Fishery Data Series No. 97-6

Assessment of the 1995 Return of Steelhead to the Karluk River, Alaska

by

Robert N. Begich

February 1997

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by

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ABSTRACT

Beginning August 15, 1995, 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 trout *Oncorhynchus mykiss*. From returns of catch calendars, an estimated 95 steelhead were harvested for personal use and 37 were released from the set gillnet fishery. In the commercial harvest sampled from tender deliveries, no steelhead were observed among 126,144 salmon *Oncorhynchus* harvested by the set gillnet fishery and 14 steelhead were observed among 319,320 salmon in the purse seine fishery. The sampled purse seine fishery harvested and sold an estimated 71 steelhead. The total estimated incidental commercial catch of steelhead from waters included in the Karluk study area between August 15 and September 30, 1995 was 203 fish.

Anglers interviewed at the Portage area of the Karluk River from September 29 through November 5 harvested 32 and released 2,466 steelhead.

A mark-recapture experiment was conducted on the Karluk River in the spring of 1996. The estimated abundance of spawning steelhead was 7,252 (SE = 674). Most of the spawning population was composed of initial spawners (82%), followed by repeat (15%) and multi-repeat (3%) spawners. Mean length for all spawning steelhead was 652 mm.

From May 25 through July 10, 1996 a total of 2,613 steelhead emigrated through a weir on the Karluk River after spawning. From recaptures of marked fish, the estimated spawning survival of steelhead was 36%. Spawning survival was 36% for females and 35% for males. Survival of male steelhead was 29% for initial spawners and 23% for repeat spawners; for females survival was 35% for initial spawners and 23% for repeat spawners. No multi-repeat spawners captured in the marking event were observed at the weir.

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 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 Shelikof Strait (Figure 1). Adult steelhead begin immigration during late August and may continue immigration through the winter months. Steelhead over-winter, spawn and emigrate to sea as kelts from May through July.

Steelhead from the Karluk River are harvested in several fisheries. The autumn steelhead immigration coincides with the return of coho salmon *O. kisutch* and late-run sockeye salmon *O. nerka* to the Karluk River. When commercial set gillnet operators and purse seine vessels target these salmon stocks, steelhead are incidentally harvested in nearshore marine waters along the southwest portion of Kodiak Island. Adult steelhead are targeted in the Karluk River by sport anglers from September through November. In addition, adult steelhead are harvested in subsistence fisheries by residents of Karluk Village during June through September and by Larsen Bay residents during October through April. Emigrant kelts are harvested in commercial fisheries along southwest Kodiak Island during June. Additionally, steelhead from the Karluk River are incidentally harvested by commercial gear in nearshore marine waters along the Pacific side of the Alaska Peninsula (Figure 2).

Emigrant kelt counts obtained at the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries Management and Development (CFMD) weir located at Karluk Lagoon have ranged from 210 to 7,014 since 1976 (Figure 3). The average annual kelt count of 2,385 fish from 1981 through 1985 declined to an average of 566

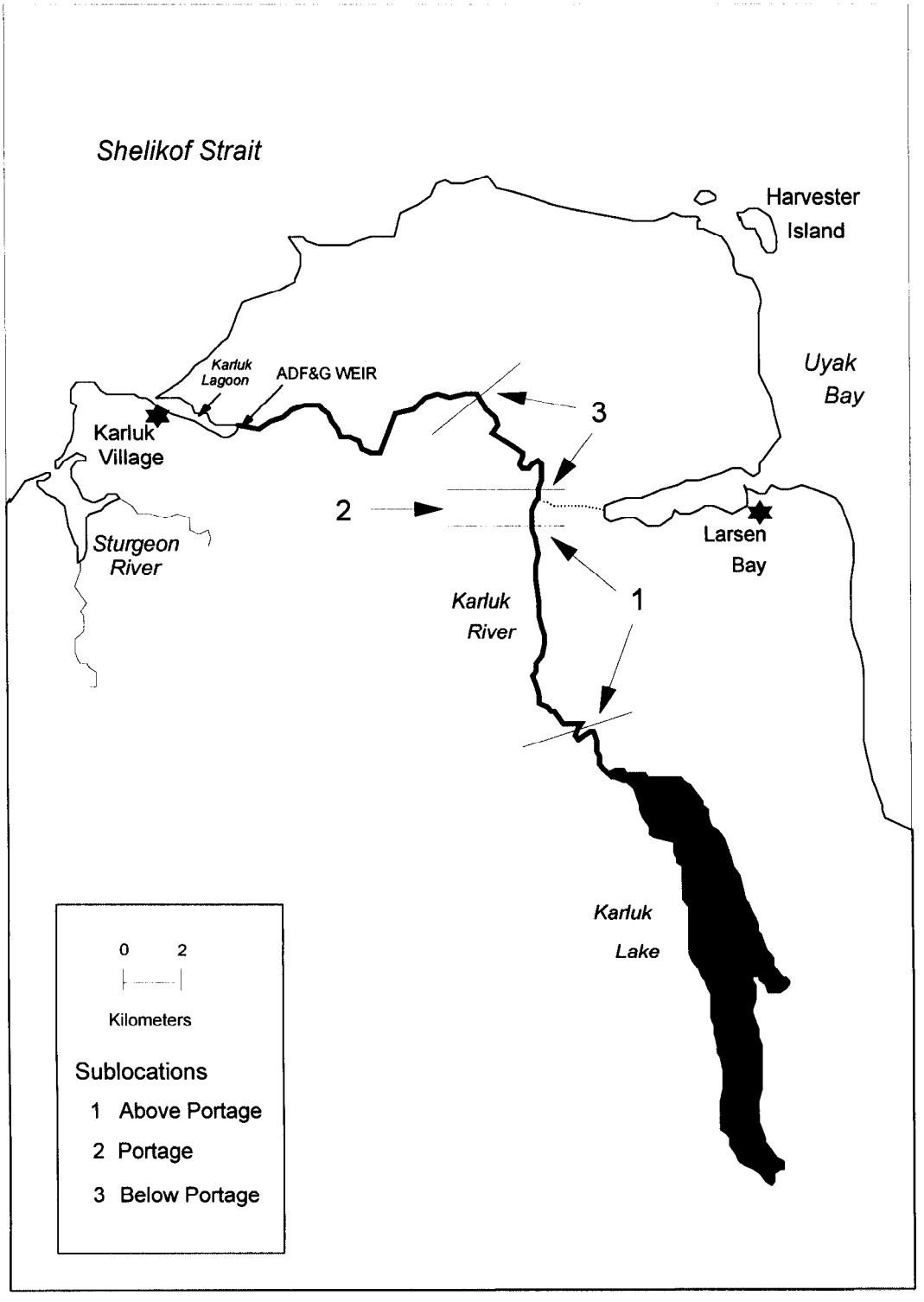


Figure 1.-Map of Karluk River freshwater study area, Portage, Larsen Bay, weir and Karluk Village.

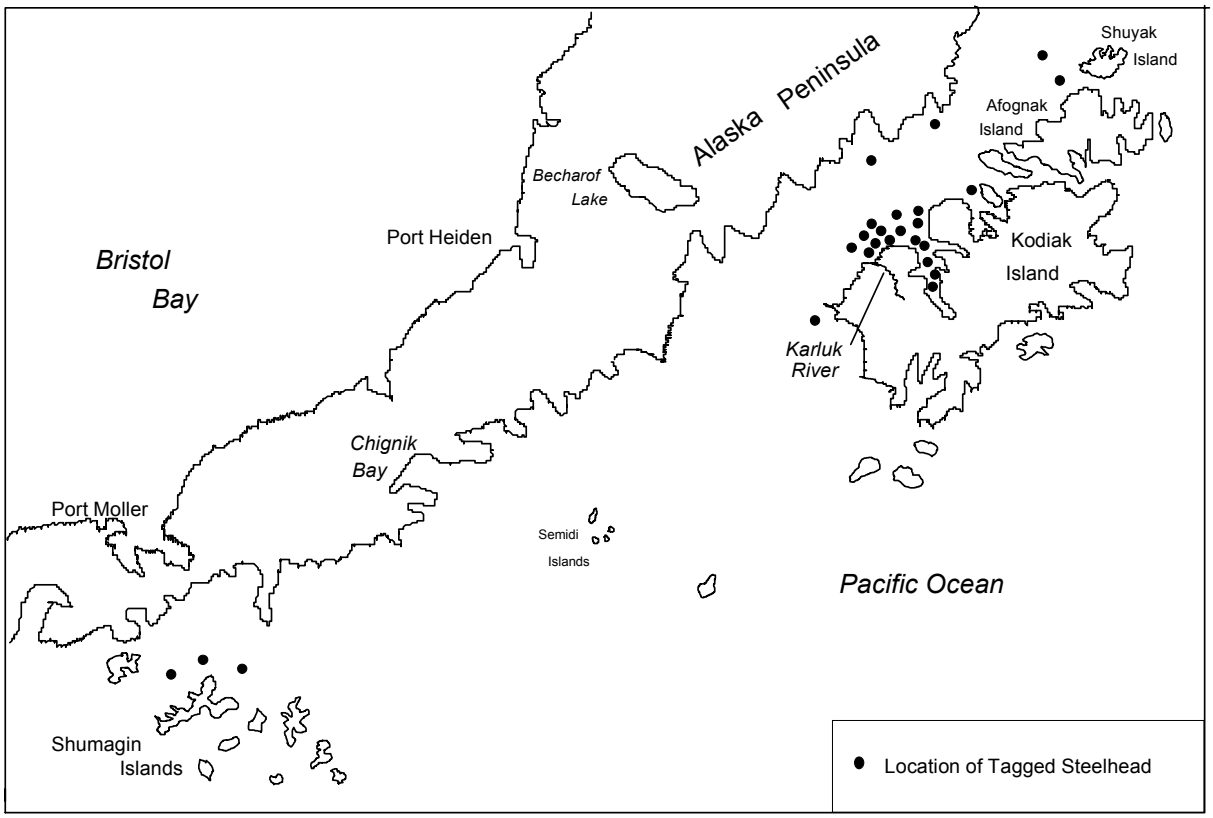


Figure 2.-Map of locations of Karluk River steelhead tag returns from Kodiak Island and Alaska Peninsula commercial salmon fisheries, June 1992 through June 1996.

fish from 1986 through 1990. This apparent decline of emigrating steelhead created concern that the population was in danger of overexploitation. However, from 1992 through 1996, emigration averaged 4,355 kelts.

In August 1991, a study was initiated to assess stock status of adult steelhead returning to and overwintering in the Karluk River. Estimated statistics 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, 1993, and 1995a and b).

This report is part of a continuing study to assess the stock status of adult steelhead returning, overwintering, and spawning at the Karluk River. For the 1995 return, the study objectives were to:

Fishing Mortality:

1. Estimate the number of steelhead retained for personal use and the number released by commercial set gillnetters operating between West Point and Rocky Point from August 15 through September 30, 1995.
2. Estimate the number of steelhead sold in the commercial set gillnet fishery between West Point and Rocky Point from August 15 through September 30, 1995.
3. Estimate the number of steelhead harvested in the commercial purse seine fishery between West Point and Sturgeon Head from August 15 through September 30, 1995.

4. Census the effort of the autumn sport fishery at the Portage area of the Karluk River.
5. Census the sport catch and harvest of steelhead at the Portage area of the Karluk River.
6. Estimate the age, sex and length composition of the sport harvest of steelhead.

Spawning Population:

7. Estimate the number of spawning steelhead in the Karluk River during the spring of 1996.
8. Estimate the age, sex, and length composition of the spawning population.
9. Enumerate emigrating kelts through the Karluk River weir during spring 1996.
10. Estimate the age, sex, and length composition of the population of emigrating kelts.

