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Karluk River Steelhead Assessment

by

Robert N. Begich

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Alaska Department of Fish and Game

Division of Sport Fish

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KARLUK RIVER STEELHEAD ASSESSMENT[1]

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Beginning August 15, 1991, commercial purse seine and set gillnet catches from selected waters along the southwest side of Kodiak Island were sampled for the incidental harvest of steelhead trout *Oncorhynchus mykiss*. One hundred and ninety three steelhead were observed in a sample of 183,706 purse seine harvested Pacific salmon *Oncorhynchus*. Purse seine vessels harvested an estimated 605 steelhead. Thirty steelhead were harvested and 37 released in a sample of 167,067 set gillnet harvested salmon. Set gillnetters harvested an estimated 100 and released an estimated 114 steelhead from the waters included in the Karluk study area between August 15 and September 30, 1991.

Sport and subsistence fisheries harvested an estimated 128 and 407 steelhead, respectively, from the 1991 return year (fall run).

The estimated abundance of steelhead in a 17.7 kilometers section of the Karluk River prior to spawning in the spring of 1992 was 2,356 fish (SE = 455). A second estimate of abundance for the entire Karluk River drainage was obtained using a weir located approximately 0.4 kilometers above the tidal influence of Karluk Lagoon. The estimated abundance of spawning steelhead in the entire Karluk drainage was 4,107 (SE = 134). Most of the spawning population was composed of initial spawners (78%), followed by repeat (18%) and multi-repeat (4%) spawners. Mean length for female initial and multi-repeat spawners was larger (616 millimeters fork length and 741 millimeters fork length, respectively), than for males (553 millimeters fork length and 695 millimeters fork length, respectively). Repeat spawners of both sexes were equal in size (655 millimeters fork length).

Spawning survival of steelhead was estimated at 67%. Spawning survival was similar between sexes (females 63% and males 62%). Survival of male initial (65%) and repeat (56%) spawners was also similar. Only one male multi-repeat spawner was sampled. Survival of females was different among spawning histories (initial 65%, repeat 62%, and multi-repeat 22%).

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, located on the southwest side of Kodiak Island, contains one of the largest known steelhead *Oncorhynchus mykiss* populations 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 immigration during late August and are believed to continue immigration through November (fall run). 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, adults are harvested in subsistence fisheries conducted by residents of Karluk Village during June through September and Larsen Bay during October through April. The fall 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. Kelts may also be vulnerable to commercial fisheries during June.

Postspawn steelhead (kelts) counts obtained at the Alaska Department of Fish and Game (ADF&G) Division of Commercial Fisheries weir located at Karluk Lagoon since 1976 have ranged from 210 to 4,203 (Figure 2). The average annual kelt count was 2,385 from 1981 through 1985, and 566 per year from 1986 through 1990. During 1991, 1,475 steelhead kelts emigrated through the weir at Karluk Lagoon. This apparent decline of the Karluk River steelhead population has created concern about overexploitation.

In 1991, a study was initiated to assess the stock status of adult steelhead returning to and overwintering in the Karluk River. The study objectives were to:

Fishing Mortality:

1. Estimate the number of steelhead harvested in the commercial purse seine fishery from August 15 to September 30, 1991 in selected commercial fishing district sections.

2. Estimate the number of steelhead harvested in the commercial set gillnet fishery from August 15 to September 30, 1991 in selected commercial fishing district sections.

3. Estimate the number of steelhead harvested in the Karluk Village subsistence fishery and the Larsen Bay subsistence fishery.

4. Estimate the number of steelhead harvested in the Karluk River sport fishery during 1991.

Spawning Population:

5. Estimate the number of spawning steelhead in the Karluk River during the spring of 1992.

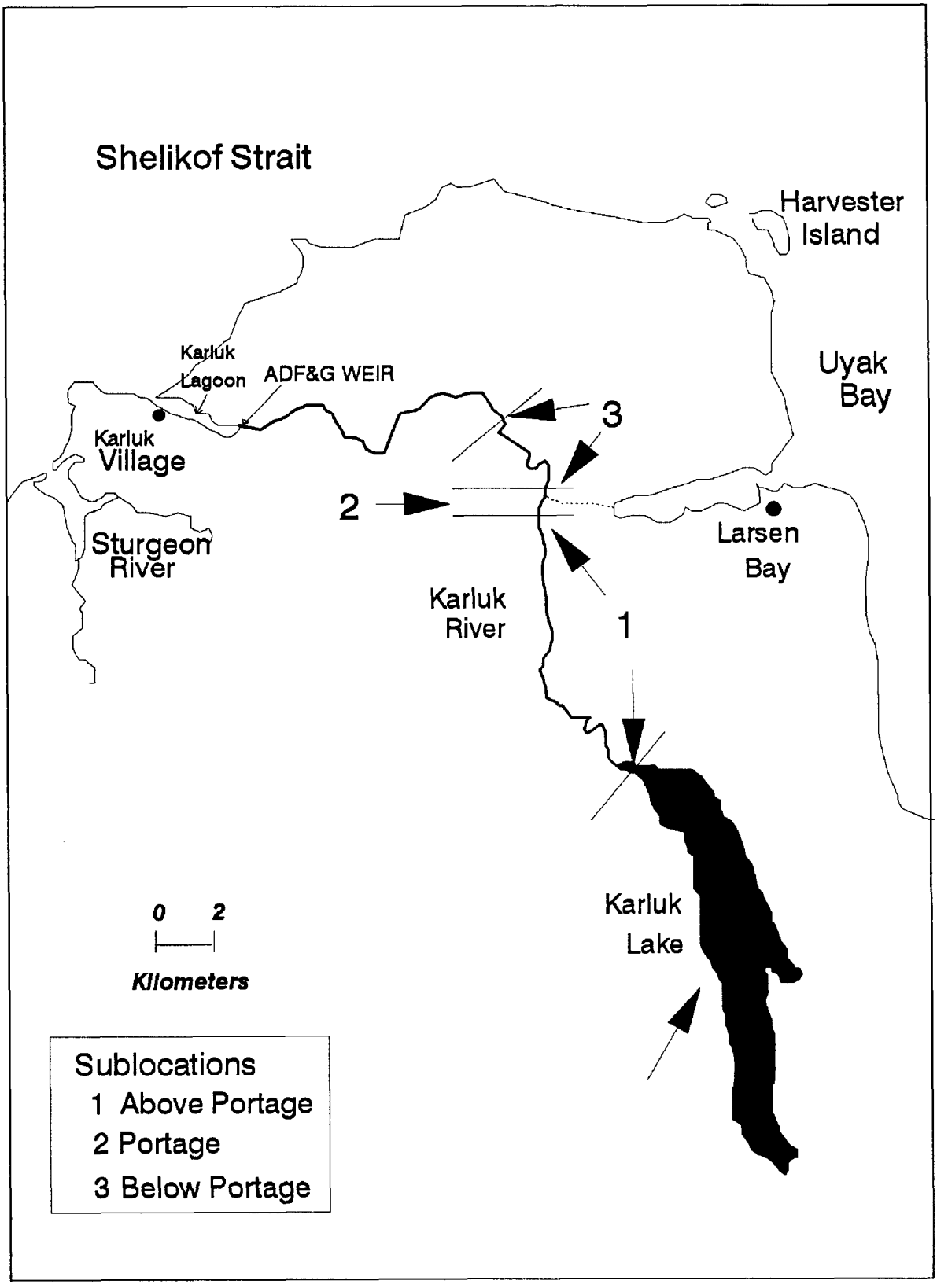

Figure 1. Map of the Karluk River freshwater study area, sampling sublocations, Portage, Larsen Bay, weir and Karluk Village.

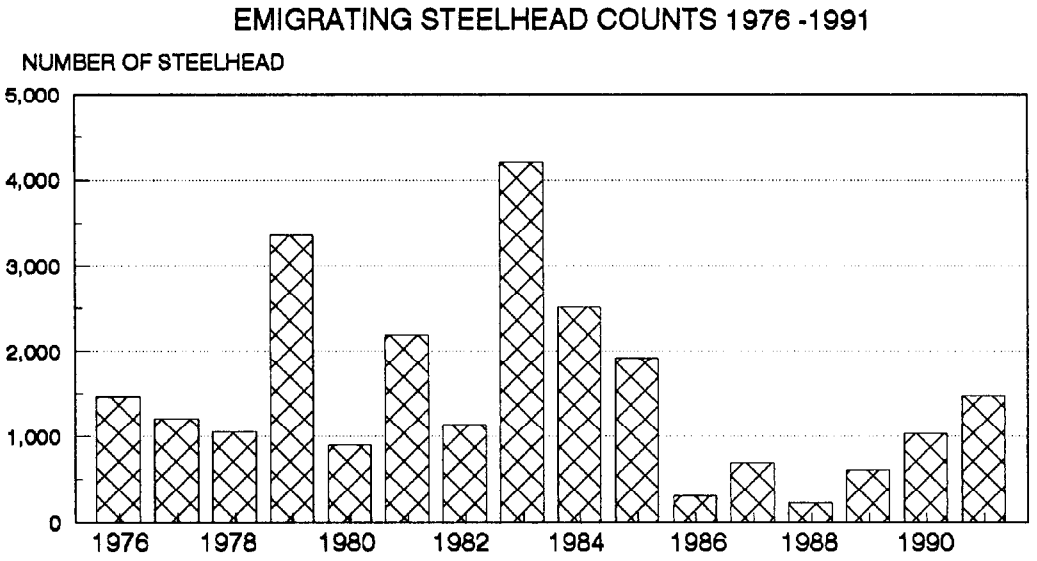

Figure 2. Historic emigrating steelhead counts obtained at the Division of Commercial Fisheries weir, Karluk River, 1976 through 1991.

