Fishery Data Series No. 98-10

Assessment of Angler Impacts to Kenai River Riparian Habitats during 1996

by

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and

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July 1998

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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ABSTRACT

From 22 May through 29 August 1996, a habitat inventory encompassing vegetative, substrate and trampling variables was conducted along the flowing waters of the Kenai River, Alaska. This project was initiated in response to the Alaska Board of Fisheries liberalizing the bag and possession limits for the inriver sockeye salmon fishery on the condition that there is no net loss of riparian habitat resulting from this management action. This is the baseline year of a 3-year habitat and angler count study on the Kenai River. A total of 15,770,420 habitat units suitable for rearing juvenile chinook salmon were estimated throughout four river reaches which encompassed 123.3 river bank miles, including some islands, of the Kenai River. Trampling within 10 feet of ordinary high water was significantly more prevalent on private than public property, river wide. The total count of sport anglers fishing from shore during the sockeye salmon fishery (9 July through 8 August 1996) was almost equally divided between anglers utilizing public and private property; however anglers utilizing public property were concentrated on 57% less shoreline than anglers utilizing private property. A comparison of angler counts between 1996 and an independent study conducted in 1995 showed an increase in the number of anglers fishing from islands, and in reach 3 a shift in angler use from public to private property during 1996. No correlation was found between levels of trampling provided by the habitat survey and shore angler counts conducted during the sockeye salmon fishery.

Key words: Kenai River, riparian habitat, trampling, angler impact, chinook salmon, sockeye salmon.

INTRODUCTION

The Kenai River (Figure 1) supports the largest freshwater sport fishery in Alaska. Fishing effort occurs throughout the drainage and targets a variety of species including chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch,* sockeye salmon *O. nerka*, pink salmon *O. gorbuscha,* resident rainbow trout *O. mykiss* and Dolly Varden *Salvelinus malma*. Of these, sockeye salmon support the majority of fishing effort.

The Kenai River supports two runs of sockeye salmon. The early run is of Russian River origin and arrives at this Kenai River tributary in early June. The late run comprises Kenai River and tributary spawners and arrives in early July. Responding to a public proposal, the Alaska Board of Fisheries (BOF) adopted regulations in 1996 to increase freshwater harvest opportunities for anglers targeting late-run Kenai River sockeye salmon. This was effected by increasing the upper limit sonar goal for adult sockeye salmon returning to the Kenai River by 100,000 during 1996 and by an additional 25,000 in each of the next 2 years (1997-1998). Through this action the Board established a sockeye salmon sonar count range for 1996 of 550,000 to 800,000; and for 1998 and after of 550,000 to 850,000 (5 AAC 21.360). In addition, the BOF liberalized bag and possession limits, effective in 1996, for the inriver sport fishery and the personal use dip net fishery occurring at the mouth of the Kenai River.

Recreational sockeye salmon fishing is prosecuted mainly from the riverbank or while standing in the river along gravel bars at or near the shoreline. Some sockeye salmon anglers use boats to access a desired fishing location, but seldom do anglers fish from boats. Because sockeye salmon angling is principally a shorebased fishery, damage to riparian habitat is a major concern to fishery managers and Kenai River property owners.

Realizing the importance of maintaining riparian habitat, the BOF expressed concern that their actions not result in further damage to riparian habitat along the Kenai River. The BOF also stated that they would reconsider the increased allocation of sockeye salmon if additional damage to riparian habitat occurred due to increased shorebased angling. The BOF also granted the commissioner of the Department of Fish and Game regulatory authority to close state, federal or municipal riparian habitat to angling if the department determines that the activity is likely to

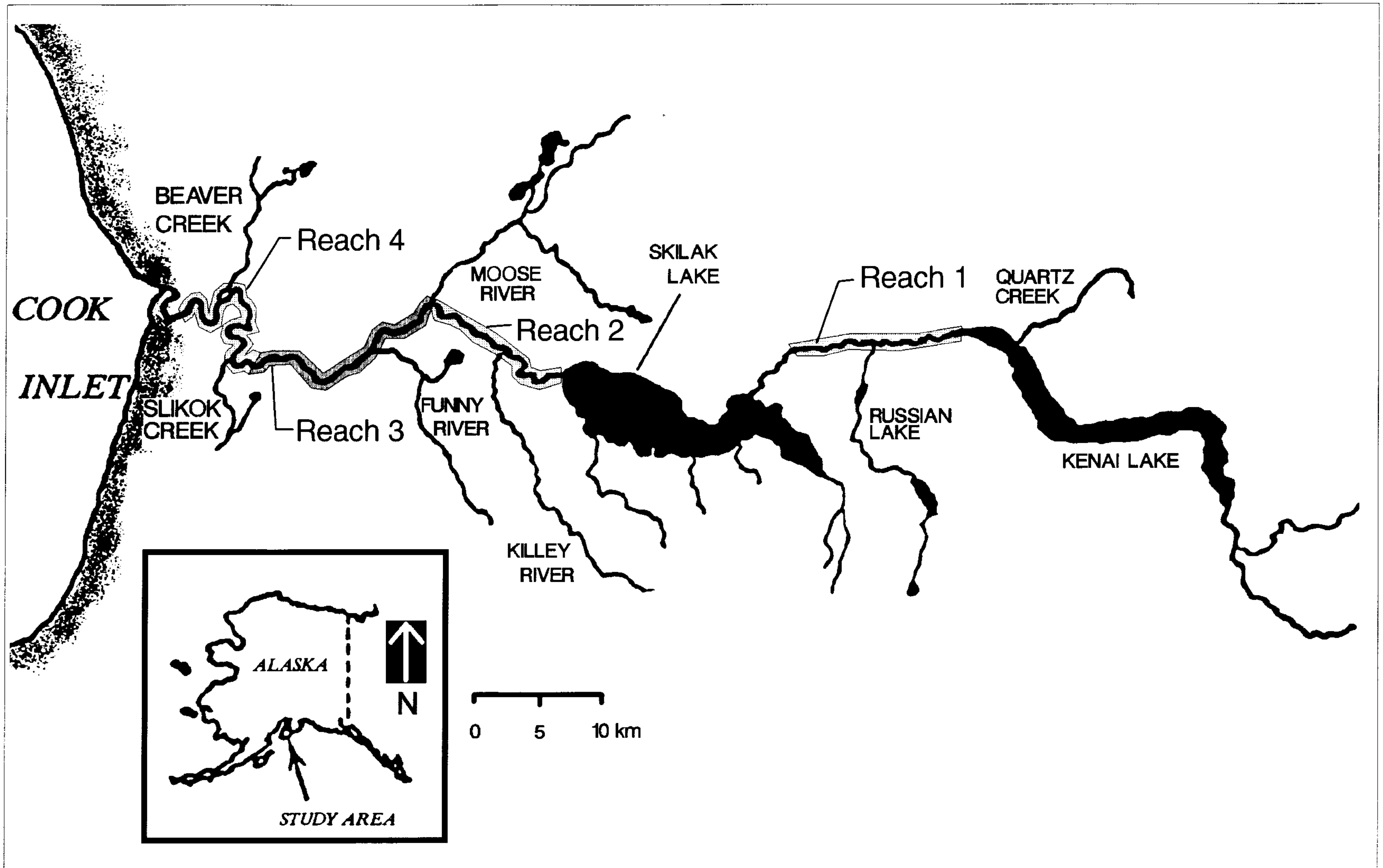

Figure 1.-Map of the Kenai River showing habitat survey reaches, 1996.

result in damage to riparian habitat. Last, the BOF asked that the department monitor use and impacts to Kenai River riparian habitat and report findings to them at their next regularly scheduled Cook Inlet regulatory meeting during 1998.

The BOF requested that habitat assessment follow procedures described by Liepitz (1994), more commonly referred to as the "309" study. This study is based on habitat units calculated for various vegetation and substrate cover types present within the riparian zone based on suitability index curves (U.S. Fish and Wildlife Service 1980) for a given indicator species (in this case, juvenile chinook salmon).

This study was implemented to monitor use of and impacts to mainstem Kenai River riparian habitat due to bank angling for sockeye salmon. Specific objectives of this project were to:

1. Estimate the total number of riparian habitat units within selected river reaches during the period 22 May to 29 August;
2. Estimate the amount of trampling which occurs within selected river reaches by public and private ownership;
3. Map the location of shore angler activities during the period 9 July through 8 August and compare with 1995 results; and
4. Determine if a significant relationship exists between angler counts and habitat units, angler counts and level of trampling, and between habitat units and level of trampling.

STUDY AREA

The Kenai River drainage encompasses approximately 2,200 square miles from its headwaters in the Kenai Mountains and Kenai Lake, to its outlet into upper Cook Inlet (Scott 1982). The total length of riverbank included in this study is approximately 166.6 lineal miles, including the left and right banks (mainland banks) and islands (including gravel bars). The Kenai River mainstem was divided into four reaches (Table 1, Figure 1). Reach 1 included the outlet of Kenai Lake to Skilak Lake (river mile [RM] 82-65), Reach 2 included the outlet of Skilak Lake to the Moose River (RM 50-36), Reach 3 covered the Moose River to the Soldotna Bridge (RM 36-21), and Reach 4 extended from the Soldotna Bridge to the Warren Ames Bridge (RM 21-5). Areas excluded from the habitat survey included the tidal area downstream of the Warren Ames Bridge (RM 5.2-0), the area upstream of Skilak Lake to Jim's Landing (total of 12.4 riverbank miles), and most of the islands (total of 20.6 riverbank miles). Five islands, all within Reach 4 (located at RM 13.2, 13.7, 14.8, 15.0, and 15.5), were the only islands surveyed.

The ownership of all land along the Kenai River corridor was determined as either public or private using maps obtained from the Kenai Peninsula Borough (KPB). Public property was further classified as State Park, State of Alaska, University of Alaska, Kenai Peninsula Borough, City of Kenai, City of Soldotna, or Federal lands.

METHODS

HABITAT ASSESSMENT

Initially, we intended to use the Habitat Evaluation Procedures (HEP) methodology described by Liepitz (1994) to assess the riparian habitat. However, after field testing this method we found it

Table 1.-Levels of sampling for surveyed areas of the Kenai River by reach, bank, date, and river mile, 1996.

Reach	Bank	Date	River Miles	Section Numbers	Sampling Rate (Sections)	Percent Sampled
1	Left	12 - 14 August	82 - 74	1 - 149	sampled 1, skipped 3	25
1	Left	11 - 12 June	73.9 - 72	151 - 194	sampled every section	100
1	Left	21 August	71.9 - 69.7	195 - 239	sampled 1, skipped 3	25
1	Right	12 - 14 August	82 - 74	1 - 149	sampled 1, skipped 3	25
1	Right	11 - 12 June	73.9 - 72	151 - 208	sampled every section	100
1	Right	21 August	71.9 - 69.7	210 - 232	sampled 1, skipped 1	50
2	Left	15 - 16 July	50 - 47.4	1 - 62	sampled 2, skipped 2	50
2	Left	16 July - 5 August	47.2 - 36	64 - 270	sampled 1, skipped 1	50
2	Right	17 July - 6 August	50 - 36.5	2 - 264	sampled 1, skipped 1	50
3	Left	17 June - 10 July	36.1 - 27.5	1 – 284[a]	sampled every section	100
3	Right	17 June - 9 July	36.1 - 21.1	1 - 284	sampled every section	100
4	Left	22 May - 10 June	21.1 -10.75	1 - 202	sampled every section	100
4	Left	7 August	10	203 - 207	sampled every section	100
4	Left	7, 27 August	10 - 5.2	208 -304	sampled 1, skipped 1	50
4	Right	22 May - 10 June	21.1 -10.75	1 - 213	sampled every section	100
4	Right	7 - 29 August	10 - 5.2	214 - 306	sampled 1, skipped 1	50

[a] Total of 283 sections; section number 139 eliminated due to error in labeling section numbers.

to be too subjective for our purposes and for this reason we modified the design in an attempt to reduce subjectivity, improve repeatability, and reduce variability between observers. In the modified study design the quantification of variables was changed from estimation of lineal footage to a simpler determination of presence or absence of a particular variable. All of the original variables described in Liepitz (1994) were retained and some new variables were added.