STEELHEAD BYCATCH IN SELECTED COMMERCIAL FISHERIES

METHODS

Commercial catches from waters of eight statistical areas between West Point and Sturgeon Head (Figure 4) were sampled for the incidental harvest of steelhead. These areas are adjacent to the Karluk River, however, steelhead stocks from other nearby

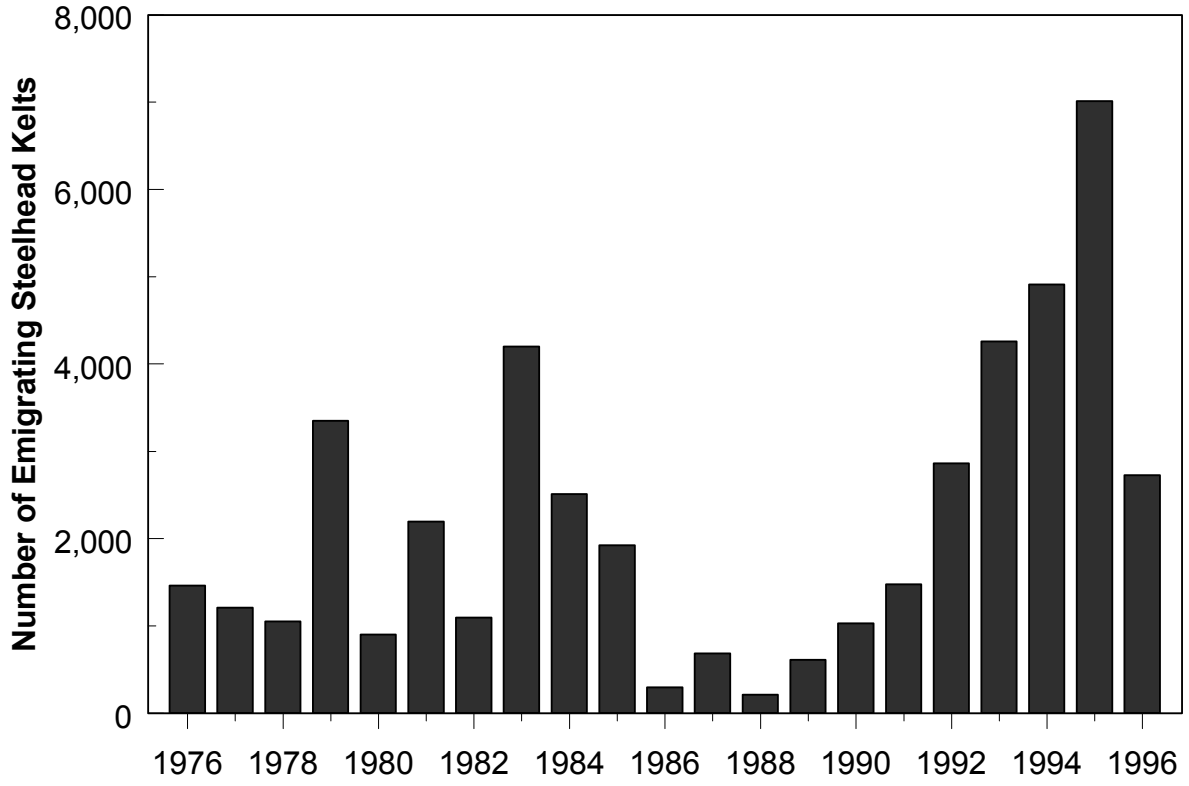


Figure 3.-Counts of emigrating kelts obtained at the Division of Commercial Fisheries Management and Development weir, Karluk River, 1976 through 1996.

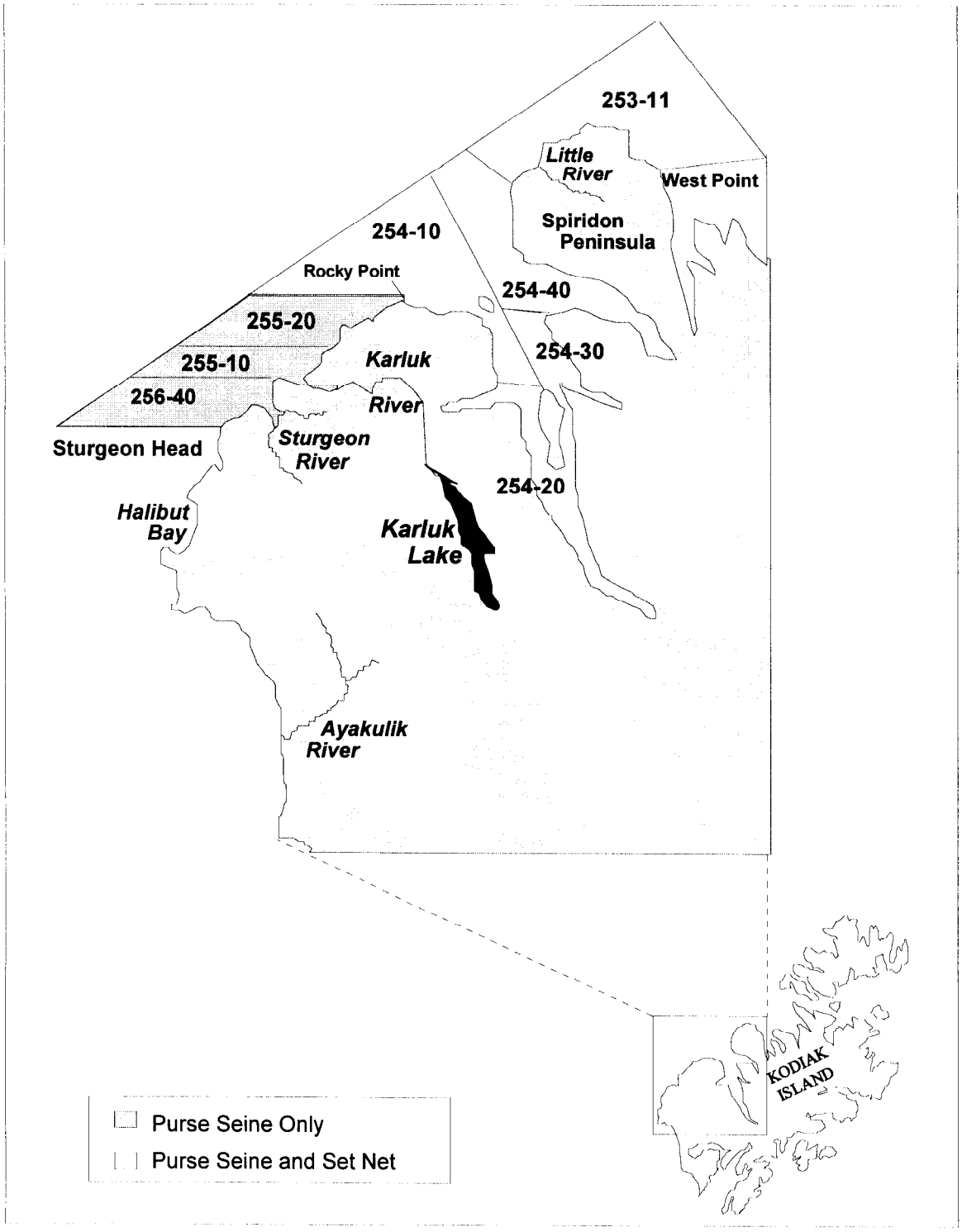


Figure 4.-Map of marine study area and Karluk River, 1996.

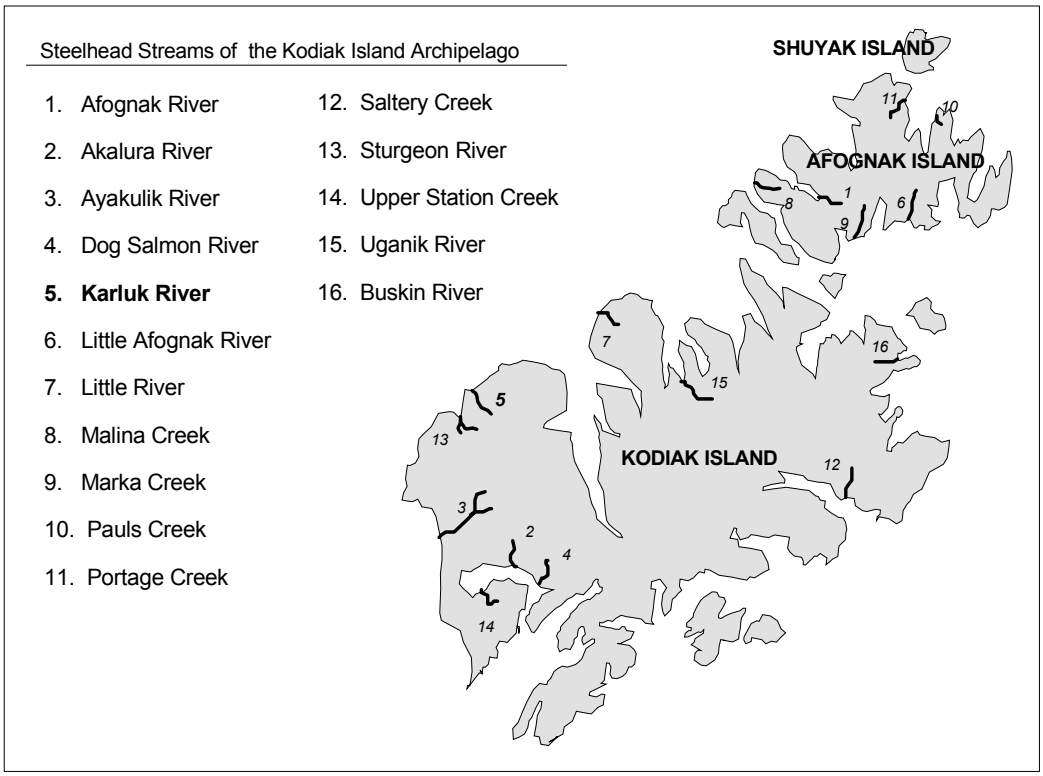


Figure 5.-Steelhead systems of the Kodiak Island Archipelago.

rivers may also be present in the harvest (Figure 5). 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, pink salmon *O. gorbuscha*, and coho salmon to the Karluk River by CFMD Division in Kodiak. We sampled commercial catches of salmon over a 6-week period, stratified by five temporal strata to detect spatial and temporal changes of steelhead bycatch. Temporal strata were:

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 provided data to estimate the number of steelhead retained and the number released by set gillnetters.

Calendar returns were used to expand steelhead catches to include 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 of steelhead retained or released to the number of salmon harvested. First, the jackknifed ratio of steelhead retained for personal use to salmon harvested ($\hat{r}_{iq}$) was estimated for each gillnetter by:

$$\hat{r}_{iq} = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{n} C_{sjq}}{\sum_{\substack{j=1 \\ j\neq i}}^{n} C_{ojq}}, \quad (1)$$

where:

$\hat{r}_{iq}$ = the jackknifed ratio of steelhead retained to salmon harvested for gillnetter i in stratum q,

C_{sjq} = number of steelhead harvested or released by set gillnetter j in stratum q,

C_{ojq} = harvest of salmon by set gillnetter j in stratum q,

n = number of set gillnet permit holders who returned calendars.

Next the ratio of steelhead retained to salmon harvested was estimated for each time stratum:

$$\hat{r}_q = n\hat{g}_q - (n-1)\bar{r}_q, \quad (2)$$

where:

$\hat{r}_q$ = the estimated ration of steelhead retained to salmon harvested in stratum q,

$\bar{r}_q$ = the average of the $\hat{r}_{iq}$, and

$$\hat{g}_q = \frac{\overline{C}_{sq}}{\overline{C}_{oq}}, \quad (3)$$

with variance:

$$\mathrm{Var}(\hat{r}_q) = \frac{(1-f)(n-1)}{n}\sum_{i=1}^{n}(\hat{r}_{iq} - \bar{r}_q)^2, \quad (4)$$

where:

$\overline{C}_{sq}$ = mean harvest of steelhead among all reporting set gillnetters in stratum q,

$\overline{C}_{oq}$ = mean harvest of salmon among all reporting set gillnetters in stratum q,

$\bar{r}_q$ = the average of the $\hat{r}_{iq}$,

f = finite population correction factor = n/N, and

N = total number of set gillnet permit holders in study area.

The total number of steelhead taken in set gillnets (C_{snq}) for personal use or released in a stratum was then estimated by:

$$\hat{C}_{snq} = \hat{r}_q C_{onq}, \quad (5)$$

where:

C_{onq} = total harvest of salmon in stratum q by all set gillnet permit holders in the study area.

The variance of the estimate of steelhead taken for personal use or released during each stratum was estimated by (Cochran 1977):

$$\mathrm{Var}(\hat{C}_{snq}) = C_{onq}^{2}\mathrm{Var}(\hat{r}_q). \quad (6)$$

The total number of steelhead retained for personal use and its variance were estimated by summing the strata estimates.

The number of steelhead released by set gillnetters was estimated in the same way, substituting the number of steelhead released for the number retained in equations 1 through 6.