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

7. Enumerate emigrating kelts through the Karluk River weir during spring, 1992.

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

ESTIMATION OF STEELHEAD BYCATCH IN SELECTED COMMERCIAL FISHERIES

Methods

During 1991, commercial catch sampling effort was concentrated in marine waters of eight statistical areas occurring between the geographic locations of West Point and Sturgeon Head (Figure 3). Selection of these waters for inclusion into the Karluk River study area was based upon their proximity to the mouth of the Karluk River. All eight statistical areas were open to commercial purse seine fishing. Three of these eight sections were 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, Kodiak.

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

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 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. This program was intended to provide a complete census of steelhead harvest and release.

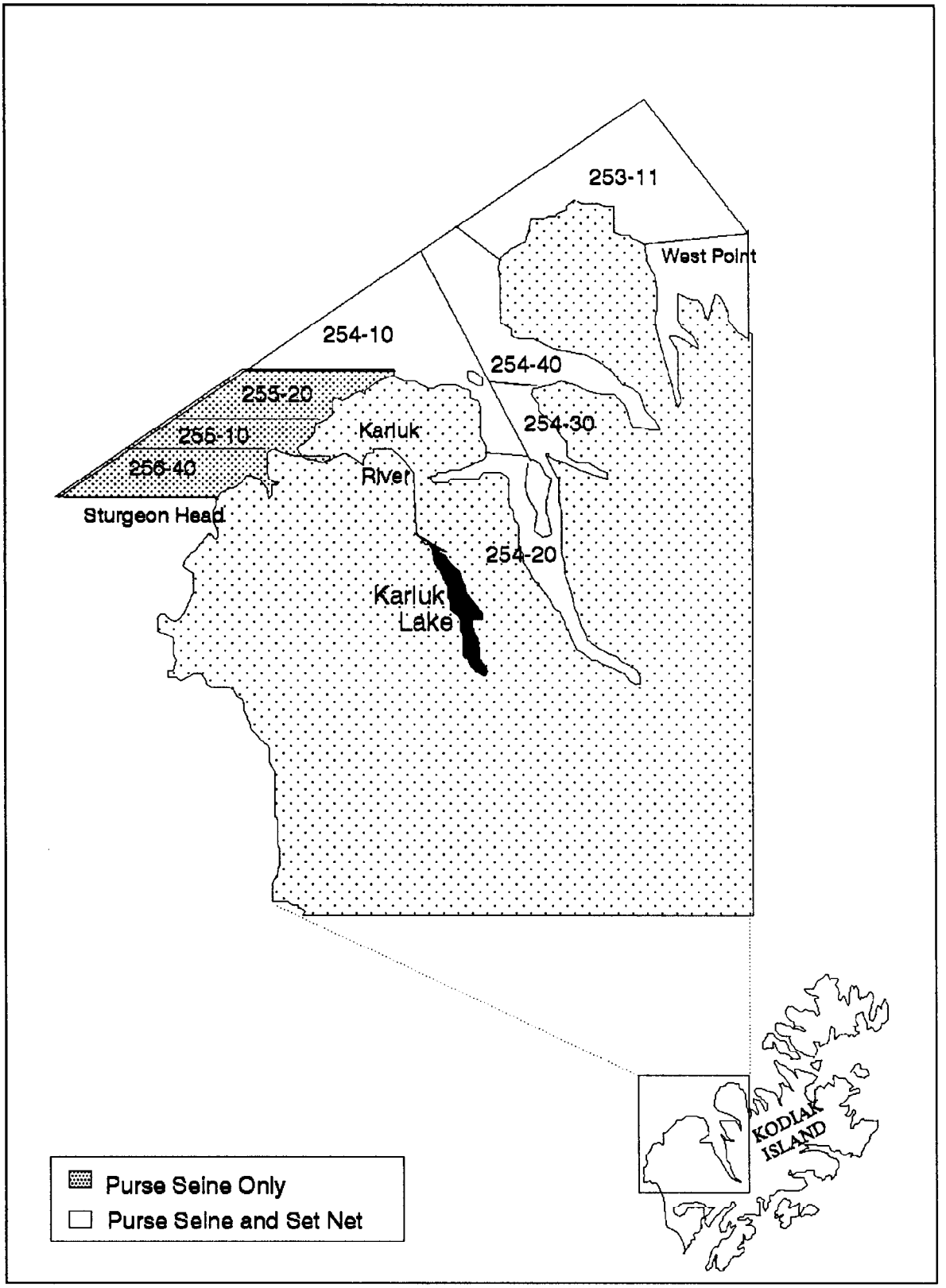

Figure 3. Map of marine study area and Karluk River, 1991.

Since nonreporting occurred, 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} = sale 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 sale of salmon in set gillnets in study area.

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

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

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 to estimate the total.

Purse Seine Fishery:

Purse seine fishery catches were sampled both on board commercial tenders and at cannery delivery docks. 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. Sampling was conducted on an opportunistic basis and as many catches were sampled as possible during each sampling period.

The fish ticket from the sampled deliveries provided the weight and number of salmon sold so that the ratio of steelhead to salmon could be computed as explained above.

Steelhead observed in purse seine 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 after its second year at sea, (3) returned to the sea, and (4) returned to spawn again the following spring. 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 at least 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

A total of 21 catch calendars were returned from the 58 set gillnet permit holders operating within the Karluk study area (Tables 1 and 2). From August 15 to September 30, sampled permit holders retained 30 and released 37 steelhead. During the same period, these same permit holders harvested 159,908 of the 477,340 salmon harvested by set gillnet gear from the Karluk study area (33.5%). The estimated bycatch of steelhead in set gillnet gear was 100 steelhead. An additional 114 fish were released.

From August 15 to September 30, 1,172,057 salmon were harvested by purse seine gear within the Karluk study area (Table 3). A total of 193 steelhead were observed in a sample of 183,706 salmon. The estimated bycatch of purse seine caught steelhead was 605 (Table 3).

Temporal trends in the steelhead bycatch were evident for both the set gillnet and purse seine fisheries (Tables 1-3). In the set gillnet fishery, the estimated ratio of steelhead-to-salmon was lowest during the first stratum (8/15-8/31) and then increased during the remaining strata. Since most of the salmon harvest occurred during the first stratum (78%), and the ratios of steelhead-to-salmon between strata were of the same order of magnitude, the

Table 1. Estimated harvest of steelhead retained for personal use in commercial set gillnets near the Karluk River, August 15 through September 30, 1991.

Stratum	Total Salmon Harvested[a]	Sample Size[b]	Steelhead Retained[c]	Ratio of Steelhead to Salmon	Estimated Steelhead Retained	SE	Relative Precision[d]
8/15-8/31	370,152	135,232	15	0.000111	41	16.0	76%
9/01-9/07	47,519	16,233	11	0.000677	32	10.6	65%
9/08-9/14	32,743	6,137	3	0.000488	16	4.8	59%
9/15-9/21	26,538	2,306	1	0.000433	11	0.7	13%
9/22-9/30	388	0					
Total	477,340	159,908	30		100	19.8	31%

[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 release of steelhead from commercial set gillnets near the Karluk River, August 15 through September 30, 1991.

Stratum	Total Salmon Harvested[a]	Sample Size[b]	Steelhead Released[c]	Ratio of Steelhead to Salmon	Estimated Steelhead Released	SE	Relative Precision[d]
8/15-8/31	370,152	135,232	26	0.000192	71	31.5	87%
9/01-9/07	47,519	16,233	6	0.000369	17	7.0	81%
9/08-9/14	32,743	6,137	5	0.000815	26	10.3	78%
9/15-9/21	26,538	2,306	0		0		
9/22-9/30	388	0					
Total	477,340	159,908	37		114	33.3	57%

[a] From fish tickets.

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

[c] From calendars.

[d] Relative precision of 95% confidence interval.

Table 3. Estimated harvest of steelhead from purse seines near the Karluk River, August 15 through September 30, 1991.

