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Biological Issues of the Kenai River and Kasilof River Early-run King Salmon Fisheries

By

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and

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

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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The Special Publications series was established in 1991 for the publication of techniques and procedures manuals, informational pamphlets, special subject reports to decision-making bodies, symposia and workshop proceedings, application software documentation, in-house lectures, and other documents that do not fit in another publication series of the Division of Sport Fish. Special Publications are intended for fishery and other technical professionals. Special Publications are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

EXECUTIVE SUMMARY

- The current BEG range for early-run Kenai River king salmon is 7,200 to 14,400 fish. Escapements greater than 16,500 do not produce well. The lowest observed escapement produced well, but there is only one year of information at this low level of escapement. Future years of returns will help better define an escapement goal for this stock, but the current BEG range should be maintained until more is known.
- There has been a decline in the number and percentage of the largest king salmon in the Kenai River. Some of this decline may be due to the targeting of large king salmon by the sport fishery, but other factors are also causing the decline. We advise that a precautionary approach to protect large king salmon should be taken.
- Disproportionate harvest of early-run king salmon by time has occurred in the past, primarily early in the season during years of fishery restrictions. This "front-end" loading of harvest should be avoided in the long-term because it could cause shifts in run-timing.
- The current regulatory sanctuaries on the Kenai River for king salmon help protect fish as they move into spawning tributaries in July. However, further protection of early-run king salmon in July may be required when returns fall below the escapement goal.
- Catch-and-release mortality is low for early-run Kenai River king salmon, but the effect of multiple captures on mortality is unknown. Catch-and-release remains a viable tool for managing early-run king salmon.
- Although there are problems with the sonar, we are confident that the overall assessment of run strength of early-run Kenai River king salmon is reliable and sufficient for managing this resource and maintaining escapements within the BEG range.
- We found no direct evidence for an increase in harvest of king salmon or overall fishing effort in the Kasilof River when the Kenai River is restricted. However, the effect of restrictions on the Kenai River on other fisheries, including the Kasilof River, should be considered when regulatory changes are made.
- Kasilof River king salmon should be managed with the current precautionary approach until more is known about this stock. An assessment project is underway that should provide better information in the future.

HISTORY AND CURRENT REGULATIONS

Prior to the February 2002 Board of Fisheries (BOF) meeting, the Kenai River Early-run King Salmon Management Plan (5 AAC 56.070) stipulated a biological escapement goal (BEG) of 7,200 to 14,400 fish. If the upper end of the BEG would be exceeded, the Plan allowed for bait in the sport fishery. If the lower end of the BEG was not being achieved, the Plan allowed for either a harvest of fish 52 inches and longer or closure of the fishery. At the February 2002 BOF meeting the department and users expressed concern about a decrease in numbers of larger king salmon and an apparent lack of stability and predictability in the fishery. Based on these concerns the BOF revised the Management Plan for early-run Kenai River king salmon to allow for a harvest of king salmon smaller than 40 inches or 55 inches and longer in length from

January 1 through June 10. Bait was not allowed during this time period. From June 11 through June 30 only king salmon 55 inches and longer could be harvested, and bait could be allowed if the BEG was being met. These regulations were designed to both increase the escapement of larger king salmon and decrease the probability of inseason restrictions to the fishery.

At the same time, a number of regulatory changes were enacted for the early-run Kasilof River king salmon fishery. These changes were: guides may not fish while guiding clients; guides may have only one set of clients per day; and, guide boats must have the Commercial Fisheries Entry Commission (CFEC) triangle number or Kenai River State Parks registration number visible on the boat. In addition, fishing is not allowed from motorized boats from January 1 to July 31, and only three of the five king salmon annual limit in Cook Inlet may come from the Kasilof River.

Due to public discontent with the new regulations and assertions that there was insufficient public input into the changes, in June 2002 the BOF rescinded the June 11-30 size regulation on the Kenai River until April 15, 2003. They also developed a proposal for the March 2003 BOF meeting to reexamine the biological, social, and economic aspects of the Kenai and Kasilof early-run king salmon fisheries and, if necessary, make changes to the Management Plan and existing sport fishing regulations.

This document provides information on biological issues surrounding Kenai River and Kasilof River early-run king salmon. The purpose of this report is to clarify the current state of knowledge of these issues; it does not represent a change in the Department's position concerning these issues since the February 2002 BOF meeting. In addition, we do not consider these two king salmon populations as stocks of concern as described in the Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222). In other words, there has been no " . . . concern arising from a chronic inability . . ." to maintain a harvestable surplus or achieve escapements of these stocks. Except for 2002, returns of early-run Kenai River king salmon have been great enough to allow for harvest and still achieve the current BEG range (Figure 1). Our assessment of the BOF proposal for the March 2003 meeting centers on the following biological issues.

BIOLOGICAL ISSUES

- **At current levels of effort and harvest potential, we are unable to meet minimum escapement objectives for early-run Kenai River king salmon without further inseason restrictions to the fishery.**

  - ***What is the escapement objective for early-run Kenai River king salmon?***

  In December 1988 the BOF decided to set the BEG at 9,000 fish based on a desired return of 27,000 fish and an assumed return-per-spawner of 3 to 1. Beginning with the 1999 season, the BEG has been a range of 7,200 to 14,400 fish which was 80% to 160% of the existing BEG of 9,000 fish. The BEG was changed from a single number to a range to provide for a wider range of escapements and to recognize uncertainty in the data. This uncertainty includes the short time series of data, the small variation in observed escapements, and the measurement error in estimating escapement, all of which affect accurate estimation of stock productivity and the spawning population that produces maximum sustained yield. The BEG was formally reviewed again by a department committee prior to the 2002 BOF meeting and no change was made. Given the uncertainty in the data and the recent review of the BEG, we do not recommend changing the BEG.

We have only 10 years (1986-1995) of complete and one year (1996) of near complete brood year data. The lowest observed escapement of 5,331 fish in 1988 produced a good return (Figure 2) and the largest return per spawner (Figure 3) and yield (Figure 4). Escapements of 8,500-12,000 fish produced moderate returns. The highest escapements of over 16,500 fish in 1986 and 1996 produced the lowest returns (Figures 2, 3, and 4). This information indicates that the one observed escapement of 5,331 fish produced a good return while escapements of 16,500 fish or more produced low returns. Estimating the returns from the high 1999 escapement and the low 2002 escapement (Figure 5) will provide additional information on the productivity of this stock. The BEG of early-run Kenai River king salmon will be re-evaluated as additional years of information are obtained.

- ***Prior to 2002 we had been meeting the early-run BEG, so what is the problem?***

It is true that prior to 2002 the BEG had been met or exceeded in all years since the Management Plan went into effect in 1989 (Figure 5). Prior to implementation of the Plan, the BEG was achieved in every year except 1988. However, the sport fishery was restricted for part of the season in 7 of the last 14 years since development of the Plan.

The Department thought that changing the BEG from a single number to a range would decrease the need for inseason restrictions, but since the change to a BEG range in 1999 we have restricted the fishery in 2 of the last 4 years. Aside from closing the fishery entirely in 2002, escapements were achieved in other years by either restricting the fishery to catch-and-release or to “trophy fishing.” The problem is that although inseason actions have maintained escapements of king salmon in the Kenai River, the overall demand for early-run king salmon still exceeds the number available for harvest during many years.

- ***In what fisheries are early-run Kenai River king salmon harvested?***

Harvest of these fish occurs in at least five fisheries: the Central Cook Inlet (CCI) marine sport fishery, the Upper Subdistrict set gillnet (Eastside set net) commercial fishery, an inriver educational fishery, an inriver sport fishery, and a new inriver federal subsistence fishery (Figure 6).

The majority of the harvest of early-run Kenai River king salmon occurs in the inriver sport fishery. Estimates of total sport harvest in the entire river have ranged from about 1,200 to over 15,000 fish since 1986 (Figure 7). In most years harvest was 2,000 to 9,000 fish. Most of this harvest occurs in the lower river. Since 1986, 60% or more of the harvest occurred downstream of the Soldotna Bridge in most years (Figure 7). Harvest and harvest rate were greatest in 1987 and 1988 (Figure 8), prior to enactment of the first Management Plan. Both harvest and harvest rate declined in 1990-1992, years the fishery was restricted to catch-and-release or trophy fishing. Harvest and harvest rate increased during the mid-1990s but have in general declined since 1998 due to inseason restrictions (1998, 2000, and 2002) or poor water clarity (2001). Harvest rate averaged 41% among years the fishery was not restricted and 20% among years the fishery was restricted.

Based on onsite creel survey data, the percentage of the harvest by guided anglers downstream of the Soldotna Bridge has gradually increased since the late 1980s (Figure 9). Guided anglers accounted for about half of the harvest downstream of the bridge during the late 1980s. The percentage increased in 1989 and again in 1990, but declined in 1991 and 1992, years the fishery was restricted. The percentage harvest by guided anglers gradually increased during the mid-1990s and, except for 2001, has been about 75% to 80% each year from 1996-2002.

Beginning in 1996, the Statewide Harvest Survey (SWHS) has estimated catch and harvest of early-run Kenai River king salmon. Annual estimates of total harvest downstream of the Soldotna Bridge by the creel survey and the SWHS were very similar (Figure 10). Because these two surveys are conducted independently of each other, this indicates that our estimates of total harvest are relatively accurate. However, estimates of harvest by guided and unguided anglers were different (Figure 11, top panel). The creel survey estimates indicated a much higher harvest by guided anglers than by unguided anglers, while the SWHS estimates indicated harvest was more similar between angler types. In other words, since 1996 the percentage harvest downstream of the Soldotna Bridge by guided anglers has been a relatively stable 75% to 80% according to creel survey data, but according to SWHS data it was 60% in 1996 and has decreased over time (Figure 11, bottom panel).

So which survey is right (or wrong) and why? We do not know the reasons for these differences, but think that the percentage harvest by angler type is somewhere between the percentages observed by these surveys. The two surveys obtain information in very different ways. In the creel survey, divisional employees collect information from anglers onsite during the fishery. The SWHS is a mail-out survey that anglers fill out after the fishing season. It is possible that there are errors in the SWHS because it requests information from unguided anglers at the top of the survey page and from guided anglers at the bottom of the page. Perhaps some anglers who took guided fishing trips for Kenai River king salmon may have inadvertently recorded their information in the first place they are requested to record information: fields for unguided anglers. This problem was observed in supplemental surveys to the SWHS in other fisheries.

If this problem occurs, then effort, catch, and harvest by unguided anglers may be overestimated while those of guided anglers may be underestimated. Conversely, it is possible that catch and harvest per unit of effort by unguided anglers from the creel survey are underestimated. These estimates come from interviews of completed-trip anglers exiting the river at public boat launches. Anglers who use their own private launches, such as landowners along the river, are likely never, or at least infrequently, interviewed. If unguided anglers using private launches in general are more successful at catching king salmon than unguided anglers using public launch facilities, catch and harvest by unguided anglers may be underestimated.

The SWHS will be redesigned in 2003, so potential problems in recording information by angler type can be assessed in the survey and used to provide more accurate estimates. Suffice it to say that estimates of total harvest are similar between the two surveys.

Data from the SWHS also provide estimates of harvest by residency: anglers who are Alaskan residents and those who are nonresidents. These estimates are currently available through 2000. These data indicate that, since 1996, 60% to 65% of the harvest of early-run king salmon in the entire Kenai River was by nonresident anglers (Figure 12). The percentage of harvest by residency-type was relatively constant among years and was similar downstream of the Soldotna Bridge and upstream of the bridge (Figure 12). The only obvious change was that in 2000 residents and nonresidents each had about the same percentage of the harvest downstream of the bridge.

Based on SWHS data, since 1996 about half (50%) of the annual harvest from the entire river was by guided nonresidents (Figure 13). This dropped to about 30% in 2000, a year the fishery was restricted. About 20% to 25% of the harvest was by unguided residents. There has been a gradual increase in the percentage of the harvest by unguided nonresidents. Guided residents generally had the lowest percentage of the harvest. Although we believe the estimates by resident type are fairly accurate, if problems mentioned above recording information by angler type (guided or unguided) exist, our information of harvest (and catch) by angler-resident type may not be accurate. We do not record residence of anglers in the onsite creel survey.

Finally, note that estimates of catch and harvest of early-run king salmon from the SWHS are of fish caught and harvested before July 1. The number of early-run king salmon caught and harvested after July 1, especially those upstream of the Soldotna Bridge, is unknown because they are mixed with late-run fish. Radio telemetry data indicated that nearly all early-run king salmon have migrated upstream of the Soldotna Bridge and 90% exited from the inriver fishery by July 14 (Figure 14).

A few early-run fish are harvested in the Central Cook Inlet (CCI) marine sport fishery and the Eastside set net commercial fishery. The number harvested in these mixed stock fisheries is unknown.

Marking juvenile fish with coded wire tags in their natal stream and sampling returning adults for tags is a standard method to estimate stock-specific harvest in mixed stock fisheries. Tags recovered from the CCI marine sport fishery indicated a number of different king salmon stocks contribute to the marine fishery; the early-run Kenai River stock is one of many. We also recognize that a small percentage of early-run Kenai and Kasilof king salmon are harvested in the Eastside set net fishery during June. However, the low number of tags recovered in both fisheries from king salmon marked in the Kenai River and marked hatchery-reared fish released into the Kasilof River at Crooked Creek indicates that harvests of these fish are likely small. We assume that late-run Kenai River king salmon comprise the entire harvest of the Eastside set net fishery.

Harvest timing information from creel surveys conducted in the CCI marine sport fishery in the mid-1990s indicated that few early-run fish were in this fishery after June 10 and especially after June 24 (Figure 15). Based on this information, since 1996 the SWHS has estimated harvest of early-run king salmon in this marine fishery occurring on or before June 24. Treatment of king salmon harvests in the Eastside set net fishery, which can begin as early as June 25, is consistent with this.

Finally, an educational fishery occurs in the lower 5 miles of the Kenai River. All king salmon harvested by this inriver fishery are assumed of Kenai River origin. Harvest is reported weekly from a permit return and has never exceeded the quota of 200 king salmon.

➢ The long-term genetic effects of targeting large king salmon are unknown.

- ***Is there a decline in the number of large early-run king salmon in the Kenai River?***

Yes. King salmon in the Kenai River and many other rivers in Alaska may live up to seven years of age. We determine age by looking at dark bands, called annuli, which form on scales. King salmon generally live two years in freshwater – the first year in the gravel when no annuli is formed and the second year in the water – and spend up to five years in the ocean before returning to spawn (i.e., a fish that lived in the gravel one year, in freshwater one year, and in the ocean five years is a fish aged 1.5 and is seven years old). There has been a decline in the numbers and percentage of the oldest and largest king salmon in the Kenai River since the late 1980s, most noticeably of fish aged 1.5 and somewhat in fish aged 1.4 (Figure 16). Although the percentage of these older, larger fish aged 1.5 has increased somewhat in the last two years, numbers of these fish remain low relative to returns observed in the late 1980s and early 1990s.

- ***What is causing the problem with large early-run king salmon?***

The exact cause(s) of decline in older king salmon during the early run is not known. However, there are several ideas about why it has occurred. Size and age of king salmon can be inherited from the parent spawners. Because of this, in fisheries with relatively high overall exploitation, selective harvest of the largest king salmon over time could cause a decrease in the percentage of older fish returning in future years.

Two conditions must be met if the fishery is the reason for fewer, larger early-run king salmon: 1) larger, older fish have had a higher harvest rate in the fishery than smaller, younger fish; and 2) age, and thus size, must be passed on as a characteristic. One way to examine harvest rate is to plot the observed annual average age of the inriver return and average age of the sport harvest (Figure 17, top panel). Although the average age of the harvest has been greater than the average age of the inriver return since 1990, the differences were not consistent and were relatively small most years. One way to examine if age is being passed on as a characteristic is to plot the observed average age of a given escapement and the average age of the returns of each of these escapements (Figure 17, bottom panel). This plot indicated that there is no clear relationship. Thus, even if the data indicate a potentially subtle higher harvest rate of older, larger fish, there is no relationship between average age of the escapement and average age of the return of these escapements. If the fishery is causing a shift to younger fish in the long-term, this shift will take a long time to occur.

Another fact of king salmon life history, at least for hatchery-stocked fish, is that larger smolts (juvenile king salmon that are ready to enter the ocean) tend to come back sooner (younger) than smaller smolts. This means that an increase in growth rate of juvenile king salmon, due to better weather or more food, can lead to larger smolt size, which in turn can lead to fish that return earlier (younger) as adults.

Another fact about king salmon from the Kenai River is that it isn’t how old Kenai River king salmon are that make them unique, but it is how fast they grow while in the ocean or their “size at age.” For instance, a seven-year-old king salmon on the Kenai River might be 55 inches long and weigh 85 pounds, while the same age fish in other rivers in southcentral Alaska might only be 40-45 inches long and weigh 50 pounds. Fortunately, this is one factor we know is NOT influencing the size of king salmon that return to the Kenai River. Size at age of Kenai River king salmon has remained fairly stable since the mid 1980s and may actually be increasing somewhat (Figure 18). We have also observed no real change or trend in the proportion of females – the sex composition – of the returns or escapements (Figure 19), or a temporal change inseason (Figure 20).

Regardless of the reason why we are seeing fewer older, larger king salmon during the early run, we should be cautious about this decline and the disproportionate harvest of these fish until more is known.

