9,245	19	0.00205	67	15.6	45%
9/15-9/21	13,344	10,055	44	0.00437	58	30.9	103%
9/22-9/30	1,582	368	8	0.02173	34	26.5	150%
Total	329,134	123,412	138		331	48.2	28%

[a] From fish tickets.

[b] Number examined.

[c] Relative precision of 95% confidence interval.

Table 3. Set gillnet harvest of steelhead by district section and sampling strata, August 15 through September 30, 1992.

District Section	Number of Steelhead by Strata						Proportion Sampled[b]	Proportion of Total Salmon Harvest[c]	Estimated Steelhead Harvest
	1	2	3	4	5[a]	Total			
253-11	2	1	1	0	0	4	0.235	0.238	20
254-10	0	0	0	0	0	0	0.000	0.289	0
254-20	2	6	3	0	0	11	0.647	0.180	55
254-30[d]								0.044	0
254-40	1	1	0	0	0	2	0.118	0.249	11
Total	5	8	4	0	0	17	1.000	1.000	86

[a] No set gillnet harvest during strata.

[b] Proportion of the total number of steelhead in sample all strata.

[c] Proportion of the total number of total salmon harvest all strata.

[d] No catch calendars were returned by setnetters from this section.

Table 4. Set gillnet release of steelhead by district section and sampling strata, August 15 through September 30, 1992.

District Section	Number of Steelhead by Strata						Proportion Sampled[b]	Proportion of Total Salmon Harvest[c]	Estimated Steelhead Released
	1	2	3	4	5[a]	Total			
253-11	4	0	3	3	0	10	0.666	0.238	53
254-10	2	1	0	0	0	3	0.200	0.289	16
254-20	0	0	1	0	0	1	0.067	0.180	5
254-30[d]								0.044	0
254-40	0	1	0	0	0	1	0.067	0.249	5
Total	6	2	4	3	0	15	1.000	1.000	79

[a] No set gillnet harvest during strata.

[b] Proportion of the total number of steelhead in sample all strata.

[c] Proportion of the total number of total salmon harvest all strata.

[d] No catch calendars were returned by setnetters from this section.

Table 5. Age composition by sex and spawning history of steelhead harvested by set gillnets and purse seines near the Karluk River, August 15 through September 30, 1992.

Spawning History	Marine Age	Females					Males				
		Sample Size	Estimated Proportion	SE	Estimated Abundance	SE	Sample Size	Estimated Proportion	SE	Estimated Abundance	SE
Initial[a]	1	10	0.130	0.038	42	13	26	0.329	0.053	109	23
	2	25	0.320	0.053	105	21	11	0.139	0.039	46	14
Repeat[b]	1	0	0.000				1	0.013		4	4
	2	3	0.038	0.013	13	7	0	0.000		0	
	3	1	0.013		4	4	0	0.000			
Multi-Repeat[c]	4	1	0.013		4	4	0	0.000			
	5	1	0.013		4	4	0	0.000			
Initial		35	0.450	0.056	147	27	37	0.468	0.057	155	27
Repeat		4	0.051	0.025	17	8	1	0.013		4	4
Multi-Repeat		2	0.025	0.018	8	6	0	0.000			
Total		41	0.519	0.057	172	28	38	0.481	0.057	159	27

[a] Adults, if returning to spawn, would be spawning for the first time.

[b] Adults, if returning to spawn, would be spawning for the second time.

[c] Adults, if returning to spawn, would be spawning three or more times.

Table 6. Length-at-age by spawning history and sex of steelhead harvested by set gillnets and purse seines near the Karluk River, August 15 through September 30, 1992.

Spawning History	Marine Age	Females			Males			All		
		Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
Initial[a]	1	10	589	20	26	560	10	36	568	6
	2	25	660	10	11	615	15	36	646	9
Repeat[b]	1	0			1	503		1	503	
	2	3	690	36	0			3	690	8
	3	1	691		0			1	691	
Multi-Repeat[c]	4	1	709		0			1	709	
	5	1	782		0			1	782	
Initial		35	640	8	37	576	18	72	607	7
Repeat		4	690	6	1	503		5	653	17
Multi-Repeat		2	746	26	0			2	746	26
Total		41	650	10	38	575	10	79	613	7

[a] Adults, if returning to spawn, would be spawning for the first time.

[b] Adults, if returning to spawn, would be spawning for the second time.

[c] Adults, if returning to spawn, would be spawning for three or more times.

coho salmon in Karluk Lagoon. Both emigrant (May through July) and immigrant (late August through September) steelhead are exposed to the Karluk Lagoon fishery.

Larsen Bay residents target steelhead at a mid-river location known as the Portage area (Figure 1), which is accessed by a trail from the head of Larsen Bay. Typically, residents target prespawning concentrations of adults that overwinter in this part of the river with rod and reel and beach seine from October through April.

ADF&G personnel conducted household interviews at both Karluk Village and Larsen Bay to determine the number of steelhead harvested by sampled households. Average harvest-per-interviewed-household was multiplied by the total number of households to estimate total harvest by each village.

The mean number of steelhead harvested for subsistence ($\bar{C}_s$) was estimated as:

$$\bar{C}_s = \frac{\sum_{i=1}^{n} C_i}{n} \qquad (4)$$

where:

C_i = harvest of steelhead in household i, and

n = total number of interviewed households.

The total harvest of steelhead by the village ($\hat{C}_v$) was estimated by:

$$\hat{C}_v = N \bar{C}_s \qquad (5)$$

where:

N = total number of households in village.

The variance of harvest was estimated by (Cochran 1977:24):

$$\mathrm{Var}[\hat{C}_v] = \frac{N^2(1-f)}{n(n-1)} \sum_{i=1}^{n} (C_i - \bar{C}_s)^2 \qquad (6)$$

where:

f = finite population correction factor = n/N.

Results

Household surveys were conducted by Division of Sport Fish personnel at Karluk Village on July 5, 1993. Residents of nine households reported harvesting 57 steelhead during the autumn of 1992 and spring/summer of 1993. Estimated mean

harvest per household was 6.33 and estimated total harvest by Karluk Village residents was 107 steelhead (Table 7).

ADF&G Division of Subsistence personnel conducted interviews at Larsen Bay, where 37 households reported harvesting 614 steelhead. Estimated mean harvest-per-household was 16.60 and estimated total harvest by Larsen Bay residents was 697 steelhead from April 1, 1992 through March 1, 1993 (Table 8).

Subsistence harvest of steelhead has been sporadically estimated since 1982 and village harvests have ranged from 17 to 697 fish (Tables 7 and 8). Harvest estimates from both villages increased markedly from 1991 to 1992. The Karluk Village harvest estimate is within the range of harvests reported since 1982, but the Larsen Bay estimate of harvest is an all time high.

ESTIMATION OF STEELHEAD HARVEST IN THE KARLUK RIVER SPORT FISHERY

Methods

Estimates of sport harvest and catch of steelhead, and effort at the Karluk River were obtained from postal surveys (Mills 1982-1993). In this survey, sport fishing parameters are estimated by location. Therefore, fishing effort (reported in angler-days) is the total fishing effort for the Karluk River and includes effort directed at other species, particularly chinook and coho salmon. Due to the small size of the Karluk River sport fishery and the corresponding number of returns, estimates were not available in 1986, 1987, and prior to 1982.

Results

The estimated sport harvest of Karluk River steelhead during the 1992 season was 40 fish (Table 9). Although this was the smallest harvest since 1989, it was within the range of harvests reported during the years 1982-1991. Release in the fishery has increased over those reported since 1990. Annual fishing effort from 1982 through 1985 averaged 1,363 angler-days and 2,645 angler-days between 1989 and 1992. Yearly effort has been variable, with the 1992 estimate of 5,430 angler-days the highest reported.