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	886,064	84,794	5	0.000058	51	24.1	92%
9/01-9/07	52,824	28,603	23	0.000804	42	4.1	19%
9/08-9/14	155,715	30,719	61	0.001985	309	81.8	51%
9/15-9/21	55,755	27,417	74	0.002699	150	39.4	51%
9/22-9/30	21,699	12,176	30	0.002464	53	18.7	69%
Total	1,172,057	183,706	193		605	95.9	31%

[a] From fish tickets.

[b] Number examined.

[c] Relative precision of 95% confidence interval.

estimates of steelhead retained or released were highest during the first stratum and declined thereafter. Similar trends in salmon harvest and the ratio of steelhead-to-salmon were evident for the purse seine fishery (Table 3). However, the ratios of steelhead-to-salmon for the first stratum were lower from the remaining strata by an order of magnitude. This resulted in the largest steelhead bycatch during the third and fourth strata (9/8-9/21).

Trends in steelhead harvest by area were also evident (Table 4). No calendars were returned from statistical area 254-30; however, this section only accounted for 3% of the total set gillnet harvest. Set gillnet steelhead harvest by area was highest in 254-10 where the largest proportion of the salmon harvest occurred (Table 4). Permit holders released more steelhead in statistical area 254-40 (Table 5). Purse seine steelhead harvest was greatest in section 255-10 near the Karluk River and in sections with large seaward boundaries (Table 6 and Figure 3).

Age and length data (Table 7) were obtained from 78 steelhead observed in purse seine catches of which 59% were males (Table 8). Both sexes were dominated by fish that had not spawned in previous years, females 62% and males 87% (Table 7). Repeat and multi-repeat spawners were observed in both sexes, females 31% and 6%; males 11% and 2%, respectively. The mean length across ages for females was 648 mm FL and for males was 577 mm FL (Table 7).

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 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 (Chatto 1987). Three Koniag Native Corporation cabins provide facilities for Larsen Bay residents at the Portage to fish with rod and reel 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.

Table 4. Set gillnet harvest of steelhead by statistical area and sampling strata, August 15 through September 30, 1991.

Statistical Area	Number of Steelhead by Stratum[d]						Proportion Sampled[b]	Proportion of Total Salmon Harvest[c]	Estimated Steelhead Harvest
	1	2	3	4	5	Total			
253-11	0	0	0	0	0	0	0.000	0.220	0
254-10	7	5	2	1	0	15	0.500	0.400	50
254-20	3	6	0	0	0	9	0.300	0.200	30
254-30[a]								0.030	
254-40	5	0	1	0	0	6	0.200	0.150	20
Total	15	11	3	1	0	30	1.000	1.000	100

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

[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] 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

Table 5. Set gillnet release of steelhead by statistical area and sampling strata, August 15 through September 30, 1991.

Statistical Area	Number of Steelhead by Stratum[d]						Proportion Sampled[b]	Proportion of Total Salmon Harvest[c]	Estimated Steelhead Release
	1	2	3	4	5	Total			
253-11	6	3	0	0	0	9	0.243	0.220	28
254-10	5	3	5	0	0	13	0.352	0.400	40
254-20	0	0	0	0	0	0	0.000	0.200	0
254-30[a]								0.030	0
254-40	15	0	0	0	0	15	0.405	0.150	46
Total	26	6	5	0	0	37	1.000	1.000	114

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

[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] 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

Table 6. Purse seine harvest of steelhead by statistical area and sampling strata, August 15 through September 30, 1991.

Statistical Area	Number of Steelhead by Stratum[d]						Proportion Sampled[b]	Proportion of Total Salmon Harvest[c]	Estimated Steelhead Harvest
	1	2	3	4	5	Total			
253-11	0	0	19	0	0	19	0.098	0.203	59
254-10	4	6	0	2	0	12	0.062	0.372	38
254-20	1	5	0	0	0	6	0.032	0.157	19
254-30	0	1	0	0	0	1	0.005	0.011	3
254-40	0	0	0	0	0	0	0.000	0.108	0
255-10	0	0	0	72	18	90	0.466	0.102	282
255-20	0	0	0	0	0	0	0.000	0.042	0
256-40	0	0	0	0	0	0	0.000	0.005	0
Unknown[a]	0	11	42	0	12	65	0.337		204
Total	5	23	61	74	30	193	1.000	1.000	605

[a] Steelhead observed while sampling tender loads consisting of catches from multiple sections within study area.

[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] 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

Table 7. Length-at-age by spawning history and sex of steelhead harvested by purse seines near the Karluk River, August 15 through September 30, 1991.

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	11	577	11	38	550	4	49	556	69
	2	9	672	10	2	584	60	11	656	87
Repeat[b]	2	8	672	8	5	627	32	13	654	115
	3	2	775	33	0			2	775	34
Multi-Repeat[c]	3	1	625		1	740		2	683	57
	4	1	801		0			1	801	
Initial		20	620	13	40	552	3	60	575	7
Repeat		10	692	15	5	627	31	15	670	13
Multi-Repeat		2	713	90	1	740	0	3	722	52
Total		32	648	12	46	577	7	78	599	8

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

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

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

Table 8. Age composition by sex and spawning history of steelhead harvested by purse seines near the Karluk River, August 15 through September 30, 1991.

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	11	0.344	0.085	85	60	38	0.826	0.056	295	86
	2	9	0.281	0.081	70	55	2	0.043	0.030	15	18
Repeat[b]	2	8	0.250	0.078	62	52	5	0.109	0.046	39	29
	3	2	0.063	0.043	15	26	0	0.000		0	
Multi-Repeat[c]	3	1	0.031		8	18	0	0.000		0	
	4	1	0.031		8	18	1	0.021		8	13
Initial		20	0.625	0.087	148	79	40	0.870	0.050	321	88
Repeat		10	0.313	0.083	74	58	5	0.110	0.046	40	29
Multi-Repeat		2	0.062	0.043	14	26	1	0.020	0.022	8	13
Total		32	0.410	0.088	248	66	46	0.590	0.073	357	72

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

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

[c] Adults if returning to the Karluk would be spawning three or more times.

The mean number of steelhead harvested for subsistence 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 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):

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

where:

f = finite population correction factor = $^{n}/_{N}$.

Results

Household surveys were conducted by Division of Sport Fish personnel at Karluk Village on October 31, 1991. No steelhead were reported harvested by subsistence beach seine fishing in Karluk Lagoon during the autumn of 1991. Household interviews were again conducted by Division of Subsistence personnel at Karluk Village during April 1992. Residents of 13 households reported harvesting 36 steelhead from April 1, 1991 to March 1, 1992. Mean harvest per household was estimated at 2.76 and total harvest by Karluk Village residents at 47 steelhead (Table 9).

A total of 35 households at Larsen Bay reported harvesting 230 steelhead. Mean harvest-per-household was estimated at 6.57 and total harvest by Larsen Bay residents at 263 steelhead from April 1, 1991 through March 1, 1992 (Table 10).

Subsistence harvest of steelhead has been sporadically estimated since 1982 and village harvests have ranged from 17 to 367 fish (Tables 9 and 10). Harvests from Larsen Bay were generally greater than those of Karluk Village.

Table 9. Subsistence harvest of steelhead from Karluk Village, 1982-1983, 1986, 1989, and April 1, 1991 through March 1992[a].

Years	Total Reported Harvest[b]	Number Households in Sample	Mean Harvest-per-Household	Number Households in Community	Estimated Community Harvest[c]	SE
1982-83	233	20	11.65	26	303	13
1986	77	19	4.05	27	109	20
1989	14	14	1.00	17	17	35
1991[d]	36	13	2.76	17	47	

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

[b] From household interviews.

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

[d] Standard error not available.

Table 10. Subsistence harvest of steelhead from Larsen Bay, 1982-1983, 1986, 1989, and April 1, 1991 through March 1992[a].

Years	Total Reported Harvest[b]	Number Households in Sample	Mean Harvest-per-Household	Number Households in Community	Estimated Community Harvest[c]	SE
1982-83	273	32	8.53	43	367	16
1986	74	37	2.00	52	104	15
1989	86	34	2.50	39	98	27
1991[d]	230	35	6.57	40	263	13

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

[b] From household interviews.

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

[d] Standard error not available.

ESTIMATION OF STEELHEAD HARVEST IN THE KARLUK RIVER SPORT FISHERY

Methods

Estimates of sport harvest, catch, and effort were obtained from postal surveys as reported by Mills (1982-1992). 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. Mills (1982-1992) does not report variances.

Results

The estimated sport harvest of Karluk River steelhead during the 1991 season was 128 fish (Table 11). This was the largest harvest since 1988, but within the range of harvests reported during the years 1982-1985. Release in the 1990 and 1991 fisheries was high in comparison to harvest. Annual fishing effort has been variable with no clear trends since 1982.