Tender-Sampled Set Gillnet and Purse Seine Fishery

The number of steelhead harvested by set gillnetters and purse seiners and sold to tender vessels for delivery to canneries was estimated by sampling of these fisheries on an opportunistic basis. During off-loading, the harvest was sorted by species and the steelhead counted. As many harvests as

possible were sampled during each fishing period.

Fish tickets from sampled deliveries provided the weight and number of salmon sold so that the jackknife ratio estimate of steelhead to salmon could be computed for each vessel by (Cochran 1977):

$$\hat{r}_{jz} = \frac{\sum_{\substack{k=1 \\ k \neq j}}^{v_z} C_{skz}}{\sum_{\substack{k=1 \\ k \neq j}}^{v_z} C_{okz}}, \quad (7)$$

where:

$\hat{r}_{jz}$ = the jackknifed ratio of steelhead retained to salmon harvested for vessel j in stratum z,

C_{skz} = harvest of steelhead by vessel k in stratum z,

C_{okz} = harvest of salmon by vessel k in stratum z, and

v_z = number of vessels sampled for steelhead in stratum z.

Next the ratio estimate was calculated:

$$\hat{r}_z = v_z \hat{h}_z - (v_z - 1)\bar{r}_z, \quad (8)$$

where:

$\hat{r}_z$ = the estimated ratio of steelhead retained to salmon harvested for stratum z, and

$$\hat{h}_z = \frac{\overline{C}_{sz}}{\overline{C}_{oz}}, \quad (9)$$

with variance:

$$\mathrm{Var}(\hat{r}_z) = \frac{(1 - f_z)(v_z - 1)}{v} \sum_{k=1}^{v_z} (\hat{r}_{kz} - \bar{r}_z)^2, \quad (10)$$

where:

$\overline{C}_{sz}$ = mean harvest of steelhead among all sampled vessels in stratum z,

$\overline{C}_{oz}$ = mean harvest of salmon among all sampled vessels in stratum z,

$\bar{r}_z$ = the average of the $\hat{r}_{kz}$

f_z = finite population correction factor = v_z/V_z, and

V_z = total number of vessels unloading fish in stratum z (from fish ticket database).

The total harvest of steelhead in the purse seine and tender-sampled set gillnet fisheries (C_{spz}) in each time stratum was then estimated by:

$$\hat{C}_{spz} = \hat{r}_z C_{opz}, \quad (11)$$

where:

C_{opz} = total harvest of salmon in the purse seine fishery in stratum z.

The variance of the estimate of steelhead catch was estimated by:

$$\mathrm{Var}(\hat{C}_{spz}) = C_{opz}^2 \mathrm{Var}(\bar{r}_z). \quad (12)$$

The total harvest of steelhead and its variance were then estimated by summing the respective estimates across time strata.

Steelhead observed in tender-sampled catches were measured from the tip-of-snout to the fork-of-tail (fork length) to the nearest millimeter, sex was determined and the fish were examined for tags or finclips. 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 the acetate impression viewed with a microfiche reader to determine age.

Scale analysis incorporated the methods of Mosher (1969), Jones (*Unpublished*) and Wallis (*Unpublished*). For example, an

assigned age of 2.2s1s is an age-5 repeat spawner which: (1) spent 2 winters (years) in fresh water prior to smolt emigration, (2) returned to spawn in fresh water in October during its second year at sea, (3) returned to the sea as a kelt in June, and (4) returned to fresh water in October to spawn again. The letter "s" represents a freshwater immigration (spawning event) and numbers represent years between events. This represents a departure from the traditional method employed by Narver and Withler (1971) for age assignment of fall immigrant steelhead, but is similar to the method used by Maher and Larkin (1955). Using the method of Narver and Withler the assigned age of this fish would have been 2.1ss.

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

Thirteen of the 42 (31%) set gillnet permit holders operating within the Karluk study area returned catch calendars. From August 15 to September 30, sampled permit holders retained 20 steelhead for personal use and released nine steelhead (Tables 1 and 2). During the same period, these same permit holders harvested 106,683 (22%) of the 477,322 salmon harvested by the set gillnet fishery. An estimated 95 steelhead (SE = 23) were retained for personal use by set gillnet permit holders and an additional 37 fish (SE = 27) were released (Tables 1 and 2).

From August 15 to September 30, 2,383,337 salmon were harvested within the Karluk study area; 477,322 by set gillnetters and 1,906,015 by purse seiners (Tables 2 and 3). No steelhead were observed in tender samples of 126,124 set gillnet-harvested salmon. A total of 14 steelhead were observed in a sample of 319,320 purse seine-harvested salmon. The total estimated harvest of steelhead in the tender-sampled purse seine fishery was 71 fish (SE = 8) (Table 3).

Three tagged steelhead of Karluk origin were recovered during the August 15 through September 30 sampling period. One was reported by a set gillnet calendar recipient and two were observed during sampling of commercial purse seine catches. These sample sizes were not sufficient for estimation of Karluk stock contribution of repeat spawning steelhead to total estimated steelhead bycatch.

Temporal trends in the steelhead bycatch were evident in both the set gillnet and purse seine fisheries (Tables 1-3). In both fisheries the ratio of steelhead-to-salmon was lower during the first stratum (8/15-8/31), than during the second stratum (9/01-9/07). In the set gillnet fishery, harvest of steelhead estimated from calendar returns was greatest during the second stratum, when 9% of the total salmon harvest occurred (Table 1). Similarly, in the purse seine fishery steelhead harvest increased during the second stratum when 5% of the salmon harvest occurred (Table 3). No commercial purse seine or set gill net harvest was sampled during the fourth (9/15-9/21) stratum and no commercial salmon harvest was reported by either fishery during the fifth (9/22-9/30) stratum.

No calendars were returned from statistical area 253-11 or 254-30, areas that together

Table 1.-Estimated number of steelhead retained for personal use by commercial set gillnetters near the Karluk River, August 15 through September 30, 1995.

Stratum	Total Salmon Harvest[a]	Sample Size[b]	Reported Number of Steelhead[c]	Ratio of Steelhead to Salmon	Estimated Steelhead Harvest	SE	Relative Precision[d]
8/15-8/31	418,111	95,728	6	0.000066	28	19	137%
9/01-9/07	43,653	9,624	14	0.001527	67	13	37%
9/08-9/14	12,001	1,331	0	0.0	0		
9/15-9/21	3,057	0					
9/22-9/30	0	0					
Total	477,322	106,683	20		95	23	48%

[a] From fish tickets.

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

[c] Obtained from catch calendar survey.

[d] Relative precision of 95% confidence interval.

Table 2.-Estimated number of steelhead released by commercial set gillnetters near the Karluk River, August 15 through September 30, 1995.

Stratum	Total Salmon Harvest[a]	Sample Size[b]	Reported Number of Steelhead[c]	Ratio of Steelhead to Salmon	Estimated Steelhead Release	SE	Relative Precision[d]
8/15-8/31	418,611	95,728	5	0.000053	22	20	175%
9/01-9/07	43,653	9,624	4	0.000353	15	19	237%
9/08-9/14	12,001	1,331	0	0.0	0		
9/15-9/21	3,057	0					
9/22-9/30	0	0					
Total	477,322	106,683	9		37	27	145%

[a] From fish tickets.

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

[c] Obtained from catch calendar survey.

[d] Relative precision of 95% confidence interval.

Table 3.-Estimated harvest of steelhead in the commercial purse seine fishery near the Karluk River, August 15 through September 30, 1995.

Stratum	Total Salmon Harvest[a]	Sample Size[b]	Number of Steelhead Observed[c]	Ratio of Steelhead to Salmon	Estimated Steelhead Harvest	SE	Relative Precision[d]
8/15-8/31	1,779,687	303,067	5	0.000009	17	2	24%
9/01-9/07	96,082	15,980	9	0.000563	54	8	27%
9/08-9/14	27,590	273	0	0.0	0		
9/15-9/21	2,656	0					
9/22-9/30	0	0					
Total	1,906,015	319,320	14		71	8	22%

[a] From fish tickets.

[b] Number examined in sample.

[c] Number steelhead in sample.

[d] Relative precision of 95% confidence interval.

accounted for 20% of the total set gillnet harvest of salmon (Table 4). Harvest of steelhead was highest in statistical area 254-20 where 17% of the total salmon harvest occurred and 44% of the salmon harvest was sampled by calendar returns. The estimated total harvest of steelhead in this area was 62 fish. Release of steelhead was reported only by catch calendar recipients fishing in statistical area 254-10 (Table 4).

Age and length data were obtained from 14 steelhead observed in purse seine catches (Tables 5 and 6; Appendix A1). The majority of fish sampled were males (57%, SE = 13; mean length 585 mm FL, SE = 28), while females accounted for 43% (SE = 13) of the sample (mean length 628 mm FL, SE = 32). Only one repeat spawning fish was observed (Tables 5 and 6).

STEELHEAD HARVEST IN THE KARLUK RIVER SPORT FISHERY

METHODS

Effort, catch, and harvest of the inriver sport fishery in the fall were obtained from three sources. First, from October 3 through November 5, an onsite creel census was conducted at the Portage area on the Karluk River. Secondly, a logbook was provided by department personnel to a commercial outfitter that established a camp downriver of the Portage area. Thirdly, anglers floating the river who had completed their raft trips were interviewed.

The Portage area is accessible by float plane from the city of Kodiak, by raft via Karluk Lake, and by trail from the head of Larsen

Bay (Figure 1). Anglers participating in the autumn sport fishery camp or stay at any of the four public-use cabins located in the Portage area, which encompasses approximately 1.5 river miles. A technician stationed at the Portage interviewed all anglers as they exited the fishery each day to obtain a complete census of all angling activity. At the outfitter's camp, information was collected daily and the logbook returned to division personnel at the end of the season. Anglers who had completed their raft trips were interviewed following their return from the Karluk River.

Information collected from each angler each day they fished included effort, catch and harvest by species, and gear type. Since all anglers were interviewed or recorded in the logbook, the interview data were summed to calculate the aforementioned fishing statistics.

Estimates of effort, catch, and harvest from 1982 through 1993 were obtained only from postal surveys (Mills 1983-1994). In the

Table 4.-Estimated number of steelhead retained for personal use and number released from the set gillnet fishery by statistical area and sampling strata, August 15 through September 30, 1995.

Stat Area	Reported Steelhead Harvest by Time Strata 1	2	3	4	5	Total	Proportion of Total Salmon Harvest	Estimated Steelhead	Proportion of Estimated Steelhead	Proportion of Sampled Salmon Harvest
Harvest										
253-11[a]							0.19			
254-10	1	6	0	[b]	[b]	7	0.40	33	0.35	0.35
254-20	5	8	0	[b]	[b]	13	0.17	62	0.65	0.44
254-30[a]							0.01			
254-40	0	0	[b]	[b]	[b]		0.23			0.21
Total	6	14	0			20	1.00	95	1.00	1.00
Release										
253-11[a]							0.19			
254-10	5	4	0	[b]	[b]	9	0.40	37	1.00	0.35
254-20	0	0	0	[b]	[b]	0	0.17	0		0.44
254-30[a]							0.01			
254-40	0	0	[b]	[b]	[b]	0	0.23	0		0.21
Total	5	4	0			9	1.00	37	1.00	1.00

[a] No catch calendars were returned by set gillnetters from these stat areas.

[b] No set gillnet harvest reported during strata.

Table 5.-Length-at-age by spawning history and sex of steelhead harvested by commercial purse seines near the Karluk River, August 15 through September 30, 1995.

	Initial Spawners[a]			Repeat Spawners[b]		
	Marine Age			Marine Age		
	1	2	Total	3	Total	Total
Females						
Number Sampled	2	4	6	0	0	6
Mean Length	528	678	628			628
SE Mean Length	12	21	32			32
Males						
Number Sampled	6	1	7	1	1	8
Mean Length	541	755	572	674	674	585
SE Mean Length	10		30			28
All						
Number Sampled	8	5	13	1	1	14
Mean Length	538	694	598	674	674	603
SE Mean Length	8	22	23			22

[a] Adults spawning for the first time in the spring of 1996.

[b] Adults spawning for the second time in the spring of 1996.

postal survey, sport fishing statistics 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 over an entire calendar year. Due to the relatively small number of returned postal surveys from anglers who stated they fished at the Karluk River, estimates were not available in 1986, 1987, and prior to 1982.

RESULTS

The sport harvest of Karluk River steelhead during the 1995 season was 32 fish, an additional 2,466 fish were released (Table 7). The age, sex, and length composition of the sport harvest was not estimated due to inadequate sample sizes.

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). 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 allowed for a mark-recapture experiment to estimate the abundance of the spawning population in the Karluk River drainage during the spring of 1996.