Three types of information were collected to describe the riparian habitat:

1. VEGETATION TYPE

    a. Herbaceous: plant whose stem withers away at the end of the growing season.

b. Woody Stem: plant whose stem continues to grow from year to year but limited to shrubs, plants with several stems instead of a single trunk (willow, alder, deciduous trees with less than 1-inch diameter trunk at breast height, low and high bush cranberry, rose, etc.).

c. Tree: plant whose stem continues to grow from year to year and whose stem consists of a **single** trunk (all spruce, deciduous trees must have a minimum of 1-inch diameter trunk at breast height).

d. Non Vegetated, natural: river bank without vegetation, caused by natural process, e.g., naturally eroding cut bank or a heavily used game trail (used predominately by animals) that has been denuded from such use.

2. COVER TYPE

a. No Object Cover: No vegetative cover present (natural or unnatural) at the ordinary high water line (OHW).

b. Emergent Vegetation: plants occurring below OHW which must grow above the waterline to survive, e.g., grasses, rushes, reeds, etc.

c. Aquatic Vegetation: plants occurring below the OHW, which remain submerged, e.g., whitewater crowfoot.

d. Debris/Deadfall: natural woody material deposited at or just below OHW, e.g., trees, root wads, etc.

e. Overhanging vegetation: plants of any type that upon annual maturity may extend beyond the OHW line towards the river, to include grasses, shrubs and trees but not mosses, low bush cranberries, crow berries, dogwood, etc.

f. Undercut Banks: shoreline that is recessed a minimum of 6 inches below the OHW line in a manner that creates a cavity suitable for juvenile chinook salmon to find refuge.

3. SUBSTRATE

a. Mud/Sand/Silt (MSS): material too small for a person to physically throw an individual particle (<1 mm).

b. Gravel (G): material between MSS and 3 inches diameter.

c. Rubble (R): material between 3 inches and 5 inches diameter.

d. Cobble (C): material greater than 5 inches diameter.

e. Pores Filled (PF): 100% of substrate present embedded with smallest substrate size. Pores filled was added to the substrate variables to describe situations where multiple aggregate types (MSS, G, R or C) were present but embedded by the smallest aggregate size and, therefore, the larger substrates were assumed unusable by rearing juvenile chinook salmon.

Each reach was divided into 100-yard sections and each section was further divided into twelve, 25-foot subsections. However, sections abutting property ownership boundaries or public easements were sometimes less than 100 yards in length. Sections on both banks were numbered consecutively starting at the upstream end of each reach. Islands within a reach were numbered consecutively starting at the upstream end of each reach. The 100-yard sections circumscribing each island were also consecutively numbered**,** starting at the upstream apex of each island and rotating in a clockwise direction around the island.

Photographs and a differentially corrected global positioning system (DGPS), with an accuracy of ±10 meters, were both used to identify each river section surveyed. Photographs included the vegetation and shoreline at the upstream end of each river section. With these tools, an individual 100-yard section could be revisited by first relocating the section using the DGPS and then matching the vegetation/landscape background with the photograph.

The ordinary high water (OHW) line was the reference point from which riparian and substrate data were collected. In the non-tidal portions of the river, the OHW line was defined as the location on the bank where the presence and action of the water is so common and usual, and so long continued in all ordinary years, as to leave a natural line or "mark" impressed on the bank or shore and indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or distinctive physical characteristics. The OHW line was distinguished by a change in substrate coloration: substrate offshore from the OHW line was lighter in color than the substrate immediately inland from the OHW line. In the tidally influenced portions of the river, the OHW line was defined as the mean high water elevation. Cover and substrate types were evaluated from the OHW offshore for a distance of 6 feet while all other variables were evaluated in a 10-foot wide onshore corridor. Each variable was evaluated based on its presence or absence within a 16-foot wide riparian and substrate corridor of each 25-foot subsection (Figure 2).

Data were collected in the field by two, 3-person crews, each crew working on opposite banks. One person in each crew operated a motorized skiff (driver), while the other two collected survey information (readers). The specific duties of each individual varied depending on river location, terrain makeup, and physical requirements; however, all duties were rotated amongst all employees throughout the day. To begin a survey, a 100-yard poly-nylon braided line was deployed along the natural contour of the riverbank, at or near the OHW line. The 100-yard line was premarked in 25-foot subsections with colored cable ties. Originally, we intended to conduct a census of all the sections, however, time constraints did not allow achievement of this goal. All of Reach 3 was censused, all other sections were systematically sampled (Table 1). Sampling rates varied between and within each reach and were established in the field depending on observed variability in riparian habitat between surveyed sections and time available to complete the study.

Only cover and substrate variables were used to calculate habitat units, a measure of the value of the habitat to rearing juvenile chinook salmon. The other information helped characterize the vegetation of the riparian corridor and catalogue trails and structures along the Kenai River. Habitat units were calculated using the formula:

$$\mathrm{HU_i} = \frac{\mathrm{NC}(0.01) + \mathrm{EV}(0.30) + \mathrm{AV}(0.65) + \mathrm{DD}(0.90) + \mathrm{OV}(0.38) +}{10} \tag{1}$$

$$\frac{\mathrm{UB}(1.00) + \mathrm{MSS}(0.76) + \mathrm{G}(0.25) + \mathrm{R}(0.21) + \mathrm{C}(0.08)}{10} \cdot \mathrm{length_i}\ ,$$

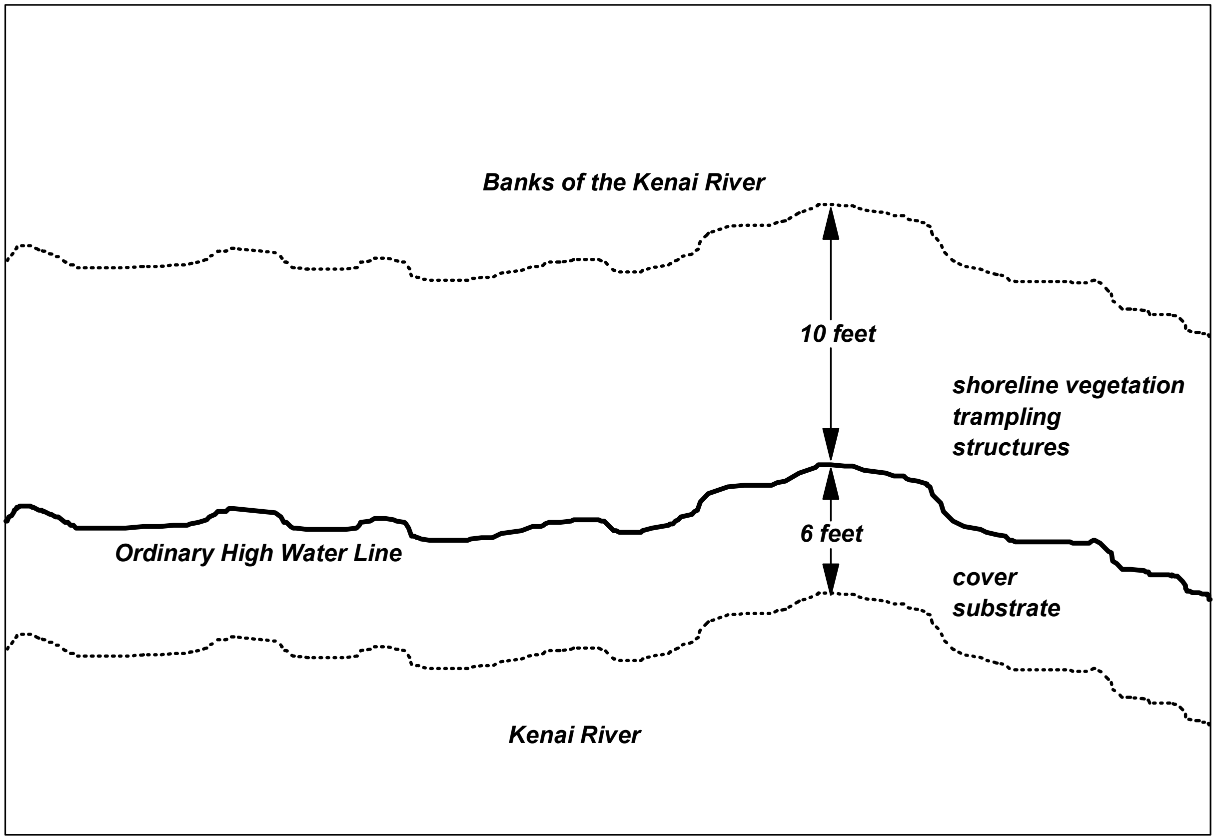

Figure 2.-Schematic depicting the sampling scheme used to assess riparian habitat and trampling in each 25-foot survey section.

where:

HU_i	=	habitat units for section i;
NC	=	percent of subsections in section i where no cover was present;
EV	=	percent of subsections in section i where emergent vegetation was present;
AV	=	percent of subsections in section i where aquatic vegetation was present;
DD	=	percent of subsections in section i where debris deadfall was present;
OV	=	percent of subsections in section i where overhanging vegetation was present;
UB	=	percent of subsections in section i where undercut banks were present;
MSS	=	percent of subsections in section i where mud, sand or silt was present (size < 0.04 in);
G	=	percent of subsections in section i where gravel was present (size 0.04 in to 2.95 in);
R	=	percent of subsections in section i where rubble was present (size 2.96 in to 4.92 in);

C = percent of subsections in section i where cobble was present (size >4.93 in); and

$length_i$ = length (in feet) of section i.

The number in parenthesis beside each cover or substrate type within the formula are the chinook salmon juvenile suitability index values (Figure 3) as reported in Raleigh et al. (1986). If multiple aggregate types were present and the substrate pores were filled (making the larger substrates unusable by rearing juvenile chinook salmon) only the smallest aggregate size was used in the calculation of HUs.

To allow comparison of unequal section lengths, habitat units were corrected to represent the number of habitat units per lineal foot. The corrected habitat units (CHU) were calculated for each section as:

$$CHU_i = \frac{HU_i}{length_i}. \tag{2}$$

Mean corrected habitat units were calculated for a reach by:

$$\overline{CHU} = \frac{\sum_{i=1}^{n} CHU_i}{n}, \tag{3}$$

where:

n = the number of sections within the reach.

One-way analysis of variance (Snedecor and Cochran 1967) was used to test the null hypothesis that there was no difference in mean corrected habitat units among reaches.

For sections not surveyed, habitat units were estimated by averaging the HUs measured from the nearest six surveyed sections, three upstream and three downstream:

$$\hat{HU}_i = \frac{\sum_{i-3}^{i+3} \text{sampled } HU_i}{\text{number of sections sampled between } i-3 \text{ and } i+3}. \tag{4}$$

The variance of the estimated habitat units was estimated by the formula:

$$V(\hat{HU}_i) = \frac{\sum_{i-3}^{i+3} (\text{sampled } HU_i - \hat{HU}_i)^2}{(\text{number of sections sampled between } i-3 \text{ and } i+3) - 1}. \tag{5}$$

TRAMPLING ASSESSMENT

Fishery managers are concerned with how trampling due to increasing angler use may affect riparian habitat. The same areas included in the habitat assessment were also included in the trampling assessment. Trampling was defined as a loss of vegetation due to terrestrial traffic, whether human or other in origin. The degree of trampling was rated as high, medium, low or none based on the following criteria:

1. High: use obvious, vegetation mat mostly denuded; denuding greater than 50% of natural vegetation.
2. Medium: use evident, vegetation mat mostly intact; denuding less than 50% of natural vegetation.
3. Low: use evident, natural vegetation mat intact; no denuding. Lawns are included in this category.
4. No Trampling: natural vegetation mat unaltered and no evidence of trails.

