Fishery Data Series No. 02-19

Assessment of Shore Angling Impacts to Kenai River Riparian Habitats, 1999

by

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and

Patricia A. Hansen

October 2002

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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ABSTRACT

This project focused on the assessment of shore angler impacts to Kenai River riparian habitats. Distribution of shore anglers along the banks of the Kenai River during 1999 in river reaches 2-4 was 46.3% on private land and 53.7% on public land. In reaches 2-4, there has been a 10.3% increase in use of public lands since 1996. Trend analyses of angler counts from 1996 to 1999 detected a significant increase in angler use of public lands by year and reach (F=6.86, df=1, P=0.04). The analyses showed there was an increasing rate of shore angler use of public lands in each river reach: reach 1, 1.3%; reach 2, 2.97%; reach 3, 6.11%; and reach 4, 0.44%. Of anglers observed in 1999, 92.0% fished from mainland banks. Of those anglers, 13.2% fished from boardwalks or docks, 54.2% fished while standing in the water, and 28.1% fished while standing on the bank. Although there was a significant change detected in angler location (bank, island, gravel bar) and structural use (bank, boardwalk, other structures) over time (1997-1999), the change was small and probably more related to natural variation in angler behavior.

Of variables assessed (level of angler use, boat wake level, stream meander, habitat type), none had a significant effect on the amount of bank erosion at 170 habitat survey sites between June 1998 and June 1999. Of the 40 angler effort sites (having intensified bank measurements and estimates of angler effort), there were no significant relationships between bank erosion and habitat variables (angler effort, boat wake level, stream meander, habitat type) between August 1998 and June 1999. Several more years of data are required before any specific relationships between bank loss and shore angler use may be concluded.

Trampling was assessed by conducting photo imagery analyses of prefishery and postfishery photographs of permanent vegetation plots. Inseason, there were significant differences detected for effects of angler effort on percent change in cover of vegetation (P<0.01), litter (P<0.01), and bare ground (P<0.02). For habitat types (herbaceous and shrub/herbaceous), increased angler effort resulted in a decrease in cover for vegetation (P<0.01), and an increase in cover for litter and bare ground (P<0.01). When comparing effects of angler effort to cover class changes between years (June 1998 to June 1999), there were no significant changes detected, indicating that plant recovery, based upon mean change in percent coverage, had occurred. This does not address changes that may be occurring in species diversity. Again, more years of data are required before any specific relationships between permanent vegetation loss and shore angler use may be concluded.

Penetrability measurements (soil resistance measured with a penetrometer) were used as an indicator of soil compaction. For 1999, there were no significant changes in penetrability detected at habitat survey sites for measurements taken at 1 in, 3 in, and 6 in soil depths. Between-year comparisons (1998 vs. 1999) also showed no significant changes by depth of measurement. These data were not correlated with angler effort estimates. To do this, we need to verify that soil composition is the same for sites being compared.

We also conducted observer measurement error tests for the vegetation analyses and bank measurement process. For the vegetation assessment process, the error has been reduced annually with present error associated with classifying each cover class being 5% for vegetation, 19% for litter, and 22% for bare ground. The error associated with the combined cover of litter and bare ground would also be 5%, but separating the two cover classes results in increased error. The within and between reader error associated with measuring bank loss was also excellent. Overall, there was less than a 6 cm error for the bank measurements or less than 1.5% error.

Key words: Kenai River, shore anglers, riparian habitat, habitat assessment, trampling, angler impacts, bank erosion, vegetation assessment, soil penetrability, GPS.

INTRODUCTION

BACKGROUND

The Kenai River (Figure 1) supports the largest freshwater sport fishery in Alaska, with an estimated 247,898 angler-days of effort in 1997 (Howe et al. 1998). Fishing effort occurs throughout the mainstem of the river but primarily occurs over a relatively short time period during June, July, and August downstream from Skilak Lake. Targeted species include 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*.

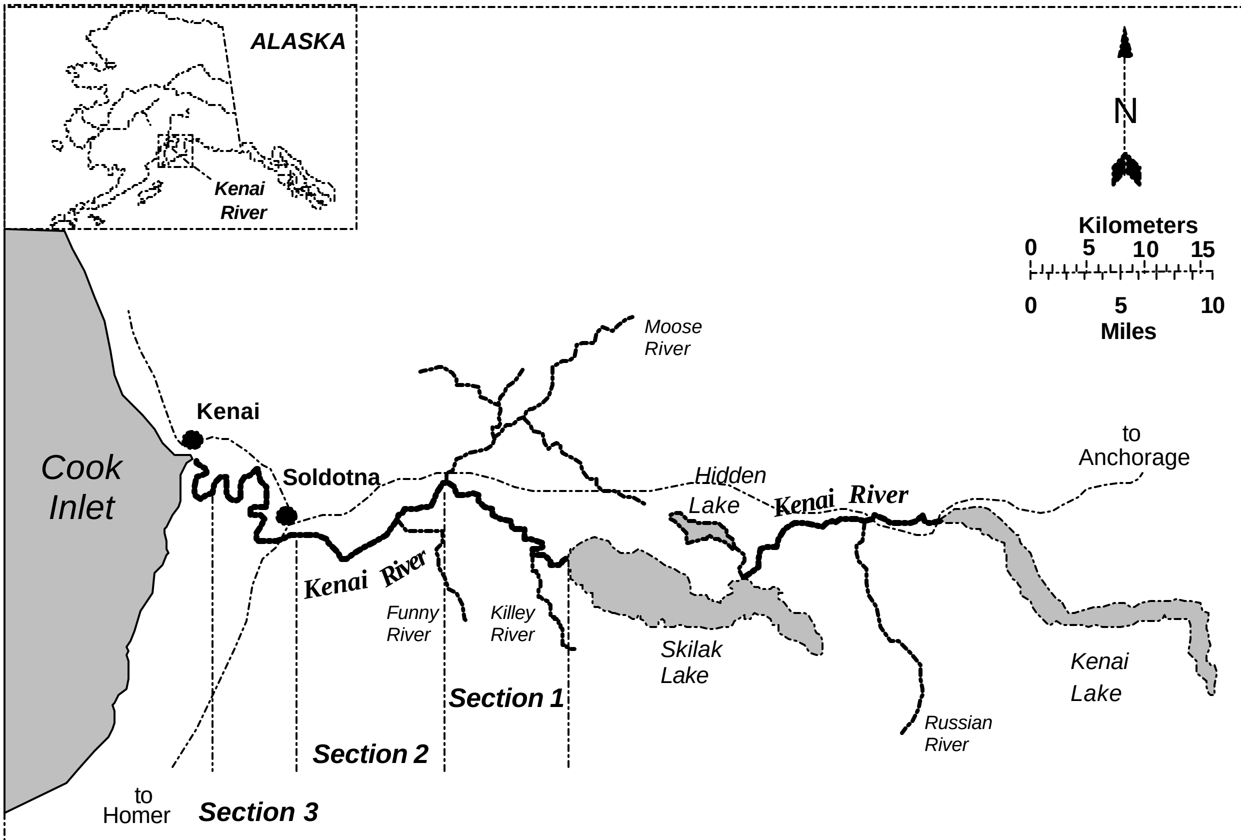


Figure 1.-Map of Kenai River showing river sections for conducting angler counts, 1999.

Presently, the majority of sport fishing effort on the Kenai River is directed at early- and late-run chinook salmon and late-run sockeye salmon. Increased interest occurred in the sport fishery during the mid 1970s when anglers discovered methods for catching chinook salmon while drifting from powered boats. There was a substantial increase in participation again in the mid 1980s as shore anglers discovered that sockeye salmon could be caught from the turbid waters of the Kenai River by applying fishing techniques used in the clear waters of the Russian River. These two discoveries contributed to the ever-increasing popularity of the Kenai River as a sport fishing destination. Angler days of effort increased from 122,138 in 1977 (Mills 1979) to 289,165 in 1987 (Mills 1988). Participation in Kenai River fisheries peaked in 1995 with 377,710 angler days of effort (Howe et al. 1996).

Most anglers fish for sockeye salmon from riverbanks or while standing in the river along gravel bars at or near the shoreline. Some sockeye salmon anglers use boats to access desired fishing locations, but anglers seldom fish from boats. Because sockeye salmon angling is principally a shorebased fishery, damage to riparian habitat is a major concern to fishery and resource managers, Kenai River property owners, and stewards of Kenai River resources.