ESTIMATION OF SPAWNING ABUNDANCE AND SURVIVAL

Methods

Steelhead overwinter in the upper Karluk River and tend to congregate in the Portage area of the River (Chatto 1987). 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 tidal influence (Figure 1). This situation allowed for two mark-recapture experiments to estimate the abundance of the spawning population in the Karluk River during the spring of 1992.

The first experiment was designed to estimate abundance in the Portage area during April and both the marking and recapture sampling events occurred in this area. A base camp was established at one of the three cabins located at the Portage area on the Karluk River. 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 left ventral fin was removed to serve as a secondary mark to assess tag loss. Fish were resampled to establish a tagged-to-untagged ratio. Sampling effort occurred in the first 17.7 km (11 mi) of the Karluk River and was divided into three sampling sublocations (Figure 1). No locations were fished on consecutive days and each location was fished at least twice.

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

Table 11. Sport harvest and release of steelhead and total fishing effort from the Karluk River sport fishery, 1982-1991[a].

Fishing Parameter	Year									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Effort[b]	1,552	2,142	534	1,223	[c]	[c]	990	1,313	2,191	1,646
Harvest	90	241	150	167	[c]	[c]	18	20	86	128
Release[d]									792	628

[a] Source: Postal surveys as reported by Mills (1982-1992).

[b] Angler-days.

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

[d] First estimated in 1990.

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

where:

M = tags released in first event,

R = tags recaptured in second event,

C = fish examined for tags in second event,

and the variance by:

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

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.

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

We assumed that there was no significant recruitment 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 and spawning history between the first sampling event (mark event) and the second sampling event (recapture event). In cases where more than 25% of the cells had expected values less than five, the likelihood ratio (G^2) chi-square (Agresti 1990) was used. Two-sample Kolmogorov-Smirnov tests (Daniel 1978) were used to compare 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. These tests may indicate possible differences in capture rate due to length (assumption 3). All tests were conducted at $\alpha = 0.05$. The secondary mark (left ventral fin clip) provided the means to estimate tag loss (assumption 2).

The second experiment was designed to estimate abundance of the spawning population for the entire drainage. Steelhead likely overwintered and spawned in areas other than the Portage area, including Karluk Lake and the lower

river. The first sampling event (mark event) for this experiment was the entire 12-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, this second experiment should provide an estimate of the spawning population in the entire Karluk drainage. From June 1 through August 4, 1992, 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 with a Floy FD-67 internal anchor tag as previously described. We attempted to scale sample 140 fish per week for aging as previously described.

Two-sample Kolmogorov-Smirnov tests were used to determine if capture rates differed due to size. This included comparing the cumulative length distributions of all fish captured in the first event with all fish captured in the second event. Contingency tables and chi-squared tests (Conover 1980) were used to test capture rate (marked:unmarked ratio) at the weir due to spawning history and sex. 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).

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:

$$\hat{p}_i = \frac{n_i}{n_t} \tag{9}$$

where:

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

n_t = the total number of steelhead in the sample, and

variance of the proportion by age was estimated as:

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

Abundance by age was estimated as:

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

with the variance (Goodman 1960):

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

Spawning Survival:

The survival of tagged fish (S_c) from experiment one (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 in experiment one in class c.

Results

Abundance:

Experiment 1. Steelhead were both marked and recaptured at the Portage area during April 16 through April 28, 1992 (Table 12). The entire sampling period was roughly divided in half to delineate marking and recapture events. A total of 221 steelhead were marked during the first event (April 16 through April 21). During the second event (April 22 through April 28), a total of 222 fish were examined of which 20 were recaptures from the first event. No tags were lost between sampling events. Probability of capture among the three sublocations was not significantly different ($\chi^2 = 2.02$, df = 2, P = 0.36). There was also no significant difference in probability of capture due to sex ($\chi^2 = 2.53$, df = 1, P = 0.11) or spawning history ($\chi^2 = 5.21$, df = 2, P = 0.07). Kolmogorov-Smirnov two-sample tests of the length distributions of all steelhead captured during the marking event versus steelhead recaptured during the second event did not detect a significant difference (D = 0.192, P = 0.5, $n_1 = 221$, $n_2 = 20$). A similar test of all fish captured in the mark event and fish captured in the recapture event also failed to detect a significant difference in the length distributions (D = .10, P = .21, $n_1 = 221$, $n_2 = 222$).

Therefore, all of the data were combined and an unstratified estimate of abundance of spawning steelhead was calculated for this section of the Karluk River. In the 16 km section of the Karluk River from the outlet of Karluk Lake to a point approximately 4.8 km below the portage, the estimated abundance of adult steelhead was 2,356 (SE = 455 fish) (Table 13).

Experiment 2. Steelhead marked and released during the first experiment (April hook and line) were used as the marking event and fish sampled at the weir as the recapture event (Table 14). A total of 2,744 fish were examined for marks at the weir, of which 277 were marked. Three percent (n = 9) of the marked steelhead had lost their tags. Temporal trends in the emigration of

Table 12. Summary of steelhead tagging data by event and sublocation, Portage area of the Karluk River, April 16 through April 28, 1992.

Marking Event 04/16-04/21		Recapture Event 04/22-04/28					
Tag Releases by Sublocation[a]	Number Released	Tag Recoveries by Sublocation[a] 1	2	3	Total	Number Not Recovered	Percent Recovered
1	148	9	2	2	13	136	8.8
2	24	0	3	1	4	20	16.6
3	49	0	2	1	3	46	6.1
Number Tagged	221	9	7	4	20	201	
Number Untagged		60	86	56	202		
Number Examined		69	93	60	222		
Percent Tagged		13	7.5	6.7	9.0		

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

Table 13. Summary of population estimates for spawning steelhead in the Karluk River, 1992.

	Marking Event			Recovery Event				Abundance	
Experiment[a]	Date	Location	Tags Released	Date	Location	Number Examined	Total Recaptured	Estimate	SE
1	04/16-04/21	Portage	221	04/22-04/28	Portage	222	20	2,356	455
2	04/16-04/28	Portage	415	06/01-08/04	Weir	2,744	277	4,107	134

[a] 1 = Abundance in Portage area (17.7 km).
2 = Abundance in Karluk River drainage.

Table 14. Summary of tagging data for steelhead released at the Portage and recovered at the Karluk weir, Karluk River, 1992.

Marking Event at Portage 04/16-04/28		Recapture Event at Weir 06/01-08/04		
Tag Releases by Sublocation[a]	Number Released	Recovered	Not Recovered	Percent Recovered
1	207	127	80	61.4
2	108	77	31	71.3
3	100	58	42	58.0
Number Tagged	415	262[b]	153	
Number Untagged		2,466		
Number Examined		2,744		
Percent Tagged		9.5		

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

[b] Does not include 9 fish which lost their tags and 6 fish whose tag numbers were read incorrectly.

marked and unmarked steelhead through the weir were similar (Figure 4). There was no significant difference in the marked:unmarked ratio at the weir due to spawning history ($\chi^2 = 5.07$, df = 2, P = 0.08). However, there was a significant difference in the marked:unmarked ratio at the weir among sexes ($\chi^2 = 49.46$, df = 1, P < 0.001). There was a significant ($G^2 = 103.23$, df = 7, P < 0.001) change among weeks of the sex ratio of steelhead emigrating through the weir (Figure 5). This was largely due to an increase in the number of initial spawning males ($G^2 = 44.80$, df = 7, P < 0.001) relative to females (Table 15). There was no change over time in the sex ratio of repeat ($G^2 = 2.03$, df = 6, P = 0.92) or multi-repeat ($G^2 = 4.98$, df = 2, P = 0.29) spawners. This testing indicates that there were steelhead, predominantly males, in other areas of the drainage that were not sampled in April. No significant difference was detected between the length distributions of all fish marked on the spawning grounds and all recaptures at the weir (D = 0.05, P = 0.763, $n_1 = 415$, $n_2 = 277$). However, a similar test between all fish captured during April and all fish captured at the weir detected a significant difference in the length distributions (D = 0.21, P < 0.001, $n_1 = 415$, $n_2 = 2,681$[1]). The estimated abundance of steelhead in the Karluk River during the spring of 1992 was 4,107 (SE = 134 fish) (Table 13).

Biological Composition of the 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 or 3 years (78%) and a mean length of 605 mm FL (Tables 16 and 17). Repeat spawners of both sexes were dominated by 3-ocean fish (98% of females and 69% males). The multi-repeat spawners were dominated by females (82%) with total marine age up to 6 years. Twenty-two percent of the prespawning concentration at the Portage area was composed of repeat (18%) and multi-repeat (4%) spawners with mean lengths of 659 mm FL and 750 mm FL, respectively. Both sexes were dominated by initial spawners (73% females and 87% males). Female initial and multi-repeat spawners were larger (mean length 632 mm and 764 mm FL) than males (573 mm and 687 mm FL) (Table 16).