The most common product of terrestrial traffic was exemplified by trails, campsites, preferred fishing locations, and lawns. Naturally denuded areas were not considered trampled. Cut banks were often denuded due to natural erosion processes and were not necessarily a function of trampling.

To determine whether trampling was present within a 25-foot subsection, an observer first evaluated what the natural vegetative mat was throughout the 10-foot wide riparian area and then evaluated any vegetation loss relative to the natural vegetative mat. In the case of a lawn, if the vegetation mat of the lawn was unaltered, the area was assigned to the low category, given the natural vegetation mat was altered. For each subsection determined to have trampling, the degree

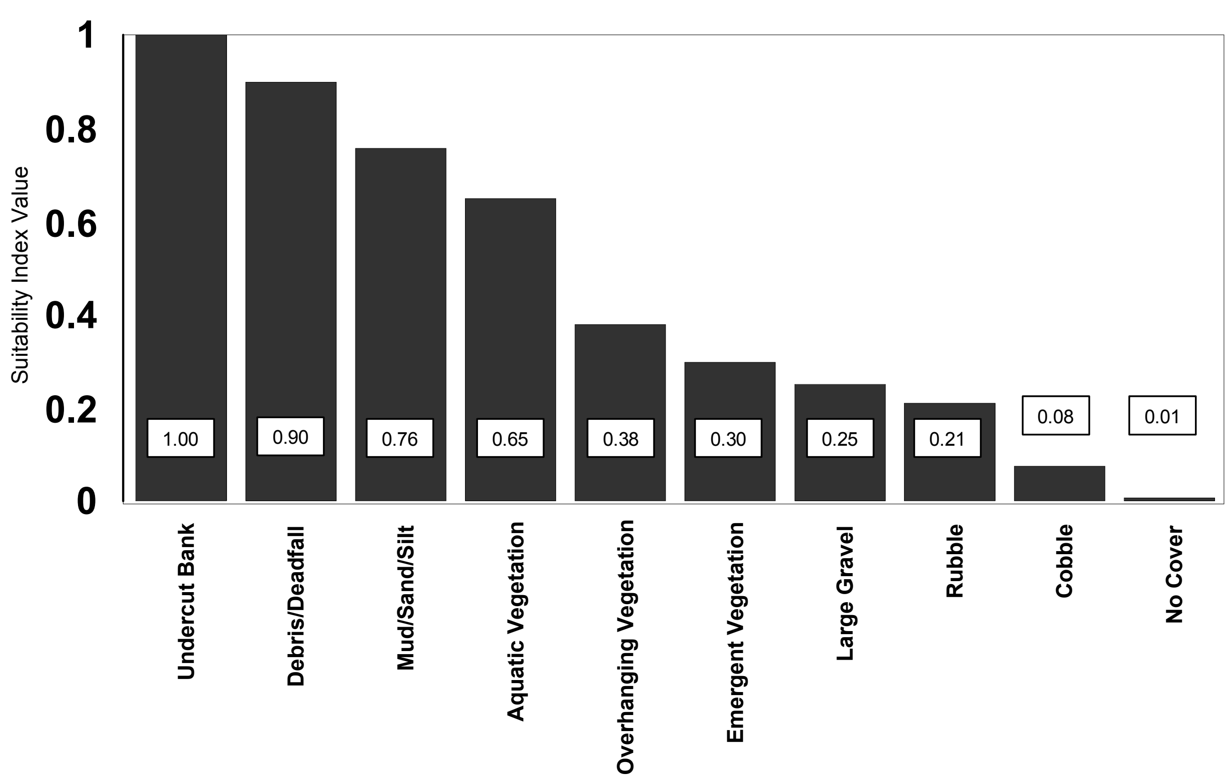

Figure 3.-Suitability index values used to calculate habitat units for various cover types.

of trampling present (high, medium, or low) was determined. If a level of trampling was predominant (observed on > 50% of the subsection) then the subsection was assigned that level of trampling. If there was no predominant level then worst case scenario was used and the subsection was given the highest level of trampling observed in that subsection.

A chi-square analysis was used to compare high, medium, low, or nontrampled areas under public and private property ownership.

ANGLER SURVEY ASSESSMENT

Surveys of anglers fishing from the banks of the Kenai River (including gravel bars and islands) were conducted during the late-run sockeye salmon fishery to determine the location and magnitude of bank angling along the mainstem Kenai River. A total of 21 surveys were systematically conducted between 9 July and 8 August 1996. Angler surveys were conducted systematically within the four river reaches. Angler surveys within Reaches 1, 3 and 4 were conducted between 1000 hours and 1800 hours and within Reach 2 between noon and 2000 hours. These sampling times were chosen to include peak hours of effort for each reach (M. A. King, Alaska Department of Fish and Game, Soldotna, personal communication). This information was used to determine if there was a relationship between trampling, habitat value, and angler counts. During each survey, locations of anglers were determined using DGPS, corrected to correspond to the location of angling. To quantify the relationship between trampling and sockeye angler activities, the distribution of anglers along the Kenai River was mapped and compared to the habitat survey results.

A chi-square analysis compared previously unpublished results of a 1995 sockeye salmon angler survey to our 1996 survey. This comparison examined the between-year relationship of private and public land use. During 1995, groups of shore anglers were counted and their physical locations (left and right riverbanks and islands) were marked on a map. These mapped data points with associated angler counts were then plotted on a map displaying private and public land ownership and compared to 1996 survey results. A total of three counts were completed on 19 July, 24 July and 10 August, during 1995.

The average daily number of anglers counted during each year were compared by river reach, island use and public and private property ownership.

Average daily angler counts for each year sampled were calculated by the formula:

$$\bar{C} = \frac{\sum_{j=1}^{n} C_j}{n}, \tag{6}$$

where:

C_j = shore angler count for reach j;

j = river reach number; and

n = number of days anglers were counted within reach j.

Scatter graphs were used to examine the relationship between habitat units, level of trampling and angler counts. Pearson correlation analysis was used to test for a significant linear relationship between the angler counts and corrected habitat units, angler counts and percent trampled, and between corrected habitat units and percent trampling. Only those sections that were measured were used for the analysis. Counts of anglers per section were summed to form the angler count for that section. The percent trampled was calculated as the percent of the section that had any level of trampling.

OBSERVER VARIABILITY

The variability between observers was tested periodically. In these "tests," several observers independently evaluated habitat and trampling for the same 100-yard section. Observer variability was calculated by first determining the mean corrected habitat unit value of a specific 100-yard section tested:

$$\overline{CHU}_i = \frac{\sum_{k=1}^{n} CHU_k}{n}, \tag{7}$$

where:

CHU_k = corrected habitat units for observer k;

n = the number of observers within a section.

The percent difference between the mean corrected habitat unit value and each observer was calculated by the formula:

$$(\%\text{difference})_k = \frac{CHU_k - \overline{CHU}_i}{\overline{CHU}_i}(100). \tag{8}$$

Finally, an average percent difference was calculated for each observer.

RESULTS

HABITAT VALUE

Approximately half (52.3%) of the 166.6 bank miles (879,648 bank feet) of river below Kenai Lake, including islands, was surveyed for habitat value (Table 2 and Figure 4). Of the remaining bank miles not surveyed (47.7%), habitat value was estimated for 21.7%. The remaining 26.0% of bank miles were neither surveyed nor estimated (Table 3). These bank miles comprised areas of low bank angler use. Reaches 3 and 4 were the most intensively surveyed areas, comprising 54% of the combined areas surveyed and estimated, and 70% of the total area surveyed.

A total of 15,770,420 habitat units (95% CI = 13,198,352 to 18,350,797) were estimated throughout the four river reaches included in the study (Table 4 and Figure 5). Of this, 11,470,279 habitat units (72.7%) were from actual surveys and 4,300,141 habitat units (27.3%) were estimated. The mean CHU was not significantly different ($F = 0.08$, $df = 4, 1589$, $P = 0.99$) between reaches (Table 5 and Figure 5), indicating reaches do not have differing values for rearing habitat.

TRAMPLING

Trampling occurred on 48% of all surveyed areas (Table 6 and Figure 6). Of this, 60% had high, 21% medium, and 19% low trampling. Trampling was significantly more prevalent ($\chi^2 = 14.03$, $df = 3$, $P < 0.003$) on private property than on public property, river wide (Table 7). Of all four

Table 2.-Ownership of Kenai River property by reach and bank showing total footage and habitat units surveyed or estimated, 1996.

Reach	Bank	Ownership	Calculation Method	Feet	Habitat Units
1	Left	Public	Surveyed	25,800	527,920
1	Left	Public	Estimated	36,900	839,006
1	Left	Private	Surveyed	2,400	65,587
1	Left	Private	Estimated	6,600	176,200
1	Right	Public	Surveyed	29,700	749,079
1	Right	Public	Estimated	35,400	852,603
1	Right	Private	Surveyed	1,200	26,182
1	Right	Private	Estimated	3,600	78,717
			Reach Total:	141,600	3,315,294
2	Left	Public & Private	Estimated	300	7,318
2	Left	Public	Surveyed	18,900	509,983
2	Left	Public	Estimated	17,100	458,742
2	Left	Private	Surveyed	21,900	575,394
2	Left	Private	Estimated	22,800	605,902
2	Right	Public & Private	Surveyed	2,700	63,895
2	Right	Public & Private	Estimated	300	9,525
2	Right	Public	Surveyed	17,566	416,245
2	Right	Public	Estimated	19,200	459,419
2	Right	Private	Surveyed	19,200	351,963
2	Right	Private	Estimated	20,100	360,669
			Reach Total:	160,066	3,819,055
3	Left	Public	Surveyed	13,415	364,862
3	Left	Private	Surveyed	67,140	1,798,787
3	Right	Public	Surveyed	15,637	462,468
3	Right	Private	Surveyed	65,557	1,823,915
			Reach Total:	161,749	4,450,032
4	Left	Public	Surveyed	41,784	868,826
4	Left	Public	Estimated	11,700	176,156
4	Left	Private	Surveyed	31,560	727,038
4	Left	Private	Estimated	3,000	47,911
4	Right	Public	Surveyed	26,950	632,001
4	Right	Public	Estimated	9,600	161,432
4	Right	Private	Surveyed	46,942	1,196,137
4	Right	Private	Estimated	4,200	66,541
4	Island	Public	Surveyed	4,685	128,983
4	Island	Private	Surveyed	6,990	181,014
			Reach Total:	187,411	4,186,039