Historically, chinook and sockeye salmon have been harvested in the commercial fishery occurring in Cook Inlet. Under current regulations by the Alaska Board of Fisheries (BOF), early-run chinook salmon returns are allocated exclusively to recreational anglers. Late-run chinook salmon may be commercially harvested, but they are primarily targeted by the inriver sport fishery. During the last decade actions by the BOF have resulted in increased inriver allocation of late-run sockeye salmon and the Department of Fish and Game has increased the biological escapement goal for late-run sockeye salmon. Both actions have provided a greater availability of sockeye salmon for the sport fishery. In 1996 the BOF not only increased the inriver allocation, but also liberalized bag and possession limits for the inriver sport fishery and the personal use dip net fishery occurring at the mouth of the Kenai River. During the 1999 BOF meetings the Late Run Sockeye Salmon Management Plan was again modified, resulting in yet another increased allocation of sockeye salmon to the Kenai River.

Realizing the importance of maintaining riparian habitats, the 1996 BOF expressed concern that their actions not result in further damage to critical riparian habitats along the Kenai River (5 AAC 21.360 and 5 AAC 56.065) (Appendices A1 and A2). The BOF stated that they would reconsider the increased allocation of sockeye salmon if additional damage to riparian habitats occurred due to increased shorebased angling. To help mitigate potential impacts to riparian habitats from shorebased angling, the BOF granted the commissioner of the Department of Fish and Game regulatory authority to close state, federal or municipal riparian habitats to angling if that activity was likely to result in damage to riparian habitat which could negatively affect the fishery resources of upper Cook Inlet.

The BOF also asked that the department monitor angler use and impacts to Kenai River riparian habitats and report findings at the next regularly scheduled Cook Inlet regulatory meeting in February 1999. Our report to the BOF in 1999 informed them of the difficulties of assessing shore angler impacts to juvenile fish habitat in riparian areas. We indicated that we had tried several methodologies (Larson and McCracken 1998; King and Hansen 1999) and that those used in 1998 (King and Hansen 2001) seemed to be providing the most meaningful information for assessing shore angler impacts.

The BOF's continuing concern for reducing riparian habitat impacts resulted in two regulatory changes in 1999. Both changes are related to increased bank erosion as related to boat wakes. First, the BOF provided for a drift-only fishery to occur on Mondays in July, previously closed to fishing from boats. This would provide a means of evaluating the popularity of non-motorized fishing on the Kenai River. Second, the BOF implemented a regulation reducing the number of passengers in guided boats from six to five (guide plus four clients), effective in 2000. This addressed concerns about larger boat wakes created by more heavily loaded boats.

The department was instructed by the BOF to continue with our assessment of shore angler impacts and to report findings at the next regularly-scheduled Upper Cook Inlet BOF meetings.

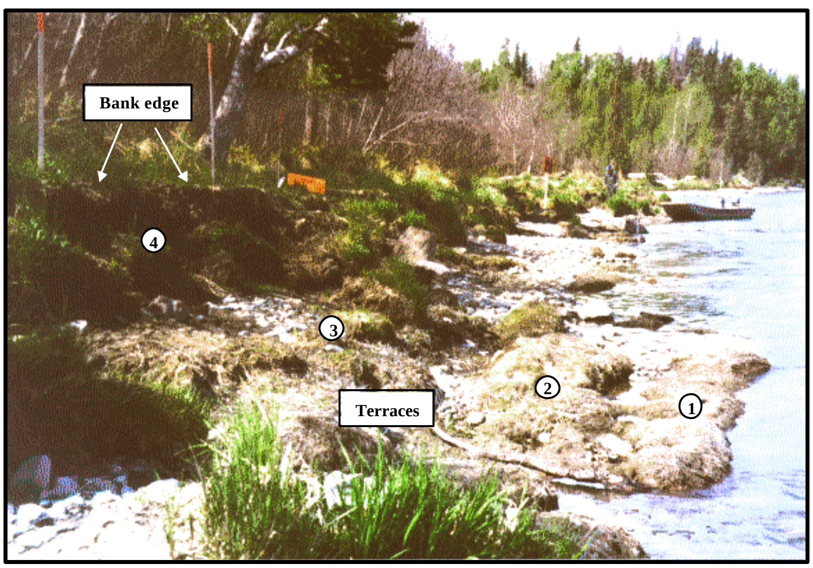
OBJECTIVES

Shore angler impacts to riparian habitat are believed to include trampling and denuding of vegetation, leading to increased calving and bank erosion. This may ultimately impact fish habitat. The natural erosion process of a riverbank often involves the undercutting of the bank by river flow energy, which leads to the bank rolling over, slumping, and eventually calving into the river. This process can be accelerated by human activities. Undercutting may occur more rapidly due to increased boat wake energy to the riverbank. Bank calving may be accelerated by increased activity on top of the riverbank. The increased activity may trample vegetation, leading to a denuded riverbank. This, in turn, causes decreased bank integrity and, when coupled with increased undercutting, results in an accelerated rate of bank calving. Photos in Figure 2 depict banks at the various stages of this process. The bottom photo was taken during a low

Undercut Bank

Fractured river bank

Trampled vegetation



Terraced river bank, below ordinary high water

Figure 2.-Stages of bank erosion.

water period (June) and shows the successional bank terraces that form, subsurface, over time, as banks calve. In June 1997, only terraces 1 and 2 were present. The question to be answered is "Do anglers significantly accelerate this process?" which may potentially have a negative impact on fish habitat.

The primary goals of this project in 1999 were to document shore angler distribution throughout the mainstem Kenai River during the sport fishery for late-run sockeye salmon and to assess shore angler impacts related to change in bank position and vegetative cover. Specific objectives were to:

1. Estimate the distribution of shore anglers within the mainstem Kenai River riparian areas downstream of Skilak Lake during the sport fishery for late-run sockeye salmon for the period 8 July to 10 August, 1999. Also, test the hypothesis that the distribution with respect to land ownership (public vs. private) and river reach has not changed through time (1996-1999).
2. Estimate mean bank loss by macrohabitat throughout the mainstem Kenai River downstream of Skilak Lake.
3. Estimate total angler effort (angler hours) at selected sites throughout the mainstem Kenai River downstream of Skilak Lake.
4. Test the hypothesis that there is no linear correlation between angler effort and bank loss.
5. Estimate inseason (before and after the sport fishery for late-run sockeye salmon) and annual (June 1998 to June 1999) changes in percent cover by cover class at 12 habitat survey sites located on the mainstem Kenai River downstream of Skilak Lake.
6. Test the hypothesis that there is no linear correlation between angler effort and changes in percent cover by cover class, both inseason and annual.

We also examined inseason (before and after the sport fishery for late-run sockeye salmon) and annual (June 1998 to June 1999) changes in soil resistance at 12 habitat survey sites located on the mainstem Kenai River downstream of Skilak Lake.

METHODS

DISTRIBUTION OF SHORE ANGLERS

The study area encompassed the Kenai River from its outlet at Skilak Lake to the Warren Ames Bridge and was divided into three sections for conducting shore angler counts (Figure 1):

Section	Description	River Mile
1	Outlet of Skilak Lake to Moose River confluence	50-36
2	Moose River confluence to Soldotna Creek	36-22
3	Soldotna Creek to Warren Ames Bridge	22-5

A shore angler was defined as any person actively fishing from the shore; this excluded anglers fishing from moving boats or boats anchored in the channel. The section of river downstream of the Warren Ames Bridge was omitted from the study because very little shore angler activity occurs there.

During the sport fishery for late-run sockeye salmon (8 July-10 August), 14 counts of shore anglers were conducted throughout the study area. Counts were conducted systematically, commencing on 8 July and occurring every third day thereafter. Results of a sockeye salmon creel survey (King 1995, 1997) showed that the level of angler participation varied with river reach and time of the day; therefore, for weeks having 3 count days, two counts were conducted at a time of anticipated high angler participation (1200–2000 hours). Other weeks had at least one count conducted at a time of anticipated high angler participation. Counts were conducted on 8 weekday days and 4 weekend days, with two counts conducted on 17 July and 23 July. The start time for a count was the same in each section and each count was completed within 2.5 hours.

Three motorized skiffs, each with two project personnel and a Garmin 45[1] differentially corrected geographic positioning system (DGPS) corrected to within 10 meters of accuracy, were required to conduct counts. The boat operator motored near the shore angler(s) being identified and provided the DGPS waypoint to the observer and recorded the following required data:

1. DGPS waypoint number of the angler or group of anglers;
2. Number of anglers;
3. Habitat survey site number, if applicable, in which the angler(s) were located;
4. Primary location of the angler: bank, island or gravel bar;
5. Secondary location: on bank, in water, boardwalk, other (dock, jetty, etc.).