- ***What is the rationale for the current slot limit at 40 inches and 55 inches?***

This is the size restriction that almost completely eliminates the harvest of 5-ocean fish (Figure 21), allows retention of a very rare record-sized fish, and allows harvest of younger, smaller fish. Although there is considerable variation from year to year, on average about 47% of the fish in the early run are less than 40 inches in total length and would be available for harvest. On average, all of the 2-ocean, nearly all of the 3-ocean, approximately 25% of the 4-ocean, and about 2% of the 5-ocean fish, are below the 40 inch lower limit, and available for harvest. It is a very rare fish that is 55 inches or greater. Average length of 4-ocean fish is 43 inches, for 5-ocean fish the average is 48 inches.

➢ There are potential long-term effects of disproportionately targeting early arriving or late arriving king salmon for harvest.

- ***Why is it a problem to harvest early-run king salmon only early or late in the season?***

Early-run Kenai River king salmon are primarily tributary spawners, with most of these fish ascending the Killey and Funny rivers (Figures 22 and 23). Although we have little conclusive evidence about spawning location, time of entry, or percentage of the run that uses these locations, it is fairly typical for earlier arriving king salmon to spawn in the Funny and Killey river tributaries and for later arriving fish to spawn in other tributaries and the mainstem. To ensure that adequate numbers of king salmon are available to spawn in all tributaries it is best that the fishery be managed to avoid disproportionately harvesting either early or late arriving fish.

- ***Have we been having a problem with early or late harvests of early-run king salmon?***

It depends. Based on creel survey data, in years with inseason restrictions harvest rates in May and early June were disproportionately higher than later in June when the fishery was restricted to catch-and-release or trophy fishing (Figure 24). Consistent disproportionate harvest of early-run king salmon in May and early June could likely have long-term biological impacts; for example, it may shift the run-timing of the returns. However, during years without inseason restrictions the harvest rates on early arriving fish were similar to those arriving later in the run (Figure 24). In addition, the percentage of the harvest and catch among guided anglers and among unguided anglers was nearly the same in years with no restrictions (Figure 25). In other words, in years without inseason restrictions the percentage of the harvest and catch occurring over the season was relatively constant (linear) and the harvest was spread over the entire return.

- ***Has the disproportionate harvest in restricted years caused any changes in run timing?***

No. The date when 25%, 50% (median), and 75% of the run has entered the river has not changed dramatically nor shown any noticeable trend over time (Figure 26). It also does not appear that run timing is related to the strength of the return (Figure 27).

➢ Savings made to early-run king salmon escapements in May and June can be lost to harvest during July.

- ***Where do early-run Kenai River king salmon spawn?***

Based on radio telemetry studies done in the early 1980s and early 1990s, early-run Kenai River king salmon primarily spawn in the larger tributaries of the Kenai River, such as the Funny and Killey rivers (Figures 22 and 23). However, early-run king salmon are also known to spawn in other smaller tributaries such as Benjamin Creek, Slikok Creek, Quartz Creek, and Grant Creek. Moreover, a percentage of early-run fish have also been found spawning in various reaches of the mainstem.

- ***Do we need to protect early-run king salmon in July?***

Yes. These same telemetry studies found that early-run king salmon can hold in confluence areas or the mainstem for some time into July before ascending tributaries to spawn (Figure 14). In general, fish destined for the smaller spawning tributaries such as Quartz Creek and Slikok Creek tended to hold for longer periods of time in the mainstem than those destined for the Funny or Killey rivers. Moreover, some early-run king salmon spawn in the mainstem during July. By July 15, 95% of Killey River spawners have left the mainstem holding areas for spawning areas (Figure 28). Similarly, by July 16, 95% of Funny River spawners have left the mainstem holding areas for spawning areas. All early-run spawners have ascended these larger tributaries by July 21. Conversely, it can take up until July 29 for 100% of Slikok Creek spawners to leave mainstem holding areas for spawning areas. Early-run king salmon may take from 4 to 38 days to migrate past the Soldotna Bridge and in general all early-run king salmon destined for spawning areas (tributaries and mainstem) upstream of the Soldotna Bridge have migrated past the bridge by July 19 (Figure 14). Regardless of final location, spawning of all early-run fish is thought to peak in mid to late July.

➢ The effects of catch-and-release mortality need to be considered in regulatory options that promote the release of king salmon.

- ***What is the catch-and-release mortality of early-run king salmon?***

This type of mortality was studied on the Kenai River during 1989-1991. Hooking mortality of early-run king salmon ranged from 12.1% for small males to 1.9% for large males. The hooking mortality rate for female early-run king salmon was 6.8%. As with most species, the most significant factor influencing mortality after hooking was hook placement and the occurrence of bleeding, with hooking in the gill or other vital areas causing most of the mortalities. Although all of the early-run fish in these studies were caught with unbaited lures, there was no difference in mortality rates of fish caught with bait, unbaited lure, or bait/lure combination during these same studies conducted on late-run Kenai River king salmon.

The number of early-run Kenai River king salmon caught by anglers and then released has ranged from 2,300 to 5,600 fish (Figure 29). This has represented from 20% to nearly 80% of the fish caught. The percentage of fish released was higher during years that the fishery was restricted inseason (i.e., 1990-1992, 1997-1998, 2000). The annual estimates of catch-and-release mortality have ranged from 150 to nearly 400 king salmon.

- ***What about fish that are hooked multiple times?***

During these same catch-and-release studies, approximately 15% of the fish (early and late run combined) were captured multiple times. Although there are very little data from which to estimate mortality rate of multiple captures, it appears that the mortality rate is cumulative so that fish caught more than once may experience a higher mortality rate than those caught only once.

➢ A biologically defensible escapement goal is central to proper management of early-run king salmon.

- ***What data were used to set the escapement goal?***

The current biological escapement goal (BEG) is 7,200 – 14,400 fish. Based on return data collected in 1985-1988, it was determined that the optimal total return of early-run king salmon was 27,000 and, assuming a return per spawner ratio of 3:1 – commonly considered reasonable for king salmon – would require 9,000 fish in the escapement. The range was based on multiplying this level of escapement by 0.8 and 1.6 (80% and 160%).

- ***Are you sure you're allowing enough fish to spawn to keep the run going?***

Yes. As mentioned above the returns, return per spawner, and yield seem highest at the lower end of the BEG range (Figures 2, 3, and 4). There has been no noticeable decline in the returns or productivity of this stock over time (Figure 1). As mentioned previously, this is NOT a stock of concern based on the Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222).

➢ Attainment of the escapement goal is currently dependent on inseason assessment of run strength and escapement using sonar and creel survey.

- ***How do we know if the escapement goal is being met?***

Numerous stock parameters (Table 1), which are estimated from a variety of sampling programs (Figure 6), are used to determine escapement and assess run strength. Total return is estimated by adding the harvest occurring in the inriver educational fishery to the estimated inriver return. Inriver return is estimated by sonar at river mile 8.5, except for 1986 when we used a tagging study. The age, sex, and size composition of the inriver return is estimated from a drift gillnetting program in the lower river.

Catch and harvest from the inriver sport fishery is estimated by an onsite creel survey downstream of Soldotna Bridge and by the SWHS upstream of the bridge. The age, sex, and size composition of the entire inriver harvest is estimated by sampling fish harvested downstream of the Soldotna Bridge. Catch-and-release mortality is estimated by multiplying catch-and-release mortality rate by estimates of fish caught and released (catch subtracted from harvest; Figure 29) obtained from the creel survey and SWHS. We assume the age, sex, and size composition of fish that die from catch-and-release is the same as that of the inriver return. Total inriver fishing mortality is the sum of harvest and catch-and-release mortality.

Finally, escapement is estimated by subtracting total inriver fishing mortality from the inriver return. The age, sex, and size compositions of the escapement were estimated similarly.

- ***Are there problems with the sonar?***

Yes, but we think the estimates of inriver return from the sonar are fairly accurate for the early run. There are some problems that result in underestimating the return and other problems that overestimate the return. Generally the sonar and inriver netting programs begin in mid-May. Fish that enter the river before mid-May, as well as king salmon that migrate behind or very near the front of the sonar equipment, are not included in the return estimate. These problems would cause an underestimate of inriver return. Conversely, we initially believed target strength (the acoustic size of a fish target) and range (the distance between the sonar equipment and the fish target) would distinguish sockeye salmon from king salmon. Recent research indicates neither of these assumptions is true, so it is likely that some early-run sockeye salmon entering the Kenai River are classified as king salmon. This will cause an overestimate of the king salmon return. We believe that these various sources of bias are relatively small and the estimated inriver return is relatively accurate because: 1) inriver return estimates based on sonar were very similar to those based on tagging studies conducted over three years in the mid 1980s; 2) few king salmon are observed in the sonar or netting program in mid-May; and 3) very few king salmon were observed when these programs began earlier than mid-May.

➢ There may be a shift in fishing effort to the Kasilof River when the Kenai River is restricted.

- ***How is the early run of king salmon to the Kasilof River doing?***

To our knowledge OK; however, our knowledge is very limited. There has never been a comprehensive stock assessment program for either the early or late run of Kasilof River king salmon. The early run has also been enhanced with a hatchery-stocking program since 1975. King salmon from Crooked Creek, a tributary of the Kasilof River and considered the primary producer of early-run fish, are the brood source for juvenile king salmon released into the creek. We are currently developing an assessment program to address data deficiencies in estimating the hatchery contribution and the age, sex, and size composition of the early-run return, inriver harvest, and escapement. This will provide the necessary data to construct brood tables for the early run beginning with the 2001 escapement.

The assessment of early-run Kasilof River king salmon to Crooked Creek has been sporadic and incomplete. Counts of all king salmon that returned to a weir at the Crooked Creek Hatchery have occurred annually since 1976 except in 1997 and 1998 (Figure 30). Total escapement was the number of fish allowed upstream of the weir. Hatchery contribution to fish counted at the weir was estimated annually since 1976 except 1991-1998. The age, size, and sex composition of the escapement has been sampled sporadically over time but in a more consistent, rigorous manner beginning in 1999. The inriver harvest of hatchery-reared fish was estimated from 1978-1990, but not since then. There have also been changes in hatchery stocking levels and size of fish released (Figure 31).

Beginning in 2000, all hatchery-reared king salmon released were marked with coded wire tags and by clipped adipose fins. This action was taken concurrent to a reduction in the number of king salmon smolt released (Figure 31). Previous releases were marked at varying rates. A portion of the 2000 release returned as 2-ocean adults in 2002. Beginning in 2004, all returning hatchery-produced adults will be marked. Our ability to control the harvest is greatly enhanced by having the ability to distinguish between the natural and hatchery returns.

The SWHS provided estimates of harvest of early-run Kasilof River king salmon beginning in 1996. Annual harvest has ranged from just over 4,000 to nearly 9,000 king salmon (Figure 32). About 40% of the harvest was by guided anglers each year except in 2001 when the percentage increased to 56%. Nonresidents accounted for 60% to 65% of the harvest (Figure 33). The percentage of the harvest was similar among unguided residents, unguided nonresidents, and guided nonresidents; in general each of the groups accounted for 25% to 35% of the harvest each year (Figure 34).

The percentage of the harvest by boat anglers increased from 40% in 1996 to 65% in 2001 (Figure 35). This increase occurred due to a gradual increase in the percentage harvest by unguided boat anglers from 1996 to 1999 and an increase by guided boat anglers from 1998 to 2001 (Figure 36). In general the percentage of the harvest has been similar between guided boat anglers and unguided shore anglers, but the percentage of the harvest by unguided shore anglers has decreased among years. A very small percentage of the harvest occurred by guided shore anglers. Most of the harvest among boat anglers was by guided nonresidents who accounted for 30% to 35% of the total harvest of king salmon in the Kasilof River during the early run (Figure 37, top panel). The percentage of the harvest was similar among guided resident, unguided resident, and unguided nonresident boat anglers. Among unguided shore anglers the percentage of harvest was similar between residents and nonresidents (Figure 37, bottom panel).

Recall that there is a potential problem in accurately estimating harvest, and thus percentage of the harvest, attributed to guided and unguided anglers. Also note that the harvest estimates are of fish harvested before July 1.

The U.S. Fish and Wildlife Service conducted a tagging study in July and August 1987 to determine the migratory destination and timing of late-run Kasilof River king salmon. Fish were captured and tagged with radio transmitters at the Department sockeye salmon sonar site (Figure 38). One-third of the tagged king salmon returned to the weir at Crooked Creek. The remaining radio-tagged fish were found spawning at the outlet of Tustumena Lake, between river kilometer 15 and 20, and at the confluence of the Kasilof River and Crooked Creek. Most of the king salmon tagged prior to July 25 went to Crooked Creek. After that date, most spawned in the mainstem.

We began an experimental tagging study in the lower river in 2002. Approximately 60 king salmon were tagged throughout July. Two of the tagged fish subsequently returned to Crooked Creek.

- ***Are we meeting the early-run escapement goal in the Kasilof River?***

The escapement goal for early-run Kasilof River king salmon is measured at a weir on Crooked Creek. The current sustainable escapement goal (SEG) for Crooked Creek is 650-

1,700 naturally produced fish (Figure 39). The number of naturally produced king salmon was at or below the low end of this range from 1999 through 2001 and within the range in 2002. Our estimate of the natural contribution to the 2002 escapement is biased high because a portion of the fishery was restricted to the harvest of marked hatchery fish only. Our best judgment is that even with a bias, the natural escapement exceeded the lower end of the SEG in 2002.

This SEG range was developed in fall 2001 using the 15th and 85th percentiles of escapements of naturally produced fish observed since 1976. The goal was estimated by subtracting brood stock and estimates of hatchery-stocked fish from weir counts of the total number of king salmon in Crooked Creek. Escapements for 1991-1998 were excluded because estimates of hatchery-stocked fish in the escapement were not available.

Escapements of naturally produced king salmon to Crooked Creek varied from one thousand to several thousand fish in the late-1970s through 1987. From 1988 through 1996 the escapement was restricted to no more than 700 spawners ocean age 3 and older, which was the escapement goal at the time. All other king salmon were used as brood stock or destroyed to minimize disease problems at the hatchery. Beginning in 1997, all king salmon except those used for brood stock were passed above the weir. Hatchery-produced king salmon were also allowed to pass up river to spawn.

- ***What happens to the harvest and escapement of early-run Kasilof River king salmon when you restrict the Kenai River fishery?***

There are no data showing that restrictions to the Kenai River king salmon fishery increases the effort and harvest (Figures 40 and 41) or decreases the escapement of Kasilof River fish. The only estimates of effort available are from the SWHS, estimates that include effort angling for all species during the entire year. Estimates of harvest of Kasilof River king salmon during the early run (i.e., harvest occurring before July 1), first available in 1996, also show no clear relationship with restrictions on the Kenai River fishery (Figure 42).

However, anecdotal evidence suggests more anglers fish at the Kasilof River when restrictions are implemented on the Kenai River fishery. Because we do not know how much sport effort is directed at early-run Kasilof River fish, we have no way to know if such a relationship exists. It is also possible that other factors affecting recent returns of early-run Kasilof River fish and/or the catch and harvest success of anglers associated with increased angler effort during years the Kenai River fishery were restricted, resulted in no obvious increase in harvest of Kasilof River fish.

ACKNOWLEDGMENTS

We thank all of the biologists, biometricians, and technicians who worked on research projects that provided information in this report. We also thank Doug Vincent-Lang, David Bernard, and Matthew Evenson for their review comments on this report. Finally, we are deeply indebted to Saree Timmons for her review comments and diligent efforts in preparing this report.

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EARLY-RUN KENAI RIVER KING SALMON
TABLE AND FIGURES

Table 1.-Summary of how stock parameter estimates are derived for early-run king salmon to the Kenai River.

Stock Parameter	Estimated directly (D) or indirectly (I)	How Estimated
Inriver return	D	Sonar at river mile 8.6
Personal use and Kenaitze educational harvest	D	Reported directly to ADF&G
Total return	I	Inriver return plus reported harvest in personal use and Kenaitze Educational fishery
Age composition of inriver return	D	Netting project near sonar site at river mile 8.6
Age composition of total return	I	Age composition of inriver return used as a surrogate
Sport catch, harvest, and effort below Soldotna Bridge	D	Onsite creel survey
Age composition of sport harvest below Soldotna Bridge	D	Collection of age samples in onsite creel survey
Age composition of hook-and-released fish above and below Soldotna Bridge	I	Age composition of inriver return used as a surrogate
Sport catch and harvest above Soldotna Bridge	D and I	Most recently: estimated by attributing a portion of the harvest in the SWHS to the early run stock
Age composition of sport harvest above Soldotna Bridge	I	Age composition of sport harvest below Soldotna Bridge used as a surrogate
Age composition of hook-and-released fish above and below Soldotna Bridge	I	Age composition of inriver return used as a surrogate
Hook-and-release mortalities	I	Multiplication of average of direct estimates of mortality rate from 1990 and 1991 (rate not specific to age or size), and the estimated number of released fish above and below the Soldotna Bridge
Escapement	I	Subtraction of all known inriver mortalities from the inriver return
Age composition of the escapement	I	Subtraction of all known inriver mortalities (by age) from the inriver return (by age)

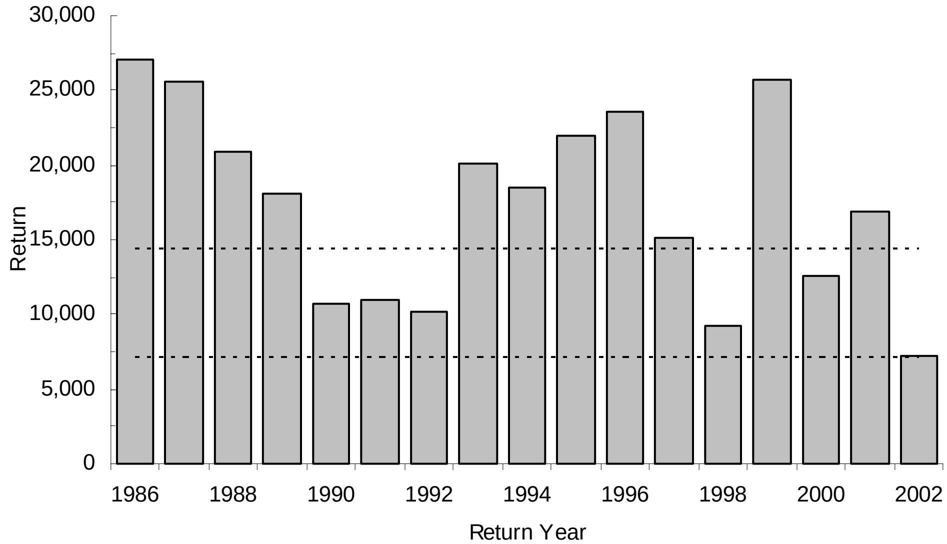

Figure 1.-Total return of early-run Kenai River king salmon. Dashed lines indicate the lower and upper values of the BEG range in effect since 1999. Estimate for 2002 is preliminary.