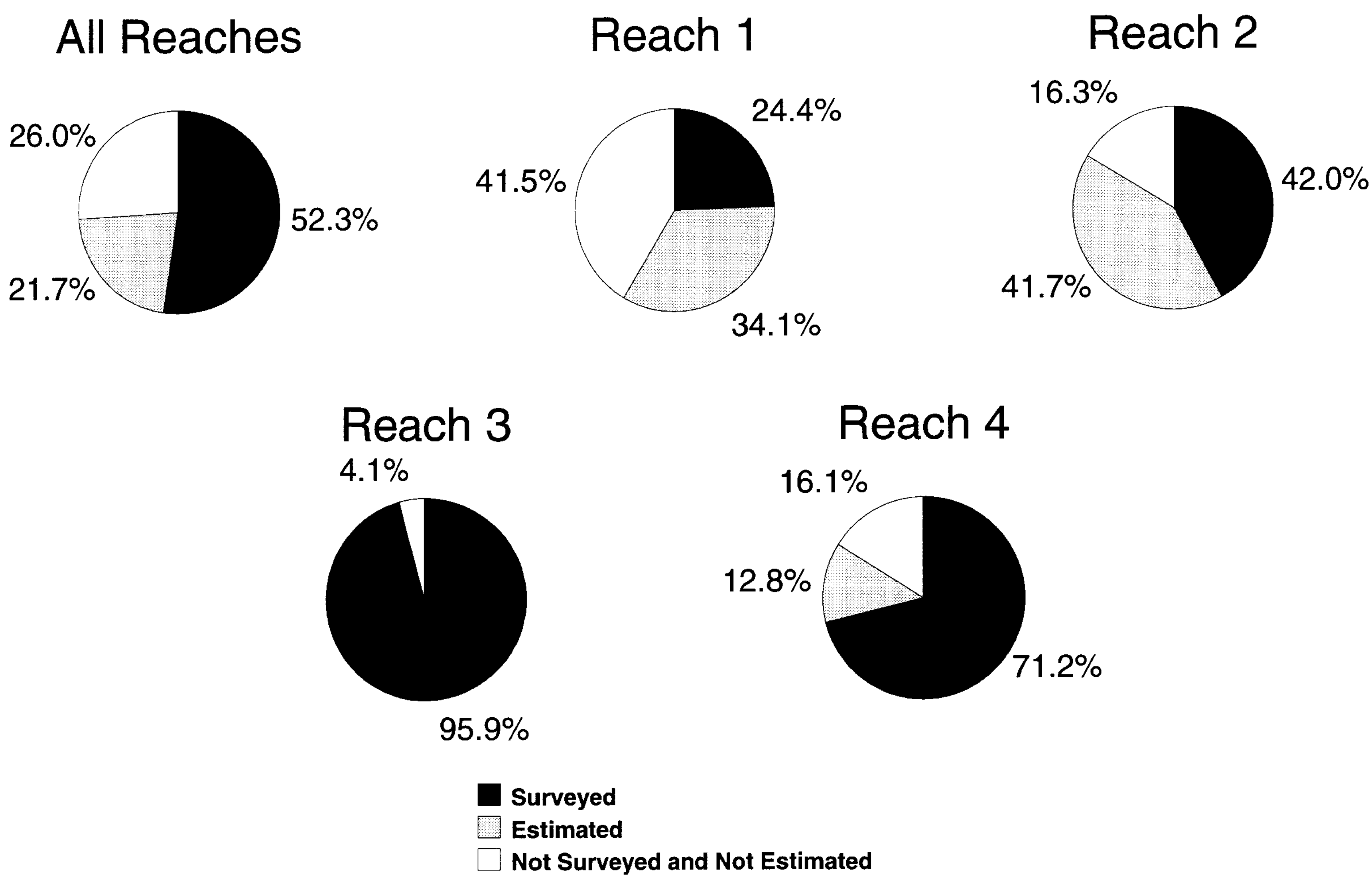

Figure 4.-Percent of Kenai River riparian habitat that was surveyed, estimated, or not surveyed and not estimated during 1996.

Table 3.-Ownership of Kenai River property by reach and bank showing total footage not surveyed and not estimated, 1996.

Reach	Bank	Ownership	Feet	Percent
1	Left	Public	30,605	17.6%
1	Right	Public	35,090	20.1%
1	Island	Public	34,680	19.9%
2	Island	Public	4,191	2.4%
2	Island	Private	26,890	15.4%
3	Island	Public	3,843	2.2%
3	Island	Private	3,150	1.8%
4	Island	Public	35,877	20.6%
		Total	174,326	

Table 4.-Number of estimated habitat units, corrected habitat units, and supporting statistics by river reach, Kenai River, 1996.

Statistic	All Areas	Reach 1	Reach 2	Reach 3	Reach 4	Islands in Reach 4[a]
Habitat Units	15,770,420	3,315,294	3,819,055	4,450,032	3,876,042	309,997
Standard Error	26,679	21,644	14,901	0	4,613	0
Measurement Error	0.16	0.16	0.16	0.16	0.16	0.16
Mean CHU[b]		23.41	23.86	27.50	22.10	26.44
Standard Error		0.1528	0.0931	0.0000	0.0262	0.0000
Measurement Error		0.16	0.16	0.16	0.16	0.16

[a] Five islands, located at river miles 13.2, 13.7, 14.8, 15.0, and 15.5, were sampled.

[b] Corrected Habitat Units.

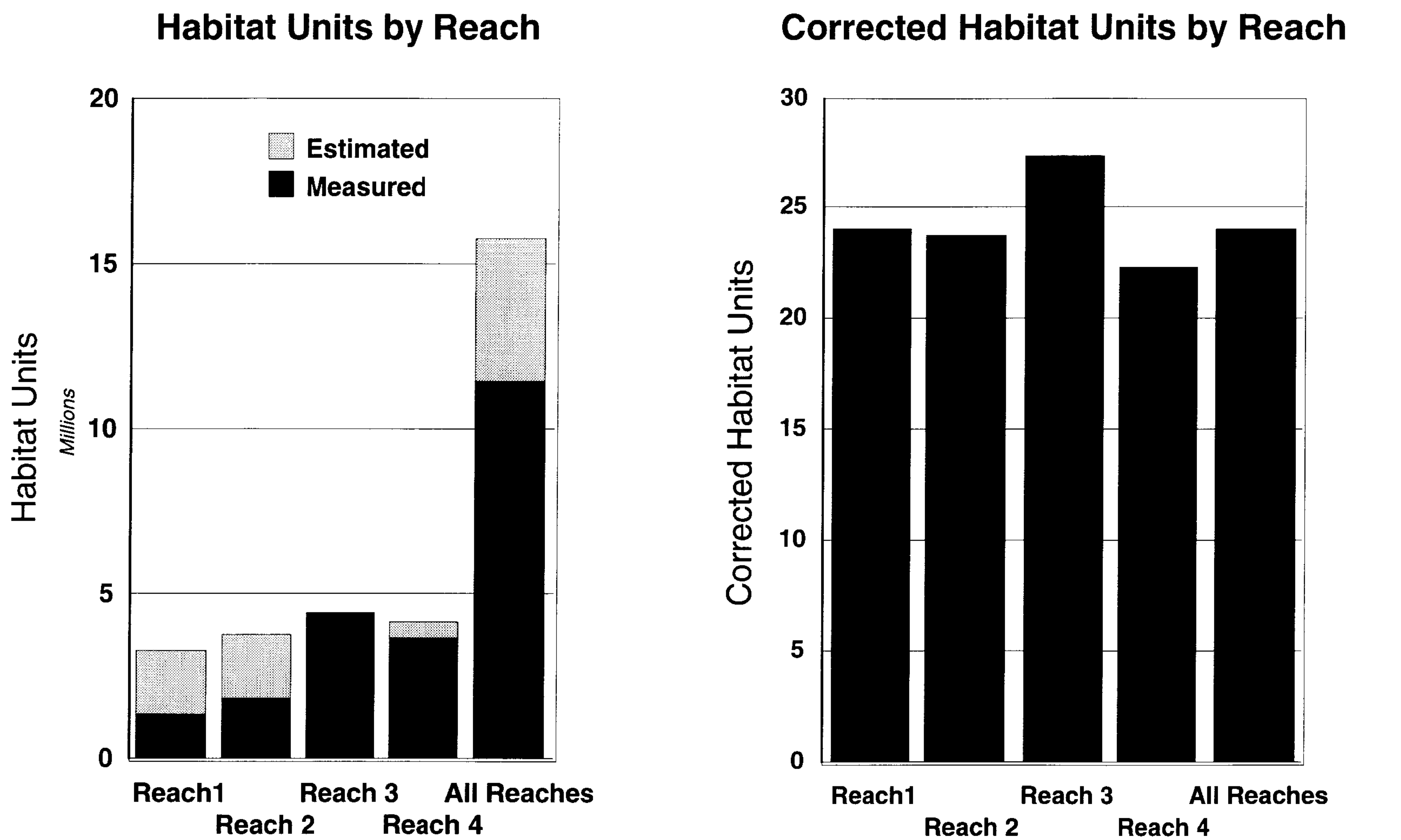

Figure 5.-Number of habitat units and corrected habitat units by reach in the Kenai River during 1996.

Table 5.-Comparison of corrected habitat units by test sections showing percent differences between observers, Kenai River, 1996.

Location			Corrected Habitat Units (CHU) by Observer						Mean	Percent difference from Mean CHU					
Reach	Bank	Section	A	B	C	D	E	F	CHU	A	B	C	D	E	F
1	Left	152	20.61	15.23				24.40	20.080	-0.56	-2.39				2.95
1	Right	177			25.22	28.02	19.13		24.119			4.55	16.16	-20.71	
3	Left	109	19.92	34.48				20.91	25.100	-20.65	37.35				-16.70
3	Left	114	32.10	32.96	33.33	34.23	32.49	34.13	33.207	-3.33	-0.75	0.36	3.09	-2.15	2.79
3	Left	152	29.51	28.97				30.55	29.675	-0.56	-2.39				2.95
3	Left	182	30.93	26.22				28.44	28.526	8.41	-8.09				-0.32
3	Left	200	27.50	26.81				28.83	27.711	-0.76	-3.26				4.02
3	Left	212	29.54	32.05		38.83	35.83		34.060	-13.27	-5.90		13.99	5.18	
3	Left	49	31.79	35.82				30.43	32.681	-2.72	9.60				-6.88
3	Left	77	30.13	34.78				34.29	33.067	-8.90	5.19				3.71
3	Right	110			30.79	31.89	32.24		31.641			-2.69	0.79	1.90	
3	Right	159			28.82	30.16	27.90		28.958			-0.49	4.14	-3.65	
3	Right	187			30.55	30.04	26.83		29.138			4.85	3.09	-7.94	
3	Right	25			36.60	32.11	28.66		32.457			12.76	-1.06	-11.70	
3	Right	26	27.10	26.17	35.66	30.83	32.56	27.40	29.953	-9.52	-12.64	19.05	2.94	8.70	-8.52
3	Right	80			36.84	35.23	35.18		35.750			3.05	-1.47	-1.59	
4	Left	100	25.72	25.18				25.66	25.519	0.77	-1.32				0.54
4	Left	124	23.12	21.58				23.49	22.731	1.70	-5.05				3.35
4	Left	136	27.90	26.22				28.30	27.472	1.56	-4.57				3.01
4	Left	176	28.06	30.86				29.56	29.492	-4.86	4.63				0.22
4	Left	210		17.75		17.82	14.13		16.564		7.16		7.57	-14.73	
4	Left	70	23.86	25.51				29.62	26.329	-9.38	-3.11				12.49
4	Right	109			31.92	31.28	32.32		31.839			0.25	-1.75	1.50	
4	Right	138			34.48	35.34			34.913			-1.23	1.23		
4	Right	169			25.75	32.34			29.046			-11.35	11.35		
4	Right	202			19.20	19.13	18.13		18.817			2.04	1.64	-3.68	
4	Right	29			34.81	32.76	34.43		33.997			2.38	-3.65	1.26	
4	Right	81			18.93	19.80	18.87		19.200			-1.39	3.13	-1.73	
									Minimum	-20.65	-24.14	-11.35	-3.65	-20.71	-16.70
									Maximum	8.41	37.35	19.05	16.16	8.70	12.49
									Average	-3.93	-0.46	2.30	3.82	-3.52	0.05

Table 6.-Trampling (feet) by reach, bank, and land ownership, Kenai River, 1996.