When conducting a count, shore anglers were counted as the boat was driven downstream from the boat launch, along the right bank, to the lower boundary of the assigned count section. Anglers were then counted as the boat was motored upstream along the left bank to the upper boundary of the count section; and, then motored downstream along the right bank until the boat returned to the boat launch, completing a circle in a counter clockwise direction. Left or right bank was determined when facing downstream. At the completion of each count, waypoints were uploaded from each GPS unit to a desktop computer.

Postseason, ArcView® software was used to map the data. The 12 angler counts for every 10 meters were summed and overlaid onto a geographic information system (GIS) basemap of the Kenai River. Summaries of angler use by land status (public or private), and angler location (primary: bank, island, gravel bar; secondary: on bank, in water, on boardwalk, other structure) were also represented on the basemap.

Angler count data for 1999 were compared to count data from 1995-1998. Chi-square tests and analyses of variance were used to test for differences in the distribution of shore anglers by year, type of land ownership, and river reach. The river reaches used for these comparisons were defined as:

[1] Product names used in this report are included for scientific completeness but do not constitute product endorsement.

Reach	Description	River Mile
1	Outlet at Kenai Lake to Jim's Landing	82 - 69
2	Outlet at Skilak Lake to Moose River	50 - 36
3	Moose River to the Soldotna Bridge	36 - 21
4	Soldotna Bridge to the Warren Ames Bridge	21 - 5

Reach 1 was not surveyed in 1998 and 1999 because shore anglers in this reach primarily target sockeye salmon returning to the Russian River. These anglers tend to congregate around the Russian River confluence. Due to limited access points, this shorebased fishery is likely to undergo minimal downstream expansion making it unnecessary to annually monitor angler distribution.

BANK LOSS

The study area encompassed the Kenai River from its outlet at Skilak Lake to the Warren Ames Bridge (sections 1-3 or Reaches 2-4). During June 1999, bank position measurements were obtained at half-mile intervals for both banks of the Kenai River, starting at river mile 50. Within the intertidal area, downstream of river mile 12, bank measurements were taken at 1-mile intervals.

Two crews of two persons each re-located sites established in 1998. Site re-location was accomplished by use of topographical maps, previously acquired GPS waypoints, and site photographs. At each bank survey site, crews verified or updated specific data:

1. The DGPS waypoint.
2. Site position relative to stream meander: inside meander, outside meander, none.
3. Macrohabitat type, based upon categories similar to those used by Viereck et al. (1982):
    a. Forest: 10%-100% of the area has a tree canopy cover, of which greater than 75% is deciduous or coniferous.
    b. Shrubland: 25%-100% of the area has a shrub canopy, but less than 10% of the area has a tree canopy. The shrubs are greater than 5 ft in height and are present at the riverbank, possibly overhanging the stream.
    c. Shrubland/Herbaceous: 25%-100% of the area has a shrub canopy, but less than 10% of the area has a tree canopy. The shrubs are mostly less than 5 ft in height. Generally, no tall shrubs are present within 20 ft of the riverbank.
    d. Herbaceous: over 5% of the area has a herbaceous canopy, but the shrub canopy cover is less than 25% and the tree canopy cover is less than 10%.
    e. Disturbed: 50% or greater of the area is characterized by human perturbations, such as lawns, structures, land clearing activities, etc.

    To assign a macro habitat type, crewmembers assessed an area bounded by at least 30 meters of riverbank and extending approximately 23 meters onshore.

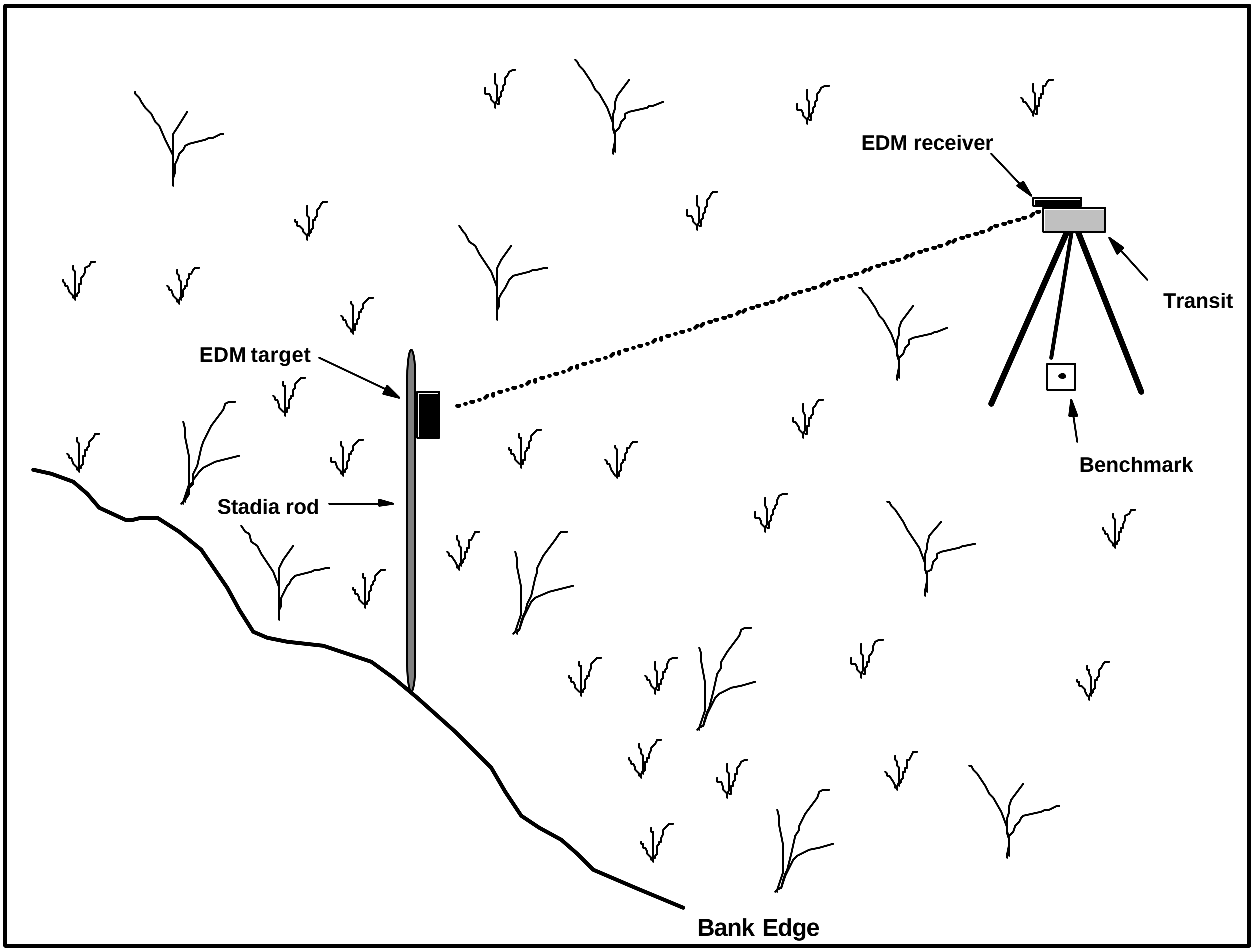


Figure 3.-Schematic of instrument layout for taking bank position measurements, 1999.

4. Level of boat activity during the primary boating season (May–September), predetermined using the results of a study conducted by Dorava and Moore (1997): low or high.
5. Level of angler use (determined postseason using historic angler count data, 1996-1999) (Larson and McCracken 1998; King and Hansen 1999, 2001):

Level of Angler Use	Mean Angler Count (x)
Low	$x \leq 1.5$
Medium	$1.5 < x \leq 3.0$
High	$x > 3.0$

With the assistance of photos, crews relocated the benchmark at each site. If necessary, benchmarks were found by locating the two backup marks and triangulating, using the previously recorded data. Also, previously placed rebar stakes, set approximately 10 feet behind the benchmark, could be used to assist in relocating the benchmark. Once the benchmark was located, crews set up a tripod with transit and plumbed to the surveyors tack on the benchmark. Following the established protocol (King and Hansen 2001; Figure 3), crewmembers obtained a distance measurement from the benchmark to the top edge of the riverbank. The crew recorded this distance and the compass bearing.