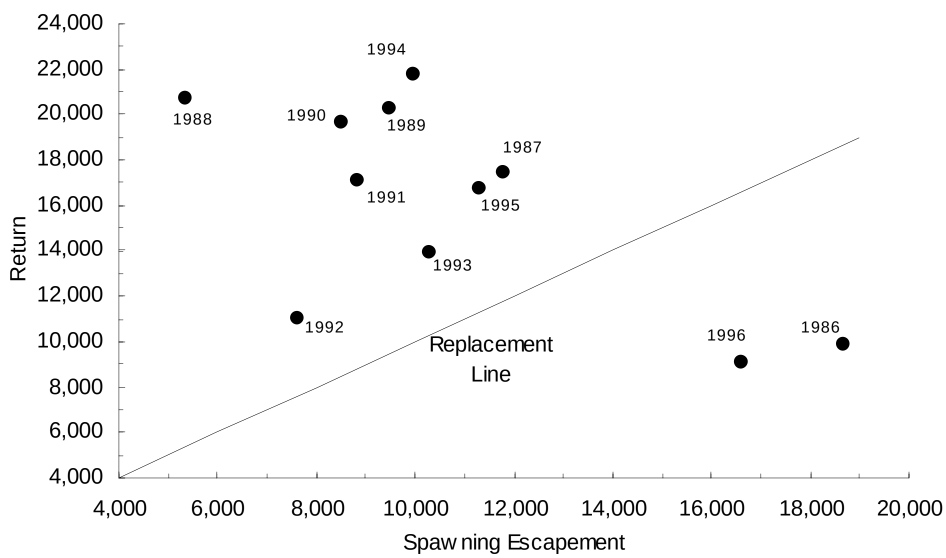

Figure 2.-Total return of early-run Kenai River king salmon for a given brood year escapement. Estimated return of the 1996 brood year escapement is preliminary.

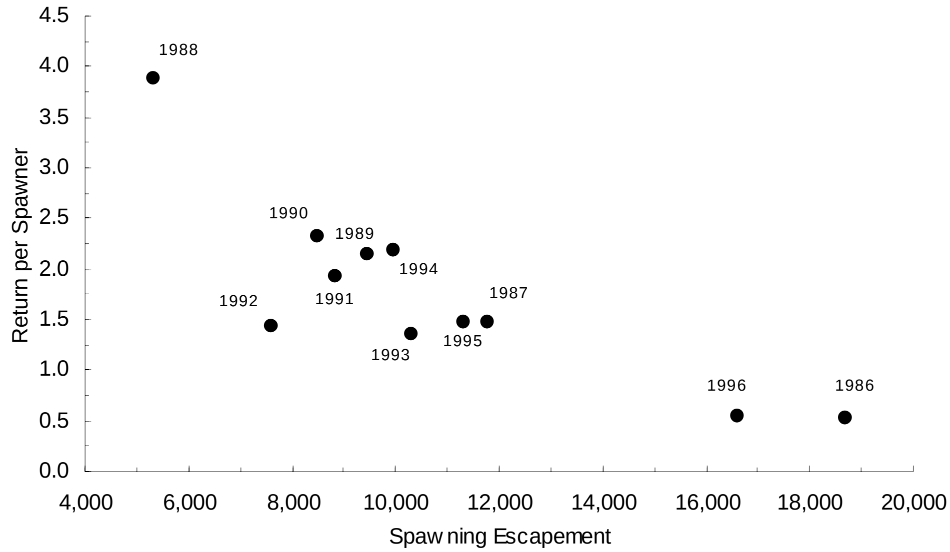

Figure 3.-Return per spawner of early-run Kenai River king salmon for a given brood year escapement. Estimated return per spawner of the 1996 brood year escapement is preliminary.

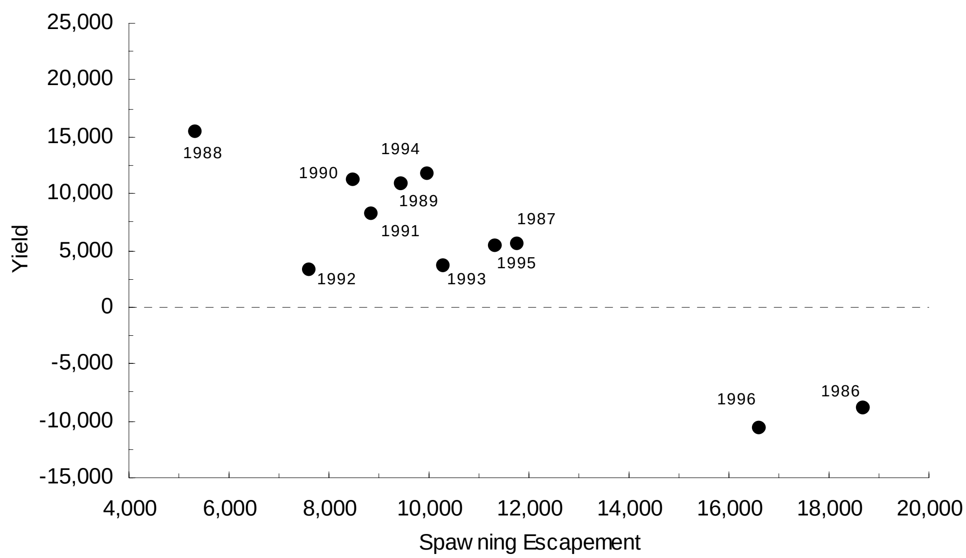

Figure 4.-Yield of early-run Kenai River king salmon for a given brood year escapement. Yield is the surplus production - the harvestable surplus - of a given escapement above the total return necessary to replace the escapement. Estimated yield of the 1996 brood year escapement is preliminary.

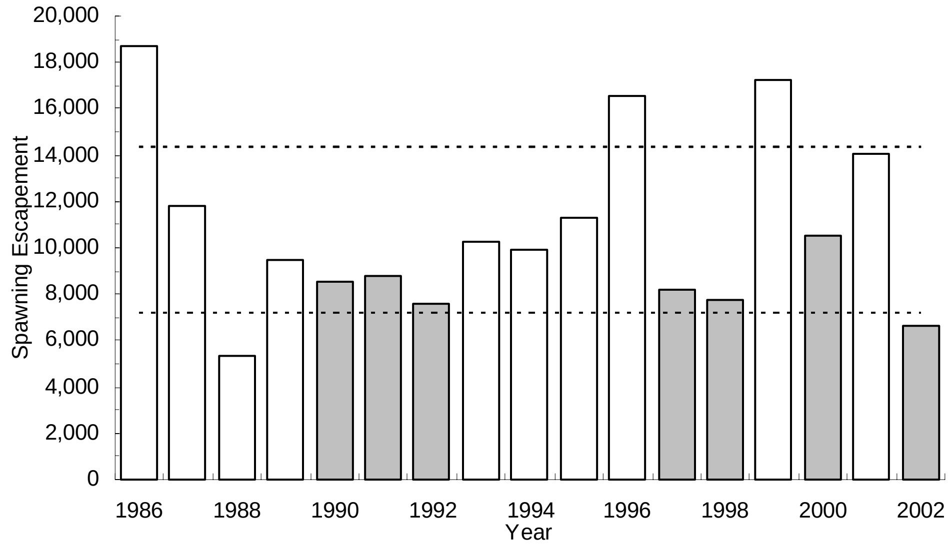

Figure 5.-Spawning escapements of early-run Kenai River king salmon. White bars indicate years of no inseason restrictions on the fishery; gray bars indicate years the fishery was restricted inseason; lines indicate lower and upper values of the BEG range in effect beginning in 1999. Estimate for 2002 is preliminary.

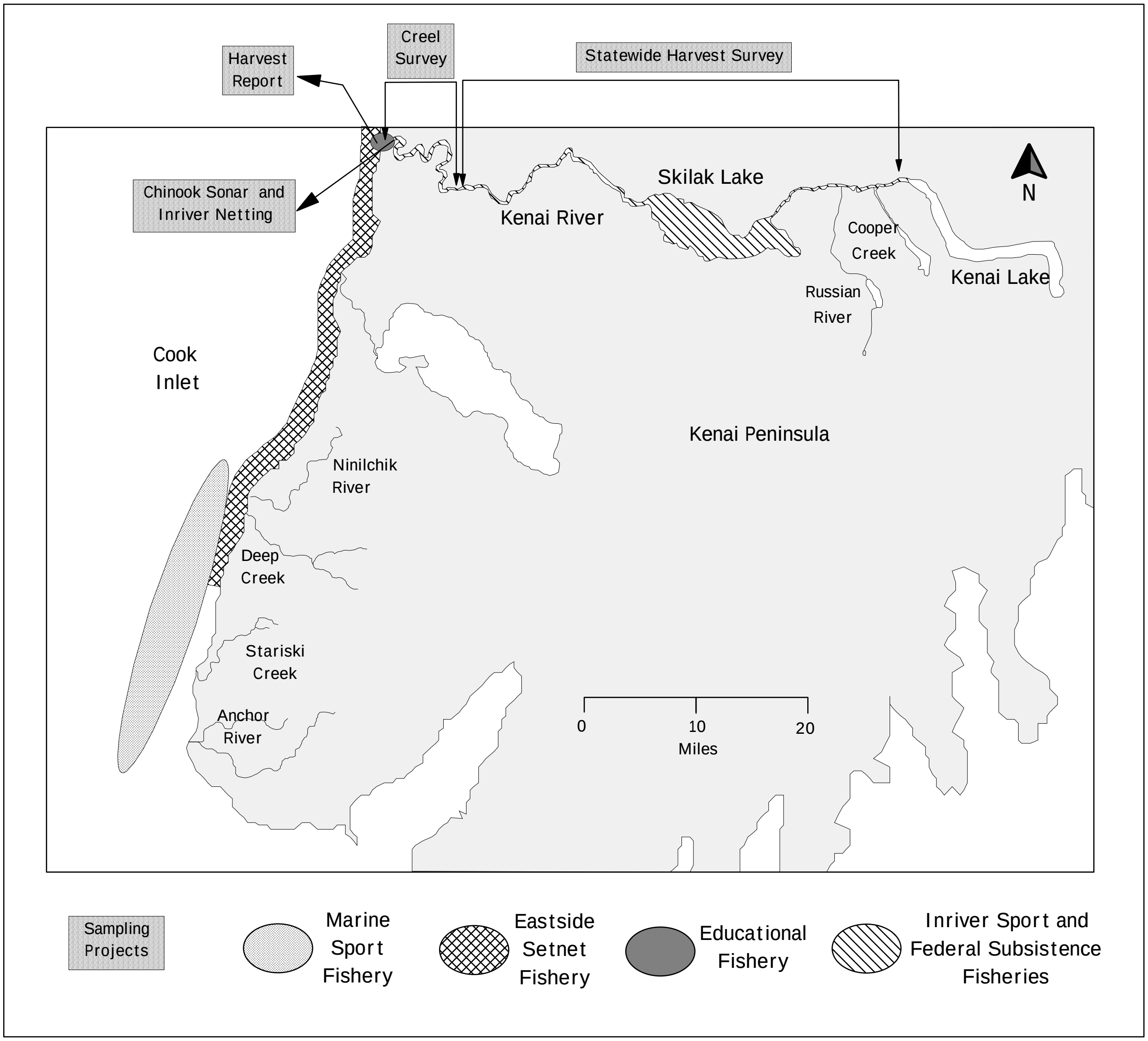

Figure 6.-Schematic map of locations of fisheries for early-run king salmon of Kenai River origin, and locations of projects for obtaining stock information for the run.

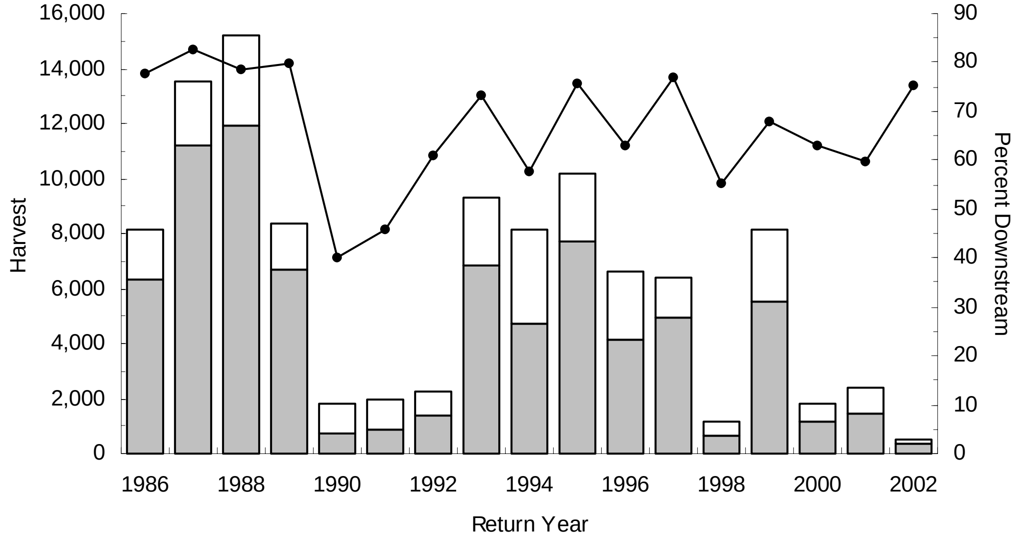

Figure 7.-Sport harvest of early-run Kenai River king salmon estimated downstream of the Soldotna Bridge by creel survey (gray bar) and upstream of the bridge by SWHS (white bar), and percent of harvest (line) that occurs downstream of the bridge. Estimates for 2002 are preliminary.

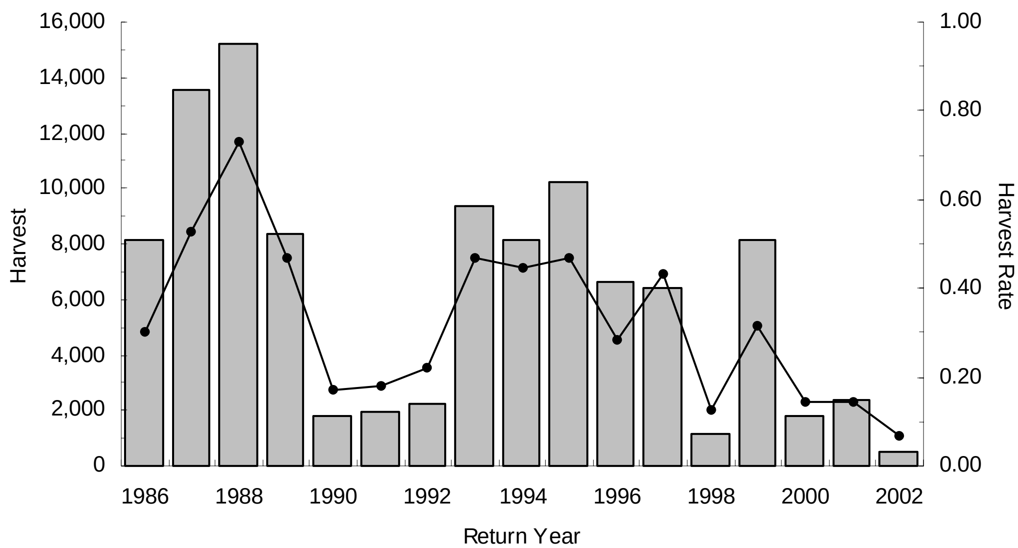

Figure 8.-Sport harvest of early-run Kenai River king salmon in the entire river and harvest rate based on harvest divided by estimated inriver return. Estimates for 2002 are preliminary.