			Trampling (feet)					No. Sections
Reach	Bank	Ownership	None	Low	Medium	High	Total	Surveyed
1	Left	Private	1,695	75	123	498	2,391	8
1	Left	Public	10,251	2,325	2,724	10,494	25,794	86
1	Right	Private	1,035	0	0	165	1,200	4
1	Right	Public	16,977	2,001	1,944	8,775	29,697	99
		Total:	29,958	4,401	4,791	19,932	59,082	197
2	Left	Private	13,362	2,697	1,821	4,005	21,885	73
2	Left	Public	10,794	4,377	1,677	2,046	18,894	63
2	Right	Public&Private	873	402	297	1,125	2,697	9
2	Right	Private	9,582	2,919	2,241	4,443	19,185	64
2	Right	Public	11,295	1,674	951	3,643	17,563	59
		Total:	45,906	12,069	6,987	15,262	80,224	268
3	Left	Private	17,162	9,247	12,695	28,016	67,140	232
3	Left	Public	3,762	971	2,207	6,464	13,404	51
3	Right	Private	26,462	6,312	6,812	25,930	65,516	226
3	Right	Public	6,085	1,123	1,602	6,820	15,630	58
		Total:	53,471	17,653	23,316	67,230	161,690	567
4	Island	Private	3,721	448	874	1,938	6,981	25
4	Island	Public	4,610	24	24	24	4,682	17
		Total:	8,331	472	898	1,962	11,663	42
4	Left	Private	12,509	1,689	3,866	13,483	31,547	111
4	Left	Public	23,467	2,253	4,315	11,749	41,784	145
4	Right	Private	25,279	4,258	4,381	12,984	46,902	163
4	Right	Public	22,278	2,711	1,259	697	26,945	98
		Total:	83,533	10,911	13,821	38,913	147,178	517
All	Both	Private	111,680	28,047	33,110	92,587	265,424	
All	Both	Public	109,519	17,459	16,703	50,712	194,393	
		Total	221,199	45,506	49,813	143,299	459,817	

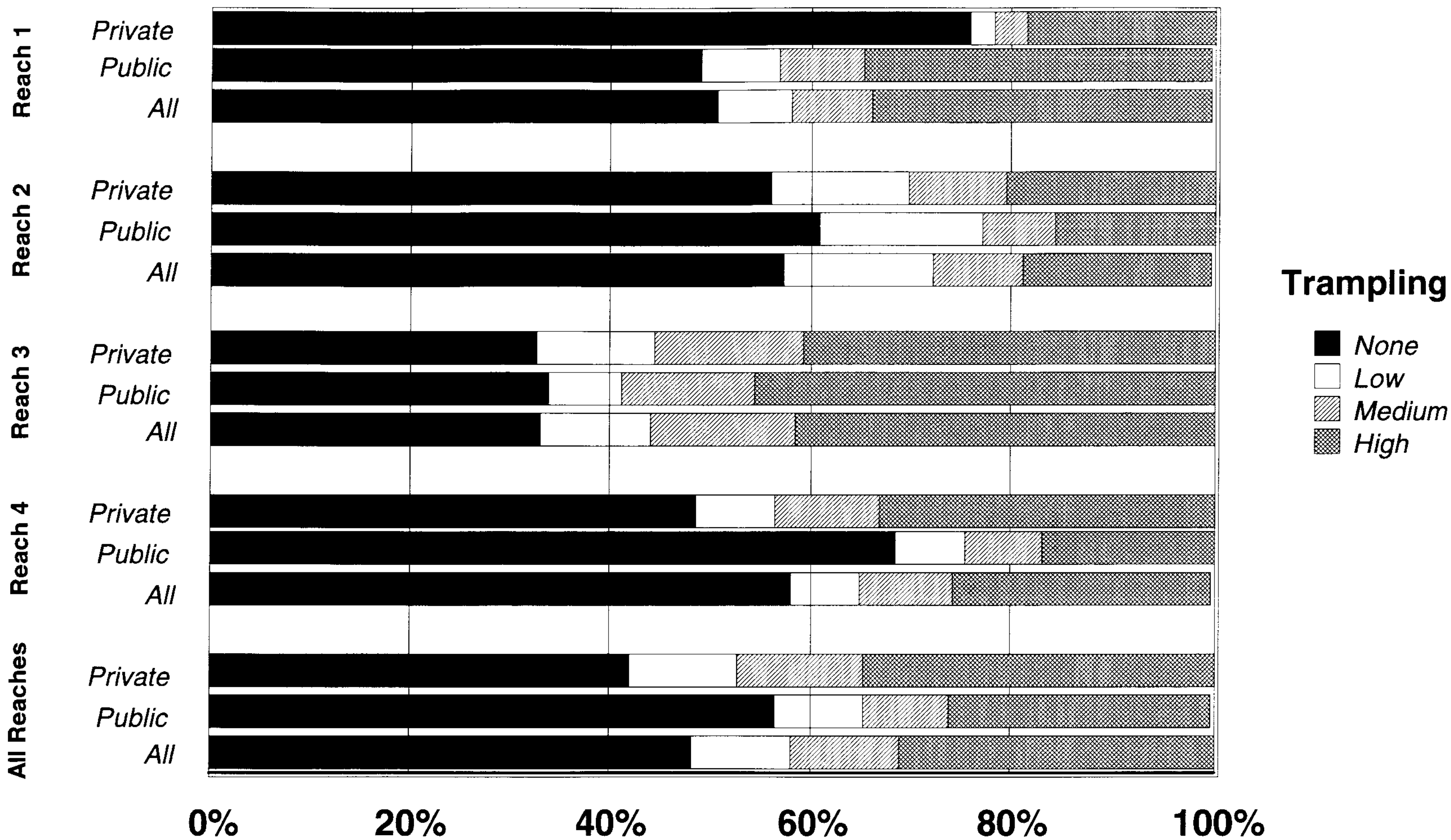

Figure 6.-Percent of Kenai River riparian habitats by degree of trampling observed during 1996.

Table 7.-Percent of trampled property under public and private ownership by reach, Kenai River, 1996.

Reach	Private Property	Public Property	Overall
1	24	51	49
2	44	39	43
3	67	66	67
4	51	31	42
Overall	58	44	48

reaches surveyed, Reach 1 contained the greatest percentage of public property and was the only reach where the most trampling occurred on public property (Table 6).

ANGLER COUNTS

A total of 8,089 anglers were counted throughout the four reaches surveyed during the period 9 July through 8 August 1996 (Table 8). Of this, 94% of the anglers fished from mainland banks and 6% fished from islands or gravel bars. There were slightly more anglers counted fishing from public property (52%), which represents 50% of the total property within the four river reaches, than private property (Figure 7).

Anglers were counted fishing from 69% of all sections, including both surveyed and estimated sections (Figure 8). The frequency of total angler use (grand total from all angler count periods) varied from a minimum of zero to a maximum of 123 anglers (Figure 9). Although most angler counts per section exceeding 48 total anglers were on public lands, some private property received extensive use as well, with one private property 300-ft section having a count of 116 anglers.

In general, anglers using public property were concentrated on fewer sections than anglers using private property. A total of 250 public property sections were utilized by 52% of the anglers counted compared to 440 private property sections utilized by 47% of the anglers counted (Figures 10-13). High public use areas were generally confined to campgrounds intended for angler use. Many of the nonutilized public lands were closed by Alaska Department of Fish and Game regulatory authority and, therefore, unavailable to anglers. Compliance with these closures appeared good.

There was a significant shift from public to private land use within Reach 3 between 1995 and 1996 (Table 9). In all other reaches the distribution between public and private use remained essentially the same between 1995 and 1996.

CORRELATION BETWEEN VARIABLES

We did not find a significant correlation between trampling, habitat units, and angler counts during the baseline year (Table 10 and Figure 14). There were habitat variables (Table 11) which

Table 8.-Counts of sport anglers by date and river reach, Kenai River, 1995 and 1996.

Year/Period	Reach 1	Reach 2	Reach 3	Reach 4	Total
1995[a]					
19 July	5	173	471	447	1,096
24 July	16	250	609	595	1,470
10 August	0	28	21	98	147
All	21	451	1,101	1,140	2,713
1995					
9 July			21	14	35
10 July		11			11
11 July	71				71
13 July		32	27	42	101
14 July	54				54
17-July			875	515	1,390
18 July		404			404
19 July	84				84
20 July			800	478	1,278
21 July	363	450			813
24 July			625	573	1,198
25 July		270			270
26 July	231				231
27 July			475	267	742
28 July		286			286
31 July	295				295
1 August			78	78	156
2 August	202	49			251
3 August			131	133	264
4 August		130			130
8 August	25				25
All	1,325	1,632	3,032	2,100	8,089

[a] Unpublished data. D. Vincent-Lang, Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, personal communication.

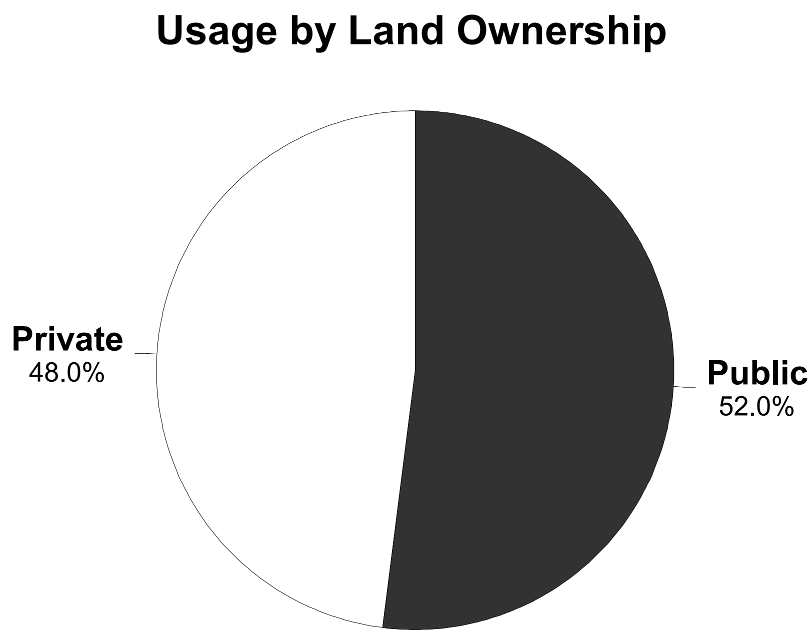

Figure 7.-Usage by land ownership of Kenai River riparian habitats by anglers observed fishing during the late-run sockeye salmon fishery in 1996.

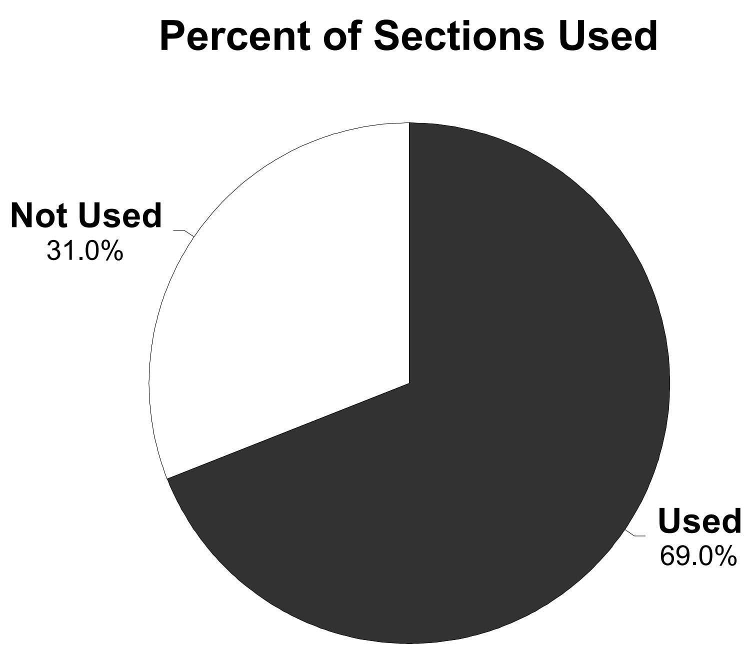

Figure 8.-Percent of sections of Kenai River riparian habitats used by anglers observed fishing during the late-run sockeye salmon fishery in 1996.