Unlike the prespawning population, the sex composition of emigrating steelhead was dominated by males (61%). Among males, 89% were first time spawners (mean length of 553 mm FL), while 10% were spawning for the second time (mean length 655 mm FL) (Tables 18 and 19). Eighty-one percent of the females were initial spawners and 16% were repeat spawners. Multi-repeat spawners was the weakest component of the spawning population but the largest in size for both sexes.

Spawning Survival

Survival by sex and age class was estimated from prespawn capture in April to postspawn weir emigration. Tag recovery rate of steelhead marked on the spawning grounds and recovered at the weir was not significantly different between sexes ($\chi^2 = 0.001$, df = 1, P = 0.98). Overall survival was 62% for females and 63% for males (Table 20). Among females, tag recovery rates differed significantly ($\chi^2 = 6.66$, df = 2, P = 0.04) by spawning history (initial 65%, repeat 62%, and multi-repeat 22%). There was no significant

[1] Only 2,681 fish were measured of the 2,744 fish examined at the weir.

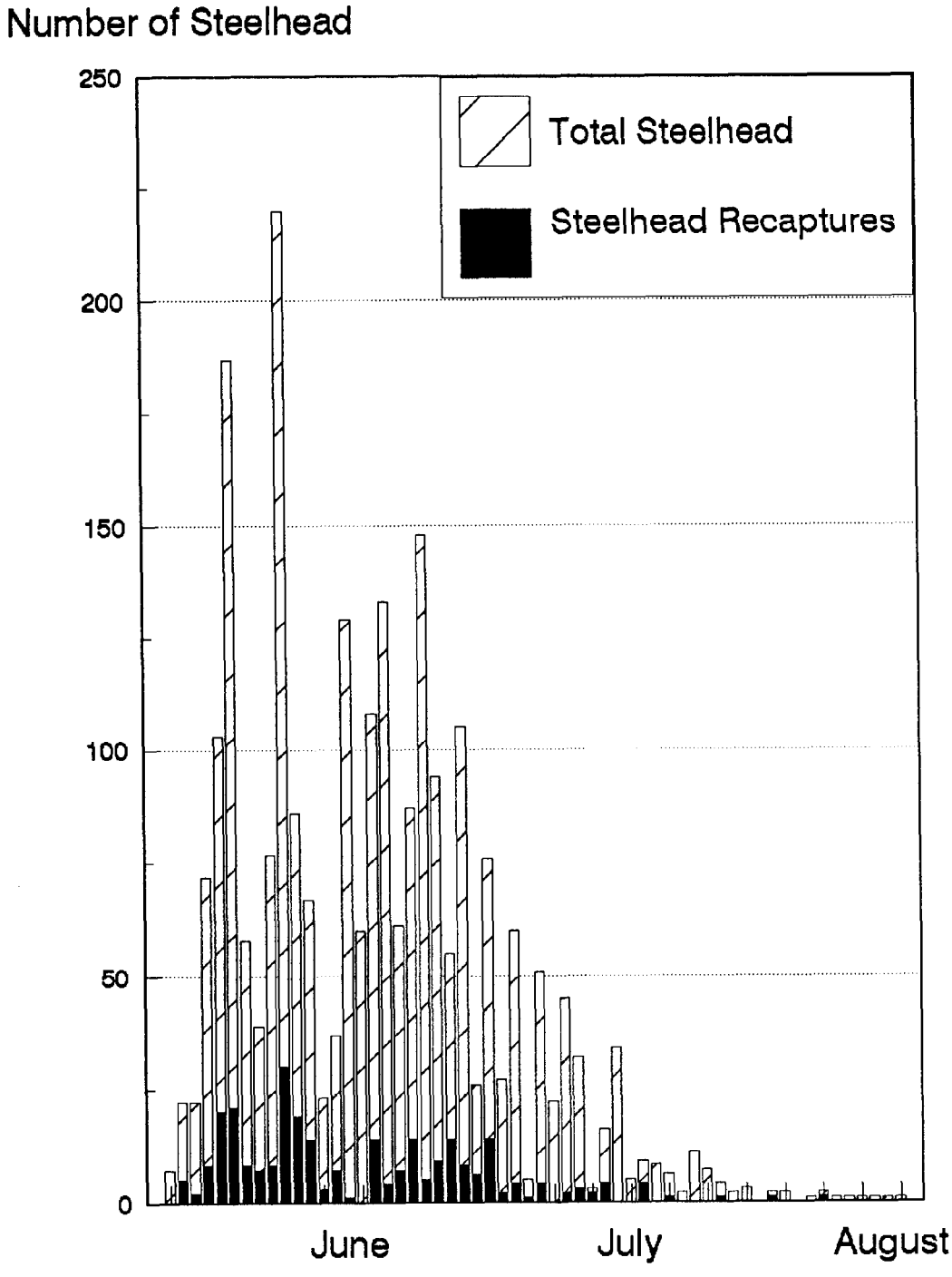

Figure 4. Daily comparison of marked and unmarked steelhead emigrating through the Karluk River weir, June 1 through August 4, 1992.

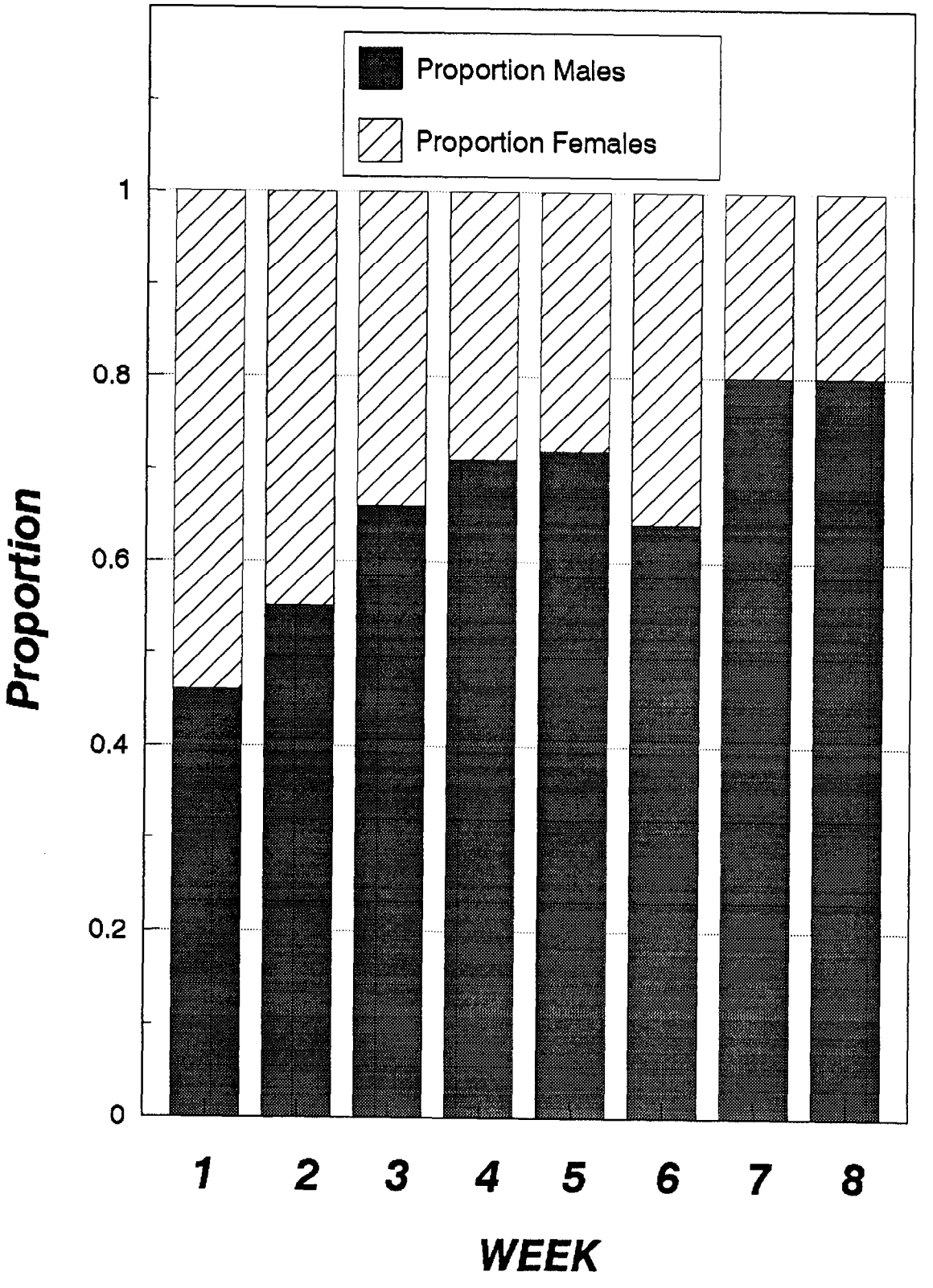

Figure 5. Weekly comparison by sex of steelhead emigrating through the Karluk River weir, June 1 through August 4, 1992.