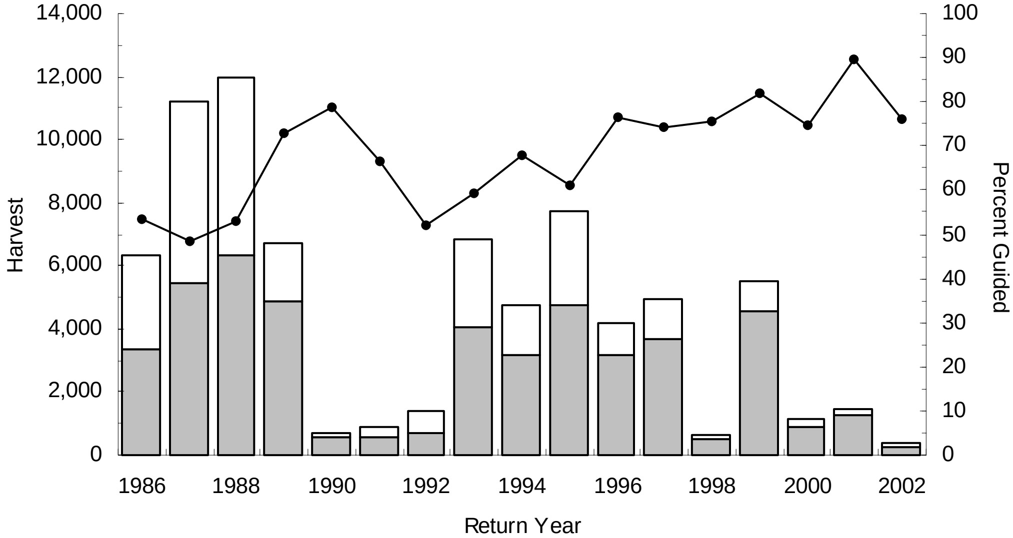

Figure 9.-Sport harvest of early-run Kenai River king salmon downstream of the Soldotna Bridge by guided anglers (gray bar) and unguided anglers (white bar), and percent of harvest by guided anglers (line). Estimates for 2002 are preliminary.

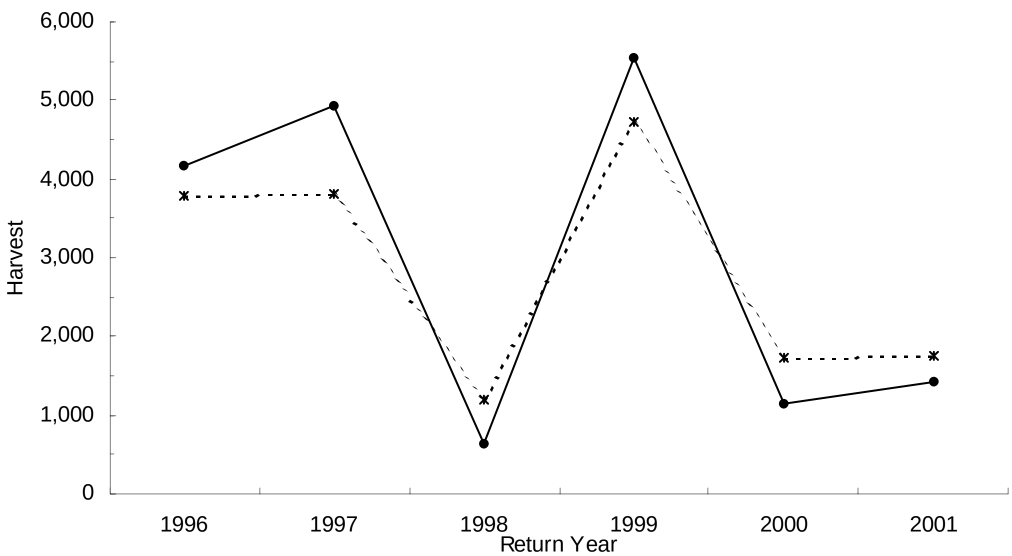

Figure 10.-Comparison of sport harvest of early-run Kenai River king salmon downstream of the Soldotna Bridge, as estimated from creel surveys (solid line) and the SWHS (dashed line).

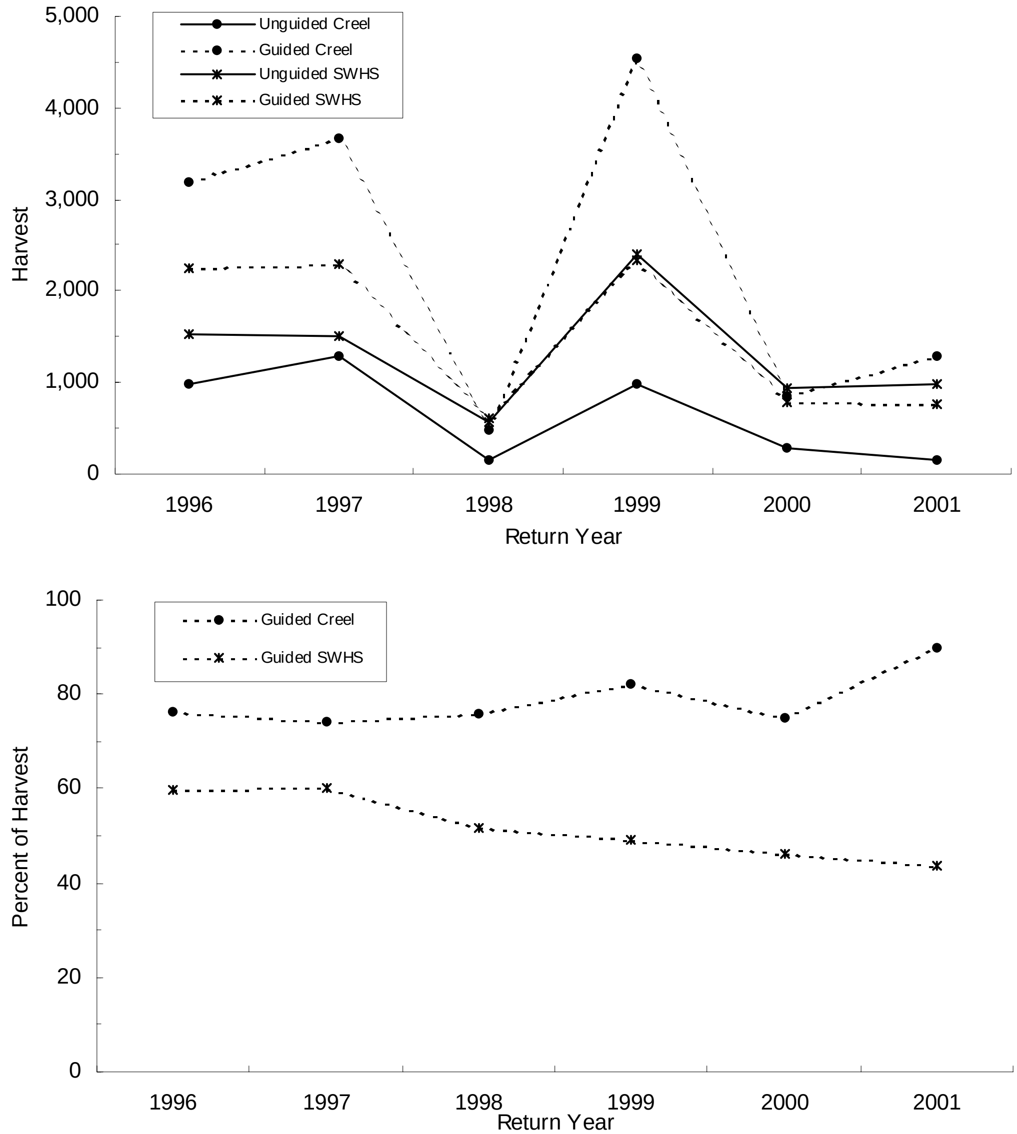

Figure 11.-Harvest of early-run Kenai River king salmon downstream of the Soldotna Bridge. Top Panel: comparison of estimates by angler type (guided and unguided) and estimation method (creel survey and SWHS). Bottom Panel: comparison of percent of harvest by guided anglers as estimated from creel surveys and the SWHS.

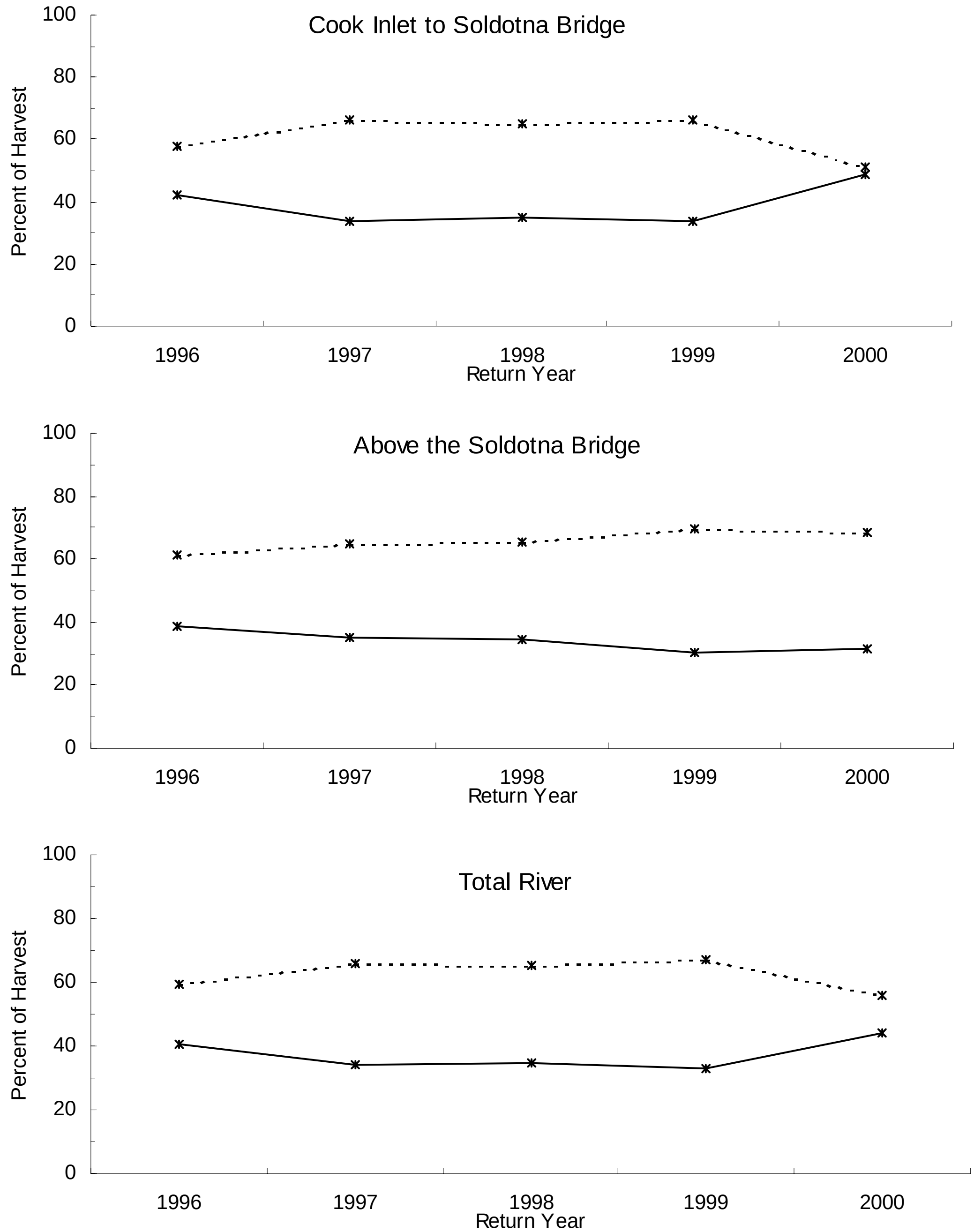

Figure 12.-Percent of harvest of early-run Kenai River king salmon by Alaskan residents (solid line) and nonresidents (dashed line) based on the SWHS.

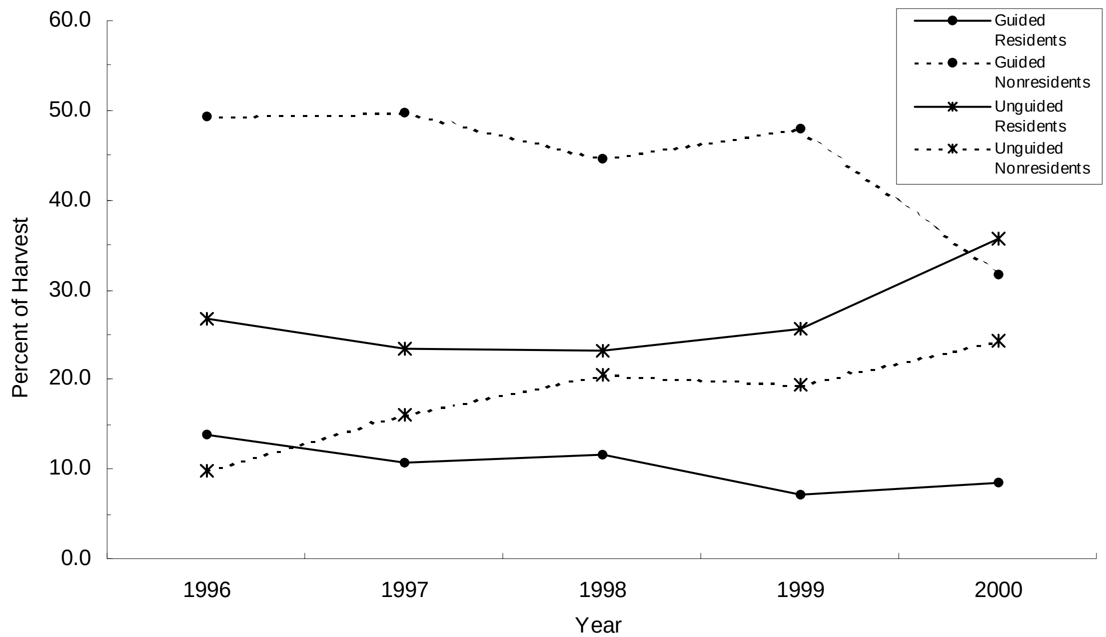

Figure 13.-Percent of harvest of early-run Kenai River king salmon, by angler type and residence type, based on the SWHS.

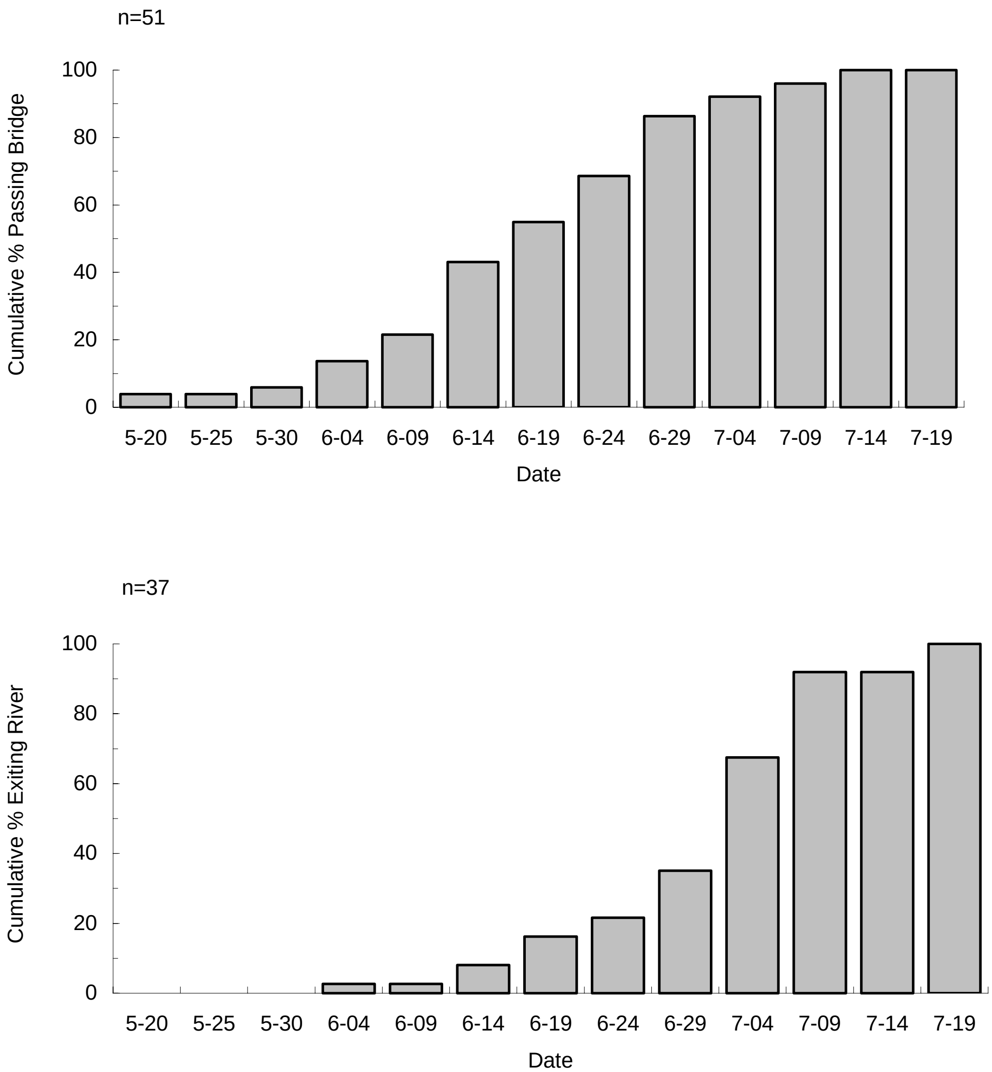

Figure 14.-Dates that early-run, radio-tagged king salmon passed the Soldotna Bridge at rm 21.1 (top panel) and exited the Kenai River to enter spawning tributaries (bottom panel) in 1980 and 1981. Adapted from Burger et al. (1983).