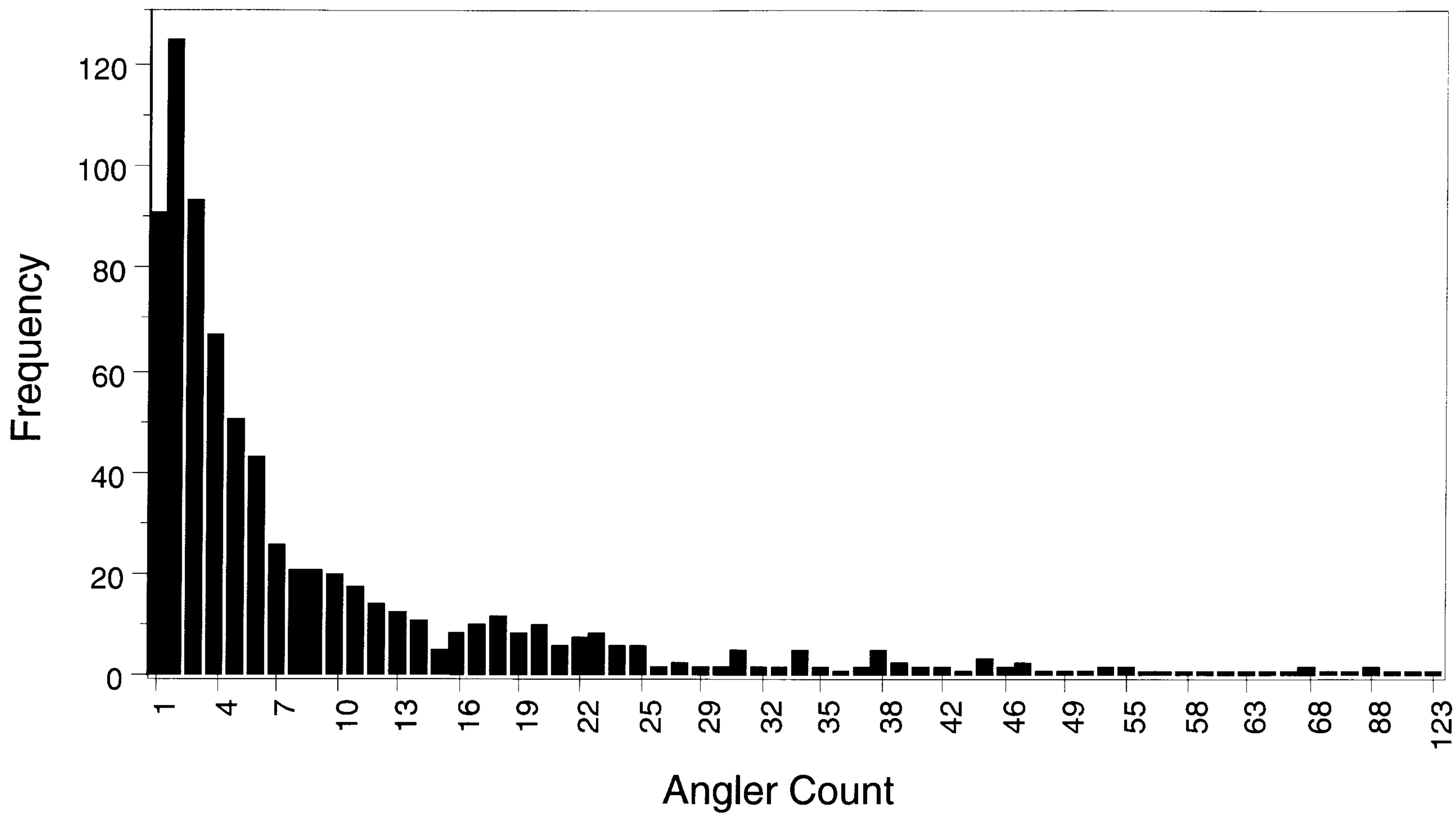

Figure 9.-Frequency of angler counts from all surveyed locations, Kenai River, 9 July through 8 August, 1996.

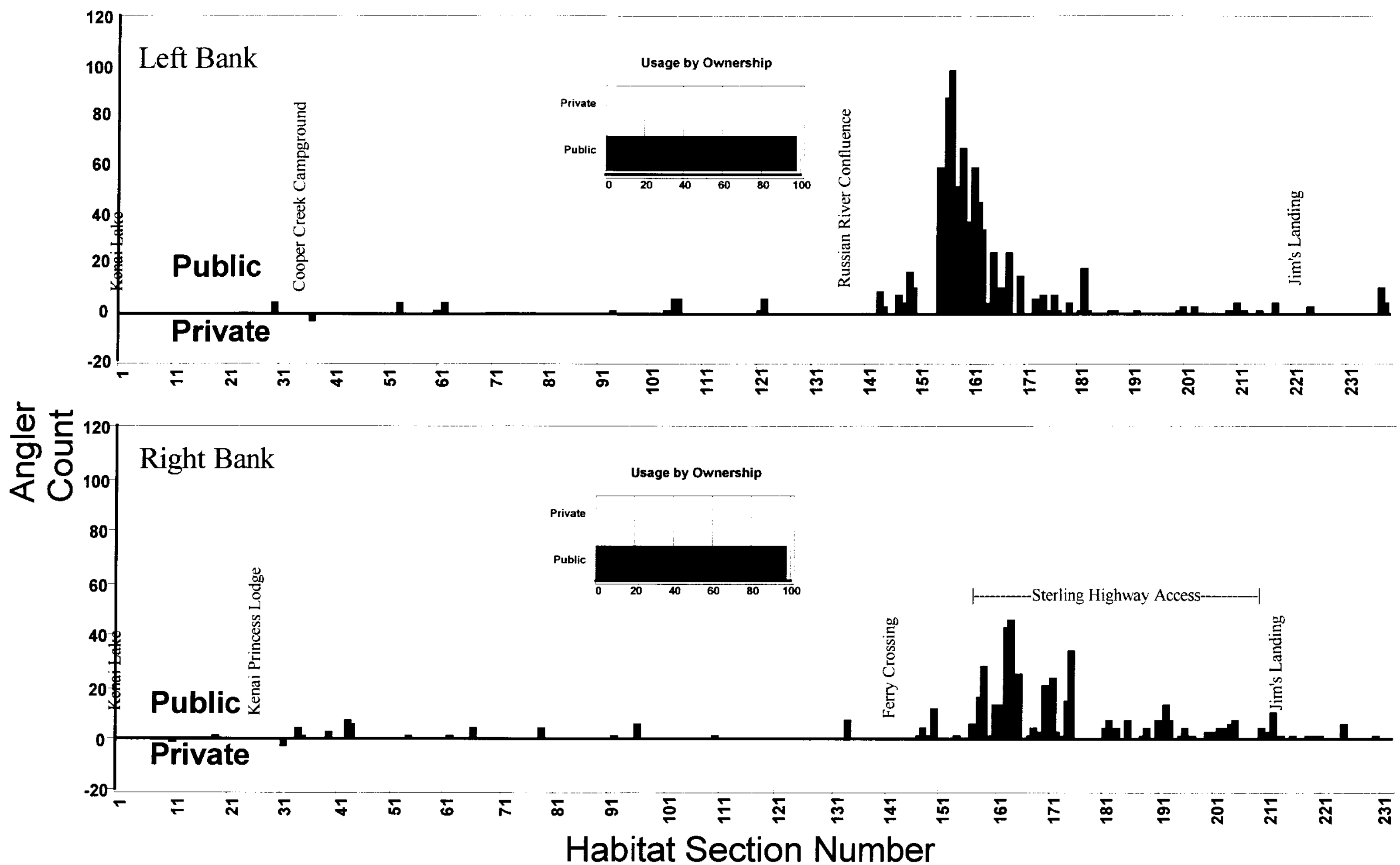

Figure 10.-Angler counts by public and private ownership and 100 yd habitat section number, Kenai Lake (RM 82) to Jim's Landing (RM 69.7), 1996.

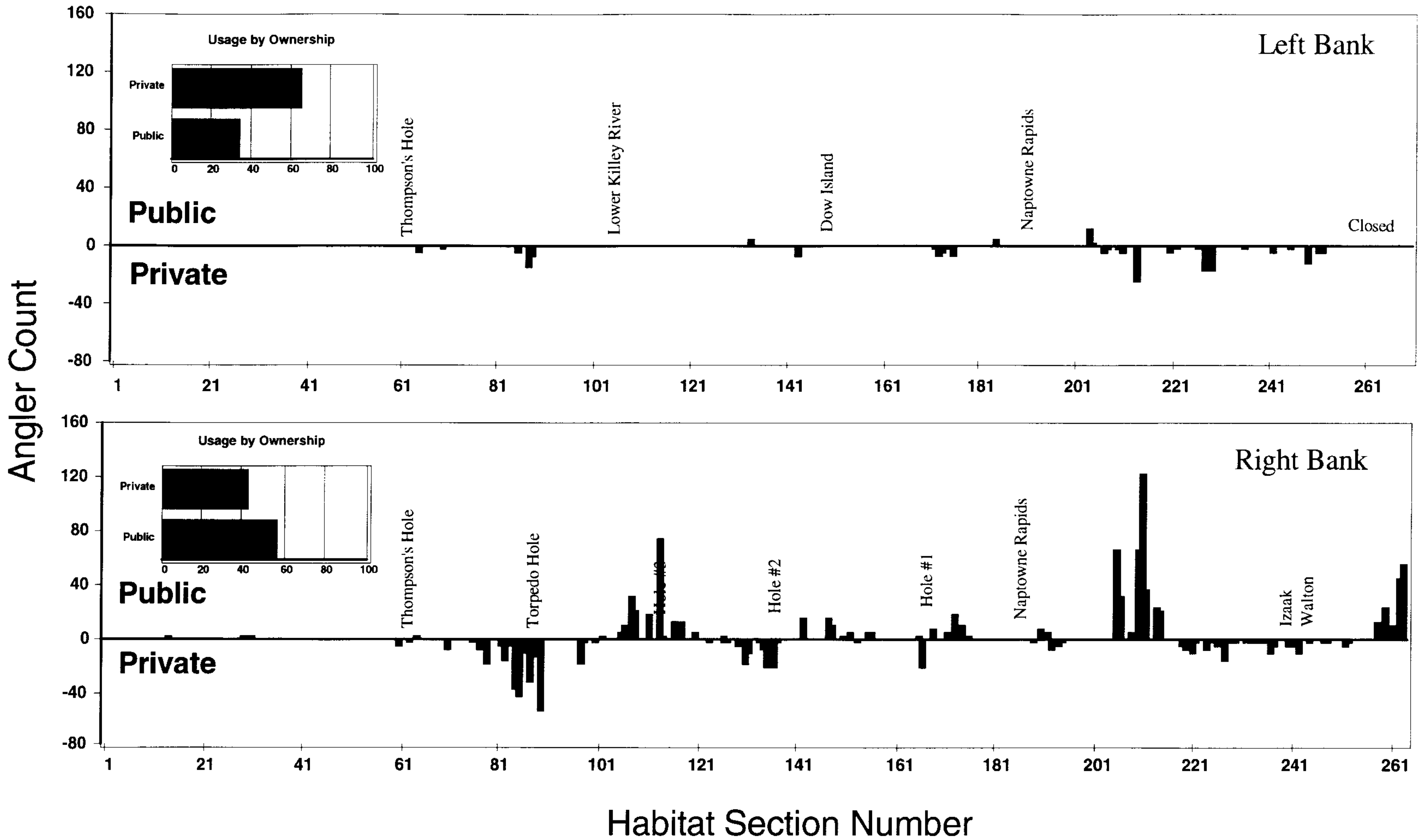

Figure 11.-Angler counts by public and private ownership and 100 yd habitat section number, Skilak Lake (RM 50) to Moose River (RM 36.7), 1996.