Table 15. Sex composition by week of emigrating steelhead from the Karluk River, 1992.

Spawning History	Sex	Weekly Totals June 1 through August 4								Total
		1	2	3	4	5	6	7	8	
Initial[a]	F	63	75	44	44	29	15	4	1	275
	M	49	82	87	101	89	42	19	5	474
Total		112	157	131	145	118	57	23	6	749
Repeat[b]	F	15	15	10	9	7	4	1	0	61
	M	10	16	11	8	4	3	2	0	54
Total		25	31	21	17	11	7	3	0	115
Multi-Repeat[c]	F	6	1	0	0	0	1	0	1	9
	M	1	1	0	1	0	0	0	0	3
Total		7	2	0	1	0	1	0	1	12
Total by Sex	F	84	91	54	53	36	20	5	2	345
	M	60	99	98	110	93	45	21	5	531
Total		144	190	152	163	129	65	26	7	876

[a] Adults spawning for the first time spring of 1992.

[b] Adults spawning for the second time spring of 1992.

[c] Adults spawning for the third or more times spring of 1992.

Table 16. Length-at-age by spawning history and sex of hook and line captures of spawning steelhead, Karluk River, April 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]	2	26	583	13	94	538	3	120	548	4
	3	128	641	3	28	670	12	156	647	3
	4	0			2	829	1	2	829	1
Repeat[b]	3	48	647	6	11	668	17	59	652	6
	4	0			5	730	21	5	730	21
	5	1	770		0			1	770	
Multi-Repeat[c]	4	4	768	34	1	624		5	740	39
	5	4	758	19	1	750		5	757	15
	6	1	770		0			1	770	
Initial		154	632	4	124	573	7	278	605	4
Repeat		49	650	6	16	687	15	65	659	6
Multi-Repeat		9	764	16	2	687	63	11	750	18
Total		212	642	4	142	587	7	354	620	4

[a] Adults spawning for the first time spring of 1992.

[b] Adults spawning for the second time spring of 1992.

[c] Adults spawning for the third or more times spring of 1992.

Table 17. Age composition by sex of spawning steelhead in the Karluk River, April 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]	2	27	0.127	0.023	179	78	94	0.662	0.040	624	315
	3	128	0.601	0.034	849	284	28	0.197	0.033	186	118
	4	0	0.000		0		2	0.014	0.009	13	23
Repeat[b]	3	48	0.225	0.029	318	122	11	0.077	0.022	73	62
	4	0	0.000		0		5	0.035	0.015	33	39
	5	1	0.005	0.005	6	11	0	0.000		0	
Multi-Repeat[c]	4	4	0.019	0.009	27	23	1	0.007	0.007	7	16
	5	4	0.019	0.009	27	23	1	0.007	0.007	7	16
	6	1	0.005	0.014	6	11	0	0.000		0	
Initial		155	0.728	0.031	1,028	338	124	0.874	0.028	823	402
Repeat		49	0.230	0.029	324	124	16	0.112	0.027	106	80
Multi-Repeat		9	0.042	0.042	60	37	2	0.014	0.010	14	23
Total		213	0.600	0.600	1,413	278	142	0.400	0.029	943	194

[a] Adults spawning for the first time in spring of 1992.

[b] Adults spawning for the second time in spring of 1992.

[c] Adults spawning for three or more times spring of 1992.

Table 18. Length-at-age by spawning history and sex of emigrating steelhead, Karluk River, 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	1	480		1	493		2	487	7
	2	56	569	8	341	528	2	397	534	2
	3	145	634	3	72	669	5	217	646	3
	4	1	727		0			1	727	
Repeat[b]	2	1	502		3	511	15	4	509	11
	3	26	644	10	20	625	14	46	636	8
	4	9	670	11	23	698	8	32	690	7
	5	3	756	5	1	730		4	750	7
Multi-Repeat[c]	4	6	731	25	2	676	16	8	717	21
	5	1	801		1	735		2	768	33
Initial		203	616	4	414	553	3	617	574	3
Repeat		39	655	10	47	655	10	86	655	7
Multi-Repeat		7	741	23	3	695	22	10	727	18
Total		249	626	4	464	564	3	713	586	3

[a] Adults spawning for the first time spring of 1992.

[b] Adults spawning for the second time spring of 1992.

[c] Adults spawning for three or more times during spring of 1992.

Table 19. Age composition by spawning history and sex of emigrating steelhead in the Karluk River, June 1 through August 4, 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	1	0.004	0.004	6	16	1	0.002	0.002	5	8
	2	56	0.223	0.026	358	112	341	0.732	0.021	1,833	130
	3	145	0.578	0.031	926	150	73	0.157	0.017	393	72
	4	1	0.004	0.004	6	16	0	0.000		0	
Repeat[b]	2	1	0.004	0.004	6	16	3	0.006	0.004	16	15
	3	27	0.108	0.019	172	82	21	0.045	0.009	113	40
	4	10	0.040	0.012	64	51	23	0.049	0.010	124	41
	5	3	0.012	0.007	19	28	1	0.002	0.002	5	8
Multi-Repeat[c]	4	6	0.024	0.009	39	39	2	0.004	0.003	11	12
	5	1	0.004	0.004	6	16	1	0.002	0.002	5	8
Initial		203	0.809	0.025	1,296	149	415	0.891	0.014	2,231	134
Repeat		41	0.163	0.023	261	98	48	0.103	0.014	258	59
Multi-Repeat		7	0.028	0.010	45	43	3	0.006	0.004	16	15
Total		251	0.390	0.030	1,602	132	466	0.610	0.016	2,505	109

[a] Adults spawning for the first time in spring of 1992.

[b] Adults spawning for the second time in spring of 1992.

[c] Adults spawning for three or more times in spring of 1992.

Table 20. Spawning survival by sex and spawning history of Karluk River steelhead, marked on the spawning grounds and recaptured at the weir, 1992.

Spawning History	Females			Males			All		
	Number Marked	Number Recaptured	Survival Estimated Proportion	Number Marked	Number Recaptured	Survival Estimated Proportion	Number Marked	Number Recaptured	Survival Estimated Proportion
Initial[a]	154	100	0.649	123	80	0.650	277	180	0.649
Repeat[b]	47	29	0.617	16	9	0.562	63	38	0.593
Multi-Repeat[c]	9	2	0.222	1	1	1.000	10	3	0.272
Total[d]	242	151	0.624	163	103	0.632	415	277	0.667

[a] Adults spawning for the first time spring 1992.

[b] Adults spawning for the second time spring of 1992.

[c] Adults spawning for three or more times during the spring of 1992.

[d] Totals may not equal the sum of the spawning history groups due to illegible scales or inability to determine sex.

difference (χ^2 = 0.64, df = 2, P = 0.73) in the tag recovery rate of males due to spawning history. Spawning survival of all steelhead was estimated at 67% (Table 20).

DISCUSSION

The estimated commercial bycatch of 819 steelhead is a minimal estimate. Set gillnet operators try to release captured steelhead still in a viable condition and retain dead fish for their own personal use. Catches are typically sorted twice; when the net is picked and again when the catch is sold to tender operators. Still, tenders deliver set gillnet catches to canneries in which steelhead can be found and my estimate does not include these fish. Furthermore, survival of steelhead after set gillnet capture can be low (Beere 1991, estimated at 6.2%), with a dead:live ratio at time of landing of 2:1.

In the purse seine fishery, catches are generally sorted only during delivery to tenders. Varying methods of fish transfer from purse seine and vessels, in combination with unfavorable working conditions, allow steelhead to be sold and delivered to canneries. Typically, tender skippers try to avoid purchasing steelhead but will retain fish for their own personal use as do seine vessel crews. During September, when salmon abundance is decreasing and steelhead abundance increasing, it is not uncommon for seiners to catch several steelhead in a single set. Some of these fish are rolled from pursed seines or tossed overboard and released alive. Survival of released purse seine captured steelhead is higher than set gillnets (70.9%, Spence 1989). Although it is not illegal to possess commercially caught steelhead except in Karluk Lagoon, commercial operators do discard unused steelhead. Steelhead kelts are also harvested in the June sockeye salmon fishery and the extent of this harvest has not been investigated.

The proximity of the Karluk River to other rivers known to support steelhead (Figure 6) makes it likely that the commercial bycatch is comprised of mixed stocks. Since 1985, commercial harvests by both gear types in the sections included in the Karluk study area during the period August 15 through September 30 has increased (Figures 7 and 8). It is likely that effort will increase late in the season (September) in response to increased returns of late-run sockeye salmon to the Karluk River. As these fisheries expand, commercial bycatch of the Karluk stock should be assessed.

The harvest of steelhead by Karluk Village residents was incidental to the subsistence salmon harvest. Conversely, the Portage area subsistence fishery by Larsen Bay residents is a directed fishery targeting overwintering steelhead. The high catchability and concentrations of these fish make them extremely vulnerable to harvest.