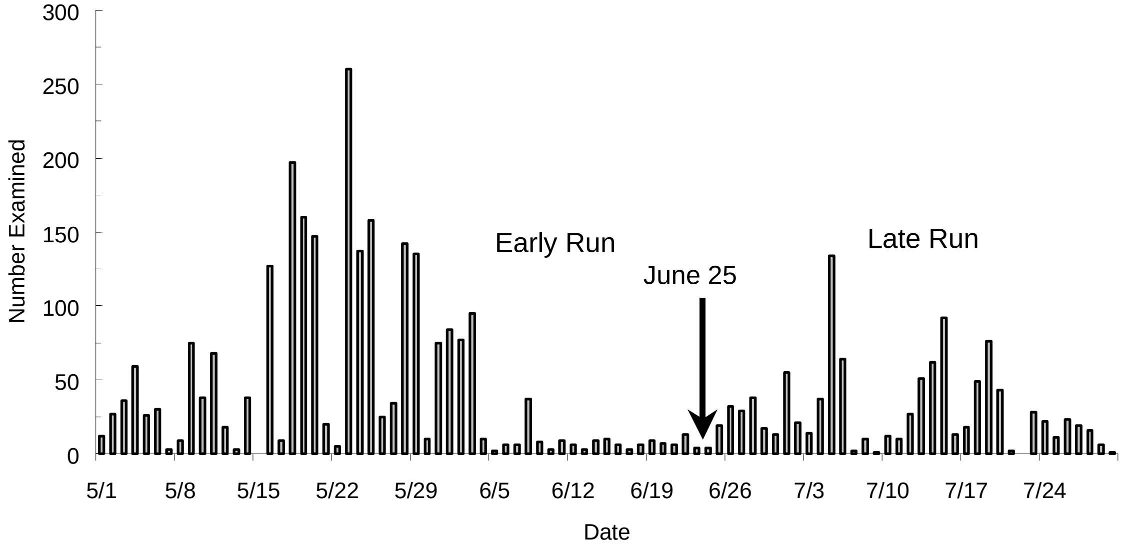

Figure 15.-Number of king salmon examined for coded wire tags, by date, in the Central Cook Inlet marine recreational fishery.

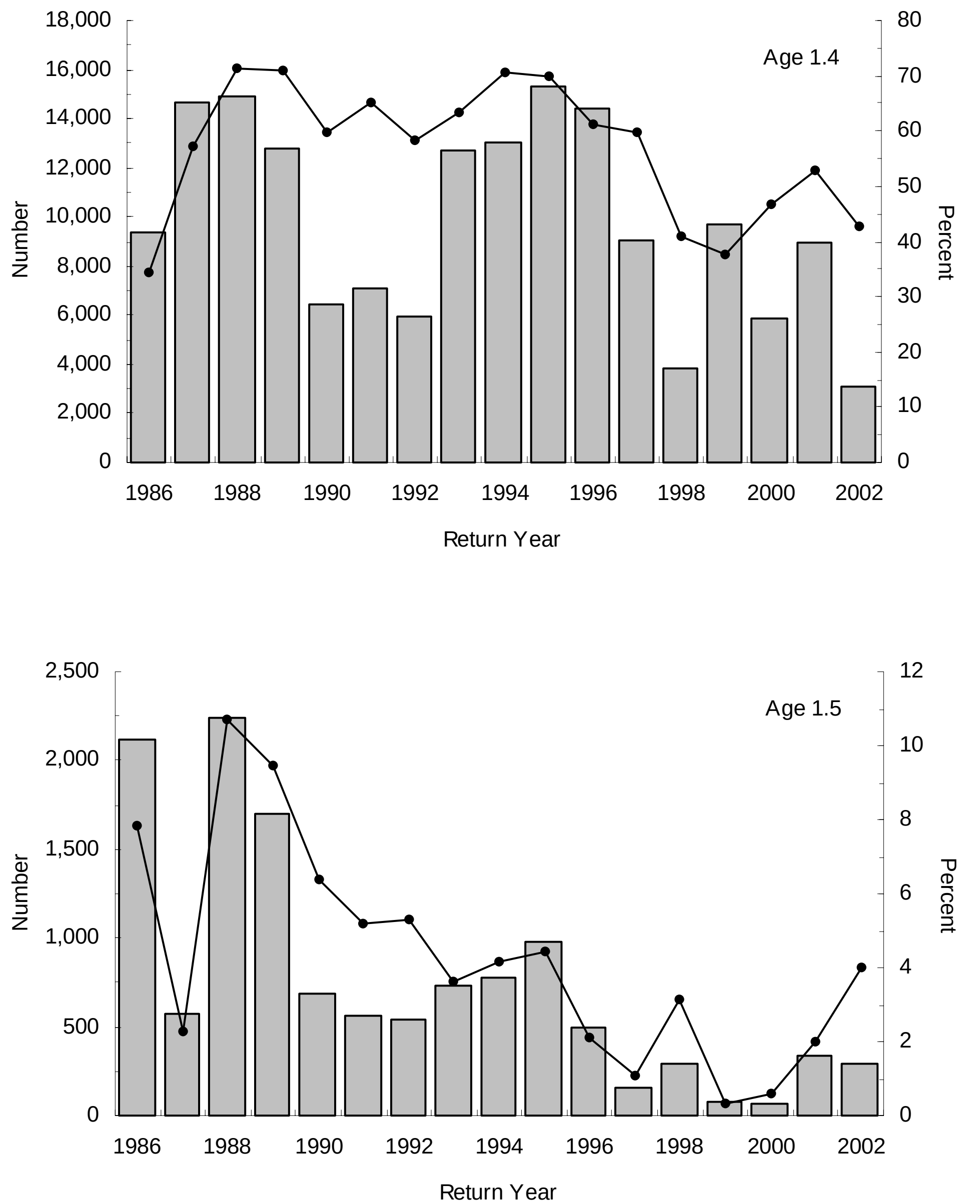

Figure 16.-Number (gray bars) and percent (lines) of early-run Kenai River king salmon aged 1.4 (top panel) and 1.5 (bottom panel) in the total return. Estimates for 2002 are preliminary.

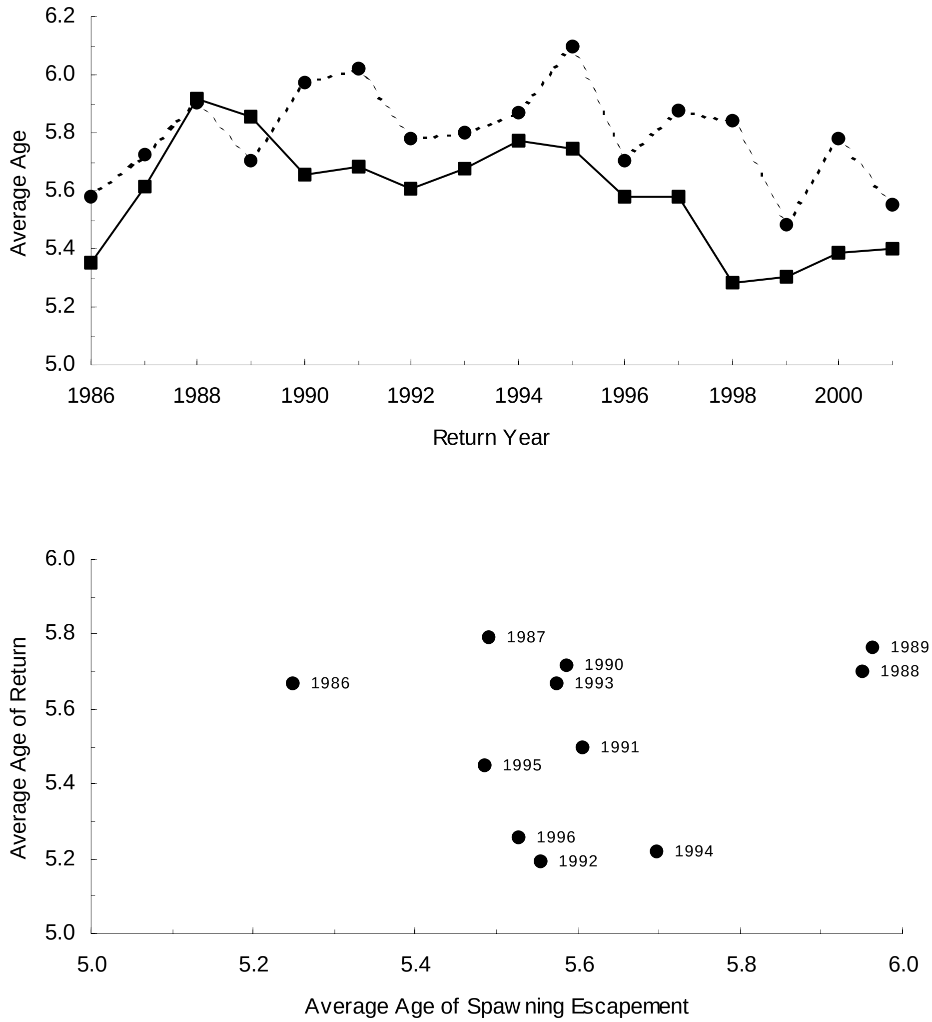

Figure 17.-Average age of early-run Kenai River king salmon. Top Panel: average age of the inriver return (solid line) and of the sport harvest (dashed line). Bottom Panel: average age of a brood year escapement and average age of adult returns from each brood year escapement. Estimated average age of return of 1996 brood year escapement is preliminary.

Figure 18.-Mean length-at-age of early-run Kenai River king salmon in the inriver return. Estimates for 2002 are preliminary.

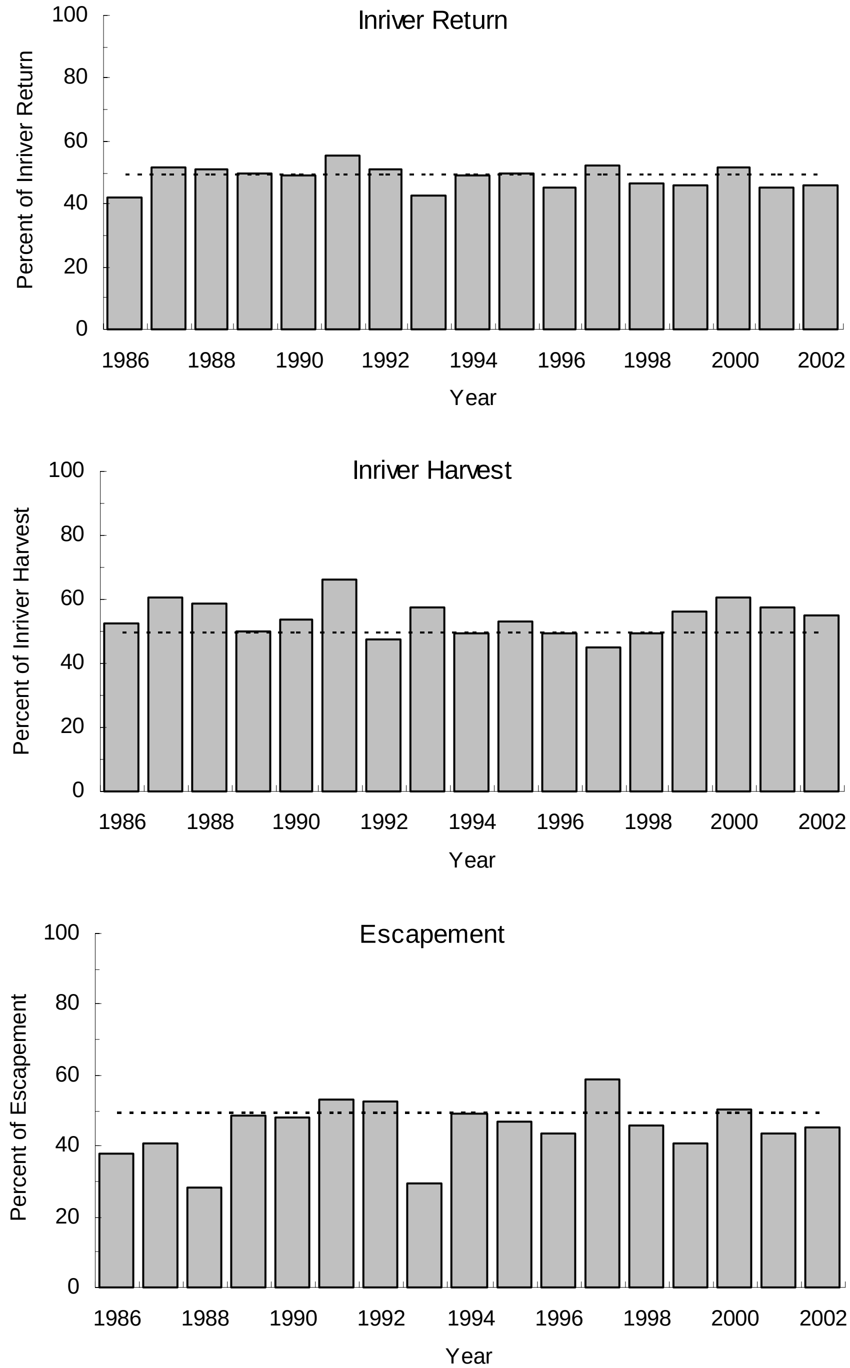

Figure 19.-Percent of females in the inriver return, inriver harvest, and escapement of early-run Kenai River king salmon. The dotted line delineates 50% mark. Estimates for 2002 are preliminary.

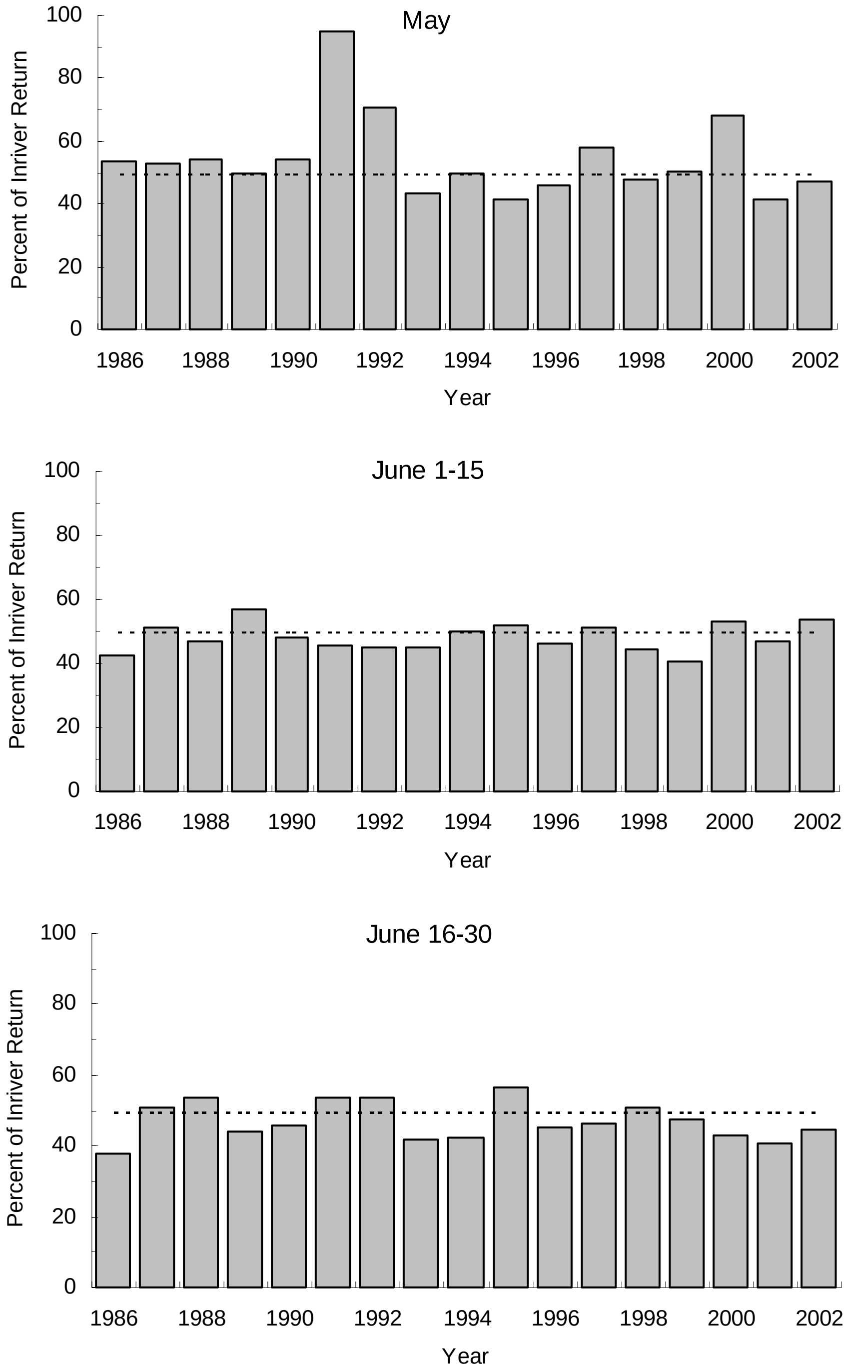

Figure 20.-Percent of females in the inriver return of early-run Kenai River king salmon during May, June 1-15, and June 16-30. The dotted line delineates 50% mark. Estimates for 2002 are preliminary.