Table 6.-Age composition by sex and spawning history of steelhead harvested by commercial purse seines near the Karluk River, August 15 through September 30, 1995.

	Initial Spawners[a]			Repeat Spawners[b]		
	Marine Age			Marine Age		
	1	2	Total	3	Total	Total
Females						
Number Sampled	2	4	6	0	0	6
Proportion	0.14	0.29	0.43	0.00	0.00	0.43
SE Proportion	0.10	0.13	0.14			0.14
Estimated Abundance	10	20	30			30
SE Abundance	7	9	10			10
Males						
Number Sampled	6	1	7	1	1	8
Proportion	0.43	0.07	0.50	0.07	0.07	0.57
SE Proportion	0.14	0.07	0.14	0.07	0.07	0.14
Estimated Abundance	30	5	36	5	5	41
SE Abundance	10	5	11	5	5	11
All						
Number Sampled	8	5	13	1	1	14
Proportion	0.57	0.36	0.93	0.07	0.07	1.00
SE Proportion	0.14	0.13	0.07	0.07	0.07	0.00
Estimated Abundance	41	25	66	5	5	71
SE Abundance	11	10	9	5	5	8

[a] Adults spawning for the first time in spring of 1996.

[b] Adults spawning for the second time in spring of 1996.

During April, a base camp was established at a cabin located at the Portage area. Fish were captured on hook and line, and measured for fork length. Sex was determined, and a scale taken for age determination. The fish were tagged near the posterior insertion of the dorsal fin 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. Sampling occurred from April 1 through April 12, in an 11.2 km (7 mi) section of the river around the Portage area. This section was divided into three sampling sublocations (Figure 1). Each location was sampled and effort was directed at multiple sites within each location where fish were known to congregate.

The marking event (first event) for this experiment was the entire 12-day sampling experiment described above. The recapture event (second event) occurred at the weir. From May 25 through July 10, 1996, all emigrating steelhead were captured in a

Table 7.-Sport harvest and release of steelhead and total fishing effort from the Karluk River sport fishery, 1982-1995.

Year	Postal Survey Effort Estimate[a]	Effort from Onsite Angler Census[b]	Postal Survey Harvest Estimate[c]	Harvest from Onsite Angler Census[b]	Postal Survey Release Estimate[c]	Release from Onsite Angler Census[b]
1982	1,552		90			
1983	2,142		241			
1984	534		150			
1985	1,223		167			
1986	[d]		[d]			
1987	[d]		[d]			
1988	990		18			
1989	1,313		20			
1990	2,191		86		742	
1991	1,646		128		628	
1992	5,430		40		898	
1993	6,984		189		3,446	
1994	10,948	538	80	21	1,387	2,598
1995	6,928	612	47	32	746	2,466

[a] Angler-days in all sport fisheries on the Karluk River from statewide postal surveys (Mills 1983-1994, and Howe et al. 1995, 1996).

[b] Obtained from onsite angler census and outfitter tent camp logbook, September 25 through November 11, 1994 (Begich 1995b); and September 29 through November 4, 1995.

[c] Harvest and release estimates from statewide postal surveys (Mills 1983-1994, and Howe et al. 1995, 1996).

[d] No estimate due to the small number of returned surveys from anglers who fished at the Karluk River.

downstream trap that was incorporated into the weir. Upon entry into the trap, steelhead were captured with a dip net, and examined for a finclip and tag. Sex was determined and the fish were measured for fork length to the nearest millimeter. All untagged kelts were tagged and given a secondary mark (finclip) as previously described. We attempted to collect scale samples from 140 fish per week as described in the previous section on estimation of bycatch in commercial fisheries.

The population abundance of spawners in the Karluk River ($\hat{N}_a$) was calculated using Chapman's modification of the Petersen estimator (Seber 1982):

$$\hat{N}_a = \frac{(M+1)(C+1)}{(R+1)} - 1, \qquad (13)$$

where:

M = number of steelhead tagged and released in the first event,

R = number of tagged fish recaptured in the second event, and

C = number of fish examined for tags in the second event.

The variance was estimated by:

$$\mathrm{Var}(\hat{N}_a) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \qquad (14)$$

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

1. There is no recruitment to the population over the duration of the experiment;
2. No marks are lost;
3. All fish have the same probability of capture in the first event or in the second event, or marked fish are randomly distributed among the unmarked fish;
4. Marking does not affect the probability of capture; and
5. All marked steelhead are reported when recovered during the recapture event.

Because steelhead that enter the Karluk River throughout the fall and early winter do not leave the system until after spawning and do not grow during winter or spawning, there is no reason to believe that recruitment, immigration or emigration occurred during the experiment.

Steelhead likely overwinter and spawn in areas other than the sampled sublocations, including Karluk Lake, and other sections of the river. If there was sufficient mixing of tagged and untagged steelhead during spawning and prior to emigration through the weir, the experiment will provide an estimate of spawner abundance for the entire drainage at the time of marking during April.

Contingency tables and chi-squared tests (Conover 1980) were used to compare the probability of capture (assumptions 3 and 4) among the sampled geographic sublocations, sex, spawning history and marine age between the mark event and the 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 Kolmogorov-Smirnov tests (Daniel 1978) were used to determine if capture rates differed due to size. The first test compared the cumulative length distributions of fish marked in the first event with those recaptured in the second event and the second test compared 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 data must be stratified to provide an unbiased estimate of abundance (Seber 1982). All tests were conducted at $\alpha = 0.05$. The secondary mark (left ventral finclip) provided the means to estimate tag loss (assumption 2). To minimize violation of the last two assumptions, all captured steelhead were handled carefully and thoroughly examined for marks.

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 hook-and-line sample alone was used to estimate the length-at-age and age composition of the spawning population. The proportion of steelhead in the spawning population in each age category was estimated as:

$$\hat{p}_y = \frac{n_{ay}}{n_a}, \qquad (15)$$

where:

n_{ay} = the number of steelhead in the sample from age category y,

sample from age category y,

n_a = the total number of steelhead in the sample.

The variance of the proportion by age was estimated as:

$$\mathrm{Var}(\hat{p}_y) = \frac{\hat{p}_y(1-\hat{p}_y)}{n_a - 1}. \quad (16)$$

Spawner abundance by age was estimated as:

$$\hat{N}_{ay} = \hat{N}_a \hat{p}_y, \quad (17)$$

with the variance (Goodman 1960):

$$V(\hat{N}_{ay}) = V(\hat{N}_a)\hat{p}_y^2 + V(\hat{p}_y)\hat{N}_a^2 - V(\hat{N}_a)V(\hat{p}_y). \quad (18)$$

The number of fish of age y migrating through the weir during time stratum f was estimated by:

$$\hat{E}_{yf} = E_f \hat{p}_{yf}, \quad (19)$$

and its variance estimated by:

$$\mathrm{Var}\left(\hat{E}_{yf}\right) = E_f^2 \mathrm{Var}\left(\hat{p}_{yf}\right), \quad (20)$$

where:

E_f = the weir count of kelts migrating through the weir during stratum f, and $\hat{p}_{yf}$ and $\mathrm{Var}(\hat{p}_{yf})$ = the proportion, and its variance, of fish of age y migrating through the weir during stratum f, estimated as described for the spawning population.

The total number of age y fish migrating through the weir was estimated as:

$$\hat{E}_y = \sum_{f=1}^{t} \hat{E}_{yf}. \quad (21)$$

The variance was estimated as the sum of the variances as:

$$\mathrm{Var}\left(\hat{E}_y\right) = \sum_{f=1}^{t} \mathrm{Var}\left(\hat{E}_{yf}\right). \quad (22)$$

The proportion of steelhead of age y in the total escapement emigrating through the weir ($\hat{p}_{ey}$)was estimated as:

$$\hat{p}_{ey} = \frac{\hat{E}_y}{E_T}, \quad (23)$$

where:

E_T = the total emigration enumerated at the weir.

The variance of this proportion was estimated by:

$$\mathrm{Var}\left(\hat{p}_{ey}\right) = \frac{\mathrm{Var}\left(\hat{E}_y\right)}{E_T^2}. \quad (24)$$

Spawning Survival

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

$$\hat{S}_y = \frac{n_{yw}}{n_{yt}}, \quad (25)$$

with variance:

$$\mathrm{Var}\left(\hat{S}_y\right) = \frac{\hat{S}_y(1-\hat{S}_y)}{n_{yt}-1}, \quad (26)$$

where:

n_{yw} = number of tagged fish at the weir of age class y, and

n_{yt} = number of tagged fish released during the marking event of age class y.

RESULTS

Abundance

From April 1 through April 12, 1996 a total of 196 steelhead were captured and released with tags. From May 25 through July 10, 1996 a total of 2,613 fish were examined for marks at the weir, of which 70 were marked (Table 8). Eleven percent (n = 8) of the recaptured 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 locations of release ($\chi^2 = 3.53$, df = 2, P = 0.17), day of release ($\chi^2 = 7.07$, df = 8, P = 0.53) or week of release ($\chi^2 = 0.01$, df = 1, P = 0.93). The probability of capture was not significantly different between males and females ($\chi^2 = 0.05$, df = 1, P = 0.82) or among spawning histories ($\chi^2 = 2.15$, df = 2, P = 0.34). Temporal trends in the emigration of marked and unmarked steelhead through the weir were not significantly different ($\chi^2 = 4.81$, df = 4, P = 0.31) (Figure 6). There was no significant difference in the marked:unmarked ratio at the weir due to spawning histories ($\chi^2 = 0.61$, df = 2, P = 0.74) or sex ($\chi^2 = 0.04$, df = 1, P = 0.85).

A significant difference was detected between the cumulative length distribution of all fish marked on the spawning grounds and all recaptured at the weir (D = 0.22, P = 0.02, $n_1 = 194$, $n_2 = 58$). A similar test of all fish marked on the spawning grounds and all captures at the weir that were measured also detected a significant difference in the length distribution of these groups (D = 0.21, P < 0.001, $n_1 = 194$, $n_2 = 2,579$). Because the cumulative length distributions of these groups (Figure 7) were parallel, rather than crossing as normally occurs in the presence of size selective sampling, the result of this test

Table 8.-Summary of tagging data for steelhead released at the Portage and recaptured at the Karluk weir, Karluk River, 1996.

Marking Event at Portage 04/01-04/12		Recapture Event at Weir 05/25-07/10		
Sublocation[a]	Number Released	Recovered	Not Recovered	Percent Recovered
1	68	26	42	38.2
2	21	2	19	9.5
3	107	34	73	31.8
Number Tag Releases	196	70 [b]	126	35.7
Number Untagged		2,543		
Number Examined		2,613		
Percent Marked Recoveries		2.7		

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

[b] Includes eight fish that lost their tags prior to the recapture event at the weir.

[c] Total may not add due to fish that lost their tags prior to the recapture event at the weir.