Sport harvest and effort for steelhead in the Karluk River is relatively low. Current regulations prohibit the harvest of steelhead from April 1 through June 14 which coincides with spawning. Total catch of steelhead in 1991 was high in comparison to harvest. There may be a large number of released fish caught incidental to the chinook salmon fishery which occurs during late May through mid-July. The potential exists for a high mortality of emigrant fish exposed to an intensive catch and release fishery with no terminal tackle

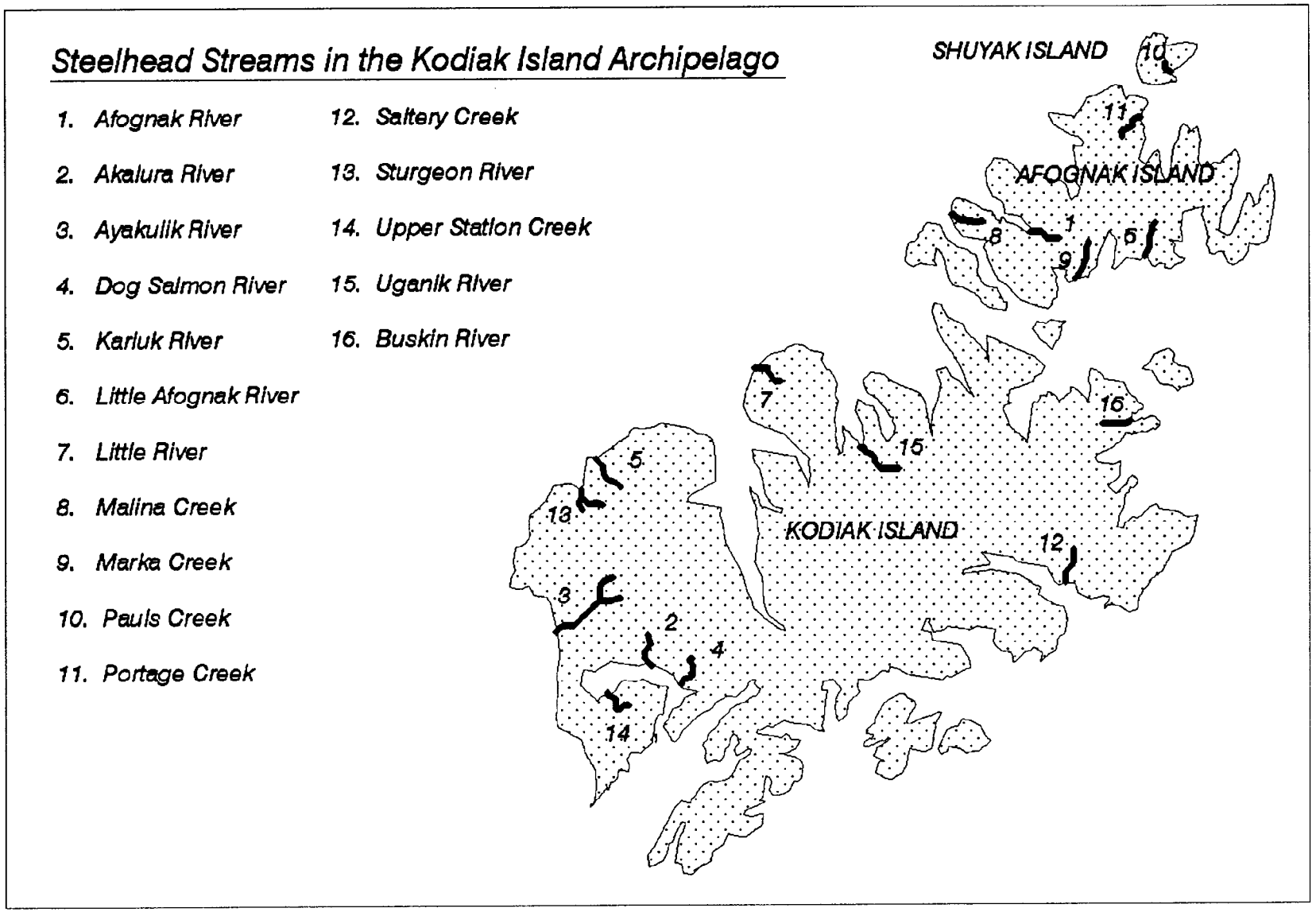

Figure 6. Steelhead systems of the Kodiak Island Archipelago.

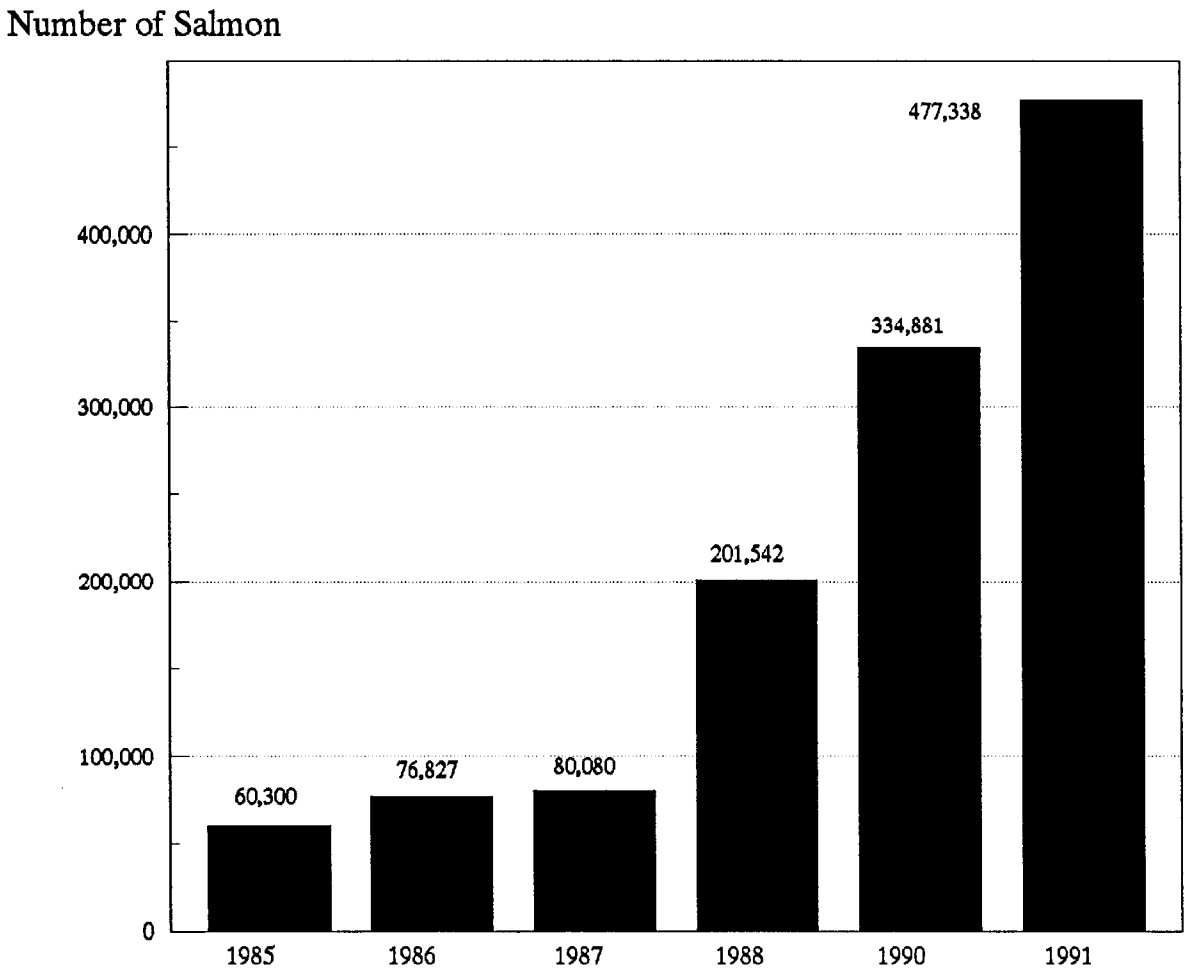

Figure 7. Historic set gillnet harvest of salmon from the five statistical areas included in the Karluk River marine study area, August 15 through September 30, 1985 through 1991.