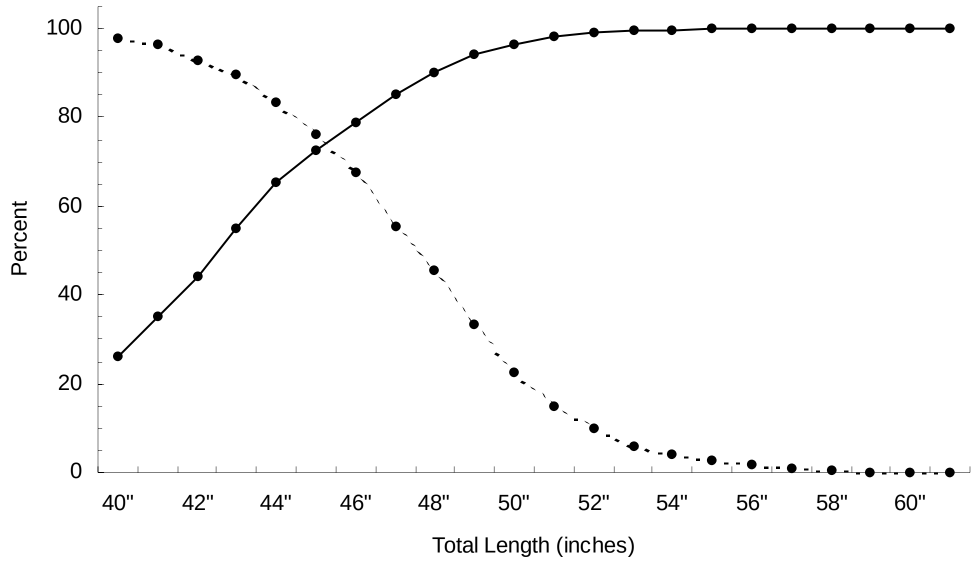

Figure 21.-Cumulative percent of early-run Kenai River king salmon aged 1.4 that are smaller (solid line), and those aged 1.5 that are larger (dotted line), than each 1-inch increment between 40 inches and 61 inches total length.

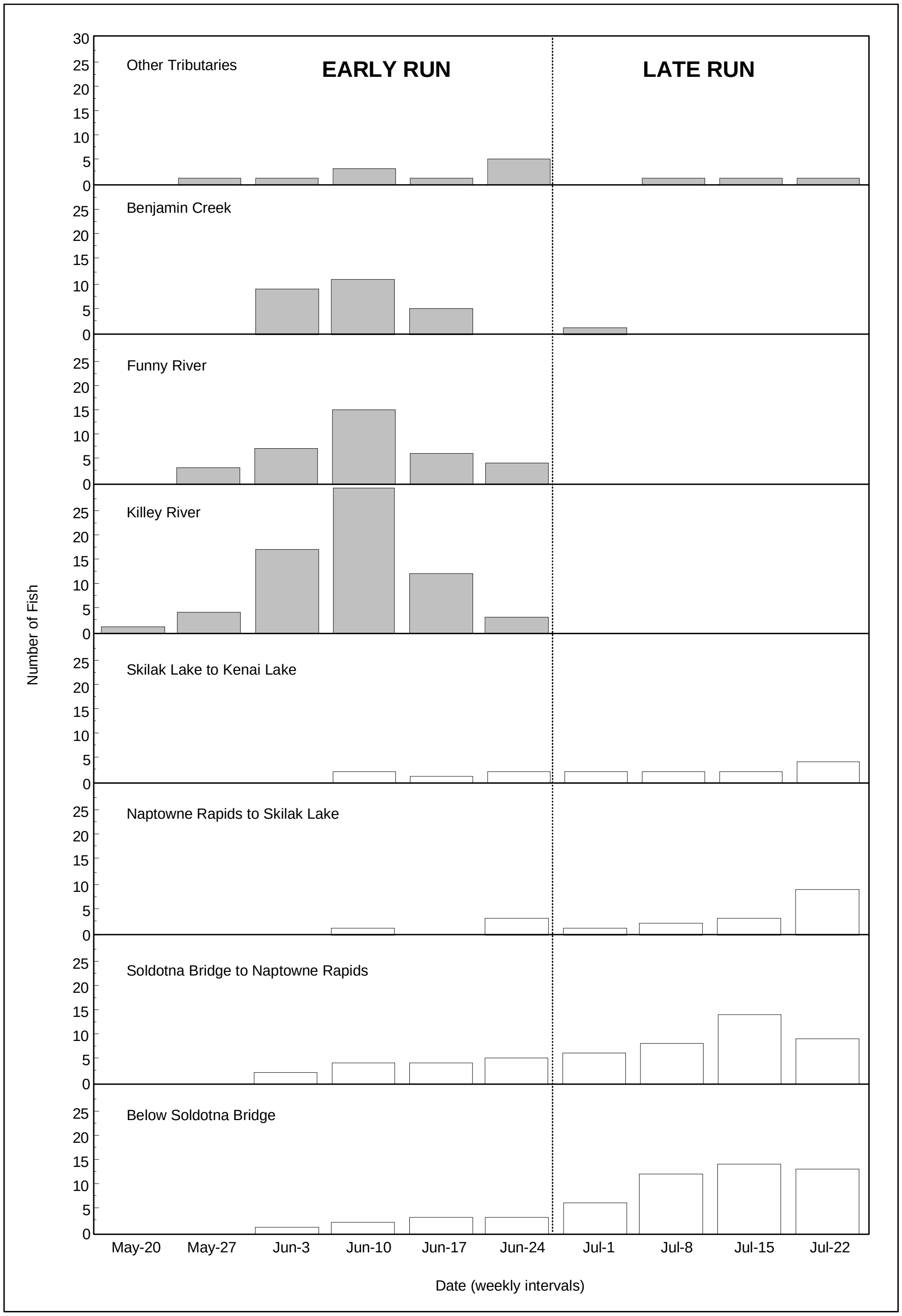

Figure 22.-Spawning destinations for 282 radio-tracked king salmon in the Kenai River, by weekly intervals of capture and release, 1989-1991. Gray bars represent fish spawning in tributaries; white bars represent fish spawning in the mainstem. Dotted line delineates fish released prior to July 1 and those released in July or August. Adapted from Bendock and Alexandersdottir (1992).

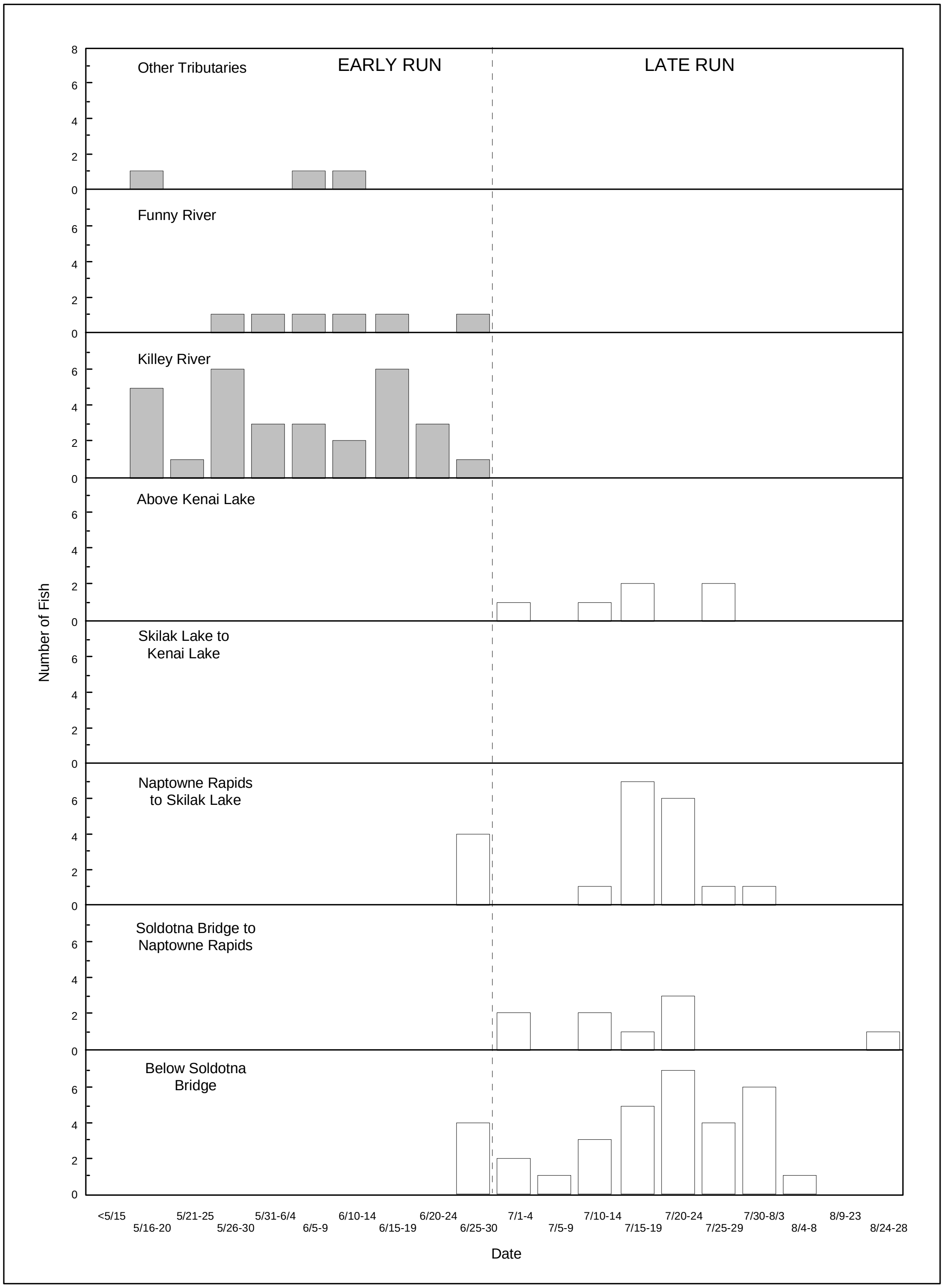

Figure 23.-Final destination of radio-tagged king salmon in the Kenai River by date captured and released. Gray bars represent fish spawning in tributaries; white bars represent fish spawning in the mainstem. Dotted line delineates fish released prior to July 1 and those released in July or August. Adapted from Burger et al. (1983).

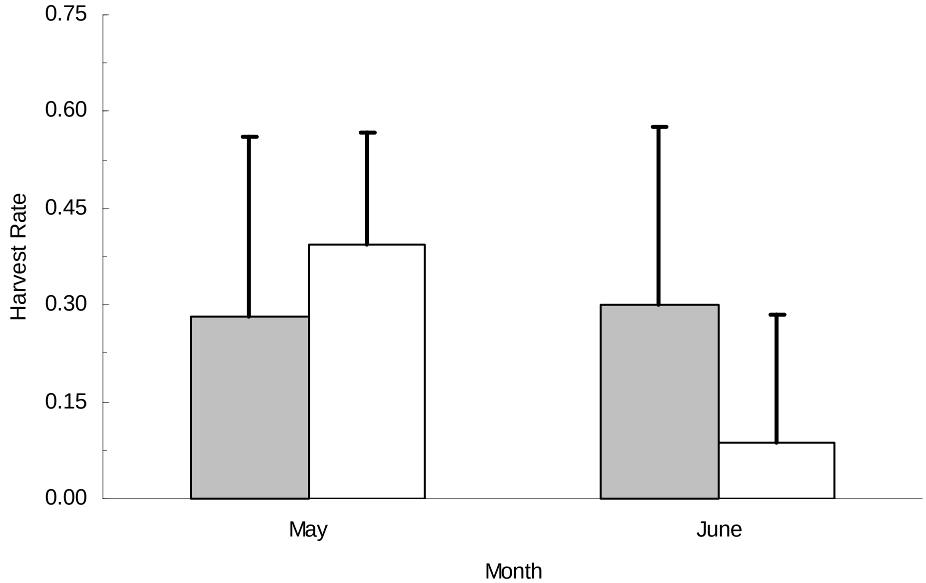

Figure 24.-Average harvest rate of early-run Kenai River king salmon in May and June during years the fishery was not restricted (gray bars) and during years the fishery was restricted (white bars). Error bar shows maximum observed harvest rate.

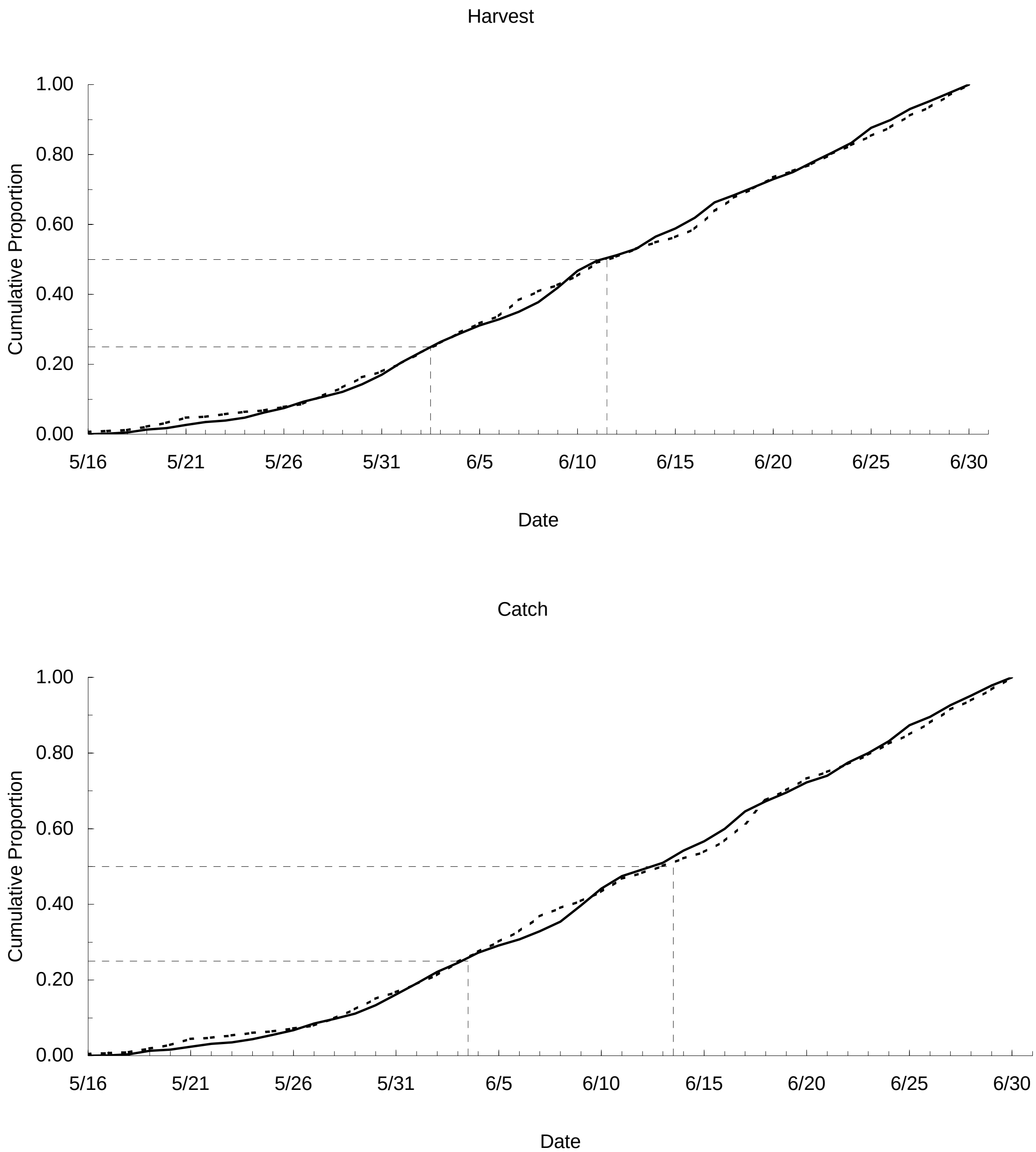

Figure 25.-Cumulative proportion of harvest (top panel) and catch (bottom panel) of early-run Kenai River king salmon by guided anglers (solid lines) and unguided anglers (dashed lines) downstream of the Soldotna Bridge during years the fishery was not restricted.