ESTIMATION OF SPAWNING ABUNDANCE AND SURVIVAL

Methods

Abundance:

Steelhead overwinter in the upper Karluk River and tend to congregate in the Portage area of the river (Chatto 1987). In the spring, steelhead disperse to spawning areas, which have not been completely documented. Upon completion of spawning, surviving adults (kelts) emigrate through a weir located approximately 19 km (12 mi) downstream of the Portage area and 0.4 km above the tidal influence of Karluk Lagoon (Figure 1). This situation allowed for a mark-recapture experiment to estimate the abundance of the spawning population in the Karluk River drainage during the spring of 1993. Sampling occurred in

Table 7. Subsistence harvest of steelhead from Karluk Village, 1982-1983, 1986, 1989, 1991 and September 1, 1992 through July 1, 1993.

Years	Total Reported Harvest[b]	Number Households in Sample	Mean Catch-per-Household	Number Households in Community	Estimated Community Harvest[c]	SE
1982-83[a]	233	20	11.65	26	303	13
1986[a]	77	19	4.05	27	109	20
1989[a]	14	14	1.0	17	17	35
1991[ad]	36	13	2.76	17	47	
1992[e]	57	9	6.33	17	107	5

[a] Source: Community Profile Database, Division of Subsistence, Alaska Department of Fish and Game, Anchorage.

[b] From household interviews.

[c] Product of mean catch-per-household and number of households in community.

[d] Standard error not available.

[e] Source: Alaska Department of Fish and Game, Division of Sport Fish survey, July 1993.

Table 8. Subsistence harvest of steelhead from Larsen Bay, 1982-1983, 1986, 1989, 1991 and April 1, 1992 through March 1993[a].

Years	Total Reported Harvest[b]	Number Household in Sample	Mean Catch-per-Household	Number Households in Community	Estimated Community Harvest[c]	SE
1982-83[a]	273	32	8.53	43	367	16
1986[a]	74	37	2.00	52	104	15
1989[a]	86	34	2.50	39	98	27
1991[ad]	230	35	6.57	40	263	
1992-1993[a]	614	37	16.60	42	697	6

[a] Source: Community Profile Database, Division of Subsistence, Alaska Department of Fish and Game, Anchorage.

[b] From household interviews.

[c] Product of mean catch-per-household and number of households in community.

[d] Standard error not available.

Table 9. Sport harvest and release of steelhead and total fishing effort from the Karluk River sport fishery, 1982-1992[a].

Year	Effort[b]	Harvest	Released
1982	1,552	90	
1983	2,142	241	
1984	534	150	
1985	1,223	167	
1986	[c]	[c]	
1987	[c]	[c]	
1988	990	18	
1989	1,313	20	
1990	2,191	86	
1991	1,646	128	628
1992	5,430	40	898

[a] Source: Postal surveys as reported by Mills (1983-1993).

[b] Angler-days.

[c] No estimate due to insufficient number of returns.

[d] First estimated in 1991.

early April, prior to spawning, in a 14.5 km (9 mi) area of the Karluk River and was divided into three sampling sublocations (Figure 1). Each location was fished and effort was directed at multiple sites within each location where fish were known to be congregated.

Fish were captured on hook and line, measured for fork length, sexed, scale sampled for age, tagged near the posterior insertion of the dorsal fin into the body with a six digit Floy FD-67 internal anchor tag, and a portion of the right ventral fin was removed to serve as a secondary mark to assess tag loss.

Population abundance ($\hat{N}$) was calculated using Chapman's modification of the Petersen estimator (Seber 1982):

$$\hat{N} = \frac{(M+1)\,(C+1)}{(R+1)} - 1 \qquad (7)$$

where:

M = tags released in first event,

R = tags recaptured in second event,

C = fish examined for tags in second event.

The variance was estimated by:

$$\widehat{Var}(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2\,(R+2)} \cdot \qquad (8)$$

The following assumptions were necessary for this closed population estimate (Seber 1982):

1. there is no recruitment in the population over the duration of the experiment;

2. no marks are lost;

3. all fish have the same probability of capture in the second sample or marked fish are randomly distributed within the population of unmarked fish;

4. marking does not affect the probability of capture; and

5. all steelhead are reported when recovered in the second sample.

The experiment was designed to estimate abundance of the spawning population for the entire drainage. Steelhead likely overwinter and spawn in areas other than the sampled sublocations, including Karluk Lake, the upper river and lower river. The first sampling event (mark event) for this experiment was the entire 18-day sampling experiment described above. The second sampling event (recapture event) occurred at the weir. If there was sufficient mixing

of tagged and untagged steelhead during spawning and prior to emigration through the weir, the experiment should provide an estimate of spawner abundance for the entire Karluk River drainage. From May 26 through July 20, 1993, all emigrating steelhead were captured in a downstream trap that was incorporated into the weir. Upon entry into the trap, steelhead were captured with a dip net, placed on a measuring board, examined for a finclip and tag, measured for fork length to the nearest millimeter, and all untagged kelts were tagged and given a secondary mark (finclip) as previously described. We attempted to scale sample 140 fish per week as previously described.

We have no reason to believe that there was any recruitment, immigration or emigration; therefore the first assumption was not tested. Contingency tables and chi-square tests (Conover 1980) were used to compare the probability of capture (assumptions 1, 2 and 4) among the geographic sublocations, sex, spawning history and marine age between the first sampling event (mark event) and the second sampling event (recapture event). In addition, chi-squared tests were used to test capture rate (marked:unmarked ratio) at the weir due to spawning history and sex. Two-sample Anderson-Darling tests (Scholz and Stephans 1987) were used to determine if capture rates differed due to size by comparing the cumulative length distributions of fish marked in the first event with those recaptured in the second event and the cumulative length distributions of all fish captured in the mark event with all fish captured in the recapture event. Differences in cumulative length distributions or capture rate among one of these groups may indicate whether the best estimator of abundance was a stratified or nonstratified Chapman modification to the Petersen model (Seber 1982). All tests were conducted at $\alpha = 0.05$. The secondary mark (right ventral finclip) provided the means to estimate tag loss (assumption 2).

Age and Length Composition:

During the hook-and-line and weir operations, steelhead were sampled to estimate mean length-at-age and age composition. Samples were categorized by total marine age and spawning history as previously described.

The proportion of steelhead in each age category was estimated as:

$$\hat{p}_i = \frac{n_i}{n_t} \qquad (9)$$

where:

n_i = the number of steelhead in the sample from age category i,

n_t = the total number of steelhead in the sample.

The variance of the proportion by age was estimated as:

$$\widehat{Var}(\hat{p}_i) = \frac{\hat{p}_i\,(1 - \hat{p}_i)}{n_t - 1} . \qquad (10)$$

Abundance by age was estimated as:

$$\hat{N}_i = \hat{N}\,\hat{p}_i. \tag{11}$$

The variance was estimated as (Goodman 1960):

$$\hat{V}(N_i) = \hat{V}(N)\,\hat{p}_i^2 + \hat{V}(p_i)\,\hat{N}^2 - \hat{V}(N)\,\hat{V}(p_i)\ . \tag{12}$$

Spawning Survival:

The survival of tagged fish (S_c) from the marking event (hook and line) to emigration and recapture at the weir was calculated by spawning history, total marine age and sex, by:

$$S_c = \frac{n_{cw}}{n_{ct}} \tag{13}$$

where:

n_{cw} = number of tagged fish at weir in class c, and

n_{ct} = number of tagged fish released during marking event in class c.