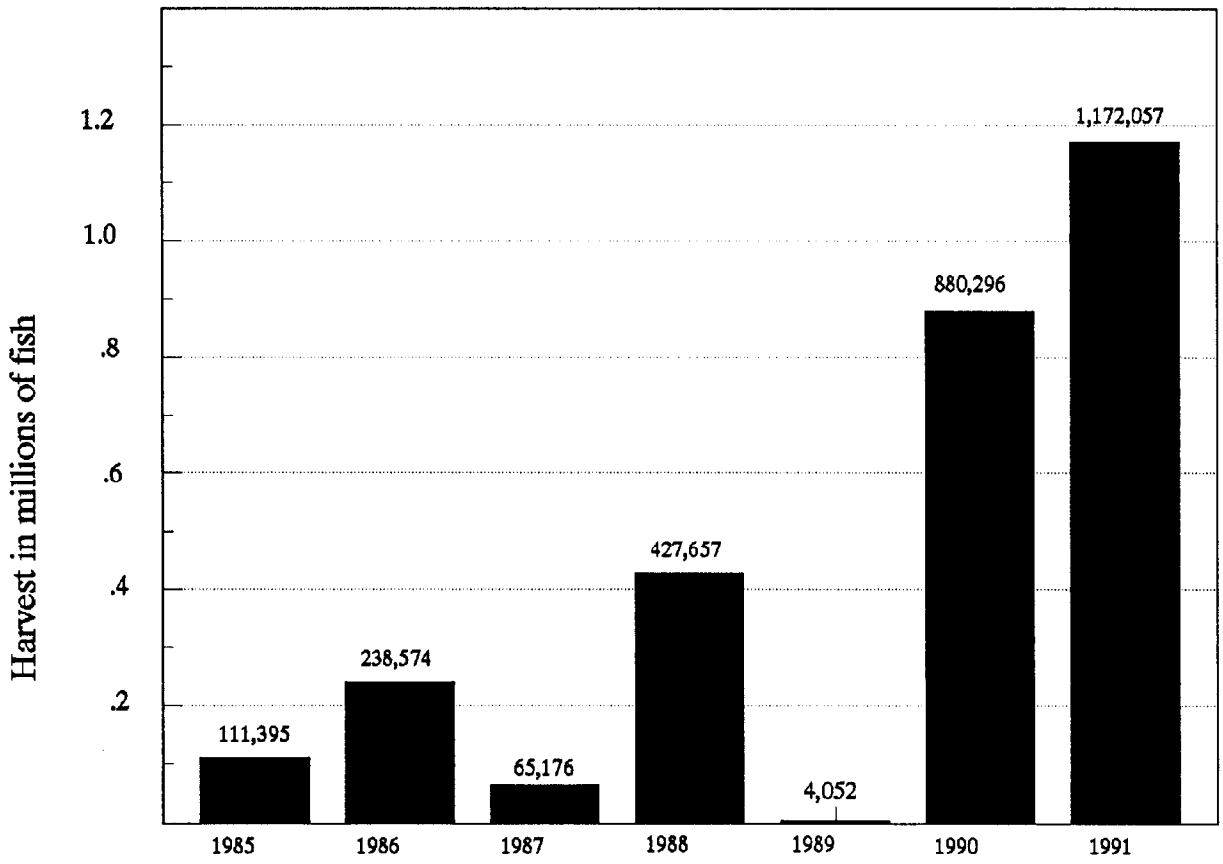

Figure 8. Historic purse seine harvest of salmon from the eight statistical areas included in the Karluk River marine study area, August 15 through September 30, 1985 through 1991.

restrictions. Therefore, future catch, harvest and effort levels, as well as effort directed at steelhead may need to be monitored if annual fishing effort increases.

The estimated abundance of 4,107 spawning steelhead does not include overwintering mortality. An accounting of the removal of sport and subsistence caught fish (128 and 407, respectively) from the estimate of spawning abundance, places the fall immigrant population at a minimum of 4,642 estimated 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 weir installation in late May. Therefore, the estimate of total return is a maximum and that of spawning survival is a minimum.

The weir has the potential to delay the steelhead emigration and increase mortality. During 1992, a downstream trap was constructed and incorporated into the weir. Consideration for downstream passage of postspawn steelhead at this and other weirs that pass emigrant steelhead needs to be included in future project planning.

The component of initial spawners (78%) in the Karluk River during 1992 was similar to historic composition (Van Hulle *Unpublished*). Historic percentages of initial spawners in the Karluk River have been: 1972, 62%; 1976, 75%; 1977, 58%; 1978, 77%; 1979, 79%; 1981, 86%. Further division of the age composition by spawning history into repeat and multi-repeat spawners with future inriver tag returns should provide insight into the temporal fluctuations of the age composition by spawning history.

Most of the scale patterns of repeat and multi-repeat spawners were interpreted as consecutive spawning. Five of the 354 legible samples obtained during April and 31 of the 713 samples obtained during weir emigration were aged as skip spawners (fish which do not return to spawn the following spring) (Appendices A, B, and C). Documented returns of fall-run fish from the Anchor River, Alaska indicate that consecutive spawners are an atypical life history pattern for fall immigrants (Wallis and Balland 1983, 1984). If consecutive spawning is the norm for Karluk River steelhead, then most of the repeat and multi-repeat spawners should be tagged in 1993. Tag recoveries will validate or refute this life history.

Information on spawning survival is limited. Estimates of abundance for Kodiak area steelhead systems are confined to indexing of immigrant runs by enumeration of emigrating fish. Continuing work should provide insight into the complex life history, population dynamics, and impact of various fisheries on the Karluk River steelhead.

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APPENDIX A

Appendix A. Length-at-age of steelhead harvested in the purse seine fishery near the Karluk River, 1991.

Age Class	Females			Males			All		
	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
2.1	3	558	63	19	543	26	22	545	24
3.1	4	587	33	13	559	27	17	566	30
2.2	4	662	37	2	584	84	6	636	62
3.2	5	679	31				5	679	31
2.2s	4	661	17	4	601	47	8	631	46
3.2s	1	692					1	692	
2.3s	1	779					1	779	
2.2s1s	1	625					1	625	
2.3s1s	1	801					1	801	
3.2s1s				1	740		1	740	
R.1	4	581	52	6	552	30	10	563	41
R.2s	3	678	31	1	730		4	691	52
R.3s	1	770					1	770	
Total	32	648	12	46	577	7	78	599	8

APPENDIX B

Appendix B. Length-at-age of steelhead hook and line captures from the spawning population, Portage area of the Karluk River, April 1992.

Age Class	Females			Males			All		
	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
2.2	7	570	69	40	529	26	47	535	37
2.3	50	632	34	17	665	65	67	640	45
2.4	1	830					1	830	
3.2	9	622	65	29	550	27	38	567	49
3.3	43	654	27	8	672	62	51	657	35
4.3	1	645					1	645	
2.2s1	16	658	42	5	680	43	21	670	47
2.3s1				2	765	63	2	765	63
3.2s1	20	639	43	3	695	22	23	646	45
2.2s2				2	718	11	2	718	11
2.3s2	1	770					1	770	
4.2s1	2	675	34				2	675	34
2.2s1s1	2	760	109				2	760	109
2.3s1s1	1	709		1	750		2	729	29
3.2s1s1	2	776	37	1	624		3	726	54
3.3s2s1	1	770					1	770	
3.3s1s1	2	785	21				2	785	21
2.2s1s1s1	1	754					1	754	
R.2	10	558	48	25	536	29	35	541	37
R.3	33	636	25	4	665	61	37	639	30
R.4				1	828		1	828	
R.2s1	10	641	26	3	620	79	13	636	40
R.2s2				1	683		1	683	
Total	212	642	4	142	587	4	354	620	4

APPENDIX C

Appendix C. Length-at-age of emigrating steelhead captured at the Karluk River weir, June 1 through August 4, 1992.

Age Class	Females			Males			All		
	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE	Sample Size	Mean Length	SE
2.1s	1	480		1	493		2	486	9
2.2s	20	535	52	179	523	27	199	524	30
2.3s	56	633	36	27	661	51	83	642	31
3.2s	15	586	50	58	540	24	73	549	36
3.3s	57	636	27	24	685	19	81	651	37
3.4s	1	727					1	727	
4.2s	2	638	24	1	541		3	606	41
4.3s	4	634	34	1	702		5	648	33
2.1s1s	1	502		2	525	11	3	517	12
2.2s1s	6	602	47	6	583	11	12	592	60
2.3s1s				1	697		1	697	
3.3s1s	1	728		2	724	91	3	725	64
3.2s1s	14	647	39	4	654	48	18	648	40
2.2s2s	3	644	26	9	697	41	12	683	44
2.3s2s	2	760	6	1	730		3	750	26
3.1s1s				1	485		1	485	
3.2s2s	1	664		5	687	27	6	683	26
4.2s1s	2	706	16				2	706	16
2.2s1s1s	2	652	11				2	652	11
2.3s1s1s				1	735		1	735	
3.2s1s1s	2	767	11	1	691		3	741	36
3.3s1s1s	1	801					1	801	
R.2s	19	584	65	105	530	32	124	538	43
R.3s	28	632	28	17	689	67	45	653	42
R.2s1s	4	666	65	10	638	49	14	646	14
R.2s2s	2	683	18	6	703	21	8	698	21
R.3s1s	2	672	32				2	672	32
R.3s2s	1	748					1	748	
R.2s1s1s	2	774	9	1	660		3	736	66
Total	249	626	4	464	564	3	713	586	3