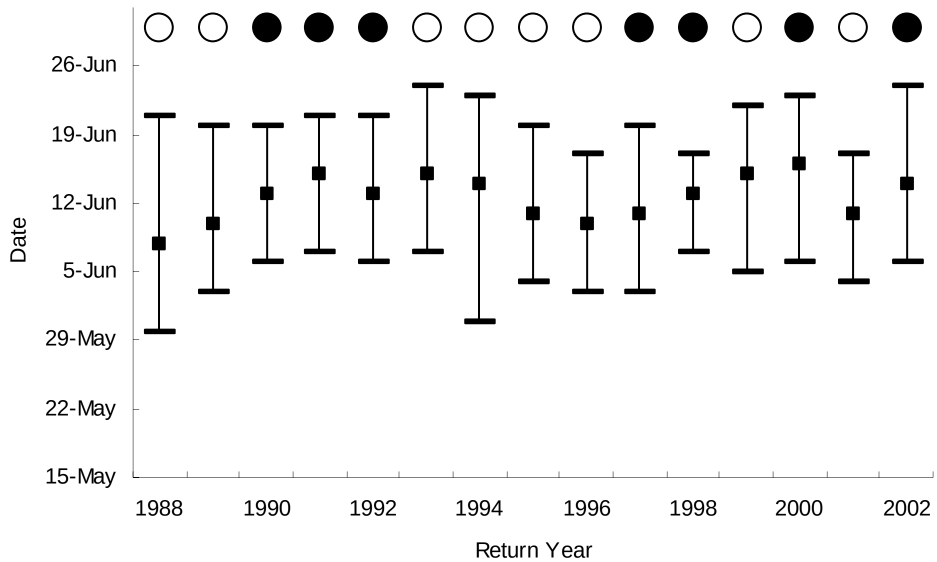

Figure 26.-Date when 25% (lower error bar), 50% (median; closed square), and 75% (upper error bar) of the inriver return of early-run Kenai River king salmon was observed during years the fishery was not restricted (open circles) and was restricted (closed circles). Estimates for 2002 are preliminary.

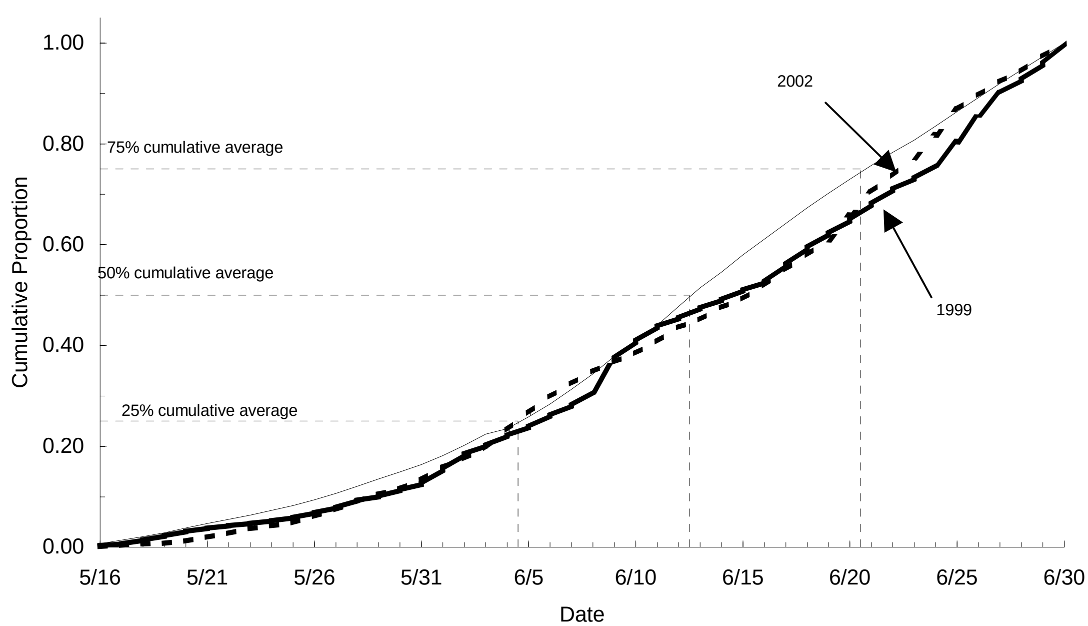

Figure 27.-Average inriver return run-timing curve of early-run Kenai River king salmon, and run-timing during the year of lowest (2002) and highest (1999) returns observed since the return was estimated by sonar. Estimates for 2002 are preliminary.

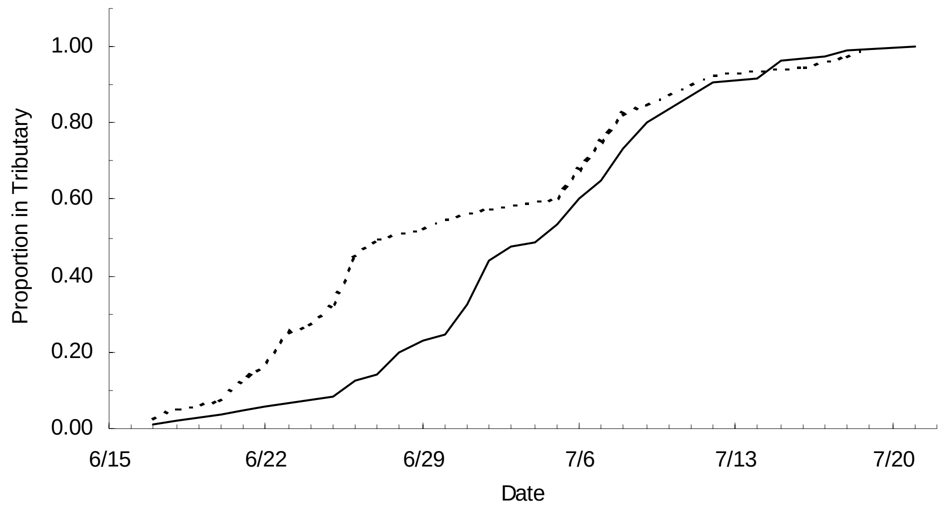

Figure 28.-Date of entry of radio-tagged early-run Kenai River king salmon into the Funny (dashed line) and Killey (solid line) rivers (1990-1991). Adapted from data collected by Bendock and Alexandersdottir (1992).

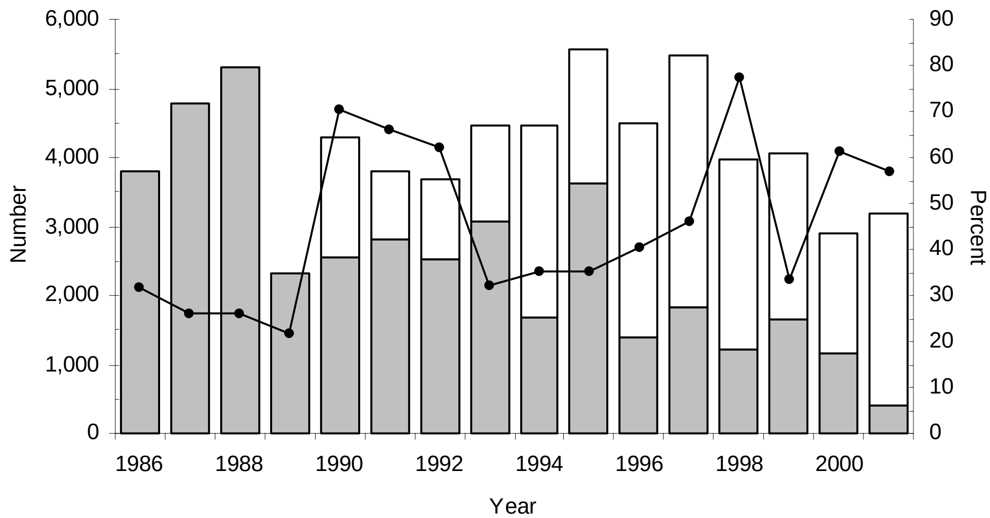

Figure 29.-Number of early-run Kenai River king salmon caught and released in the inriver recreational fishery downstream of the Soldotna Bridge (gray bar) and upstream of the bridge (white bar), and percent (line) of all fish caught that were released.

EARLY-RUN KASILOF RIVER KING SALMON FIGURES

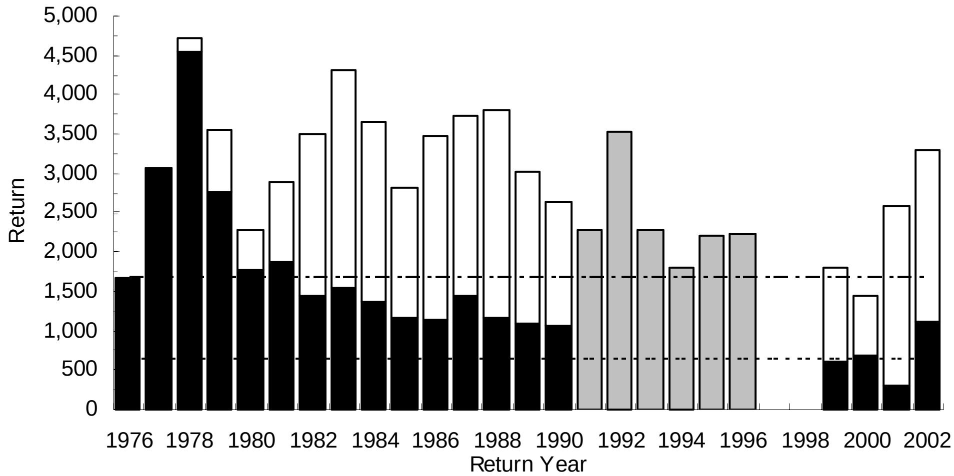

Figure 30.-Return of naturally-produced (black bar), hatchery-stocked (white bar), or combination of both groups of unknown composition (gray bar), of early-run Kasilof River king salmon to a weir at Crooked Creek. There was no weir in 1997 or 1998. Dashed lines indicate the lower and upper values of the SEG range in effect beginning in 2002. Estimates for 2002 are preliminary.

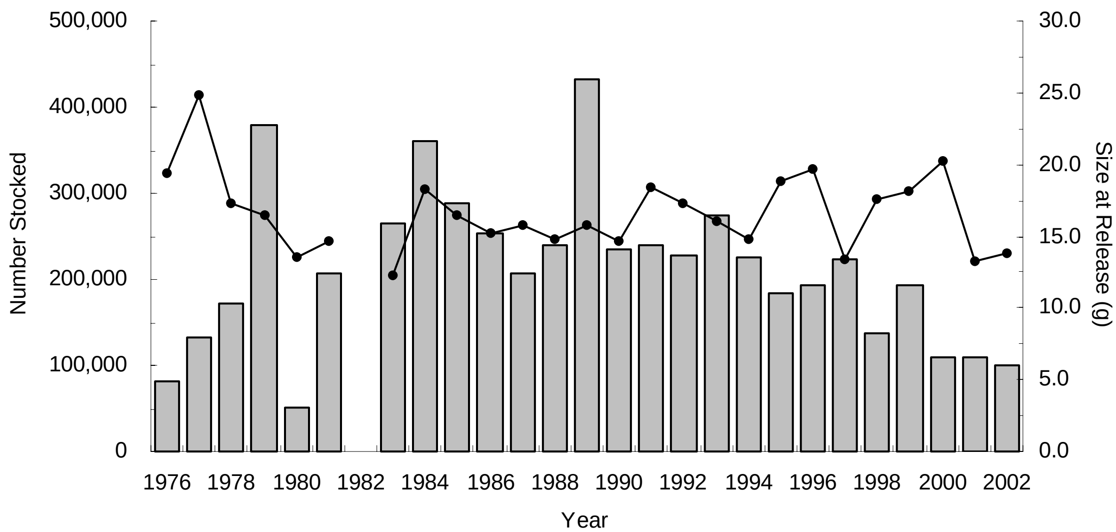

Figure 31.-Number (gray bar) and average size (line) of hatchery-produced early-run Kasilof River king salmon stocked at Crooked Creek, excluding fingerlings stocked in early years of the program. Estimates for 2002 are preliminary.

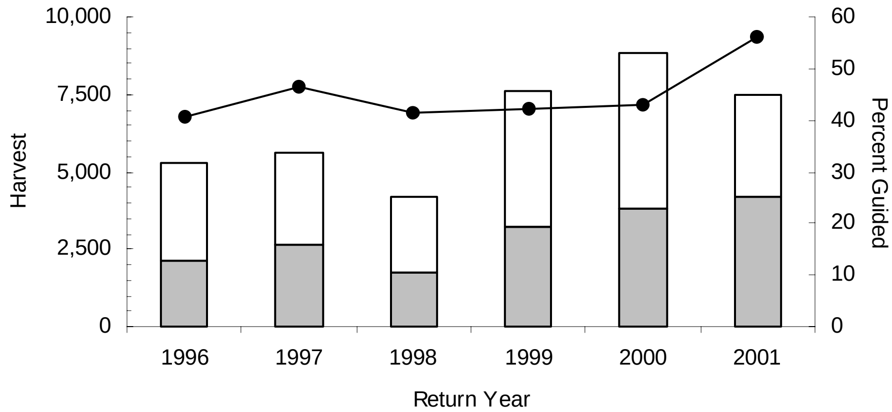

Figure 32.-Harvest of early-run Kasilof River king salmon by guided anglers (gray bar) and unguided anglers (white bar), and percent of harvest by guided anglers (line).

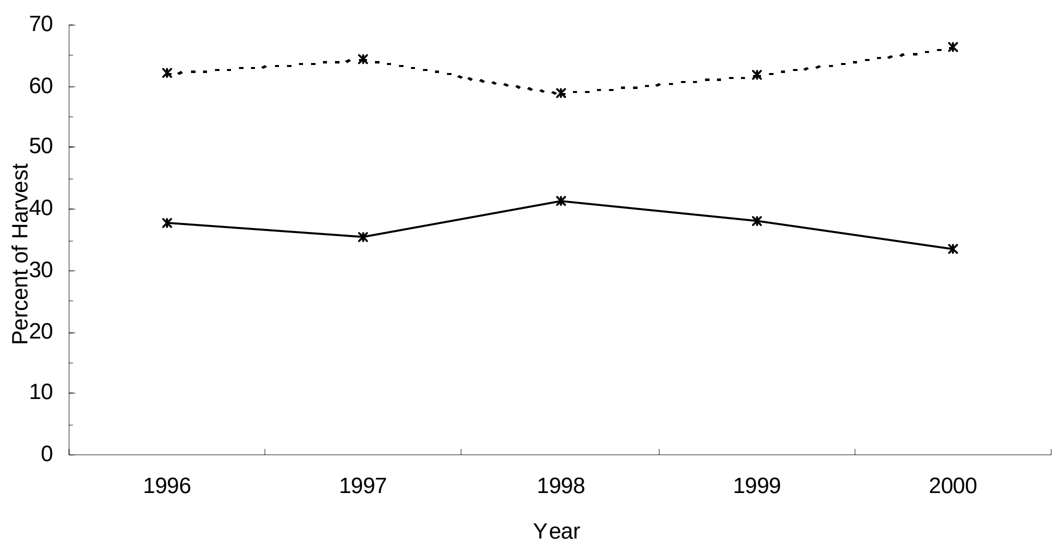

Figure 33.-Percent of harvest of early-run Kasilof River king salmon by residents of Alaska (solid line) and nonresidents (dashed line).

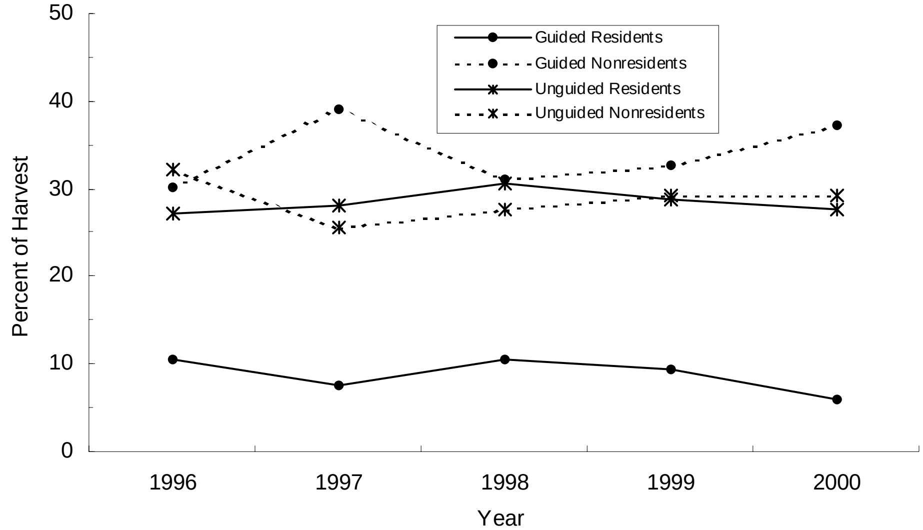

Figure 34.-Percent of harvest of early-run Kasilof River king salmon, by angler type and residence type.

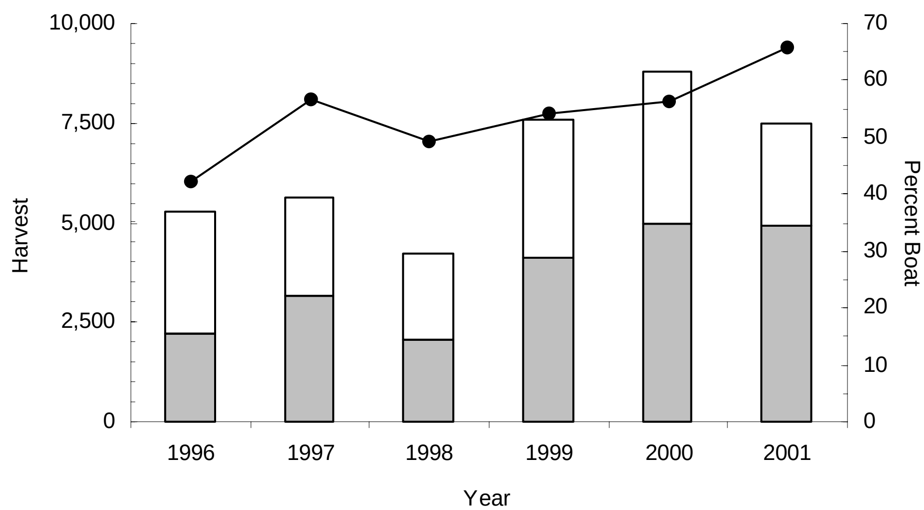

Figure 35.-Harvest of early-run Kasilof River king salmon by boat anglers (gray bar) and shore anglers (white bar), and percent of harvest by boat anglers (line).