To help improve the repeatability of taking the bank measurement, the crew did the following:

1. Took several photographs of the riverbank while the stadia rod remained in the same position used for taking the measurement;
2. Placed a 6-inch nail on the ground, perpendicular to the bank, at the base of the stadia rod and then pressed it flush into the ground;
3. Rotated the transit 180° and placed a rebar backup stake along the bearing line and 5 meters from the benchmark.

In the future, measurements will be taken by siting to a plumb bob on the backup stake, rotating the transit 180°, and then siting the stadia rod at the bank. The position of the stadia rod may be adjusted based upon the location of the nail.

The crew also recorded other descriptive and identifying information about the site, to include a revised sketch. Photographs were taken of the bank edge location with a mile marker sign, the backup marks, and benchmark. These photos assist in identifying the site when returning for future measurements.

Using the measurements for the distance from the benchmark to the riverbank, we calculated the change in bank position as:

$$\Delta = \text{most recent measurement} - \text{baseline measurement.} \quad (1)$$

An analysis of variance was used to test if level of angler use, meander, boat wake level or habitat type had a significant effect on the change in distance. The following model was used:

$$\Delta_{ijkl} = \mu + \alpha_i + \beta_j + \phi_k + \lambda_l + \varepsilon_{ijkl}, \quad (2)$$

where:

Δ_{ijkl} = the change in distance from a benchmark to the river bank (postfishery distance – prefishery distance),

μ = overall mean,

α_i = the effect of the i^{th} level of angler use,

β_j = the effect of the j^{th} habitat type,

f_k = the effect of the k^{th} level of wake,

l_l = the effect of the l^{th} level of meander,

ε_{ijkl} = random error associated with the i^{th} level of angler use in the j^{th} habitat type with k^{th} level of wake and the l^{th} level of meander.

BANK LOSS AND ANGLER EFFORT

To better understand the relationship between shore angler impacts and bank loss, 40 of the bank survey sites (20 herbaceous and 20 shrubland/herbaceous) were selected in 1998 for more intensive measurement of bank loss and estimation of angler effort, hereafter referred to as angler effort sites. These two macrohabitat types were selected because we felt that these

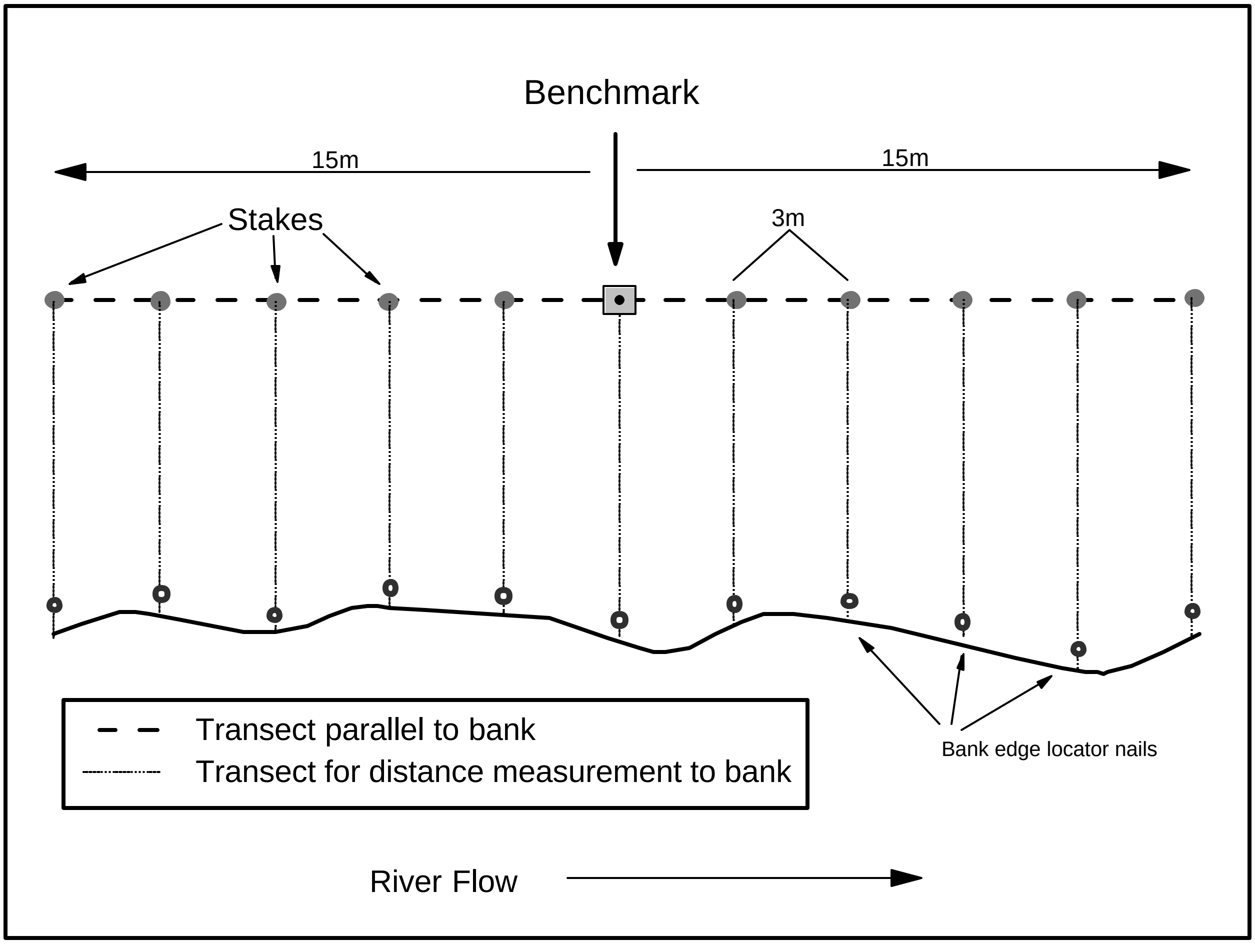


Figure 4.-Schematic of transects for distance to bank measurements at angler effort sites, 1999.

macrohabitats were more sensitive to impact from angler traffic. For each macro-habitat type, sites were randomly selected such that each "level of angler use" category (see Angler Distribution section) was nearly equally represented. Each of the angler effort sites included 30 lineal meters of riverbank. The measurements were taken in June (prefishery).

Bank Loss

At the "angler effort" sites, the crew used the established protocol (King and Hansen 2001) to obtain 11 measurements to the riverbank over a 30-meter distance (Figure 4). All data were recorded in the designated manner. Again, to improve repeatability of the measurement process, crewmembers placed a 6-inch nail near the top edge of the riverbank using the same procedure described in the above Bank Loss section.

Each angler effort site was flagged at the upstream and downstream boundaries to assist in identifying the sites when conducting angler effort counts.

For each of the 40 angler effort sites, a mean of the bank position change was estimated as:

$$\bar{X}_z = \frac{\sum_{i=1}^{n} \Delta_{zl}}{n_z}, \tag{3}$$

where:

$\bar{X}_z$ = mean for the change in bank position at site z,

Δ_{zl} = change in bank measurement at measurement location l at site z, and

n_z = number of sampling locations at site z.

Angler Effort

During the sport fishery for late-run sockeye salmon, angler effort for each sample day was estimated for each of the 40 sites specified above. A sample day consisted of a 16-hour period (0600-2200 hours). Days were sampled as described above for shore angler distribution. Five counts of shore anglers were conducted systematically within each sample day. The time of the first count of a day was chosen at random as a whole or half hour between 0600-0930 hours, with the remaining four counts occurring at 2.5 hour intervals. Each angler observed during a count represented one angler hour.

We conducted shore angler counts using three motorized boats with two project personnel per boat (a boat operator and an observer). The boat operator motored past the flagged survey sites in their assigned area and the observer counted and recorded the number of anglers at each site at that moment. All data were recorded on the designated data form. Between angler counts, personnel entered data into an Excel spreadsheet using a lap top computer.

Total angler effort measured in angler hours was estimated for each site as:

$$\hat{E} = \sum_{d=1}^{D} \left(\bar{c}_d * ahd * sr \right), \tag{4}$$

where:

$\bar{c}_d$ = average number of angler hours on day d, $\frac{\sum_{p=1}^{n_d} c_{dp}}{n_d}$,

c_{dp} = number of anglers observed during count p on day d,

n_d = number of angler counts on day d,

ahd = angler hours per day (=16),

sr = systematic sampling rate of days (=3), and

D = total number of days sampled.