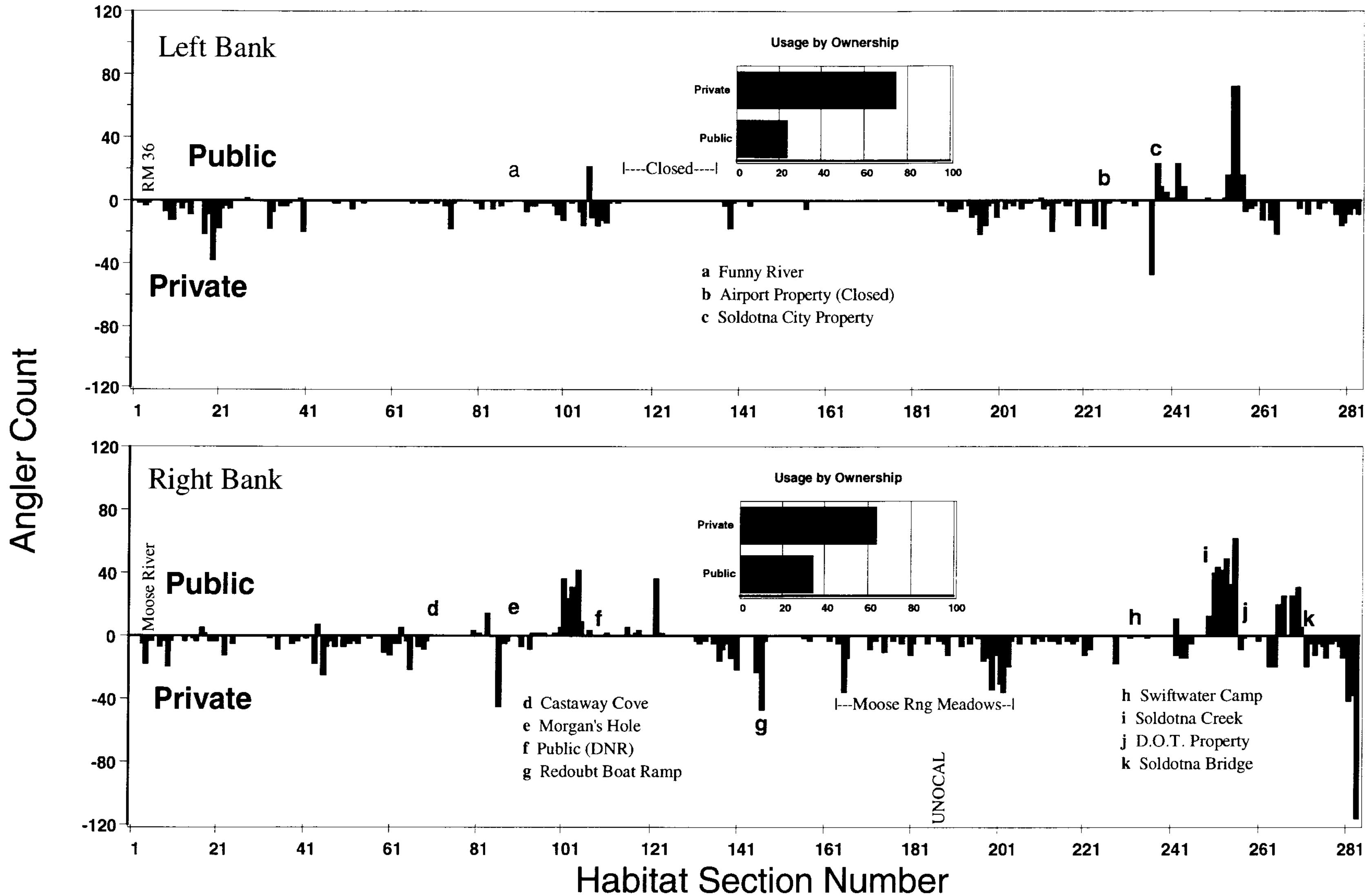

Figure 12.-Angler counts by public and private ownership and 100 yd habitat section number, Moose River (RM 36.7) to Soldotna Bridge (RM 21), 1996.

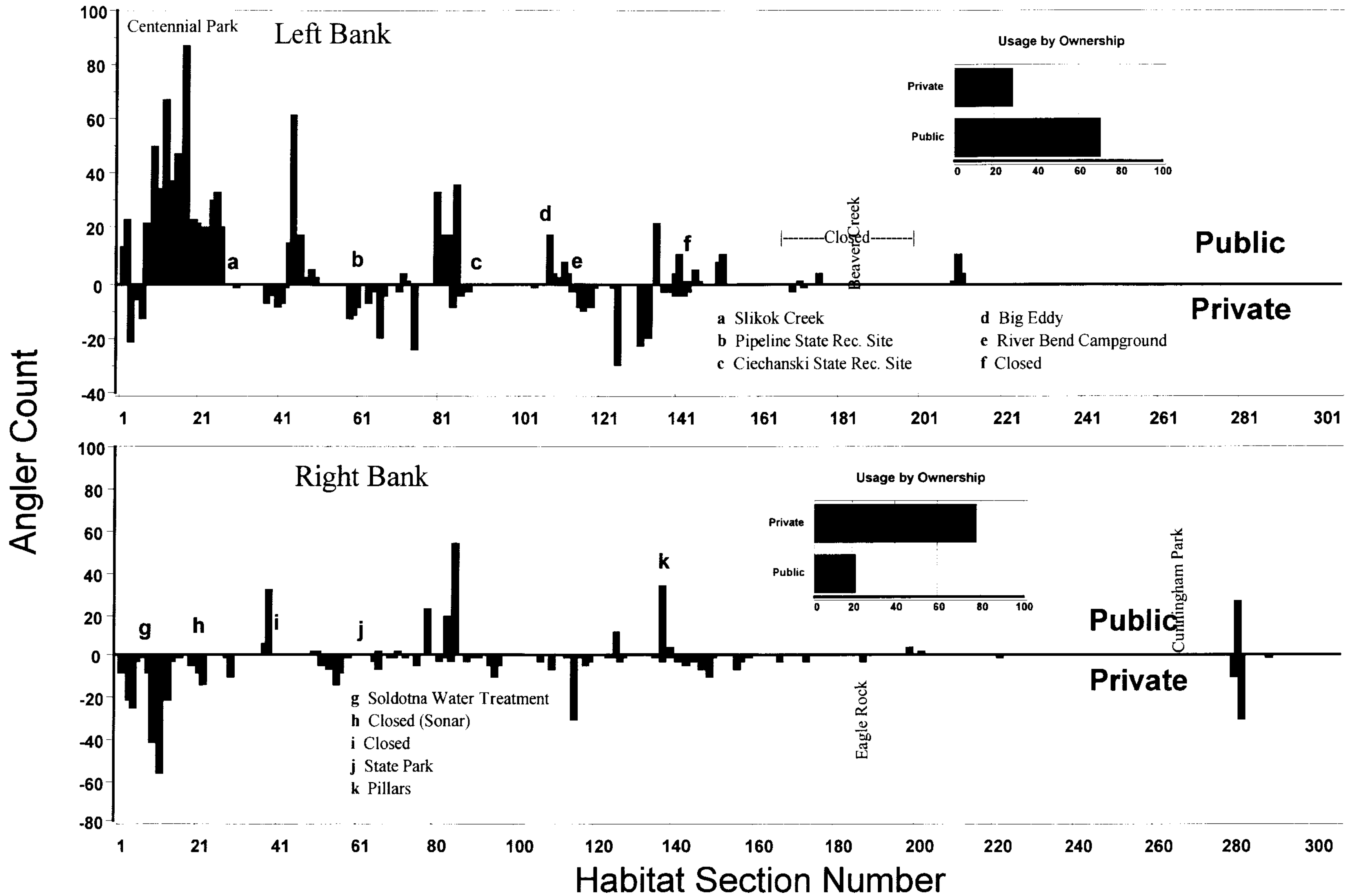

Figure 13.-Angler counts by public and private ownership and 100 yd habitat section number, Soldotna Bridge (RM 21) to Warren Ames Bridge (RM 5), 1996.

Table 9.-Chi-square comparison of mean shore angler counts by year, reach and property ownership, Kenai River, 1995 and 1996.

Reach	Year	Mean Public	Mean Private	Percent Public	Percent Private	χ^2	df	P
1	1995	77.3	0.7	99.1	0.9	0.046	1	0.830
	1996	146.9	1.8	98.8	1.2			
	Total	224.3	2.5	98.9	1.1			
2	1995	65.0	76.7	45.9	54.1	1.504	1	0.220
	1996	104.8	94.4	52.6	47.4			
	Total	169.8	171.1	49.8	50.2			
3	1995	237.0	149.7	61.3	38.7	79.682	1	0.001
	1996	106.3	261.4	28.9	71.1			
	Total	343.3	411.1	45.5	54.5			
4	1995	177.3	168.3	51.3	48.7	1.746	1	0.186
	1996	129.9	98.3	56.9	43.1			
	Total	307.2	266.6	53.5	46.5			
All	1995	556.6	395.4	58.5	41.5	8.783	1	0.003
	1996	487.9	455.9	51.7	48.3			
	Total	1,044.5	851.3	55.1	44.9			

Table 10.-Pearson correlation coefficient statistics testing for relationships between corrected habitat units, angler counts and percent trampling, Kenai River, 1996.

	Corrected Habitat Units	Angler Counts	Percent Trampling
Corrected Habitat Units		r = -0.100 ρ = 0.000 n = 1,428	r = 0.128 ρ = 0.000 n = 1,559
Angler Counts	r = -0.100 ρ = 0.000 n = 1,428		r = 0.219 ρ = 0.000 n = 1,428