Results

Abundance:

A total of 350 steelhead were captured by hook-and-line and released with marks. Of 4,103 fish examined for marks at the weir, 204 had marks (Table 10). Nine percent (n = 18) of the marked steelhead had lost their tags. The probability of capture at the weir of fish released in the first event was not significantly different among the geographic sublocations of release ($\chi^2 = 1.428$, df = 2, P = 0.49), sex ($\chi^2 = 1.136$, df = 1, P = 0.29), spawning history ($\chi^2 = 0.535$, df = 2, P = 0.77), or marine age ($\chi^2 = 3.563$, df = 3, P = 0.31). Significant differences were detected between the cumulative length distributions of all fish marked on the spawning grounds and all recaptures at the weir ($T_{akn} = 4.16$, P = 0.007, $n_1 = 349$, $n_2 = 204$) (test 1); and all fish marked on the spawning grounds and all captures at the weir ($T_{akn} = 46.16$, P < 0.001, $n_1 = 349$, $n_2 = 4{,}069$) (test 2). Although the test statistic for test 1 indicates dissimilar length distributions between events, a plot of the cumulative length distribution (Figure 4) displays a parallel distribution. Furthermore, the probability of capture during event 2 at the weir was equal for all sizes of steelhead. A single unstratified estimate of abundance was calculated and pooled data from each strata were used in estimates of age composition. The estimated abundance of steelhead in the Karluk River drainage during the spring of 1993 was 7,026 fish (SE = 308).

Temporal trends in the emigration of marked and unmarked steelhead through the weir were similar (Figure 5). There was no significant difference in the marked:unmarked ratio at the weir due to spawning history ($\chi^2 = 0.063$, df = 2, P = 0.97). However, there was a significant difference in the marked:unmarked

Table 10. Summary of tagging data for steelhead released at the Portage area and recaptured at the Karluk weir, Karluk River, 1993.

Marking Event at Portage 04/04-04/20		Recapture Event at Weir 05/26-07/20		
Tag Releases by Sublocation[a]	Number Released	Recovered	Not Recovered	Percent Recovered
1	133	68	65	51.1
2	110	56	54	50.9
3	107	62	45	57.9
Number Tag releases	350	186[b]	164	
Number Untagged		3,899		
Number Examined		4,103		
Percent marked recoveries		4.9		

[a] 1 = Above Portage; 2 = Portage Area; 3 = Below Portage.

[b] Does not include 18 fish which lost their tags.

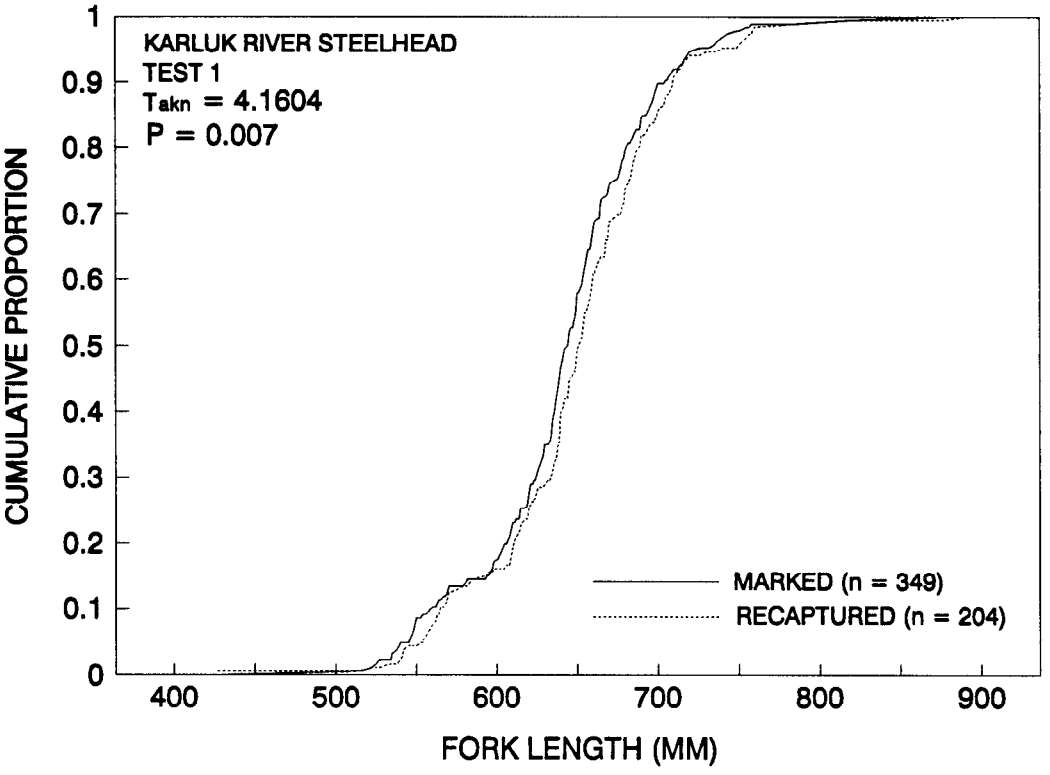

Figure 4. Cumulative length distribution plot (test 1) of all steelhead marked on the spawning grounds (event 1) and all steelhead recaptured at the weir (event 2), Karluk River 1993.

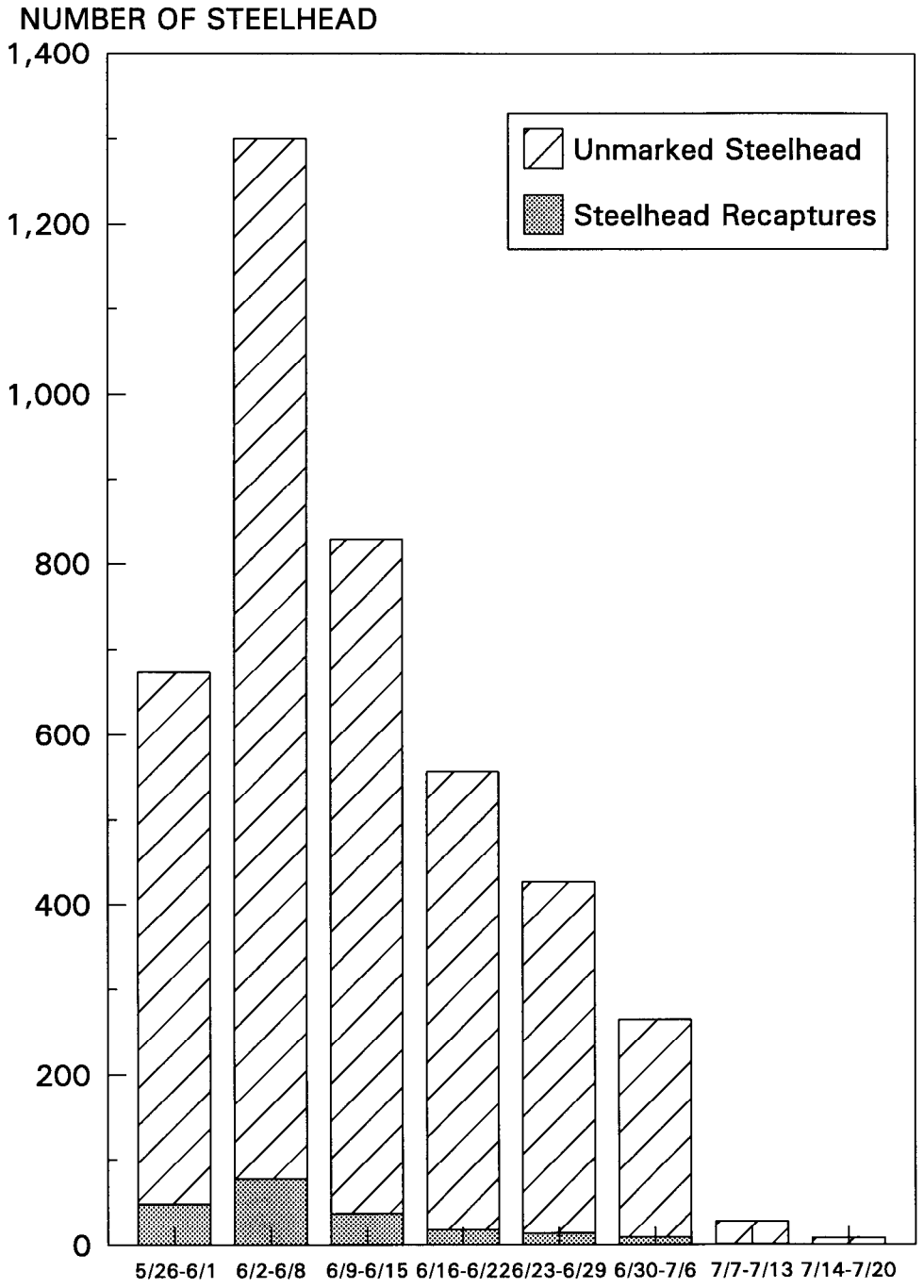

Figure 5. Weekly comparison of marked and unmarked steelhead emigrating through the Karluk River weir, May 26 through July 20, 1993.