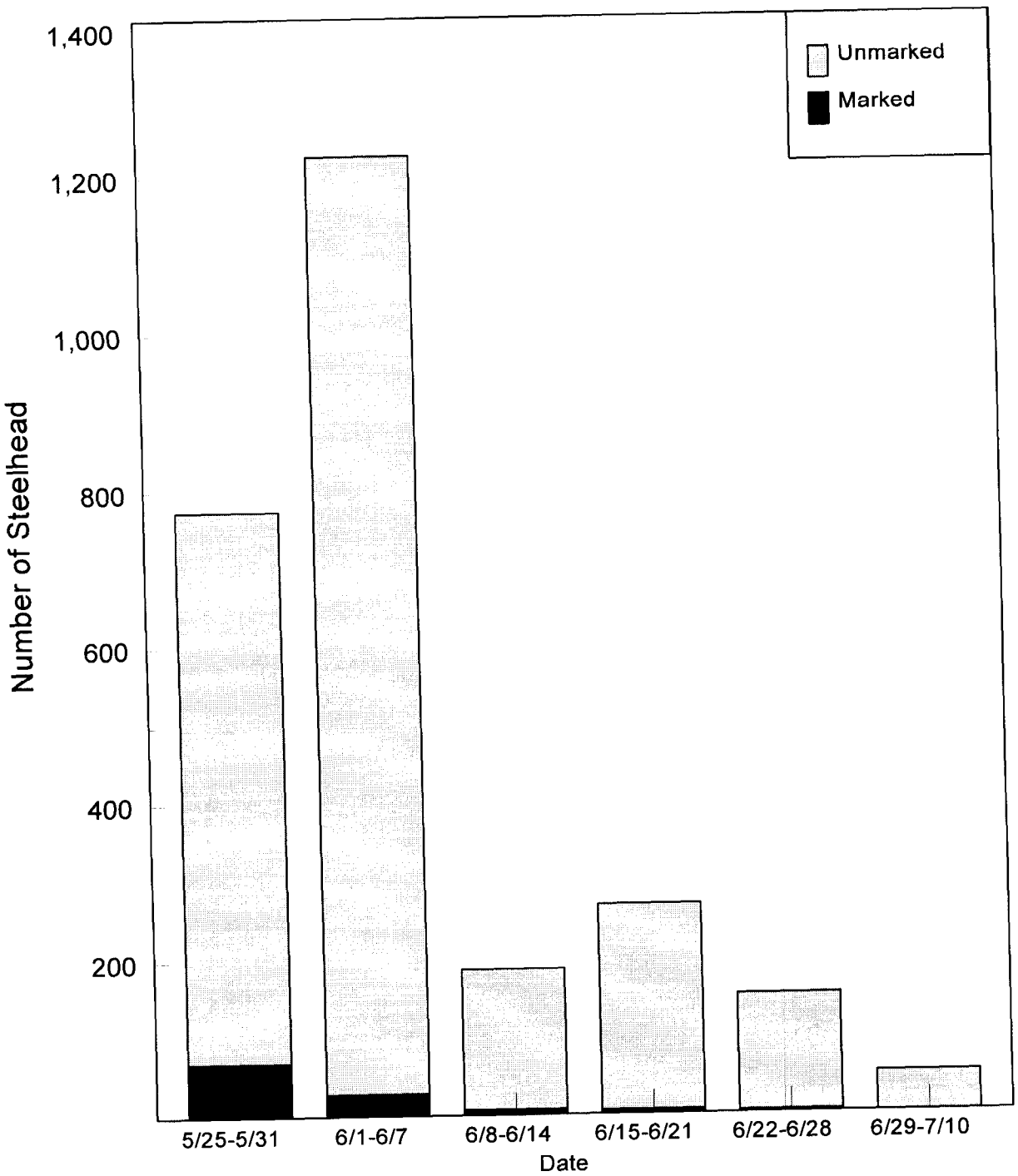
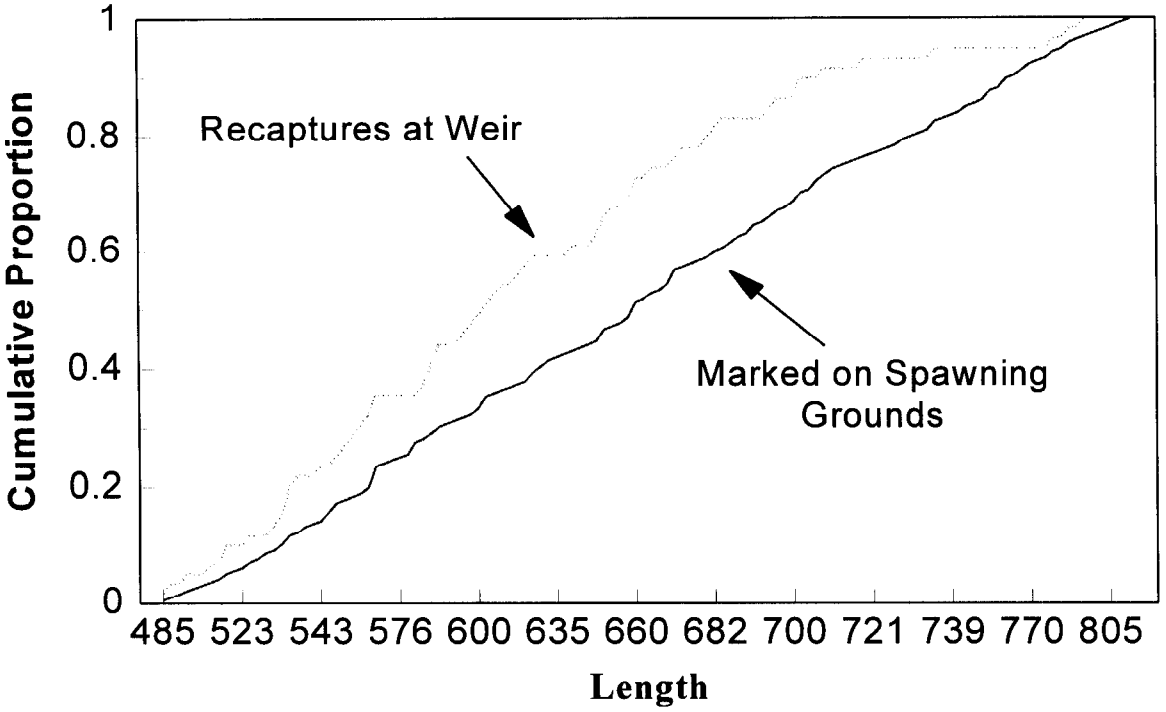


Figure 6.-Weekly comparison of marked and unmarked steelhead emigrating through the Karluk River weir, May 25 through July 10, 1996.



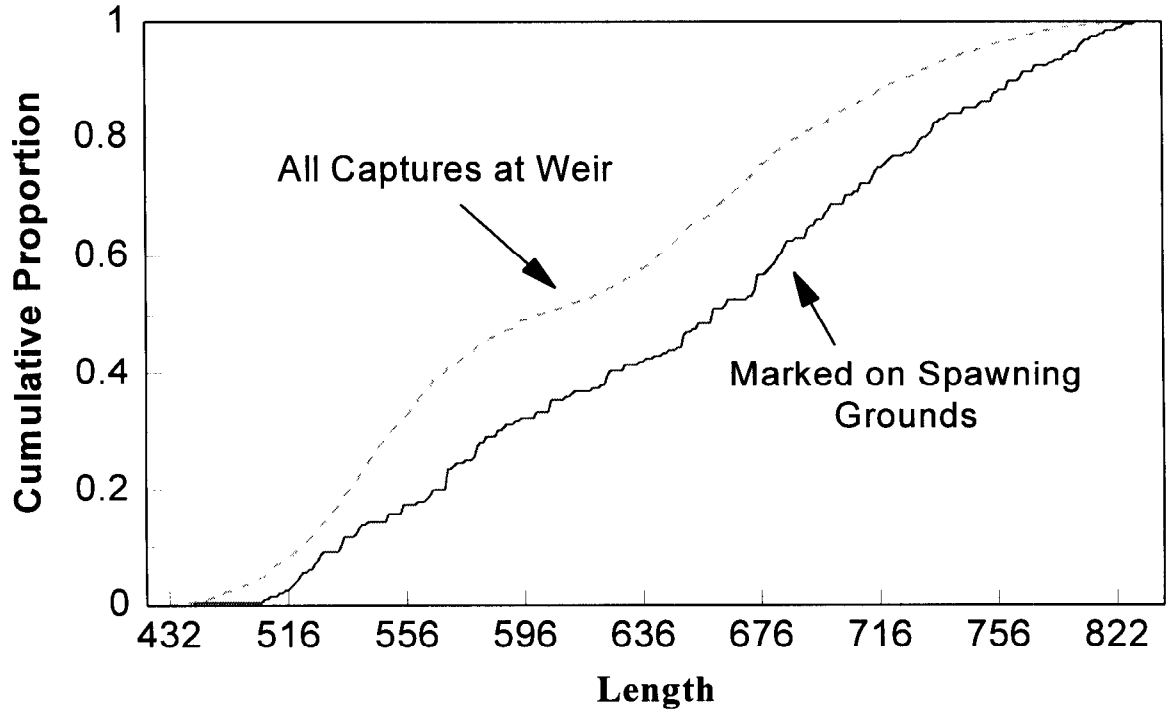


Figure 7.-Cumulative length distribution of all steelhead marked on the spawning grounds and all recaptured at the weir, and of all steelhead marked on the spawning grounds and all captured at the weir.

is likely due to random measurement error and to the large sample size, allowing us to detect differences that are biologically meaningless. Therefore, a single unstratified estimate of abundance was calculated. The estimated abundance of steelhead spawning in the Karluk River drainage during the spring of 1996 was 7,252 fish (SE = 674).

There was no significant difference in spawning history among weeks for all fish emigrating through the weir ($\chi^2 = 8.71$, df = 10, P = 0.56). Additionally, there was no significant difference in sex composition among weeks at the weir for initial spawners ($\chi^2 = 9.54$, df = 5, P = 0.09), repeat spawners ($\chi^2 = 4.72$, df = 5, P = 0.45) or multi-repeat spawners ($\chi^2 = 6.88$, df = 5, P = 0.23).

However, there was a significant difference among weeks in the proportion of males relative to females emigrating through the weir ($\chi^2 = 64.958$, df = 5, P < 0.001). This was largely due to the higher proportion of emigrating males observed during the first week of the kelt emigration and an increase in the number of females observed thereafter (Figure 8 and Table 9). Subsequent testing among sexes, spawning histories, and marine age detected significant differences in the marine age between sexes among all steelhead at the weir ($\chi^2 = 25.76$, df = 10, P < 0.001), and also significant differences in marine age between sexes among initial spawners at the weir ($\chi^2 = 26.66$, df = 10, P < 0.001). Due to these differences in the marine age composition over the duration of the emigration, estimates of the age composition by sex, spawning history, and marine age were stratified.

Biological Composition of the Spawning Population

The majority of steelhead sampled on the spawning grounds were initial spawners (82%, SE = 3) with a mean length of 635 mm FL (SE = 7) (Tables 10 and 11; Appendix A2). Mean length across all ages for spawning steelhead was 652 mm FL (SE = 6). Forty-four percent (SE = 4) of the spawning population was female. Thirty-five percent (SE = 4) of the fish that were aged were initial spawning females and 8% (SE = 2) repeat spawning females. Fifty-six percent (SE = 4) of the spawning population was male. Forty-seven percent (SE = 4) of the fish that were aged were initial spawning males and 8% (SE = 2) repeat spawning males (Table 10). Within each spawning history, females tended to be older than males. Repeat spawning females were mostly (77%, SE = 12) 5-ocean fish. The majority of the male repeat spawner category was 3- and 4-ocean fish. Females accounted for 75% (SE = 22) of the multi-repeat spawners with total marine age up to 7 years. Both sexes were dominated by initial spawners (79%, SE = 5, of the females and 85%, SE = 4, of the males).

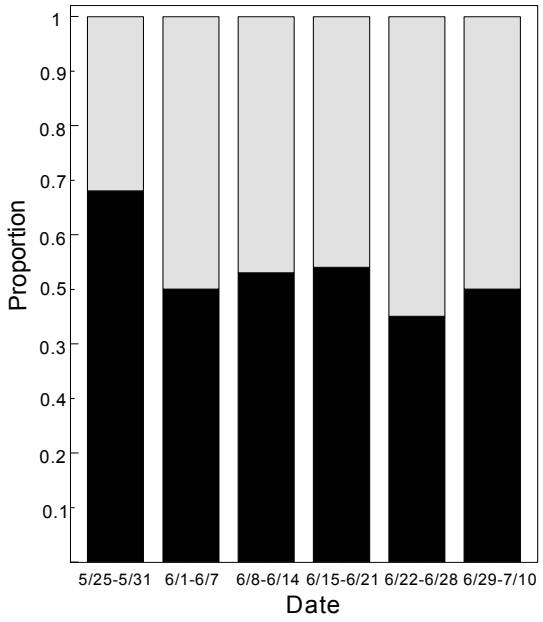


Figure 8.-Weekly comparison of the proportion of male (dark bars) and female (light bars) steelhead emigrating through the Karluk River weir, May 25 through July 10, 1996.

Table 9.-Sex composition of emigrating steelhead by week, Karluk River, 1996.

Spawning History	Sex	Weekly Totals May 25 through July 10						
		1	2	3	4	5	6	Total
Initial[a]	F	29	32	45	41	45	12	204
	M	75	58	58	61	47	24	324
	Total	104	90	103	102	92	36	528
Repeat[b]	F	7	12	14	13	19	8	73
	M	8	6	6	8	13	1	42
	Total	15	18	20	21	32	9	115
Multi-Repeat[c]	F	1	5	4	2	3	1	16
	M	5	1	2	2	1	1	12
	Total	6	6	6	4	4	2	28
Total	F	37	49	63	56	67	21	293
	M	88	65	66	71	61	26	377
Total		125	114	129	127	128	47	670

[a] Adults spawning for the first time in spring of 1996.