Variance of total angler effort for each site was estimated as:

$$v(\hat{E}) = \left(1 - \frac{D}{3D}\right) \frac{\sum_{d=2}^{D} (\hat{E}_d - \hat{E}_{d-1})^2}{2D(D-1)} + \frac{3D}{D} \sum_{d=1}^{D} v(\hat{E}_d), \tag{5}$$

where:

$$v(\hat{E}_d) = v(\bar{c}_d)(ahd)^2 \text{, and}$$

$$v(\bar{c}_d) = \frac{\sum_{p=2}^{n_d}(c_{dp} - c_{d(p-1)})^2}{2n_d(n_d - 1)}.$$

BANK LOSS AND ANGLER EFFORT

An analysis of variance was used to test if angler effort had a significant impact on mean change in bank position between years at the angler effort sites. Equation 2 was used, where:

Δ_{ijkl} = the mean change in distance from benchmark (and other stakes) to the river bank (most recent measurement – baseline measurement).

TRAMPLING AND ANGLER EFFORT

Vegetation Analysis

To assess the impact of trampling, we have conducted annual vegetation assessment since 1997. In 1997, twelve herbaceous and shrubland/herbaceous macrohabitats (defined in the Bank Loss and Angler Effort section) were selected for vegetation assessment. (These sites were also included in the Bank Loss and Angler Effort assessment.)

For each macrohabitat type, six sites were selected, two sites from each category for level of angler use (defined in the Bank Loss section). Sites with low angler use were defined as being pristine, characterized by receiving little or no human use. All other sites received varying levels of moderate to high angler use. Site selection was based on previous angler count data (1995, 1996) and field inspection. Specific high use areas within parks, waysides, and campgrounds, which received substantial human activity for reasons other than angling, were not considered. The location of the 12 survey sites, the 150-ft transect within each site, and the four permanently marked vegetation plots (48 in x 30 in) along each transect are described in King and Hansen (1999).

Using DGPS, site photos, a metal detector and a tape measure, two project personnel relocated each habitat survey site, its respective transect and four vegetation plots. Permanent rebar stakes, inserted flush with the ground at the two corners of each plot lying along the 150-ft vegetation transect (example: stakes at 30 ft and 34 ft), were re-located. Two corners of a 48 in x 30 in quadrat were placed on the rebar stakes such that a long side of the quadrat fell on the transect line with the remainder of the quadrat extending 30 in toward the river. Photographs of the plot were taken using a Minolta® 35 mm camera. While standing on a stepladder, a technician centered the camera over the plot approximately 5 ft above ground level and took a picture. Occasionally it was necessary to use an umbrella to canopy the plot to minimize shadowing effects. Sometimes an automatic flash was used to further enhance lighting uniformity. Photos were taken of all vegetation plots at the end of June (prefishery) and again in mid August (postfishery). Photos were cataloged by habitat survey site, plot, and date.

Postseason, the photos were scanned and the computer images analyzed using Adobe PhotoShop® software following the protocol for photo imagery analysis outlined by Dietz and Steinlein (1996). Area by cover class (vegetation, litter, bare ground, and water) and percent cover by cover class were estimated.

A multivariate analysis of variance was used to test if angler effort had a significant impact on mean percent change between pre- and postfishery for each cover class. The following model was used:

$$\Delta_{ijkl} = \mu + \beta_i + \alpha_j + \gamma(\alpha)_{jk} + \beta\gamma(\alpha)_{jk} + \varepsilon_{ijk,} \quad (6)$$

where:

- Δ_{ijkl} = the change in percent cover (postfishery percent – prefishery percent),
- μ = overall mean,
- β_i = the effect of the i^{th} estimate of angler effort,
- α_j = the effect of the j^{th} habitat type,
- $\gamma(\alpha)_{jk}$ = the effect of the k^{th} site in the j^{th} habitat type, and
- $\beta\gamma(\alpha)_{jk}$ = the interaction between the i^{th} estimate of angler effort and the k^{th} site in the j^{th} habitat type.
- ε_{ijk} = random error associated with the i^{th} level of angler use in the j^{th} habitat type with k^{th} level of wake and the l^{th} level of meander.

To assess the ability of vegetation to recover from angler impacts, the above multivariate analysis was used to test if angler effort had a significant impact on mean percent change between June 1998 and June 1999 where:

- Δ_{ijkl} = the change in percent cover (June 1999 percent – June 1998 percent).

Soil Analysis

A soil penetrometer was used to measure soil penetrability (resistance), interpreted as an indicator of soil compaction. Measurements were taken at depths of 1 in, 3 in, and 6 in since soil compaction by human foot traffic primarily occurs within the first 6 in of the surface (Kuss 1983; Dotzenko et al. 1967). Tests were conducted at the 12 habitat survey sites used to assess trampling. Project personnel took five resistance measurements within each of the permanent vegetation plots used to assess trampling, one in each of the four corner areas and one in the middle.

These data were collected before and after the fishery with the change calculated as:

$$\Delta = \text{postfishery value} - \text{prefishery value}. \quad (7)$$

For each of the 12 habitat survey sites, a mean for the change in resistance, at depth, was estimated as:

$$\overline{X}_{zj} = \frac{\sum_{y=1}^{n_{zj}} \Delta_{zjy}}{n_{zj}}, \quad (8)$$

where:

- $\overline{X}_{zj}$ = mean for the change in resistance measurement for soil depth j at site z,

Δ_{zjy} = change in resistance measurements at plot y for soil depth j at site z, and

n_{zj} = number of plots for soil depth j at site z.

Since we did not sample for soil type, it was not possible to look at change by habitat type—there could have been different soil types at each site that would have resulted in different resistance measurements based upon the composition of the soil. Therefore, change comparisons were made within sites by using a one-sample t-test to test the hypothesis:

$H_o: \Delta = 0$ against the alternative:

$H_a: \Delta < 0$.

The overall type I error was set at 0.10 and was adjusted to 0.009 for each individual test to control for experimentwise error.

We also used the above procedure to calculate annual change in resistance as:

$$\Delta = \text{June 1999 value} - \text{June 1998 value.} \quad (9)$$

RESULTS AND DISCUSSION

DISTRIBUTION OF SHORE ANGLERS

For the 12 days which angler counts were conducted in 1999, the riverwide count totals (reaches 2-4) ranged from 65 anglers on 8 July to 1,884 anglers on 23 July (Table 1). Counts between 20 and 29 July were the highest observed and exceeded 1,000 anglers. Angler counts showed a nearly 3-fold increase between 14 and 17 July, using the higher count on 17 July. Angler counts began declining between 29 July and 1 August (counts of 1,026 and 645) and substantially dropped by 7 August to 189. The highest angler count in a specific river reach was 908 anglers, occurring in reach 3 on 23 July.

Of anglers counted, 46.3% were located on private lands and 53.7% were on public lands (Table 2, Figure 5). Only in reach 3 was angler land usage closely split between public and private land ownership (48.1% public and 51.9% private). The percent of public land use by anglers has been increasing annually since 1996. In reach 2 in 1999, public land received 27% greater use than private land which was a significant change (χ^2 = 87.3, df = 3, P < 0.01) over previous years when angler use of public and private lands was nearly equal. In reach 4 in 1999, public land received 10.6% greater use than private land, a decline from 1998, but similar to land use in 1996.

Analysis of covariance detected a linear trend in percent angler use of public lands over time (F = 6.86, df = 1, P = 0.04). Specifically, there has been an increasing rate of use for public lands from 1996 to 1999 in all reaches: reach 1, 3.17%; reach 2, 2.97%; reach 3, 6.11%, and reach 4, 0.44%.

In 1997 and 1998, the riverwide mean count of shore anglers decreased by over 250 from 1996 (Table 3). This may be indicative of a decrease in angler participation. However, the 1999 river-wide mean count of shore anglers returned to 1996 levels.

In 1999, the majority of shore anglers (92.0%) were bank anglers, i.e., fishing from mainland banks, while only 4.1% of the anglers fished from islands and 3.9% fished from gravel bars (Table 4, Figure 6). Of the bank anglers, 54.2% stood in the water while fishing and 28.1%

Table 1.-Counts of shore anglers during the recreational fishery for late-run sockeye salmon, by river reach, Kenai River, 1995-1999.