ratio at the weir among sexes ($\chi^2 = 4.61$, df = 1, $P < 0.032$). There were also significant differences among spawning histories between sexes at the weir, initial ($\chi^2 = 167.00$, df = 2, $P < 0.001$), repeat and multi-repeat ($\chi^2 = 36.938$, df = 1, $P < 0.001$). This was due to a large number of initial spawning females relative to males observed at the weir (Table 11 and Figure 6). Due to these results, age and length data collected at the weir were used to estimate the age composition of the spawning population. Subsequent testing among and between sexes, spawning histories and time detected a significant difference in the number of initial spawning fish at the weir. Therefore, the age composition by sex and spawning history of the emigrating population was stratified.

Biological Composition of the Spawning Population and Emigration:

The length and age composition of steelhead spawning in the Karluk River was divided into three categories by spawning history. These categories were then partitioned by total marine age (in years) among the sexes. The majority of steelhead sampled on the spawning grounds were initial spawners with total marine age of 2, 3 or 4 years (87%) and a mean length of 657 mm FL (Table 12, Appendix A2). Thirteen percent of the prespawning concentration at the Portage area was composed of repeat (12%) and multi-repeat (1%) spawners with mean lengths of 663 mm FL and 790 mm FL, respectively (Tables 12 and 13). Repeat spawning females were dominated by 5-ocean fish (47%) followed by 4-ocean (35%) and 3-ocean (18%) fish, while 3-ocean fish dominated the male repeat spawner age category. Both sexes were dominated by initial spawners (90% females and 82% males). Female repeat and multi-repeat spawners were larger (mean length 697 mm and 790 mm FL) than males (636 mm and 705 mm FL) Initial spawning males were larger than females (mean length 669 mm and 650 mm FL) (Table 12).

The sex composition of emigrating steelhead was dominated by females (65%), of which 89% were initial spawners (mean length 635 mm FL) (Tables 14 and 15, Appendix A3). Among males, 81% were first time spawners (mean length 618 mm FL), while 19% were spawning for the second time (mean length 600 mm FL). Multi-repeat spawners were observed only in females (1%) (mean length 774 mm FL).

Spawning Survival:

Survival by sex and spawning history was estimated from prespawn capture in April to postspawn weir emigration. Survival by marine age was not calculated due to small sample sizes. Overall survival was 55% for females and 50% for males (Table 16). Tag recovery rates were not significantly different due to spawning history among either sex, females ($\chi^2 = 0.899$, df = 2, $P = 0.64$) and males ($\chi^2 = 1.469$, df = 2, $P = 0.48$). Spawning survival of all steelhead was estimated at 58% (Table 16).

DISCUSSION

The 1992 commercial salmon harvest of 329,134 fish from statistical areas included in the Karluk study area during the August 15 to September 30 sampling period was below harvest levels observed during 1991 when 1,649,397 salmon were harvested (Figures 7 and 8). Likewise, the total estimated

Table 11. Sex composition by week of the emigrating steelhead, Karluk River, 1993.

Spawning History	Sex	Weekly Totals May 26 through July 20. 1	2	3	4	5	6	7	8	Total
Initial[a]	F	36	84	78	88	96	98	11	4	495
	M	69	26	31	34	30	29	4	1	224
	Total	105	110	109	122	99	127	15	5	719
Repeat[b]	F	3	14	12	5	7	5	2	2	50
	M	18	10	11	6	3	1	1	0	50
	Total	21	24	23	11	10	6	3	2	100
Multi-Repeat[c]	F	1	1	0	1	1	0	0	0	4
	M	0	0	0	0	0	0	0	0	0
	Total	1	1	0	1	1	0	0	0	4
Total	F	40	99	90	94	104	103	13	6	549
	M	87	36	42	40	33	30	5	1	274
Total		127	135	132	134	137	133	18	7	823

[a] Adults spawning for the first time spring of 1993.

[b] Adults spawning for the second time spring of 1993.

[c] Adults spawning for the third or more times spring of 1993.

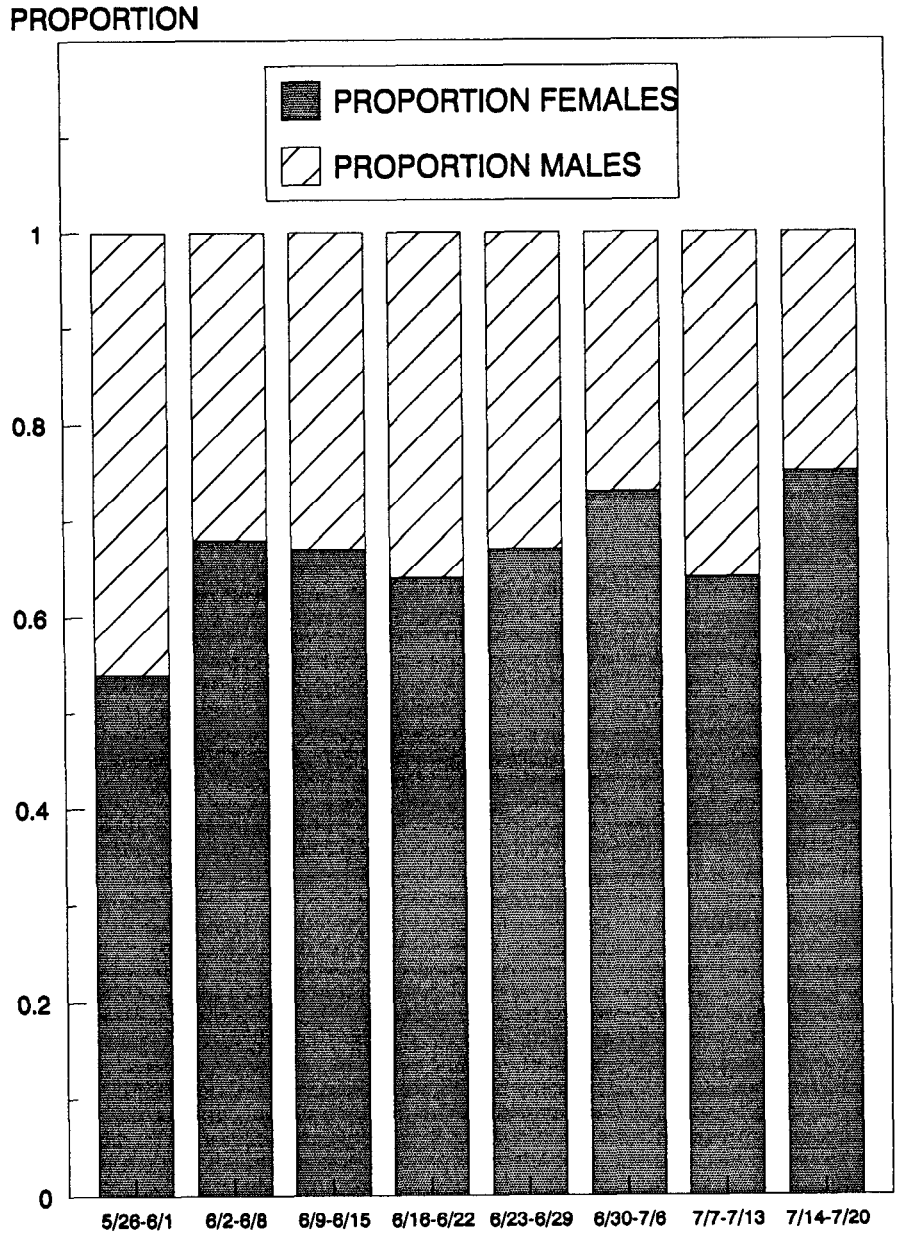

Figure 6. Weekly comparison by sex of steelhead emigrating through the Karluk River weir, May 26 through July 20, 1993.