[b] Adults spawning for the second time in spring of 1996.

[c] Adults spawning for at least the third time in the spring of 1996.

Like the spawning population, the majority of emigrating steelhead were males (55%), of which 85% (SE = 2) were initial spawners (mean length 561 mm FL, SE = 3) and 12% (SE = 2) repeat spawners (mean length 639 mm FL, SE = 10) (Tables 12 and 13 and Appendix A3). Seventy-eight percent (SE = 2) of the emigrating population were initial, followed by repeat (17%, SE = 2) and multi-repeat (5%, SE = 1) spawners (Table 12).

Spawning Survival

Estimated survival of all steelhead was 36% (SE = 3) (Table 14). Survival of initial spawning steelhead was 32% (SE = 4), 35% (SE = 6) for females and 29% (SE = 5) for males. Survival for repeat spawning fish was the same for both sexes (23%, SE = 8). No multi-repeat spawners marked were recaptured, consequently their survival was estimated to be 0.0 %. However, multi-repeat spawners were observed at the weir, thus survival for this spawning history is biased low due to a small sample marked on the spawning grounds.

DISCUSSION

The total estimated bycatch of 203 steelhead during the 1995 commercial salmon fishery is

Table 10.-Age and sex composition of spawning steelhead trout in the Karluk River, April 1996, based on hook-and-line captures of the spawning population.

	Initial Spawners[a]				Repeat Spawners[b]				Multi-Repeat Spawners[c]				
	Marine Age				Marine Age				Marine Age				Grand
	2	3	4	Total	3	4	5	Total	5	6	7	Total	Total[d]
Females													
Number Sampled	6	53	1	60	0	3	10	13	0	2	1	3	86
Proportion	0.04	0.31	0.01	0.35	0.00	0.02	0.06	0.08	0.00	0.01	0.01	0.02	0.44
SE Proportion	0.01	0.04	0.01	0.04		0.01	0.02	0.02		0.01	0.01	0.01	0.04
Estimated Abundance	256	2,261	43	2,560		128	427	555		85	43	128	3,182
SE Abundance	105	332	43	356		74	137	156		60	43	74	404
Males													
Number Sampled	51	28	1	80	5	6	2	13	0	1	0	1	110
Proportion	0.30	0.16	0.01	0.47	0.03	0.04	0.01	0.08	0.00	0.01	0.00	0.01	0.56
SE Proportion	0.04	0.03	0.01	0.04	0.01	0.01	0.01	0.02		0.01		0.01	0.04
Estimated Abundance	2,176	1,194	43	3,413	213	256	85	555		43		43	4,070
SE Abundance	325	234	43	421	96	105	60	156		43		43	468
All													
Number Sampled	57	81	2	140	5	9	12	26	0	3	1	4	196
Proportion	0.34	0.48	0.01	0.82	0.03	0.05	0.07	0.15	0.00	0.02	0.01	0.02	1.00
SE Proportion	0.04	0.04	0.01	0.03	0.01	0.02	0.02	0.03		0.01	0.01	0.01	
Estimated Abundance	2,432	3,455	85	5,972	213	384	512	1,109		128	43	171	7,252
SE Abundance	346	424	60	594	96	129	150	225		74	43	86	674

[a] Adults spawning for the first time in the spring of 1996.

[b] Adults spawning for the second time in the spring of 1996.

[c] Adults spawning for at least the third time in the spring of 1996.

[d] Totals do not sum across the rows because sex was known for 26 fish that could not be aged.

Table 11.-Length-at-age, by spawning history and sex, of hook-and-line captures of the spawning population of the Karluk River, April 1996.

	Initial Spawners[b] Marine Age				Repeat Spawners[c] Marine Age				Multi-Repeat Spawners[d] Marine Age				Grand
	2	3	4	Total	3	4	5	Total	5	6	7	Total	Total[d]
Females													
Number Sampled	6	53	1	60	0	3	10	13	0	2	1	3	86
Mean Length[a]	517	673	710	658		695	746	734		738	795	757	678
SE Mean Length	8	5		8		7	6	8		13		20	7
Males													
Number Sampled	51	28	1	80	5	6	2	13	0	1	0	1	110
Mean Length[a]	558	719	860	618	607	695	818	680		830		830	631
SE Mean Length	4	12		10	15	23	18	24					9
All													
Number Sampled	57	81	2	140	5	9	12	26	0	3	1	4	196
Mean Length[a]	554	689	785	635	607	695	758	707		769	795	775	652
SE Mean Length	4	6	75	7	15	15	10	13		32		23	6

[a] Fork length (millimeters).

[b] Adults spawning for the first time spring of 1996.

[c] Adults spawning for the second time spring of 1996.

[d] Adults spawning for at least the third time in the spring of 1996.

[e] Totals do not sum across the rows because sex was known for 26 fish that could not be aged.

within the range of estimated bycatch reported since sampling of these fisheries began in 1991 (Table 15) and, like previous estimates, does not include steelhead sorted on the fishing grounds prior to arrival of catches at canneries, nor does it include incidental catch/harvest of kelts which occurs in commercial fisheries during June and July. From 1992 through 1995 all steelhead kelts emigrating through the Karluk River weir were tagged. Tag recoveries from sampled commercial fisheries could be used to estimate contribution of repeat spawning fish of Karluk River origin to commercial steelhead bycatch. However, because few tags were recovered during commercial catch sampling, contribution cannot be estimated. Bycatch is probably composed of mixed stocks, including initial and repeat spawning fish of Karluk River origin and adults from other systems that are within or are in close proximity to the statistical areas sampled such as the Ayakulik, Sturgeon, Little, and Uganik rivers (Figure 5). Commercial salmon harvests during 1995 were similar to those observed during catch sampling of the set gillnet fishery and greater than the harvest observed in the purse seine fishery during 1991 when the total estimated catch of steelhead exceeded 800 fish (Table 15 and Figure 9).

Table 12.-Age composition by spawning history and sex of steelhead emigrating through the Karluk River weir, May 25 through July 10, 1996.

	Initial Spawners[a]				Repeat Spawners[b]				Multi-Repeat Spawners[c]					
	Marine Age				Marine Age				Marine Age					Grand
	2	3	4	Total	3	4	5	Total	4	5	6	7	Total	Total[d]
5/25-6/14/96														
Females														
Number Sampled	30	74	3	107	2	7	25	34	2	2	5	1	10	151
Proportion	0.20	0.49	0.02	0.71	0.01	0.05	0.17	0.23	0.01	0.01	0.03	0.01	0.07	1.00
SE Proportion	0.03	0.04	0.01	0.04	0.01	0.02	0.03	0.03	0.01	0.01	0.01	0.01	0.02	0.00
Est. Abundance	184	455	18	658	12	43	154	209	12	12	31	6	61	928
SE Abundance	30	38	11	34	9	16	28	32	9	9	14	6	19	0
Males														
Number Sampled	171	20	0	191	13	11	1	25	6	2	0	0	8	224
Proportion	0.76	0.09	0.00	0.85	0.06	0.05	0.00	0.11	0.03	0.01	0.00	0.00	0.04	1.00
SE Proportion	0.03	0.02		0.02	0.02	0.01	0.00	0.02	0.01	0.01			0.01	0.00
Est. Abundance	921	108		1,029	70	59	5	135	32	11			43	1,207
SE Abundance	34	23		29	19	17	5	25	13	8			15	0
All														
Proportion	0.52	0.26	0.01	0.79	0.04	0.05	0.07	0.16	0.02	0.01	0.01	0.00	0.05	1.00
SE Proportion	0.02	0.02	0.00	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.01	
Est. Abundance	1,106	563	18	1,687	82	102	159	344	45	23	31	6	105	2,135
SE Abundance	46	44	11	45	21	24	29	41	16	12	14	6	24	0
6/15-7/10/96														
Females														
Number Sampled	21	77	0	98	1	7	32	40	0	2	2	2	6	144
Proportion	0.15	0.53	0.00	0.68	0.01	0.05	0.22	0.28	0.00	0.01	0.01	0.01	0.04	1.00
SE Proportion	0.03	0.04		0.04	0.01	0.02	0.03	0.04		0.01	0.01	0.01	0.02	0.00
Est. Abundance	34	126		161	2	11	52	66		3	3	3	10	236
SE Abundance	7	10		9	2	4	8	9		2	2	2	4	0
Males														
Number Sampled	121	11	1	133	10	11	1	22	3	1	0	0	4	159
Proportion	0.76	0.07	0.01	0.84	0.06	0.07	0.01	0.14	0.02	0.01	0.00	0.00	0.03	1.00
SE Proportion	0.03	0.02	0.01	0.03	0.02	0.02	0.01	0.03	0.01	0.01			0.01	0.00
Est. Abundance	182	17	2	200	15	17	2	33	5	2			6	239
SE Abundance	8	5	2	7	5	5	2	7	3	2			3	0
All														
Proportion	0.46	0.30	0.00	0.76	0.04	0.06	0.11	0.21	0.01	0.01	0.01	0.01	0.03	1.00
SE Proportion	0.02	0.02	0.00	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.01	
Est. Abundance	216	143	2	361	17	28	54	99	5	5	3	3	16	475
SE Abundance	11	11	2	12	5	6	8	11	3	3	2	2	5	0

-continued-

Table 12.-Page 2 of 2.

	Initial Spawners[a] Marine Age				Repeat Spawners[b] Marine Age				Multi-Repeat Spawners[c] Marine Age					Grand
	2	3	4	Total	3	4	5	Total	4	5	6	7	Total	Total[d]
5/25-7/10/96[e]														
Females														
Proportion	0.08	0.22	0.01	0.31	0.01	0.02	0.08	0.11	0.00	0.01	0.01	0.00	0.03	0.45
SE Proportion	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00
Est. Abundance	219	581	18	818	14	54	206	275	12	16	34	9	71	1,164
SE Abundance	31	39	11	36	9	16	29	33	9	9	14	7	19	0
Males														
Proportion	0.42	0.05	0.00	0.47	0.03	0.03	0.00	0.06	0.01	0.00			0.02	0.55
SE Proportion	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00			0.01	0.00
Est. Abundance	1,103	124	2	1,229	85	76	7	168	37	12			49	1,446
SE Abundance	35	24	2	29	19	18	6	26	13	8			15	0
All														
Proportion	0.51	0.27	0.01	0.78	0.04	0.05	0.08	0.17	0.02	0.01	0.01	0.00	0.05	1.00
SE Proportion	0.02	0.02	0.00	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.01	
Est. Abundance	1,322	705	20	2,047	99	130	213	442	49	28	34	9	120	2,610
SE Abundance	47	46	11	46	21	24	30	42	16	12	14	7	25	0

[a] Adults spawning for the first time in spring of 1996.

[b] Adults spawning for the second time in spring of 1996.

[c] Adults spawning for at least the third time in the spring of 1996.

[d] The grand total for each sex in each time strata is not estimated, these are observed counts for each sex at the weir.

[e] Proportions by sex and age class in the total emigration (5/25-7/10/96) are calculated from the estimated abundance for each class, which is summed across time strata.

The disparity in the total estimated bycatch of steelhead between these years could be explained by temporal trends in salmon harvests. No commercial harvest was reported during the late September 9/22-9/30 stratum during 1995. In the 1991 fishery harvests extended into late September. The highest bycatches in 1991 occurred in mid-September, past the time when sampling stopped in 1995. Temporal shifts in both the purse seine and set gillnet fisheries into the later half of September have the potential to impact adult steelhead returning to the Karluk River (Table 15).

During the autumn of 1995 anglers who fished the Karluk River for steelhead and were interviewed by ADF&G personnel released 99% of all steelhead caught (Table 7). Current sport fishing regulations allow anglers to harvest two steelhead daily, of which only one may be 20 inches (508 mm) or more in total length. Since effort, catch, and harvest levels were similar to those observed during the 1994 autumn creel census at the Portage area, no changes in the sport fishing regulations regarding steelhead need to be pursued at this time.

Table 13.-Length-at-age of emigrating steelhead by spawning history and sex, Karluk River, 1996.