Date	Count No.	Reach 1[a]	Reach 2	Reach 3	Reach 4	Total
1995[b]		255[c]	451	1,101	1,161	2,968
1996[d]		1,189[c]	1,532	2,942	1,846	6,320
1997		2,220	1,473	2,555	2,108	8,356
1998[e]			2,365	5,200	3,964	11,529
1999						
8-Jul	1		12	25	28	65
11-Jul	1		44	71	66	181
14-Jul	1		35	101	130	266
17-Jul	1		86	175	229	490
	2		157	242	380	779
20-Jul	1		198	722	541	1,461
23-Jul	1		263	881	674	1,818
	2		310	908	666	1,884
26-Jul	1		309	804	666	1,779
29-Jul	1		220	472	334	1,026
1-Aug	1		298	215	132	645
4-Aug	1		150	73	41	264
7-Aug	1		39	77	73	189
10-Aug	1		49	80	51	180
1999 Totals			2,170	4,846	4,011	11,027

[a] No angler counts were conducted in Reach 1 in 1998 and 1999.

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

[c] These counts were omitted in previous analyses; includes anglers downstream of Jim's Landing to Skilak Lake.

[d] Some anglers were excluded from the previously reported totals because not all had been assigned to public or private property.

[e] There were two angler counts per count day in 1998.

Table 2.-Angler counts by year, reach and property ownership, Kenai River, 1995-1999.

Reach	Year	No. of Counts[a]	Total Public	Total Private	Mean Public	Mean Private	Percent Public	Percent Private	X^2 [b]	df	P
	1995[c]	3	233	0	77.7	0.0	100.0	0.0			
1[d]	1996	8	1,175	14	146.9	1.8	98.8	1.2	12.67	1	<0.01
	1997	12	2,215	5	184.6	0.4	99.8	0.2			
	1995	3	240	211	80.0	70.3	53.2	46.8			
2	1996	8	810	722	101.3	90.3	52.9	47.1	87.30	3	<0.01
	1997	12	778	695	64.8	57.9	52.8	47.2			
	1998	22	1,199	1,166	54.5	53.0	50.7	49.3			
	1999	14	1,379	791	98.5	56.5	63.5	36.5			
	1995	3	452	649	150.7	216.3	41.1	58.9			
3	1996	8	874	2,068	109.3	258.5	29.7	70.3	287.05	3	<0.01
	1997	12	1,013	1,542	84.4	128.5	39.6	60.4			
	1998	22	2,368	2,832	107.6	128.7	45.5	54.5			
	1999	14	2,330	2,516	166.4	179.7	48.1	51.9			
	1995	3	703	458	234.3	152.7	60.6	39.4			
4	1996	8	1,062	784	132.8	98.0	57.5	42.5	72.30	3	<0.01
	1997	12	1,051	1,057	87.6	88.1	49.9	50.1			
	1998	22	2,414	1,550	109.7	70.5	60.9	39.1			
	1999	14	2,217	1,794	158.4	128.1	55.3	44.7			
	1995	3	1,628	1,318	542.7	439.3	55.3	44.7			
All[e]	1996	8	2,746	3,574	343.3	446.8	43.4	56.6	219.75	3	<0.01
	1997	12	2,842	3,294	236.8	274.5	46.3	53.7			
	1998	22	5,981	5,548	271.9	252.2	51.9	48.1			
	1999	14	5,926	5,101	423.3	364.4	53.7	46.3			

[a] In general, only one angler count was conducted on a count day except in 1998 which had two angler counts every count day.

[b] Chi square analyses did not include the 1995 counts. These counts were not representative of the fishery: only three counts conducted, with two done on peak days.

[c] For comparison, the number of anglers on public land in Reach 1 in 1995 was reduced by 22 because these anglers were counted between Jim's Landing and the inlet to Skilak Lake.

[d] No angler counts were conducted in Reach 1 in 1998-1999.

[e] Totals exclude Reach 1 for 1996-1999. Chi square analyses done for reaches 2-4, 1996-1999.

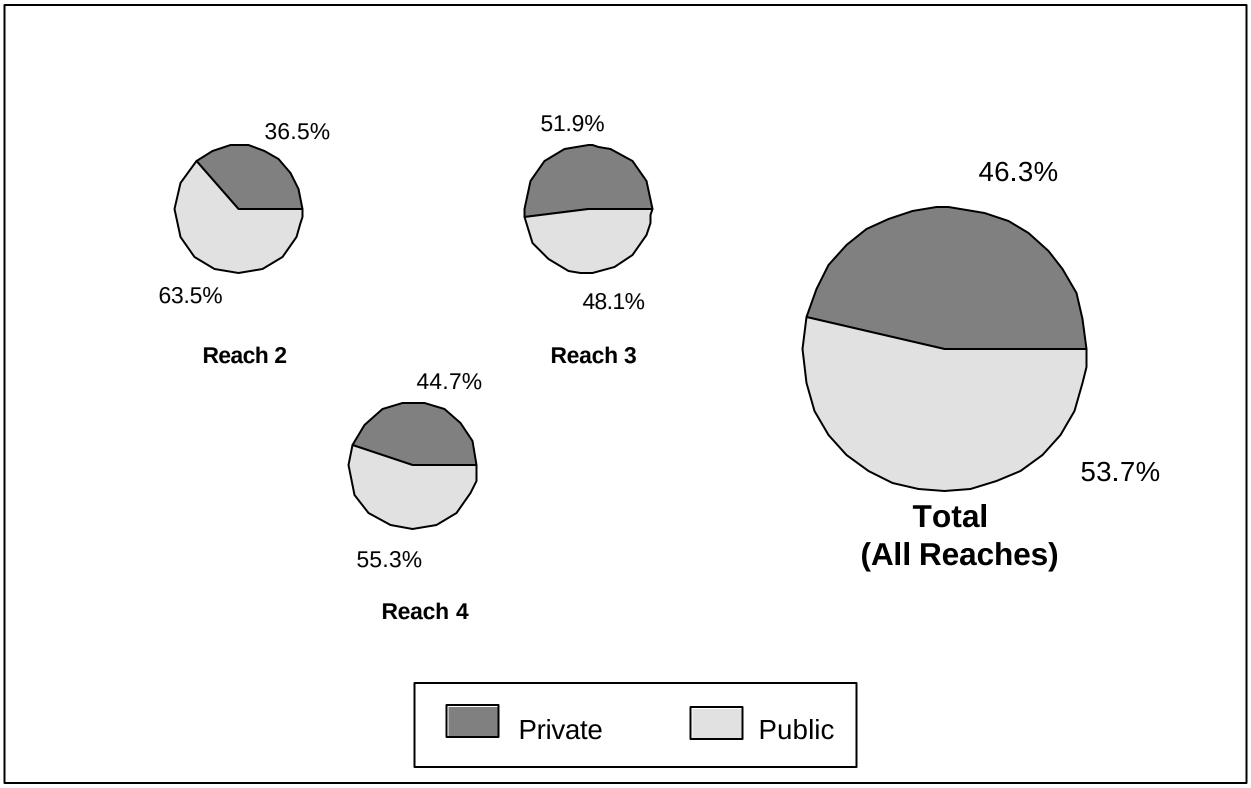


Figure 5.-Percent of anglers using public and private lands during the sport fishery for late-run sockeye salmon, Kenai River, 1999.

Table 3.-Mean counts of shore anglers during the sport fishery for late-run sockeye salmon, Kenai River, 1996-1999.

		Reach 2		Reach 3		Reach 4		All Reaches	
Year	No. of Counts	Count	Mean	Count	Mean	Count	Mean	Count	Mean
1996	8	1,532	192	2,942	368	1,846	231	6,320	790
1997	12	1,473	123	2,555	213	2,108	176	6,136	511
1998	22	2,365	108	5,200	236	3,964	180	11,529	524
1999	14	2,170	155	4,846	346	4,011	287	11,027	788

Table 4.-Angler location and structural use during the sport fishery for late-run sockeye salmon, Kenai River, 1997-1999.