Table 12. Length-at-age by spawning history and sex of hook-and-line captures of the spawning population, April 1993.

Spawning History	Marine Age	Females			Males			All		
		Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
Initial[a]	2	12	555	7	32	570	1	44	566	7
	3	163	657	3	63	706	6	226	671	3
	4	0			5	838	12	5	838	12
Repeat[b]	3	3	593	14	13	592	9	16	592	9
	4	6	678	14	7	695	10	13	685	9
	5	8	751	7	1	760		9	755	8
Multi-Repeat[c]	4	1	760		1	705		2	733	28
	5	2	806	11				2	806	11
Initial		175	650	4	100	669	9	275	657	4
Repeat		17	697	16	21	636	14	38	663	12
Multi-Repeat		3	790	14	1	705		4	790	14
Total		195	656	4	122	663	8	317	659	4

[a] Adults spawning for the first time spring of 1993.

[b] Adults spawning for the second time spring of 1993.

[c] Adults spawning for the third or more times spring of 1993.

Table 13. Age composition by sex of spawning steelhead trout in the Karluk River, 1993.

Spawning History	Marine Age	Females					Males				
		Sample Size	Estimated Proportion	SE	Estimated Abundance	SE	Sample Size	Estimated Proportion	SE	Estimated Abundance	SE
Initial[a]	2	35	0.043	0.007	299	51	106	0.129	0.012	905	91
	3	458	0.557	0.017	3910	210	113	0.137	0.012	965	94
	4	2	0.002	0.002	17	12	5	0.006	0.003	43	19
Repeat[b]	3	11	0.013	0.004	94	28	40	0.049	0.007	342	55
	4	29	0.035	0.006	248	46	10	0.012	0.004	85	27
	5	10	0.012	0.004	85	27	0	0.000			
Multi-Repeat[c]	4	3	0.004	0.002	26	15	0	0.000			
	5	1	0.001	0.001	8	9	0	0.000			
Initial		495	0.601	0.017	4,226	220	224	0.272	0.016	1913	137
Repeat		50	0.061	0.008	427	61	50	0.061	0.008	426	61
Multi-Repeat		4	0.005	0.002	34	17	0	0.000			
Total		549	0.667	0.016	4,687	235	274	0.333	0.016	2,339	154

[a] Adults spawning for the first time in spring of 1993.

[b] Adults spawning for the second time in spring of 1993.

[c] Adults spawning for three or more times spring of 1993.

Table 14. Age composition by spawning history and sex of steelhead emigrating through the Karluk River weir, May 26 through July 20, 1993.

Spawning History	Marine Age	Females					Males				
		Sample Size	Estimated Proportion	SE	Estimated Abundance	SE	Sample Size	Estimated Proportion	SE	Estimated Abundance	SE
5/26 - 6/08/93											
Initial[a]	2	2	0.014	0.010	18	13	21	0.172	0.034	125	25
	3	118	0.849	0.030	1,057	38	69	0.566	0.045	411	33
	4	0	0.000		0		4	0.033	0.016	24	12
Repeat[b]	3	3	0.022	0.012	27	15	23	0.189	0.036	137	51
	4	8	0.058	0.019	72	25	5	0.041	0.018	30	13
	5	6	0.043	0.017	54	22	0	0.000		0	
Multi-Repeat[c]	4	2	0.015	0.010	18	13	0	0.000		0	
	5	0	0.000		0		0	0.000		0	
Initial		120	0.863	0.029	1,075	36	94	0.770	0.038	560	28
Repeat		17	0.122	0.028	152	35	28	0.229	0.032	167	28
Multi-Repeat		2	0.015	0.010	18	13	0	0.000		0	
Total[d]		139	0.631		1,245		122	0.369		727	

-continued-

Table 14. (Page 2 of 3).

Spawning History	Marine Age	Females Sample Size	Females Estimated Proportion	Females SE	Females Estimated Abundance	Females SE	Males Sample Size	Males Estimated Proportion	Males SE	Males Estimated Abundance	Males SE
6/09 - 7/20/93											
Initial[a]	2	33	0.080	0.013	113	19	85	0.559	0.040	392	28
	3	340	0.829	0.018	1,168	26	44	0.289	0.037	203	26
	4	2	0.005	0.003	7	5	1	0.007	0.007	5	5
Repeat[b]	3	8	0.019	0.007	28	10	17	0.112	0.026	78	18
	4	21	0.051	0.011	72	15	5	0.033	0.015	23	10
	5	4	0.009	0.005	14	7	0	0.000		0	
Multi-Repeat[c]	4	1	0.002	0.002	3	3	0	0.000		0	
	5	1	0.002	0.002	3	3	0	0.000		0	
Initial		375	0.916	0.014	1,289	19	130	0.855	0.029	600	20
Repeat		33	0.080	0.422	114	19	22	0.145	0.029	101	21
Multi-Repeat		2	0.004	0.003	6	5	0	0.000		0	
Total[d]		410	0.668		1,409		152	0.332		701	

-continued-

Table 14. (Page 3 of 3).

Spawning History	Marine Age	Females					Males				
		Sample Size	Estimated Proportion	SE	Estimated Abundance	SE	Sample Size	Estimated Proportion	SE	Estimated Abundance	SE
5/26 - 7/20/93											
Initial[a]	2	35	0.032	0.006	131	25	106	0.127	0.012	517	47
	3	458	0.545	0.017	2,225	71	113	0.150	0.012	614	51
	4	2	0.002	0.001	7	6	5	0.007	0.003	29	12
Repeat[b]	3	11	0.013	0.004	55	16	40	0.053	0.007	215	32
	4	29	0.035	0.006	144	26	10	0.013	0.004	53	16
	5	10	0.017	0.004	68	18	0	0.000		0	
Multi-Repeat[c]	4	3	0.005	0.002	21	10	0	0.000		0	
	5	1	0.001	0.001	3	3	0	0.000		0	
Initial		495	0.579	0.017	2,363	70	224	0.284	0.016	1,160	64
Repeat		50	0.065	0.009	267	35	50	0.066	0.009	268	35
Multi-Repeat		4	0.006	0.003	24	11	0	0.000		0	
Total[d]		549	0.650		2,654		274	0.350		1,428	

[a] Adults spawning for the first time in spring of 1993.

[b] Adults spawning for the second time in spring of 1993.

[c] Adults spawning for three or more times in spring of 1993.

[d] Total not estimated, observed counts at weir.

Table 15. Length-at-age by spawning history and sex of emigrating steelhead, Karluk River, 1993.

Spawning History	Marine Age	Females			Males			All		
		Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
Initial[a]	2	35	563	9	106	546	3	141	551	3
	3	458	640	1	113	678	4	571	646	2
	4	2	712	20	5	799	11	7	774	18
Repeat[b]	3	11	646	14	39	577	8	50	592	8
	4	29	714	7	10	689	16	39	706	7
	5	10	727	13				10	727	13
Multi-Repeat[c]	4	3	779	15				3	779	15
	5	1	760					1	760	
Initial		495	635	2	224	618	5	719	629	2
Repeat		50	702	7	49	600	10	99	651	1
Multi-Repeat		4	774	12				4	774	12
Total		549	642	1	273	615	5	822	634	2

[a] Adults spawning for the first time spring of 1993.

[b] Adults spawning for the second time spring of 1993.

[c] Adults spawning for three or more times during spring of 1993.

Table 16. Spawning survival by sex and spawning history of Karluk River steelhead, marked on the spawning grounds and recaptured at the weir, 1993.