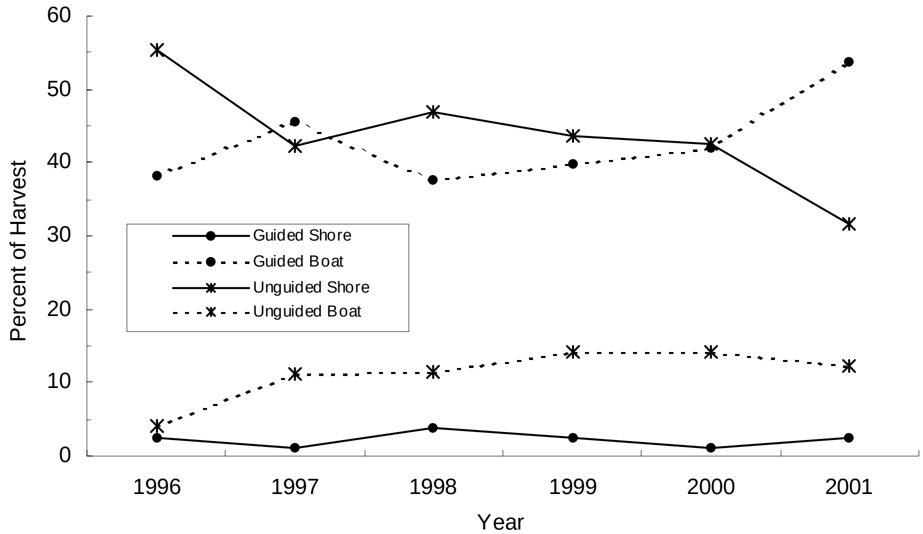

Figure 36.-Percent of harvest of early-run Kasilof River king salmon, by angler type for both boat and shore anglers.

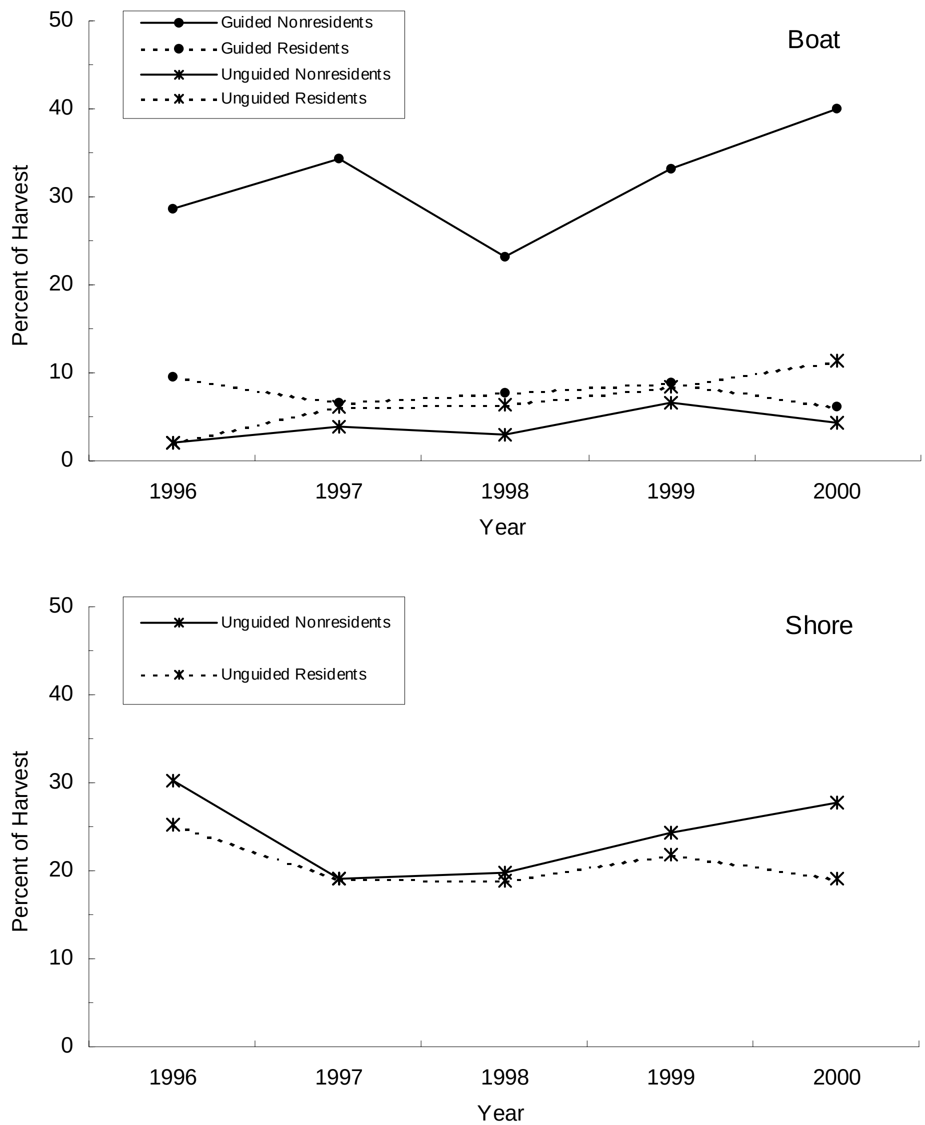

Figure 37.-Percent of harvest of early-run Kasilof River king salmon, by angler type and residence type for both boat and shore anglers.

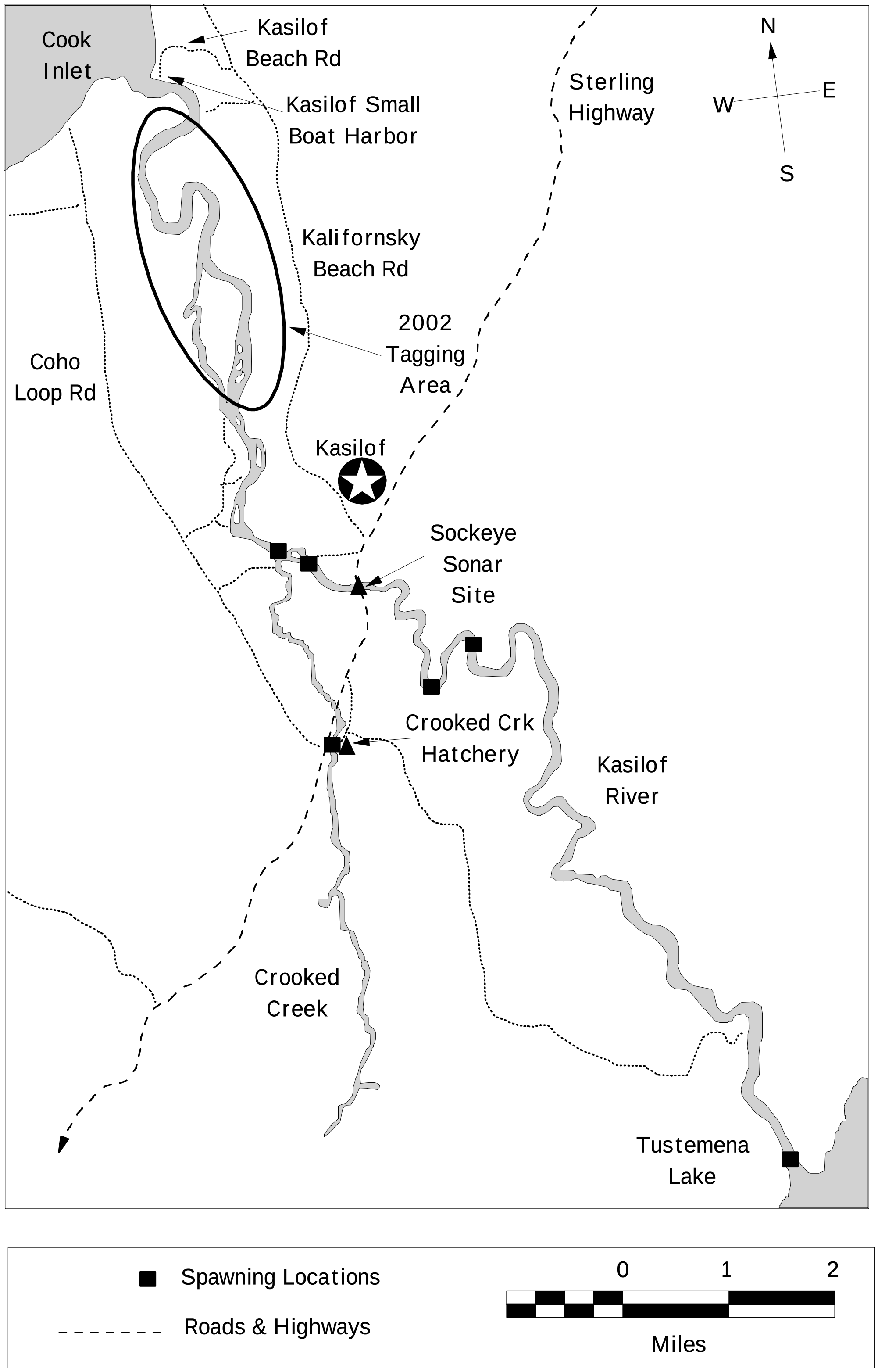

Figure 38.-Spawning destination for radio-tagged late-run Kasilof River king salmon in 1987. Adapted from Faurot and Jones (1990).

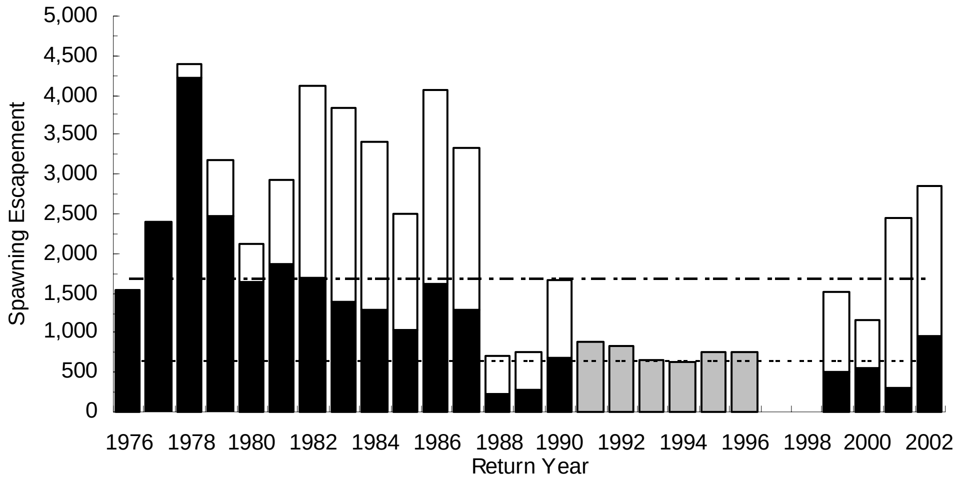

Figure 39.-Spawning escapement of naturally-produced (black bar), hatchery-stocked (white bar), or combination of both groups of unknown composition (gray bar), of early-run Kasilof River king salmon to a weir at Crooked Creek. There was no weir in 1997 or 1998. Dashed lines indicate the lower and upper values of the SEG range in effect beginning in 2002. Estimates for 2002 are preliminary.

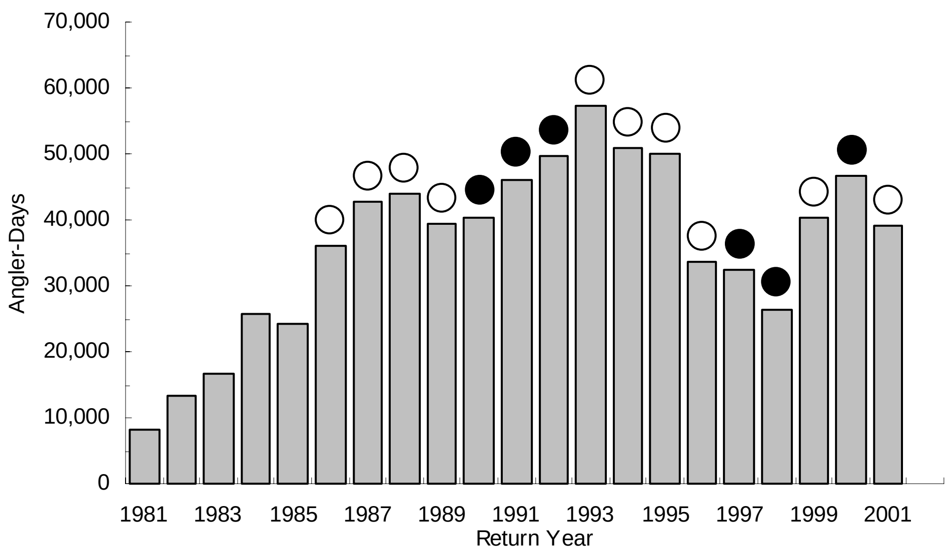

Figure 40.-Effort (angler-days) in all Kasilof River recreational fisheries, estimated from the SWHS. Open circles indicate years of no restrictions on the early-run Kenai River king salmon fishery while closed circles indicate years with restrictions to the Kenai River fishery.

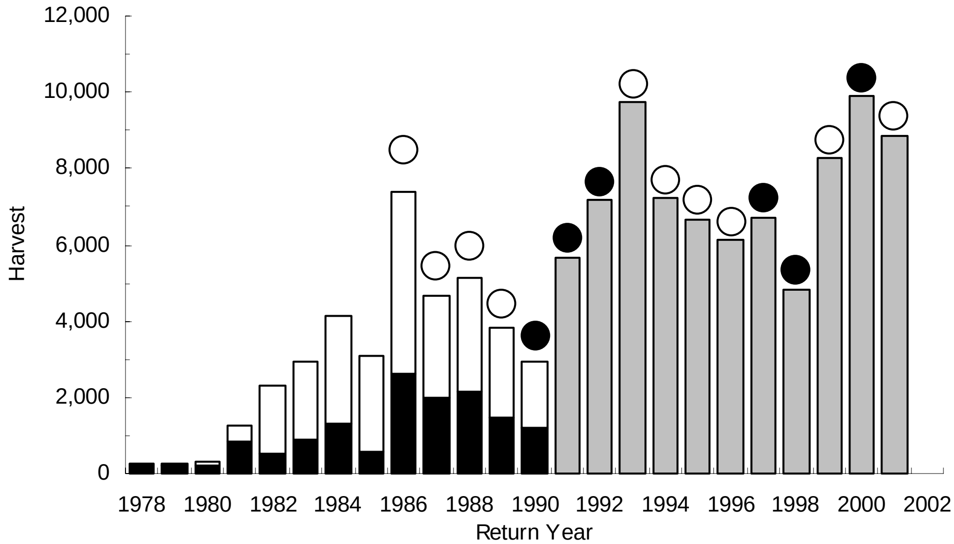

Figure 41.-Harvest of naturally-produced (black bar), hatchery-stocked (white bar), or combination of both groups of unknown composition (gray bar), of Kasilof River king salmon (early and late runs combined), estimated from the SWHS. Open circles indicate years of no restrictions on the early-run Kenai River king salmon fishery while closed circles indicate years with restrictions to the Kenai River fishery.

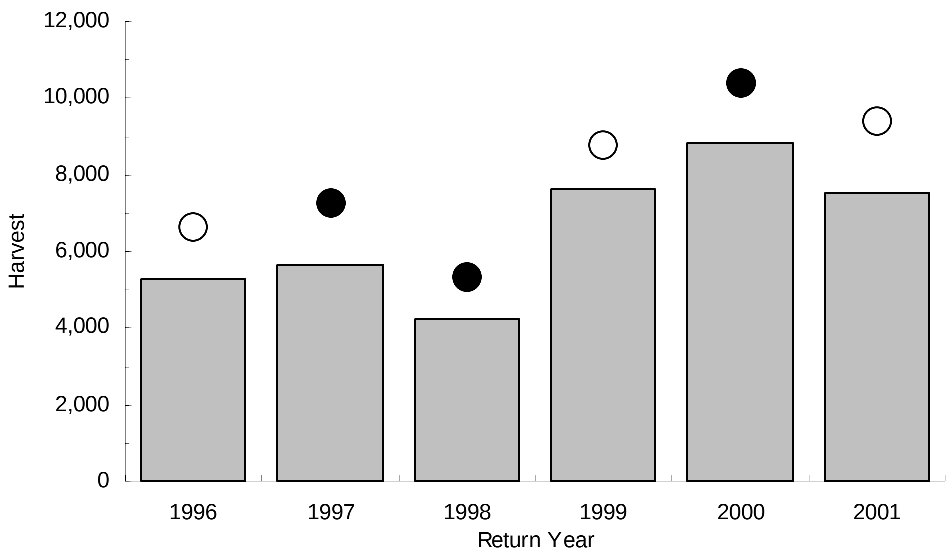

Figure 42.-Harvest of early-run Kasilof River king salmon, estimated from the SWHS. Open circles indicate years of no restrictions on the early-run Kenai River king salmon fishery while closed circles indicate years with restrictions to the Kenai River fishery.