	Angler Location						Angler Structural Use					
		Reach						Reach				
Year	Location	2	3	4	Total	%	Stucture	2	3	4	Total	%
1997	Bank	1,319	2,412	1,915	5,646	92.0	On Bank	397	771	540	1,708	27.8
	Gravel Bar	88	62	128	278	4.5	In Water	962	1,249	1,249	3,460	56.3
	Island	66	81	65	212	3.5	Boardwalk	65	452	275	792	12.9
	Total	1,473	2,555	2,108	6,136		Other	49	83	44	176	2.9
							Total	1,473	2,555	2,108	6,136	
1998	Bank	2,200	4,896	3,645	10,741	93.2	On Bank	463	1,534	885	2,882	25.0
	Gravel Bar	162	61	136	359	3.1	In Water	1,674	2,394	2,495	6,563	56.9
	Island	3	243	183	429	3.7	Boardwalk	78	1,092	366	1,536	13.3
	Total	2,365	5,200	3,964	11,529		Other	150	180	218	548	4.8
							Total	2,365	5,200	3,964	11,529	
1999	Bank	2,032	4,528	3,589	10,149	92.0	On Bank	641	1,573	771	2,985	27.1
	Gravel Bar	108	102	220	430	3.9	In Water	1,240	2,233	2,760	6,233	56.5
	Island	30	216	202	448	4.1	Boardwalk	179	924	239	1,342	12.2
	Total	2,170	4,846	4,011	11,027		Other	110	116	241	467	4.2
							Total	2,170	4,846	4,011	11,027	

stood on the bank. The remaining bank anglers (17.7%) fished from boardwalks or other structures. Both island and gravel bar anglers tended to stand in the water while fishing (over 77% for each group), with the remaining anglers from these groups tending to stand on the nearest exposed land (island or gravel bar).

Summary

Peak participation in the sport fishery for late-run sockeye salmon occurred from mid July to the end of the month and, as documented in previous studies (King 1995, 1997), is strongly related to the anticipated timing of the return.

In 1999, angler usage of public and private lands in reaches 2-4 tended more toward public land (53.7%) which corresponds with current waterfront information for these reaches: 67.4% of waterfront is public (Mike Wiedmer, Alaska Department of Fish and Game, Anchorage, personal communication). For all reaches, the percent of public and private land used by anglers is closely related to the percent of public and private waterfront property available (Figure 7). For example, in reach 2 public and private land ownership is nearly equal and so is angler use of these, except in 1999. In reach 3, there is greater availability of private land (66.7%) with a greater percentage of anglers (51.9%) using private land. The reverse is true in reach 4 with greater public land ownership (65.2%) and greater angler use of public lands (55.3%).

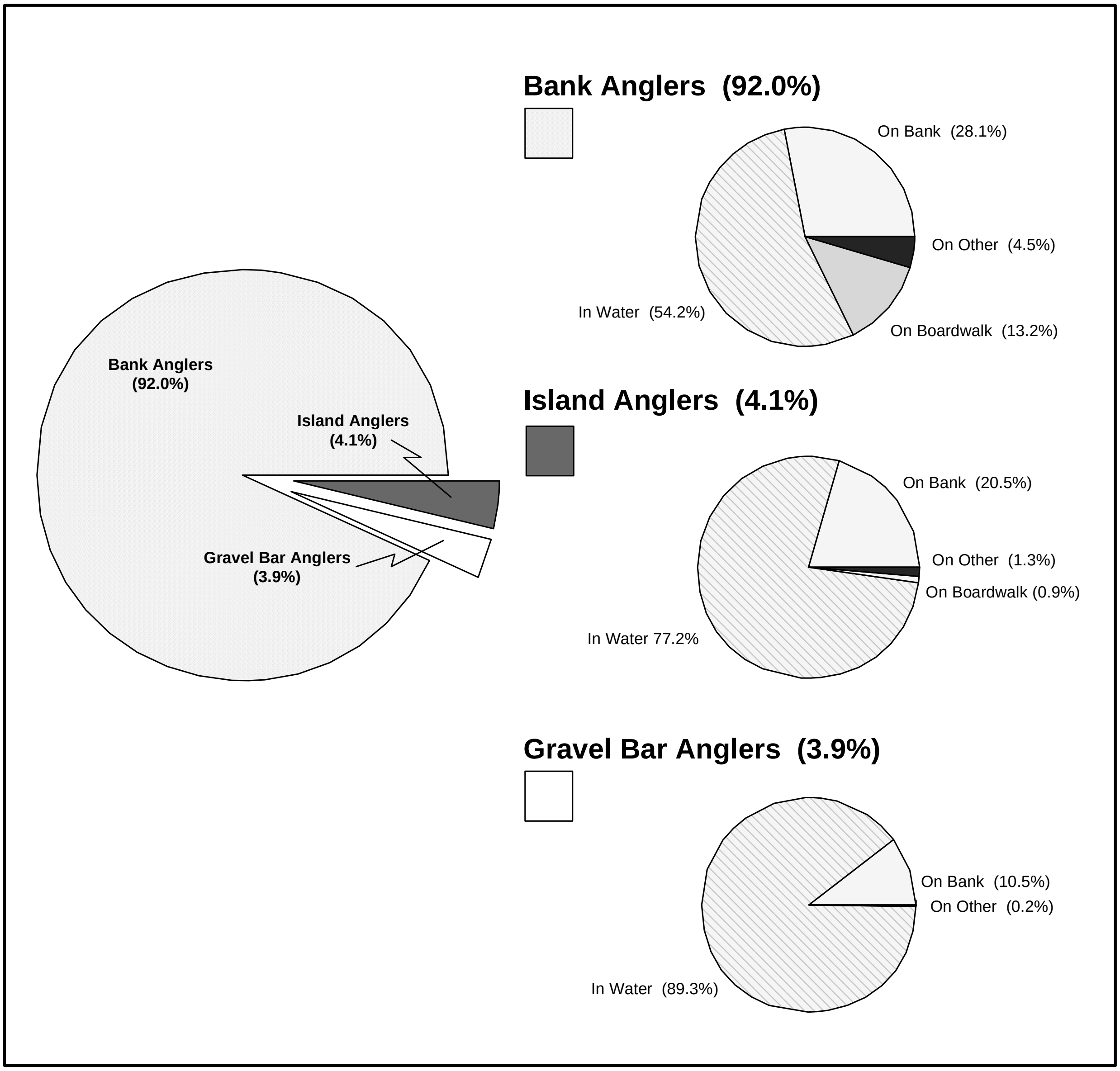


Figure 6.-Angler distribution by their primary fishing location and structural use during the sport fishery for late-run sockeye salmon, Kenai River, 1999.

In reviewing the "bank fishing closures" implemented by the Department in 1996 and continued through 1999 (Table 5), a total of 16.5 miles of mainland banks have been closed to fishing. Public perception is that these closures may have shifted angler use from private to public lands. However, bank locations closed to fishing in 1996 and 1997 were the same, so the increased use of public lands in 1997 would be unrelated to the bank closures. In 1998 and 1999, many of the bank closures were on properties which had formerly been privately owned and then sold to the State of Alaska with the intent of being placed in a conservation status. These properties received low level or no shore angler use, so it is unlikely that many anglers were relocated to public lands.