	Females			Males			All		
Spawning History	Number Marked	Number Recaptured	Survival	Number Marked	Number Recaptured	Survival	Number Marked	Number Recaptured	Survival
Initial[a]	175	98	0.560	100	49	0.490	275	147	0.535
Repeat[b]	18	8	0.444	21	12	0.571	39	20	0.513
Multi-Repeat[c]	2	1	0.500	1	0	0.000	3	1	0.333
Total[d]	195	107	0.549	122	61	0.500	350	204	0.583

[a] Adults spawning for the first time spring 1993.

[b] Adults spawning for the second time spring of 1993.

[c] Adults spawning for three or more times during the spring of 1993.

[d] Totals may not add due to illegible scales or inability to determine sex.

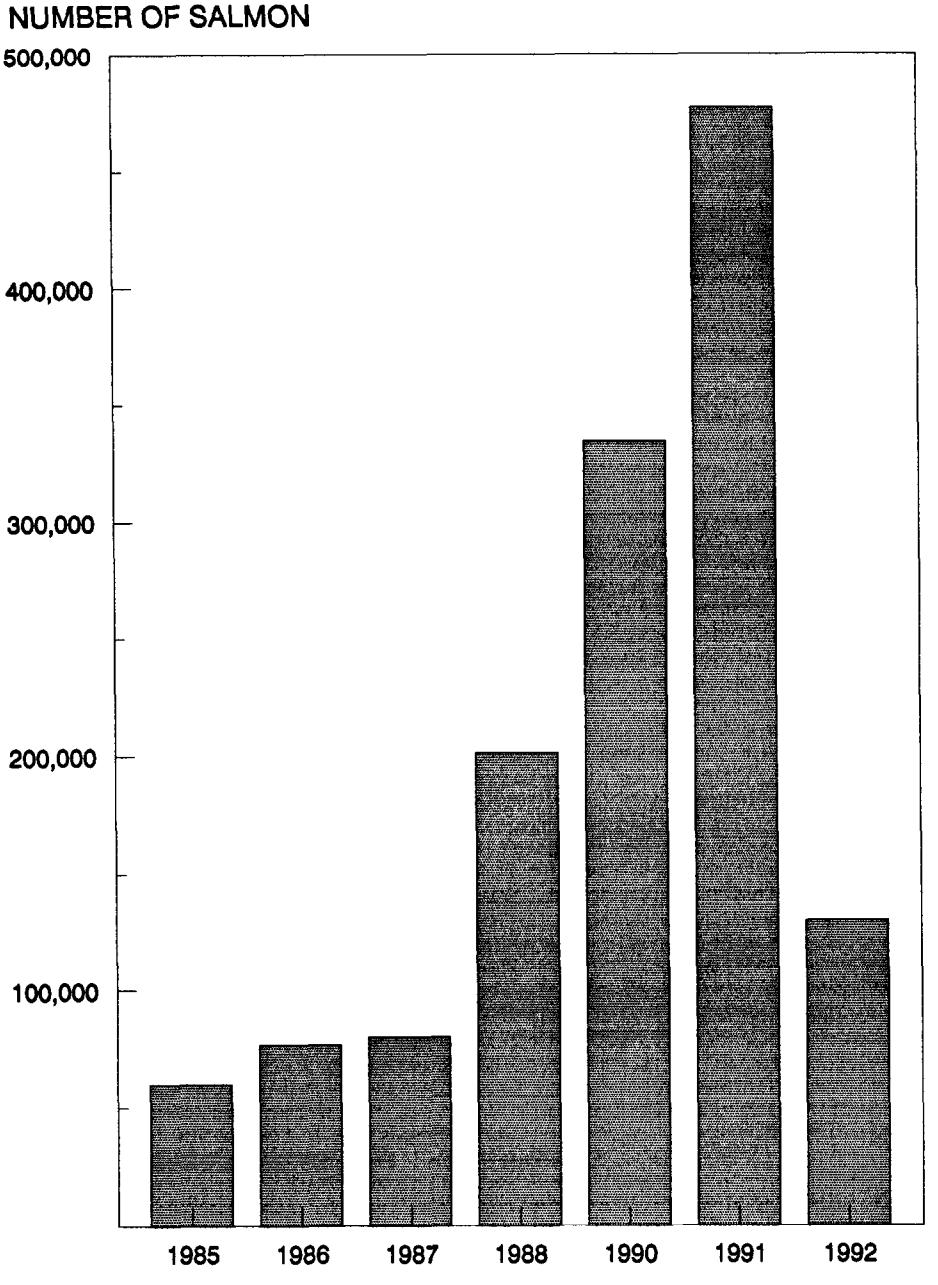

Figure 7. Historic set gillnet harvest of salmon from the five statistical areas included in the Karluk River marine study area, August 15 through September 30, 1985 through 1992. There was no set gillnet fishery in 1989 due to the *Exxon Valdez* oil spill.

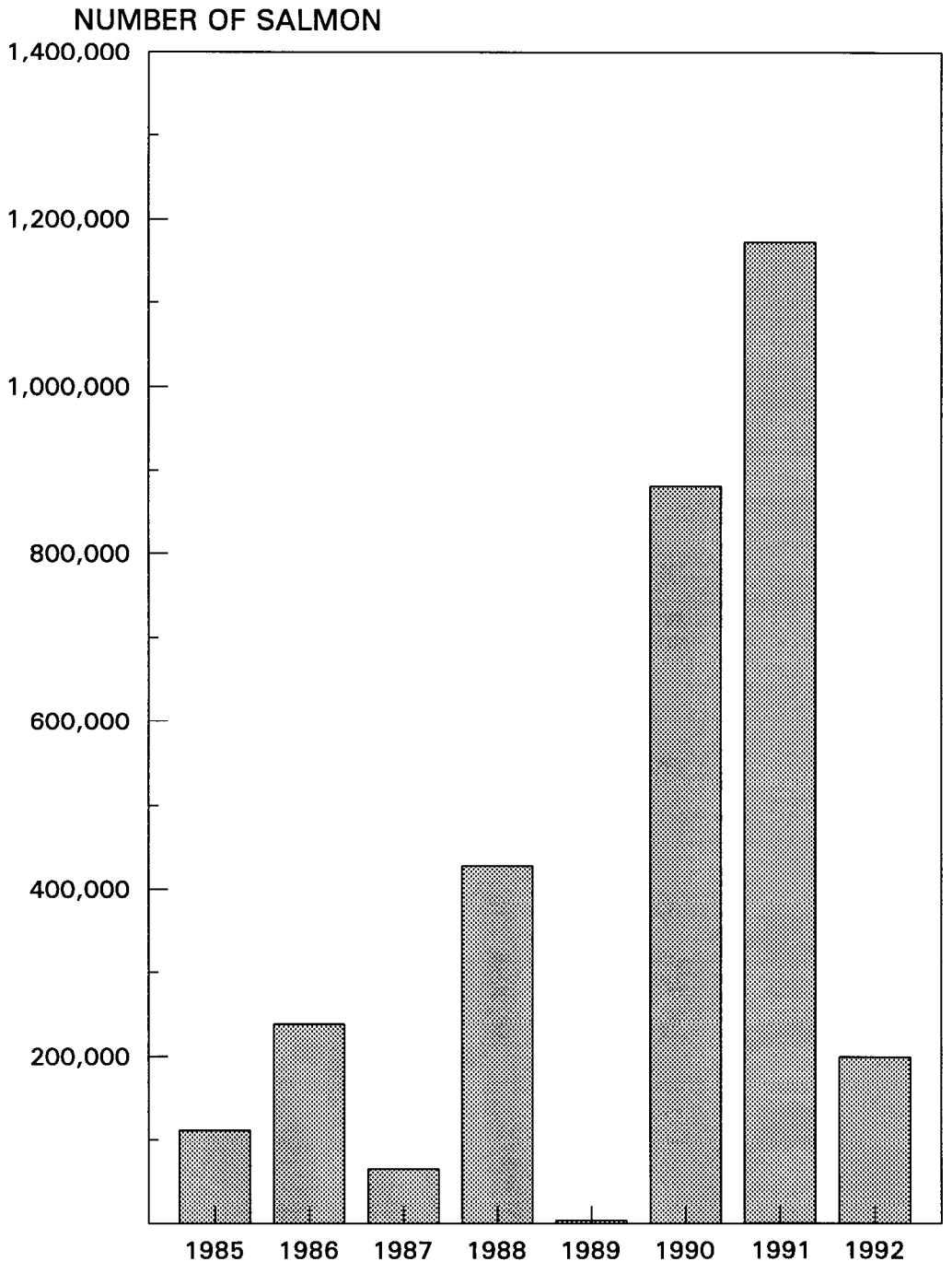

Figure 8. Historic purse seine harvest of salmon from the eight statistical areas included in the Karluk River marine study area, August 15 through September 30, 1985 through 1992.

commercial bycatch of steelhead declined from 819 to 417 fish. Future trends in commercial harvest from these statistical areas are uncertain and will likely fluctuate in response to the success of returning late-run (September) sockeye to the Karluk River.