	Initial Spawners[b]				Repeat Spawners[c]				Multi-Repeat Spawners[d]					
	Marine Age				Marine Age				Marine Age					Grand
	2	3	4	Total	3	4	5	Total	4	5	6	7	Total	Total[e]
Females														
Number Sampled	51	151	3	205	3	14	57	74	2	4	7	3	16	1,164
Mean Length[a]	547	657	728	631	611	667	724	708	650	676	749	781	724	661
SE Mean Length	6	3	36	4	6	12	5	5	50	15	14	25	15	2
Males														
Number Sampled	292	31	1	324	23	22	2	47	9	3	0	0	12	1,446
Mean Length[a]	545	711	804	561	576	697	727	639	626	628			626	576
SE Mean Length	1	5		3	5	8	33	10	16	53			17	2
All														
Number Sampled	343	182	4	529	26	36	59	121	11	7	7	3	28	2,610
Mean Length[a]	545	666	747	588	580	685	724	681	630	655	749	781	682	614
SE Mean Length	2	3	32	3	5	7	5	6	15	24	14	25	14	2

[a] Fork length (millimeters).

[b] Adults spawning for the first time spring of 1996.

[c] Adults spawning for the second time spring of 1996.

[d] Adults spawning for at least the third time in the spring of 1996.

[e] Total of all fish measured at the weir, including those that were not aged.

The sport fishing statistics of effort, catch and harvest estimated through the Statewide Harvest Survey are biased low for the Karluk River steelhead fishery. This is because anglers who purchase fishing licenses after August 30 are not included in the postal survey sample. This results in a biased estimate for the Karluk fishery because steelhead are targeted from mid-September through November, and the fishery attracts a growing number of non-resident anglers who purchase licenses after August 30. Therefore, as the total number of angler days of effort expended at the Karluk River continues to increase, periodic censusing of the autumn steelhead fishery at the Portage area of the Karluk River should be pursued so that growth in this fishery can be accurately assessed.

Another source of inriver mortality for Karluk River steelhead are the subsistence fisheries conducted by residents of both Karluk Village and Larsen Bay. These fisheries were not sampled during 1996, but have been sporadically surveyed since 1982 (Appendices B1 and B2). The Karluk Village subsistence fishery targets immigrating salmon, primarily beginning in May and continuing until October. Effort increases in response to the

Table 14.-Spawning survival of steelhead marked on the spawning grounds and recaptured at the weir by sex and spawning history, Karluk River, 1996.

	Initial[a]	Repeat[b]	Multi-Repeat[c]	Total[d]
Females				
Number marked	60	13	3	86
Number Recaptured	21	3	0	31
Estimated Survival	0.35	0.23	0.00	0.36
SE Survival	0.06	0.12	0.00	0.05
Males				
Number marked	82	13	1	110
Number Recaptured	24	3	0	39
Estimated Survival	0.29	0.23	0.00	0.35
SE Survival	0.05	0.12	0.00	0.05
All				
Number marked	142	26	4	196
Number Recaptured	45	6	0	70
Estimated Survival	0.32	0.23	0.00	0.36
SE Survival	0.04	0.08	0.00	0.03

[a] Adults spawning for the first time in the spring of 1996.

[b] Adults spawning for the second time in the spring of 1996.

[c] Adults spawning for at least the third time in the spring of 1996.

[d] Totals do not add because the age of some steelhead could not be determined due to illegible or regenerated scales.

influx of chinook, sockeye and coho salmon during those months. With large numbers of emigrant kelts available in this fishery during the latter part of May and June, and returning adults available in September, it is likely that steelhead are taken annually in the village subsistence salmon harvest. Therefore, the reporting of catch and harvest of steelhead in this fishery should be included on subsistence harvest permits so impacts of this fishery can be assessed. In Karluk Lagoon, state regulations allow the incidental harvest of steelhead for subsistence use in net fisheries directed at immigrating salmon.

The Portage area winter fishery prosecuted by residents of Larsen Bay 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. In addition, rod and reel is not a legal subsistence gear while on state or private lands such as the Karluk River. Steelhead may be taken on the upper Karluk River by

Table 15.-Summary of commercial catch sampling for the incidental catch of steelhead trout from the Karluk River marine study area, August 15 through September 30, 1991 through 1995.

	Strata					
	8/15-8/31	9/01-9/07	9/08-9/14	9/15-9/21	9/22-9/30	Total
1991[a]						
Set Gillnet[b]	112	49	42	11	e	214
Tender Purse Seine	51	42	309	150	53	605
Total	163	91	351	161	53	819
1992[c]						
Set Gillnet[b]	93	41	22	9	e	165
Tender Purse Seine and Set Gillnet	65	107	67	58	34	331
Total	158	148	89	67	34	496
1993[d]						
Set Gillnet[b]	38					38
Tender Purse Seine	20					20
Tender Set Gillnet	5					5
Total	63					63
1994						
Set Gillnet[b]	82	24	0	25	101	232
Tender Purse Seine	40	9	f	16	e	65
Tender Set Gillnet	16	12	f	16	e	44
Total	138	45	0	57	101	341
1995						
Set Gillnet[b]	50	82	0	0	0	132
Tender Purse Seine	17	54	e	e	f	71
Tender Set Gillnet	0	0	e	e	f	0
Total	67	136	0	0	0	203
Mean Total	118	84	88	57	38	384

[a] No tenders unloading set gillnet catches were sampled.

[b] Set Gillnet = Total number of steelhead retained for personal use and number released, obtained from catch calendar survey.

[c] Tender sampling included combined set gillnet and purse seine catches.

[d] No commercial catches were sampled following 8/15-8/31 strata due to commercial closures.

[e] Commercial harvest not sampled.

[f] No commercial harvest reported.

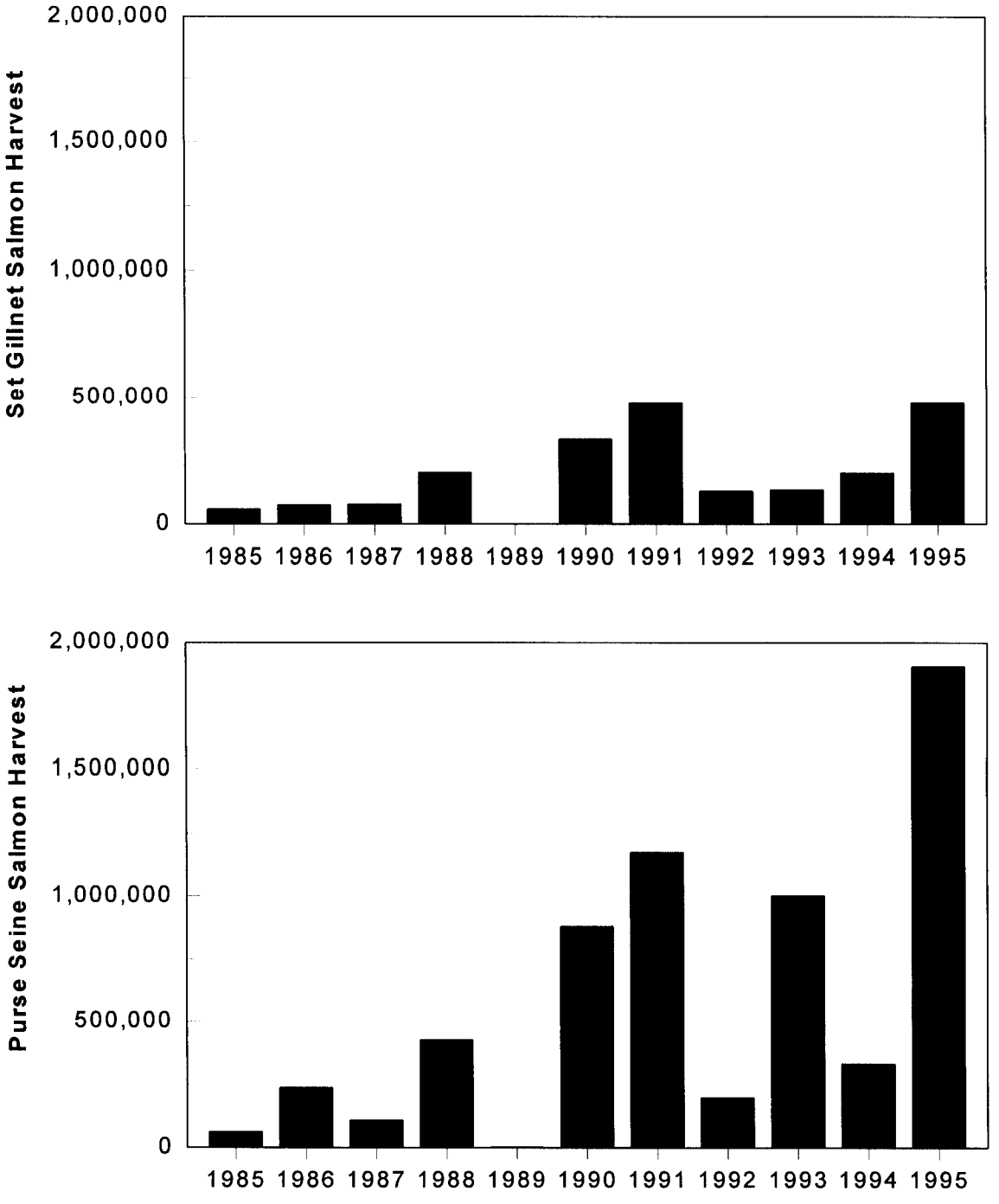


Figure 9.-Set gillnet and purse seine harvest of salmon from the five statistical areas included in the Karluk marine study area, August 15 through September 30, 1985 through 1995. There was no set gillnet fishery in 1989 due to the *Exxon Valdez* oil spill.

rod and reel from June 15 through March 31 under sport fishing provisions with a limit of two fish per day of which only one may be in excess of 20 inches (508 mm) in length. The close proximity of the Portage area on the Karluk River to the village and historic subsistence patterns (Figure 1 and Appendix B2) make it likely that residents will continue to annually target overwintering steelhead at this location. This accessibility, combined with the high catchability and concentrations of these fish at the Portage, make them vulnerable to harvest during winter months. Therefore, so that total harvest estimates of steelhead during this localized winter sport fishery can be better assessed, consideration should be given to collection of reliable harvest data from this fishery.

The estimated abundance of 7,252 spawning steelhead is within the range of estimates observed since 1992 (Table 16). However,

Table 16.-Population estimates and spawning survival to weir emigration of Karluk River steelhead by sex, 1992 through 1996.

	1992	1993	1994	1995	1996	Mean
Females						
Estimated Spawning Population	1,602	4,687	4,188	6,629	3,182	4,058
SE Spawning Population	132	235	321	388	392	
Weir Count[a]	999	2,654	2,203	4,214	1,160	2,246
Estimated Survival	0.62	0.55	0.43	0.68	0.36	0.53
SE Survival	0.03	0.04	0.05	0.03	0.05	
Males						
Estimated Spawning Population	2,505	2,339	4,928	4,174	4,070	3,603
SE Spawning Population	109	154	347	327	457	
Weir Count[a]	1,583	1,428	2,435	2,487	1,445	1,876
Estimated Survival	0.63	0.50	0.51	0.54	0.35	0.51
SE Survival	0.04	0.05	0.05	0.04	0.05	
All						
Estimated Spawning Population	4,107	7,026	9,116	10,803	7,252	7,661
SE Spawning Population	134	308	522	437	674	
Weir Count[a,b]	2,744	4,103	4,638	6,743	2,613	4,168
Estimated Survival	0.67	0.58	0.51	0.62	0.36	0.55
SE Survival	0.03	0.04	0.04	0.03	0.06	

[a] Number of emigrant steelhead examined for marks.

[b] Total number of fish is greater than the sum of males and females because sex was not determined for some fish in the emigration.

steelhead were observed in the lower river and lagoon by both village residents and weir personnel prior to, during and immediately following weir installation. Therefore, the 1996 estimate of survival is biased low.

Spawning survival to emigration observed in 1996 is below the range of survival estimated since 1992 (Table 16). Unusually low water conditions during 1996 may have contributed to the early emigration (Figure 10) and could have contributed to the low spawning survival.

This spawning survival estimate includes only inriver survival and does not consider the period of reconditioning to the marine environment. A more accurate accounting of spawning survival should include survival of emigrating kelts in the marine environment. We have the data to investigate the relationship between kelt counts and the age, sex and spawning histories of subsequent returns. Continued capture and tagging of a portion of the spawning population and censusing of emigrating kelts at the weir will allow estimation of spawner abundance, providing relationships between kelt counts and spawning population size.