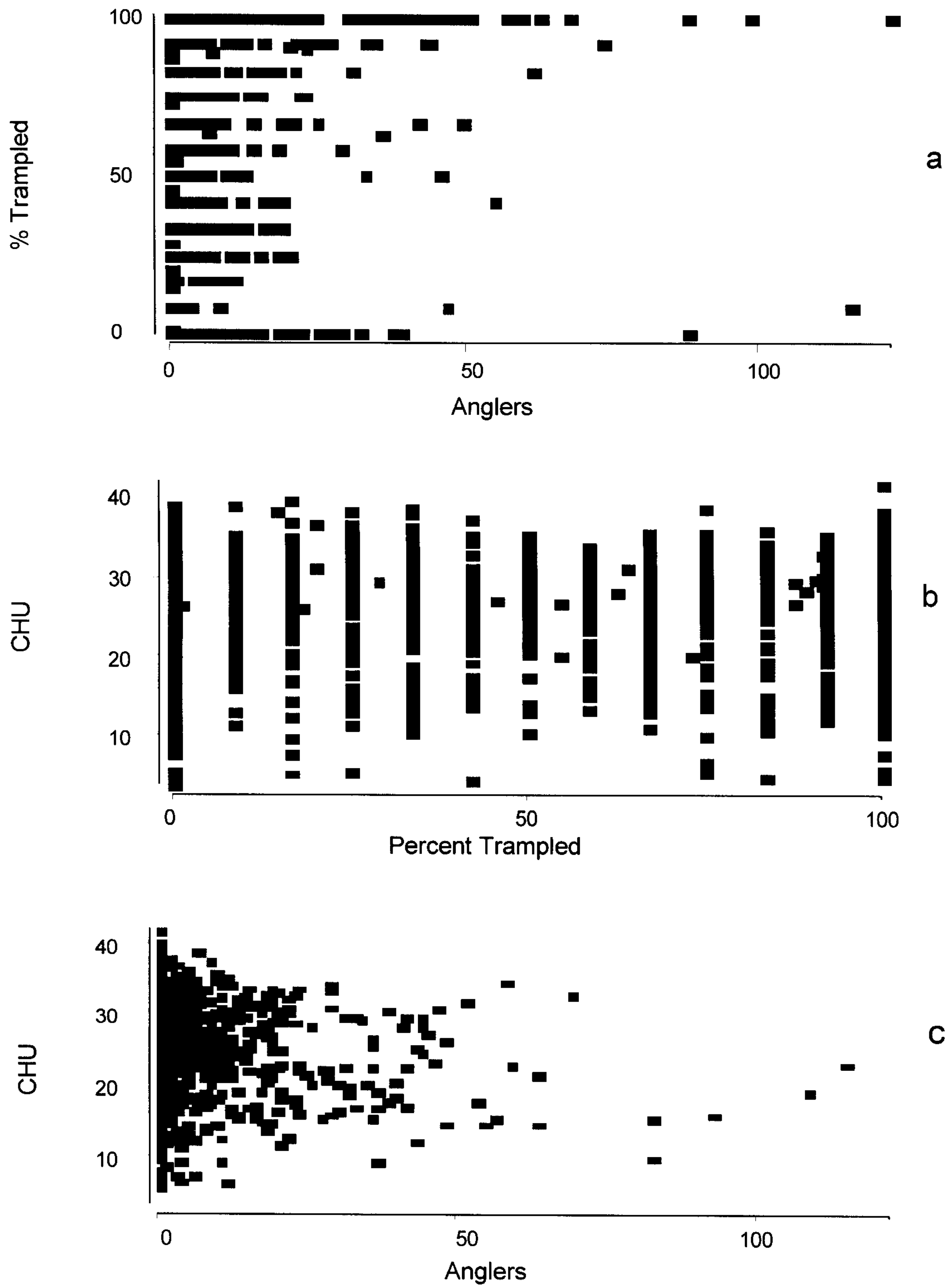

Figure 14.-Relationship of (a) percent trampled to number of anglers, (b) corrected habitat units (CHU) and percent trampled, and (c) CHU and number of anglers for surveyed sections of the Kenai River, 1996.

Table 11.-Comparison of individual habitat variables to corrected habitat units, angler counts, and percent trampling, Kenai River, 1996.

Variable	Habitat Variable[a] →	HV	NC	EV	AV	DD	OV	UB	MSS	G	R	C
CHU[b]	Pearson's Correlation Coefficient	0.104	-0.364	-0.061	0.200	0.370	0.204	0.552	0.131	0.382	0.378	0.278
	P Value	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Number of Observations	1559	1559	1559	1559	1559	1559	1559	1558	1558	1558	1558
Angler Counts	Pearson's Correlation Coefficient	-0.075	0.089	-0.079	-0.021	-0.082	-0.092	-0.062	-0.006	0.097	0.117	0.156
	P Value	0.004	0.001	0.003	0.432	0.002	0.001	0.020	0.821	0.000	0.000	0.000
	Number of Observations	1428	1428	1428	1428	1428	1428	1428	1427	1427	1427	1427
Trampling	Pearson's Correlation Coefficient	-0.002	-0.148	-0.252	-0.042	-0.079	-0.001	0.155	-0.030	0.164	0.230	0.238
	P Value	0.949	0.000	0.000	0.098	0.002	0.978	0.000	0.243	0.000	0.000	0.000
	Number of Observations	1559	1559	1559	1559	1559	1559	1559	1558	1558	1558	1558

[a] HV = Herbaceous Vegetation
EV = Emergent Vegetation
AV = Aquatic Vegetation
DD = Debris/Deadfall
OV = Overhanging Vegetation
UB = Undercut Banks
MSS = Mud/Sand/Silt
G = Gravel
R = Rubble
C = Cobble
NC = No Cover

[b] Corrected Habitat Units.

displayed a relatively strong correlation (undercut banks [0.552], gravel [0.382] and rubble [0.378]), but this is likely due to the high frequency of these variables occurring throughout the riparian corridor.

OBSERVER VARIABILITY

Measurement error between observers within any given 100-yard section was 16% (Table 4). A comparison of cumulative corrected habitat units across all 28 sections (Table 5), however, indicates the average observer variability was within 4%. The mean measurement error between observers within any given 100-yard section was 16% (Table 4); however, a comparison of cumulative corrected habitat units across all 28 test sections (Table 5) indicate the average observer variability here was within 4% and is likely a more realistic reflection of observer variability throughout the four river reaches. Individual observers were not consistently higher or lower in their evaluation of specific variables than their counterparts. As a result, the variability between observers in total habitat units within a reach is expected to be less than the mean measurement error of individual sections.

DISCUSSION

The primary purpose of this study was to provide the BOF with information to assess whether additional damage to riparian habitat occurred due to increased shorebased angling resulting from the regulatory actions taken to increase harvest opportunities. Two programs have been fielded by the department to assess Kenai River riparian habitat and impacts to these habitats: this study and Liepitz' (1994). Deficiencies in both studies compromise our ability to detect impacts to riparian habitat due to bank angling. The Liepitz study was designed to specifically assess structural and habitat impacts. A deficiency of the Liepitz study is that there is no measure of variance, either observer or natural. This seriously compromises our ability to detect changes in habitats over time. We attempted to correct this problem by employing different techniques based on presence/absence criteria to measure habitat; however, application of these techniques resulted in an ability to only detect gross changes in habitat and diluted this study's ability to quantify and detect changes.

The variation between observers appeared related to several factors: (1) individual attention to detail, (2) observer's level of understanding of cover definitions, and (3) relative recent experiences by observers with a given cover type. Empirically, testing observers at the beginning of the day seemed to be helpful in decreasing the variability between observers, especially early in the study and when different cover types were encountered for the first time. All cover types varied in their degree of presence, with scarce occurrences being the most likely to be missed by an observer. Rare cover types, like aquatic vegetation, were hard to detect on the fringes of their occupied areas. Some amount of subjectivity is inherent in the study design and with that we can expect some amount of variability. It may be possible to reduce measurement error; Roper et al. (1995) found that as the number of habitat types used to classify a stream increase, consistency among observers decreased. Minimizing the habitat criteria collected by observers, to include only the most important, may decrease observer variability in the future. The elimination of information pertaining to structures and vegetation types not used in the actual calculation of habitat units should be considered.

Trampling was one of the most subjective definitions of the habitat survey and was one of the more argumentative categories amongst observers. Trampling was not always observable without first scaling riverbanks within most 25-foot subsections. Also, landowners were sensitive to anyone climbing their riverbanks. With a scalloped shoreline, it was debatable whether trampling fell within the 10-foot riparian study zone. Levels of trampling could change dramatically over a short lineal distance, several times within a 25 foot subsection, and the interpretation of these changes between observers was often strongly debated. Sand deposits from the fall of 1995 also added to the difficulty in establishing a clear trampling definition. As a result of a previous year's flood, sand deposits were common along much of the riparian zone surveyed. When sand deposits occurred on the top of trails, by definition, they were usually considered high trampled areas. How quickly these sand deposits revegetate could affect levels of trampling recorded over subsequent years regardless of angler impacts. By using the worst-case scenario for calculating trampling within a 25-foot increment, much of the variability recorded by observers was buffered and we believe our ability to detect future changes were improved.

The failure to find a significant correlation between trampling, habitat units, and angler counts during the baseline year brings into question the value of using habitat units as an appropriate measuring device for evaluating angler use and angler impacts to habitat units. Due to the presence/absence study design, trampling needs to be severe enough to alter the river bank structure and/or totally denude existing vegetation within a 25-foot increment before its impacts will greatly affect the habitat unit calculations. Severe trampling does occur at limited high use areas but severe trampling is not a river-wide phenomenon. The direct impacts of trampling to riparian habitat are difficult to quantify because trampling occurs less commonly at the immediate edge of riverbanks. Trampling has its greatest impact to riparian habitat in areas inshore of the OHW line and, therefore, beyond the direct influence to our habitat calculation model.

Although early results do not indicate a relationship between trampling, habitat units, and angler counts, final analysis of these relationships within all reaches will not be possible until 1997. The habitat survey was essentially completed within Reaches 3 and 4, the two reaches with the highest total angler counts, and the Russian River area of Reach 1 by the start of the angler count survey. Any trampling that was recorded in these reaches either survived the fall flood of 1995 or was established between the flood event (28 September 1995) and the time of the habitat survey and are not reflective of sockeye salmon sport angler impacts during 1996.

Whether or not sport angling affects rearing habitat remains unknown. When riverbanks collapsed during the 1995 flood, riverbank trails were often the sites of bank calving and trampling was suspected of accelerating stream bank erosion. What effect this has on fish habitat remains unclear. The change caused by the calving of a stream bank is a complex event that can be both beneficial and detrimental to fish. For example, a collapsed bank can add preferred habitat to the stream by placing material in the stream which creates cover and velocity breaks, but can also be detrimental, by increasing the silt load. This study provides baseline data from which additional information should be added before detailed interpretations are attempted. The collection of water depth, velocity, clarity, temperature, chemistry, vegetation density, invertebrate drift and composition, juvenile fish migratory behavior and water column habitation, to name just a few criteria, would greatly improve our understanding of how angling affects various riparian habitat values to fish.

The BOF granted the commissioner of the Department of Fish and Game regulatory authority to close state, federal or municipal riparian habitat to angling if that activity is likely to damage riparian habitat. Under this authority, the Department closed 13 mainstem riparian habitat and several island riparian habitat to bank fishing prior to the start of the 1997 sockeye salmon fishery (approximately 10 miles). Based on our angler surveys, compliance with these closures appeared good. The shift in angler use from public to private property between 1995 and 1996 may be a direct result of these closures and this could have fishery management implications if further area restrictions are required.

Increased sockeye salmon angler use of islands and gravel bars between 1995 and 1996 may help alleviate angler impacts to mainland riverbanks. Many of the islands and gravel bars observed used by sockeye salmon anglers appeared to be mostly rubble/cobble deposits and contained little or no vegetation. These areas are exposed during low water periods and are accessed by anglers using boats or by wading from the mainland. It is possible that fishing from islands and gravel bars may provide increased opportunity for sockeye salmon anglers without severely impacting riparian habitat so long as the undisturbed vegetated portions of these islands are not impacted. These areas currently provide important nearshore habitats for newly-emergent chinook salmon fry.

At present, we can not link habitat units to fish production and a direct relationship between riparian habitat and fish production is not realistic without first understanding the entire Kenai River watershed ecosystem. This study focused on the relationship between riparian habitat and juvenile chinook salmon, a very simplistic approach which ignores the value of riparian habitat to other species and life stages. It is not realistic to expect the relative change in habitat units from one year to the next, based on one life stage of a single species, to be reflective of the health of an entire ecosystem. For this reason, we do not feel that the HEP methods should be the only tool for evaluating angler impacts to riparian habitat or evaluating riparian habitat to fish production along the Kenai River.

The purpose of this study was to provide specific answers to questions important to the BOF, specifically angler impacts to riparian habitat and how these impacts may affect fish production. Based on information collected in this study, we do not feel this study design adequately assessed angler impacts to riparian habitat. A more comprehensive study involving precise measurements of vegetation types and densities on specific sites, repeated before and after angler use, would have more utility for analyzing angler impacts to riparian habitat.

RECOMMENDATIONS

In conclusion, we recommend that future work to assess riparian habitat values <u>not</u> be based solely on HEP methods and resultant habitat units. Instead, we propose that future assessment of angler impacts to riparian habitat be based on a matrix of indicators that include:

- Trends in participation in Kenai River sockeye salmon fisheries;

- Trends in shore angler use and distribution;

- Assessment of angler impacts to specific riparian habitat, and
- Trends in the number and type of structural alterations along the river and macro-habitats present.

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