During 1992, all emigrating steelhead passing through the weir at Karluk Lagoon were tagged. No tagged steelhead were observed during commercial sampling in 1992 and no tags were voluntarily returned from commercial operators fishing within the Karluk study area. Therefore, the percentage of the 417 steelhead harvested that were repeat or multi-repeat spawners bound for the Karluk could not be estimated. The proximity of the Karluk to other systems supporting steelhead populations (Figure 9) makes it likely that steelhead bycatch is comprised of mixed stocks. Future trends in commercial harvest from selected statistical areas should be monitored and if these fisheries expand, stock contribution needs to be assessed.

The harvest of steelhead by Karluk Village residents, in the Lagoon, was incidental to the subsistence salmon harvest. In Karluk Lagoon, state regulations allow the incidental harvest of steelhead for subsistence use in net fisheries directed at immigrating salmon. Conversely, the Portage area subsistence fishery by Larsen Bay residents is a directed fishery targeting overwintering steelhead. Current federal and state regulations prohibit the directed harvest of steelhead trout for subsistence use in the Kodiak area. Furthermore, it is illegal to use rod and reel to harvest steelhead for subsistence purposes. Steelhead may be taken on the upper Karluk by rod and reel from June 15 through March 31 with a limit of 2 per day of which only 1 may be in excess of 20 inches in length. The high catchability and concentrations of these fish make them extremely vulnerable to harvest during the winter and spring months. Dissemination of information of current state and federal regulations in place on the Karluk should be directed at residents of Larsen Bay to fully protect the spawning population and attain an orderly and lawful winter/spring sport fishery.

Sport harvest of steelhead in the Karluk River is relatively low. Total catch of steelhead in 1991 and 1992 was high in comparison to harvest, approximately 90% of all steelhead caught were released. Emigrating kelts are available from late May through mid-July. These fish are exposed to increasing fishing effort as a result of an expanding chinook salmon fishery. Since effort expended on the Karluk is increasing, future catch, harvest and effort levels will need to be monitored.

The estimated abundance of 7,026 spawning steelhead does not include overwintering mortality. Considering sport and subsistence removal (40 and 804, respectively) plus the estimate of spawning abundance places the fall immigrant population at a minimum of 7,830 fish. Since I have no estimate of the contribution of Karluk River fish to the commercial harvest, I can only speculate as to the abundance of the total adult return. Also, emigrating steelhead were observed by Karluk Village residents and ADF&G personnel prior to the onset of weir installation on May 22, 1993. Therefore, the estimate of spawning survival is a minimum.

The component of initial spawners (87%) in the Karluk River during 1993 was higher than observed in 1992 (78%; Begich 1992) and higher than the range of historic composition (Van Hulle *Unpublished*). Historic percentages of initial

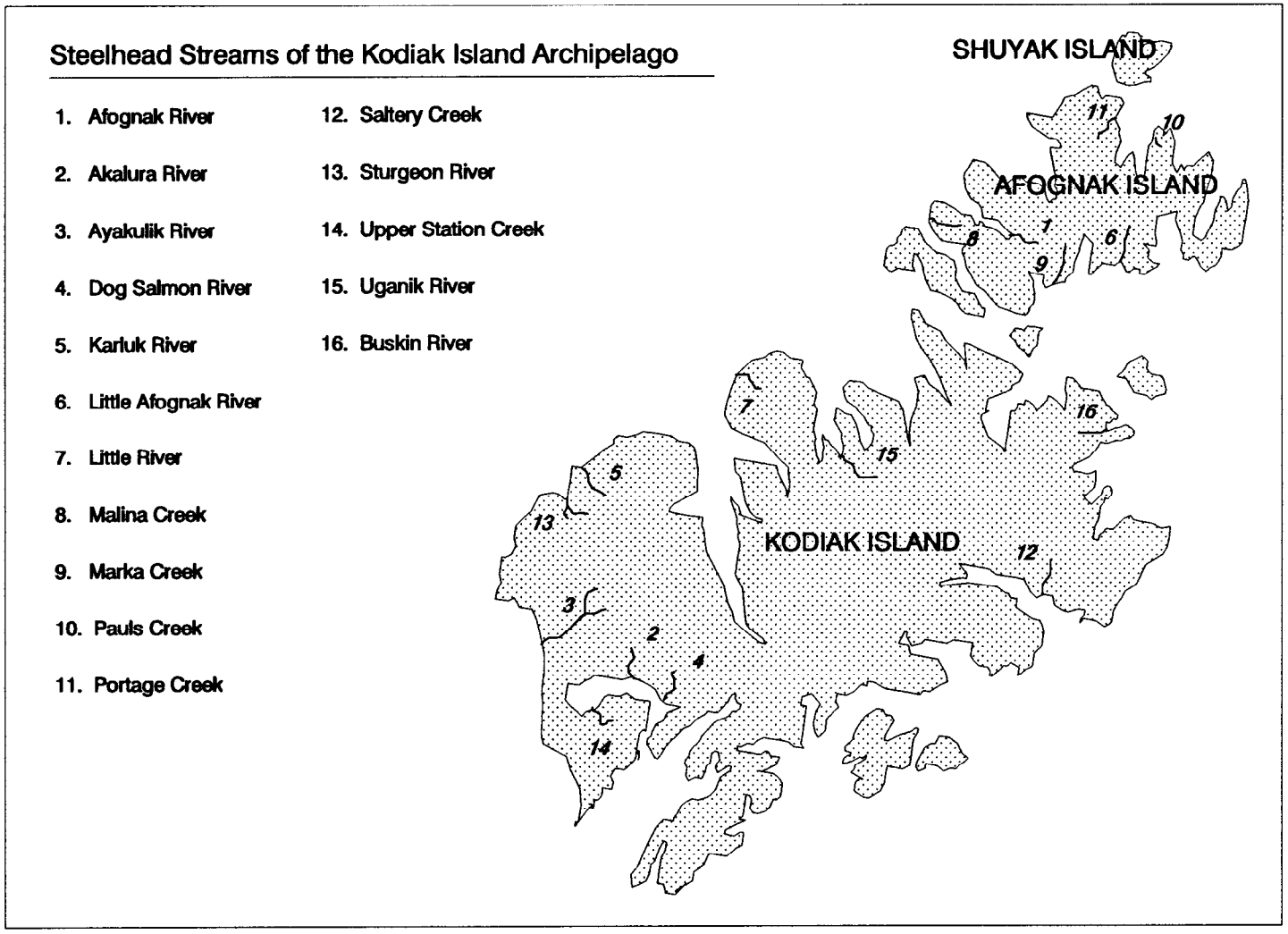

Figure 9. Steelhead systems of the Kodiak Island Archipelago.

spawners in the Karluk River have been: 1972, 62%; 1976, 75%; 1977, 58%; 1978, 77%; 1979, 79%; 1981, 86%. Additionally, the imbalance observed in the sex ratio of the emigrating population during 1992 (60% male:female 40%) and in 1993 (35% male:female 65%) is not similar to what was observed at the Ayakulik River (49% male:female 51%) during 1993 (Appendix B1 and B2). Future inriver tag returns from the Karluk should provide insight into the temporal fluctuations of the age and sex composition by spawning history.