The component of initial spawners (82%) in the Karluk River during April of 1996 was within the range reported since this study

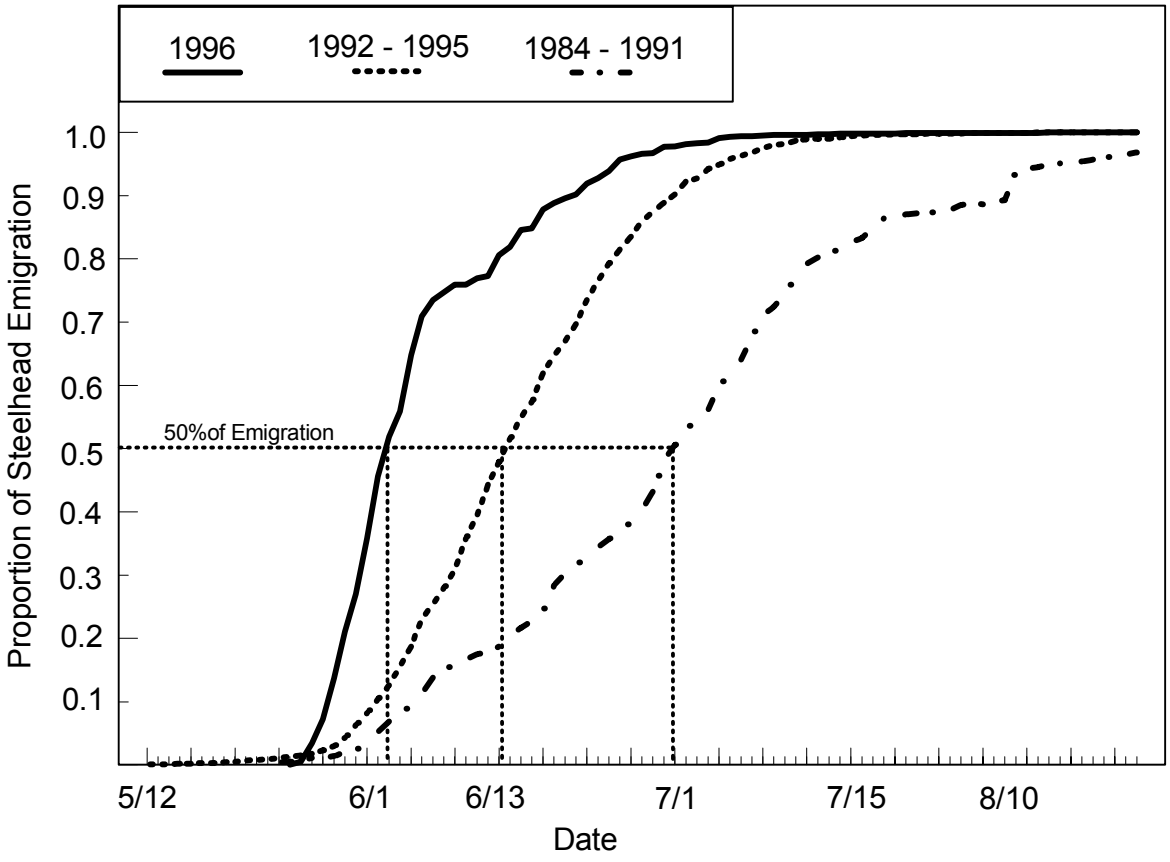


Figure 10.-Time of emigration of Karluk River steelhead, 1984 through 1996.

began (78%-87%) (Begich 1992, 1993, and 1995a and 1995b). Data collected at the Karluk weir since 1992 indicate steelhead kelt respawning is an important addition to annual spawner abundance (Table 17).

ADF&G also operates a weir at the nearby Ayakulik River annually. During 1996, 70% of all steelhead sampled for age were initial spawning fish at the Ayakulik River (Appendix C1 and C2). Interestingly, a repeat spawning fish tagged at the Karluk River weir in 1994 was recaptured at the Ayakulik weir in 1996. This is the first Karluk recapture in this nearby system, and the fourth year in which emigrating kelts at the Ayakulik River have been examined for marks and subsampled for age while marked fish of Karluk origin have been at large (Figure 5). Therefore, straying of adult repeat spawning steelhead between these two systems is most likely an anomaly.

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Table 17.-Recapture history of steelhead released with marks at Karluk weir 1992-1995, and recaptured at Karluk weir 1993 through 1996.

Year Released	Number Released With Marks	Recaptures at weir 1993	1994	1995	1996	Total[a]
1992	2,584	236	487	66	19	808
1993	4,084		225	1,037	34	1,296
1994	4,910			414	384	798
1995	6,466				227	227
Mean	4,511					782

[a] Number of marked repeat or multi-repeat spawners observed at weir, not the sum of individual fish.

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APPENDIX A. LENGTH-AT-AGE DATA FOR STEELHEAD FROM THE KARLUK RIVER STUDY AREA, 1995

Appendix A1.-Length-at-age of steelhead captured in the purse seine fishery near the Karluk River, 1995.

	Females			Males			All		
Age Class[a]	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE
2.1	2	528	12	2	536	17	4	532	11
2.2	2	679	22	1	755		3	704	26
R.1	0			4	544	12	4	544	12
R.2	2	678	35	0			2	678	35
R.2s1	0			1	674		1	674	
Total	6	628	32	8	585	28	14	603	22

[a] R = regenerated freshwater annulus.

Appendix A2.-Length-at-age of hook-and-line captures of the spawning population, Karluk River, April 1996.

	Females			Males			All		
Age Class[a]	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE
2.2	4	512	10	28	561	5	32	555	6
2.3	24	666	7	15	744	9	39	696	8
3.3	3	689	23	1	684		4	688	17
2.2s1	0			3	594	15	3	594	15
2.2s2	0			3	703	32	3	703	32
2.3s1	0			2	690	6	2	690	6
2.3s2	5	749	9	2	818	12	7	769	14
3.3s2	1	735		0			1	735	
2.3s2s1s	1	751		0			1	751	
2.3s2s2	1	795		0			1	795	
R.2	2	527	5	24	554	5	26	552	5
R.3	27	676	7	12	688	22	39	680	9
R.4	1	710		1	860		2	785	53
R.2s1	0			2	626	18	2	626	18
R.2s2	0			2	717	12	2	717	12
R.3s1	1	705		1	630		2	668	27
R.3s2	4	746	7	0			4	746	7
R.3s2s1	1	725		1	830		2	778	37
Total[b]	86	678	7	110	631	9	196	652	6

[a] R = regenerated freshwater annulus.

[b] Totals do not add because some fish that were measured could not be aged due to illegible or regenerated scales.

Appendix A3.-Length-at-age of emigrating steelhead captured at the Karluk weir, Karluk River, 1996.

	Females			Males			All		
Age[a]	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE
2.2s	26	546	9	177	544	2	203	544	2
2.3s	76	657	4	15	698	7	91	664	4
3.2s	2	554	8	13	555	6	15	555	5
3.3s	16	685	5	0			16	685	5
2.2s1s	0			10	576	9	10	576	9
2.2s2s	3	675	28	8	701	16	11	694	14
2.3s1s	4	657	9	0			4	657	9
2.3s2s	25	720	7	1	760		26	721	6
3.3s2s	4	736	20	0			4	736	20
2.2s1s1s	0			3	606	17	3	606	17
2.2s2s1s	2	661	13	0			2	661	13
2.3s2s1s	3	761	18	0			3	761	18
2.3s2s2s	1	756		0			1	756	
2.2s1s1s1s	0			1	608		1	608	
R.2s	23	549	9	102	545	3	125	545	3
R.3s	59	649	4	16	724	6	75	665	5
R.4s	3	728	36	1	804		4	747	32
R.2s1s	3	611	6	13	576	7	16	582	9
R.2s2s	2	650	0	14	695	9	16	689	8
R.2s1s1s	2	650	50	6	635	23	8	639	19
R.3s1s	5	676	32	0			5	676	32
R.3s2s	28	725	7	1	694		29	724	7
R.2s2s1s	0			1	728		1	728	
R.3s1s1s	2	691	28	1	547		3	643	51
R.3s2s1s	3	759	10	0			3	759	10
R.3s2s2	2	756	38	0			2	794	38
R.3s1s1s1s	1	680		0			1	680	
Total aged	295	655	4	383	573	3	678	609	3
Total sexed	1,164	661	2	1,446	576	2	2,610	614	2

[a] R = regenerated freshwater annulus.

APPENDIX B. HISTORICAL SUBSISTENCE HARVESTS FROM KARLUK VILLAGE AND LARSEN BAY

Appendix B1.-Subsistence harvest of steelhead by residents of Karluk Village, 1982-1994. Not sampled during 1995 or 1996.

Years	Total Reported Harvest[b]	Number Households in Sample	Mean Harvest 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[a]	36	13	2.76	17	47	[d]
1992[e]	57	9	6.33	17	107	5
1993[e]	0	6	0.00	17	0	[d]
1994[e]	20	8	2.5	14	35	8

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

[b] From household interviews.

[c] Product of mean harvest 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, covered the period from the September prior to the survey year to July of the survey year.

Appendix B2.-Subsistence harvest of steelhead by residents of Larsen Bay since 1982. Not sampled during 1996.

Years	Total Reported Harvest[b]	Number Households in Sample	Mean Harvest per Household	Number Households in Community	Estimated Community Harvest[c]	SE
1982-1983[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
1990-1991[a]	215	38	5.66	43	243	[d]
1991-1992[a]	230	35	6.57	40	263	[d]
1992-1993[a]	614	37	16.6	42	697	6
1993-1994[a]	312	40	7.80	49	382	7
1994-1995[e]	0	21	0.00	45	0	

[a] Source: Community Profile Database, Division of Subsistence, Alaska Department of Fish and Game, Anchorage. Survey years 1990 through 1993 cover the period from April 1 of the survey year to March 31 of the following year.

[b] From household interviews.

[c] Product of mean harvest 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, August 1995.

APPENDIX C. AYAKULIK RIVER STEELHEAD LENGTH-AT-AGE AND SPAWNING HISTORIES, 1996

Appendix C1.-Length-at-age of emigrating steelhead captured at the Ayakulik weir, Ayakulik River, 1996.

	Females			Males			All		
Age Class[a]	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE	Number Sampled	Mean Length	SE
2.2s	9	613	26	23	554	5	32	571	11
2.3s	46	664	4	17	674	14	63	667	5
2.4s	0			1	842		1	842	
3.2s	2	548	2	2	576	7	4	562	8
3.3s	4	679	11	2	723	44	6	694	19
2.2s1s	0			2	574	31	2	574	31
2.2s2s	0			1	664		1	664	
2.3s1s	1	611		1	510		2	561	36
2.3s2s	7	723	20	3	749	4	10	731	14
3.2s2s	1	689		0			1	689	
3.3s2s	1	729		0			1	729	
2.3s2s2s	2	777	44	0			2	777	44
3.3s2s2s	1	765		0			1	765	
R.2s	2	543	2	7	537	14	9	561	24
R.3s	15	679	8	8	669	14	23	675	7
R.2s1s	0			1	654		1	654	
R.2s2s	0			4	698	20	4	698	20
R.3s1s	3	698	12	3	602	28	6	650	25
R.3s2s	6	714	18	1	793		7	724	18
R.2s1s1s	1	754		1	619		2	687	48
R.3s2s2s	1	785		0			1	785	
Total[b]	115	675	5	82	623	9	197	653	5

[a] R = Regenerated freshwater annulus.

[b] Totals do not add because some fish that were measured could not be aged due to illegible or regenerated scales.

Appendix C2.-Length-at-age of emigrating steelhead by spawning history and sex, Ayakulik River, 1996.

Spawning History	Marine Age	Females Sample Size	Females Mean Length	Females SE	Males Sample Size	Males Mean Length	Males SE	All Sample Size	All Mean Length	All SE
Initial[a]	2	13	608	23	32	552	8	45	568	10
	3	65	668	4	27	676	11	92	671	4
	4	0	755		1	842		1	842	
Repeat[b]	3	0			3	601	27	3	601	27
	4	5	679	17	9	641	25	14	655	18
	5	14	720	13	4	760	10	18	729	11
Multi-Repeat[c]	4	1	754		1	619		2	687	48
	5	0			0			0		
	6	0			0			0		
	7	4	776	22	0			4	776	22
Initial		77	659	2	60	613	11	138	639	6
Repeat		51	709	11	16	663	31	35	688	12
Multi-Repeat		5	771	18	1	619		6	746	28
Total[d]		115	675	5	82	623	9	197	653	5

[a] Adults spawning for the first time in the spring of 1996.

[b] Adults spawning for the second time in the spring of 1996.

[c] Adults spawning for at least the third time in the spring of 1996.

[d] Totals do not add because some fish that were measured could not be aged due to illegible or regenerated scales.