During 1992, 2,720 kelts that emigrated through the Karluk River weir were tagged (Begich 1992). Most (96%) of the scale patterns of the repeat and multi-repeat spawners at this time were interpreted as consecutive spawning fish (return yearly to fresh water). Nine percent of the total 1992 emigrating population had scale patterns which were interpreted as consecutive spawners. During 1993, 85% of all emigrating repeat and multi-repeat spawners were aged as consecutive spawning fish, while 11% of the total 1993 emigrating population had scale patterns which were interpreted as being consecutive spawners. In addition, 236 steelhead (6%) of the 1993 emigrating population were recaptures from 1992 (consecutive spawners). These 236 recaptures represent 9% of the steelhead which emigrated through the weir in 1992. Given the above information: (1) large numbers of steelhead may be emigrating the Karluk prior to weir installation, (2) mortality in the lagoon and marine waters between spawning events may be significant, and (3) interpretation of the marine age of Karluk steelhead may be incorrect. Steelhead do emigrate the Karluk prior to weir installation, but the magnitude is unknown. Seasonal mortality of steelhead is associated with spawning and mortality between freshwater events or at the time of re-entry into the marine environment is unknown. Incorrect age determination can be caused by absorption of a year of saltwater growth during a freshwater (spawning) event. This would result in the misinterpretation of the number of years between spawning checks by one year. During the 1994 field season, every returning adult repeat spawner should be tagged regardless of whether the fish spawned in 1992 (skip spawner) or 1993 (consecutive spawner). These tag recoveries will allow for validation of repeat spawning life history. If not, seasonal sampling of inriver adults may be necessary to validate and define life history characteristics.

Overall spawning survival of Karluk steelhead was estimated at 67% in 1992 and 58% in 1993. Multiple years of determination of spawning mortality may assist in developing relationships between kelt and spawner abundance.

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APPENDIX A

Length-at-Age Data for Steelhead from the Karluk River Study Area, 1993

Appendix A1. Length-at-age of steelhead harvested in the set gillnet and purse seine fisheries near the Karluk River, August 15 through September 30, 1993.

Age Class	Females			Males			All		
	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
2.1	3	561	21	4	536	9	7	546	8
3.1	3	614	43	8	582	19	11	591	17
4.1	0			2	634	52	2	634	52
2.2	8	635	11	2	562	6	10	620	11
3.2	9	680	9	5	682	19	14	681	7
3.2s	3	690	6	0			3	690	6
3.3s	1	691		0			1	691	
3.2s2s	1	709		0			1	709	
3.3s2s	1	782		0			1	782	
R.1	4	592	23	12	542	10	16	554	11
R.2	8	662	15	4	559	14	12	628	16
R.1s	0			1	503		1	503	
Total	41	650	8	38	575	10	79	613	7

Appendix A2. Length-at-age of hook and line captures of the spawning population, April 1993.

Age Class	Females			Males			All		
	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
2.2	6	558	15	15	575	15	21	570	10
2.3	92	650	3	37	705	7	129	666	3
2.4				1	820		1	820	
3.2	3	534	21	1	522		4	531	13
3.3	15	677	12	2	688	4	17	679	11
3.4				3	854	15	3	854	15
4.2				1	546		1	546	
2.2s1	2	583	17	6	589	15	8	587	13
2.3s1	4	681	17				4	531	13
3.2s1				2	576	17	2	576	17
2.2s2				1	675		1	675	
2.3s2	6	752	9	1	790		7	771	12
3.3s1	1	638					1	638	
3.3s2	1	755					1	755	
3.2s2	1	708					1	708	
4.3s1				1	729		1	729	
2.2s1s1	1	760					1	760	
2.2s2s1	1	790					1	790	
3.2s1s1				1	705		1	705	
3.3s1s1	1	821					1	821	
R.2	3	568	21	15	569	11	18	569	9
R.3	56	663	6	24	708	10	80	677	6
R.4				1	810		1	810	
R.2s1	1	615		5	602	13	6	605	11
R.2s2s				5	692	12	5	692	12
R.3s2	1	740					1	740	
Total	195	656	4	122	663	6	317	659	4

Appendix A3. Length-at-age of emigrating steelhead captured at the Karluk River weir, 1993.

Age Class	Females			Males			All		
	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
2.2s	14	578	16	59	545	4	73	551	5
3.2s	8	547	21	11	559	6	19	554	9
2.3s	271	636	2	68	675	5	339	644	1
3.3s	44	645	4	11	710	7	55	658	5
2.4s	1	740		3	776	9	4	767	11
3.4s	1	683		1	791		2	737	76
2.2s1s	4	673	19	18	579	9	22	595	11
3.2s1s	1	645					1	645	
2.3s1s	12	712	9	3	649	43	15	699	12
3.3s1s	5	750	11				5	750	11
2.4s1s	1	728					1	728	
2.2s2s				1	693		1	693	
3.2s2s				1	710		1	710	
2.3s2s	6	740	15				6	740	15
3.3s2s	1	665					1	665	
3.3s1s1s	1	760					1	760	
R.2s	13	557	11	36	540	5	49	544	5
R.3s	143	642	3	34	664	7	177	646	3
R.4s				1	831		1	831	
R.2s1s	6	638	25	21	575	13	27	589	11
R.3s1s	11	706	5	2	742	23	13	711	9
R.3s2s	2	712	42				2	712	42
R.2s1s1s	3	779	18				3	779	18
R.2s2s	1	634		3	685	25	4	672	13
Total	549	642	1	273	615	5	822	634	2

APPENDIX B

Length-at-Age Data for Steelhead from the Ayakulik River, 1993

Appendix B1. Length-at-age of emigrating steelhead captured at the Ayakulik River weir, May 25 through July 15, 1993.

Age Class	Females			Males			All		
	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
2.2s	1	585		6	541	9	7	546	2
3.2s	1	567		2	545	15	3	553	11
2.3s	25	656	7	22	674	13	47	664	7
3.3s	10	683	22	3	692	20	13	685	5
2.4s	1	700					1	700	
2.2s1s	1	547		7	599	7	8	592	17
2.3s1s	8	745	15	2	733	47	10	743	6
2.2s2s	1	700					1	700	
3.2s2s	1	740					1	740	
2.2s1s1s				1	759		1	759	
2.3s1s1s	2	773	4				2	773	4
R.2s	1	594		5	525	16	6	536	4
R.3s	10	658	6	10	663	29	20	660	3
R.2s1s				5	610	18	5	610	18
R.3s1s	4	724	5	1	750		5	729	4
R.2s2s				1	710		1	710	
R.3s2s2s	1	761					1	761	
Total	66	687	3	65	637	10	131	663	6

Appendix B2. Length-at-age by spawning history and sex of emigrating steelhead, Ayakulik River, 1993.

Spawning History	Marine Age	Females			Males			All		
		Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
Initial[a]	2	3	582	6	13	536	7	16	544	8
	3	45	662	5	35	673	11	80	667	6
	4	1	700		0			1	700	
Repeat[b]	3	1	547		12	604	13	13	599	13
	4	13	735	4	4	732	22	17	734	9
Multi-Repeat[c]	4	0			1	759		1	759	
	5	2	773	4	0			2	773	4
	7	1	761		0			1	761	
Initial		49	658	5	48	635	13	97	647	7
Repeat		14	726	4	16	636	17	30	676	14
Multi-Repeat		3	769	5	1	759		4	776	1
Total		66	687	8	65	637	10	131	663	6

[a] Adults spawning for the first time spring of 1993.

[b] Adults spawning for the second time spring of 1993.

[c] Adults spawning for three or more times during spring of 1993.