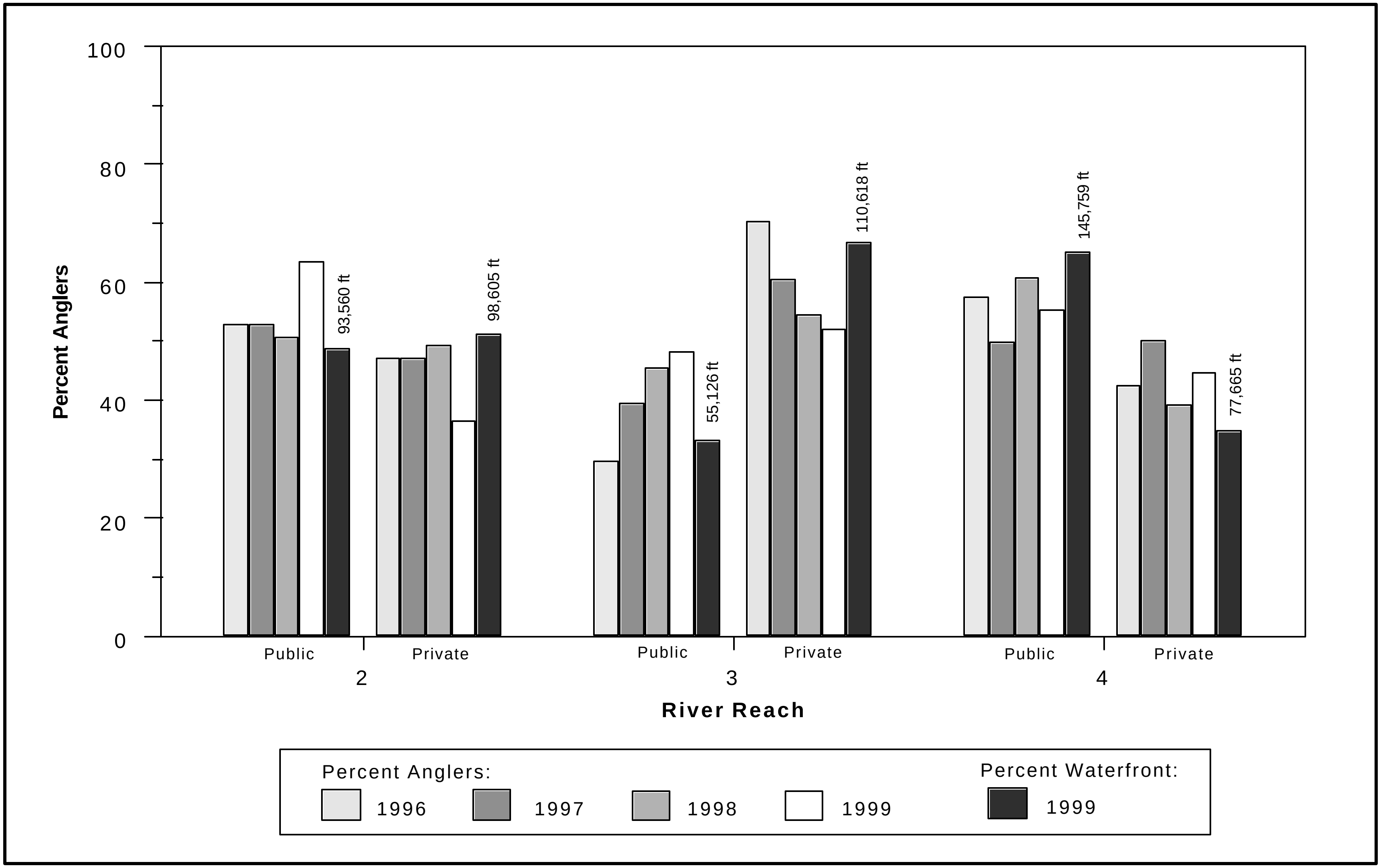


Figure 7.-Percent of anglers using public and private lands (1996-1999) and percent of public and private waterfront land (1999), by river reach, Kenai River.

Table 5.-Miles of riverbank closed to angling, by river reach, Kenai River, 1996-1999.

Year	Reach 1	Reach 2	Reach 3	Reach 4[a]	Total
1996	0.4	0.1	2.9	2.5	5.9
1997	0.4	0.1	2.9	2.5	5.9
1998	0.4	0.1	10.9	4.2	15.6
1999	0.4	0.6	11.3	4.2	16.5

[a] Excludes shorelines of islands between river miles 17.0 to 17.3.

Although some anglers fish from islands and gravel bars (8%), most anglers fish from the mainland banks (92%) (Figure 6). Anglers fishing from islands and gravel bars primarily accessed these locations by boat. Anglers fishing from shore tended to access their fishing locations on foot. Only 13.2% of the shore anglers actually fished from boardwalks and other structures. Considering that less than 1% of waterfront downstream of Skilak Lake has boardwalks (Mike Wiedmer, AK Department of Fish and Game, Anchorage, personal communication), it appears that when boardwalks are present anglers do tend to use these which helps to minimize shore angler impacts to riparian habitats. Philosophically, shore anglers who stand in the water (54.2%) are more likely to reduce their overall impact to riparian habitats. But, how they access the river and whether they move from one fishing location to another by walking on top of the bank or in the water are the determinants of the level of riparian habitat impact. Those anglers who actually stand on the banks while fishing (28.1%) are more likely to cause impacts to riparian habitats throughout the entire time of their fishing trip.

We also analyzed annual changes in angler behavior by angler location and structural use (Table 4). Between years there was a significant change in angler location ($\chi^2 = 28.2$, df = 4, $P < 0.001$) and in structural use by mainland bank ($\chi^2 = 2.9$, df = 6, $P < 0.01$). Although these changes were significant, the shift was so small that it may be more related to annual variation in angler behavior. More years of data would establish if there was truly a trend developing.

BANK LOSS

Bank measurements were taken at 170 sites. The number of sites for each habitat type were 4 shrub, 8 disturbed, 29 shrub/herbaceous, 34 herbaceous (two new in 1999), and 99 treed. Four sites were excluded from the analyses: two sites that exceeded 1.5 m of bank change and two sites that were new in 1999 thus having only one measurement. Site characteristics and bank measurements are in Appendix C1. Change in benchmark to bank edge distances from June 1998 to June 1999 ranged from a loss of 3.83 m to a gain of 2.13; however, most measured change was less than 0.3 m (Figures 8-11 and Appendix C1).

Data analysis showed there was no significant effect of habitat type, level of angler use, stream meander, or boat wake level on the amount of erosion at these bank measurement locations (Table 6).

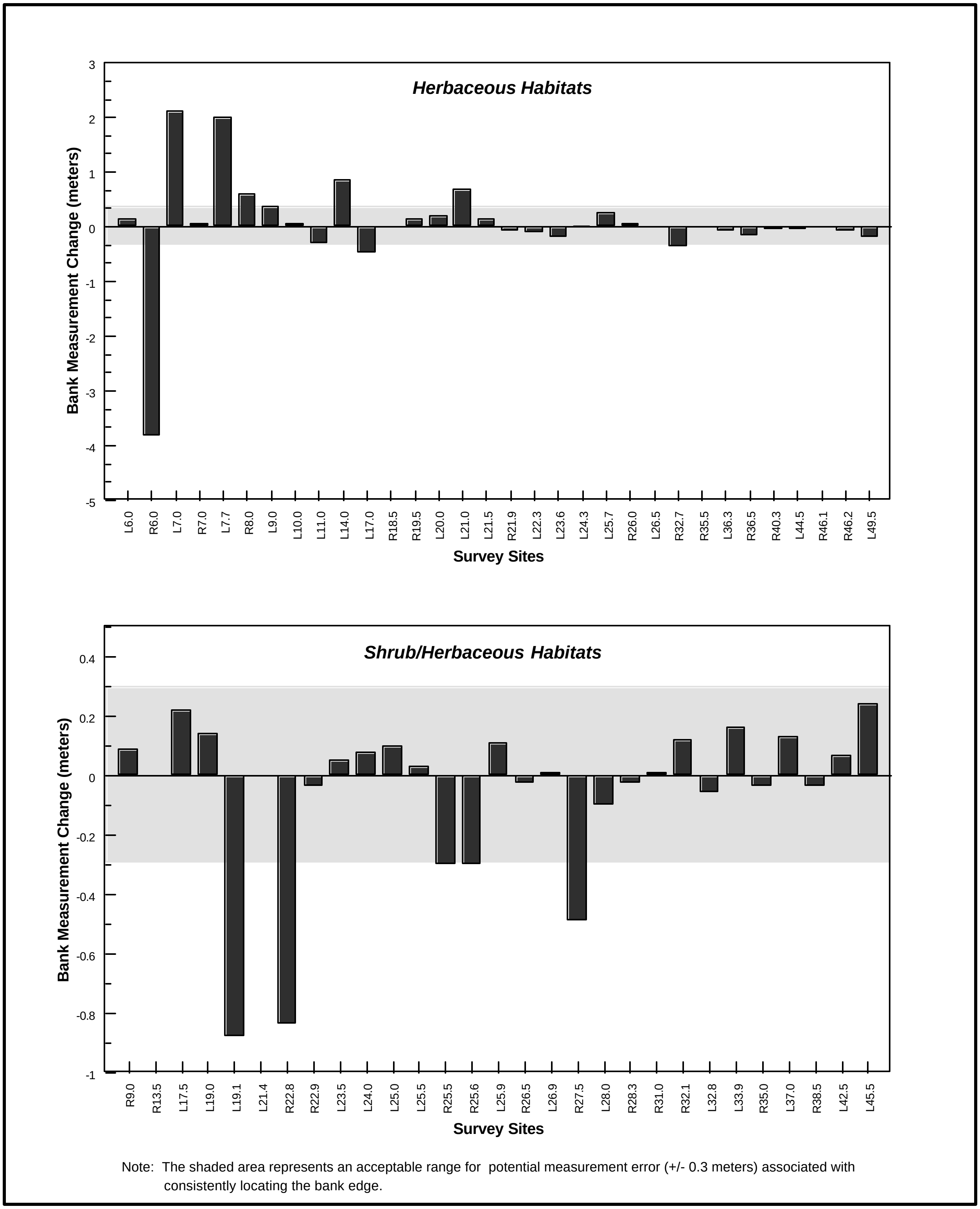
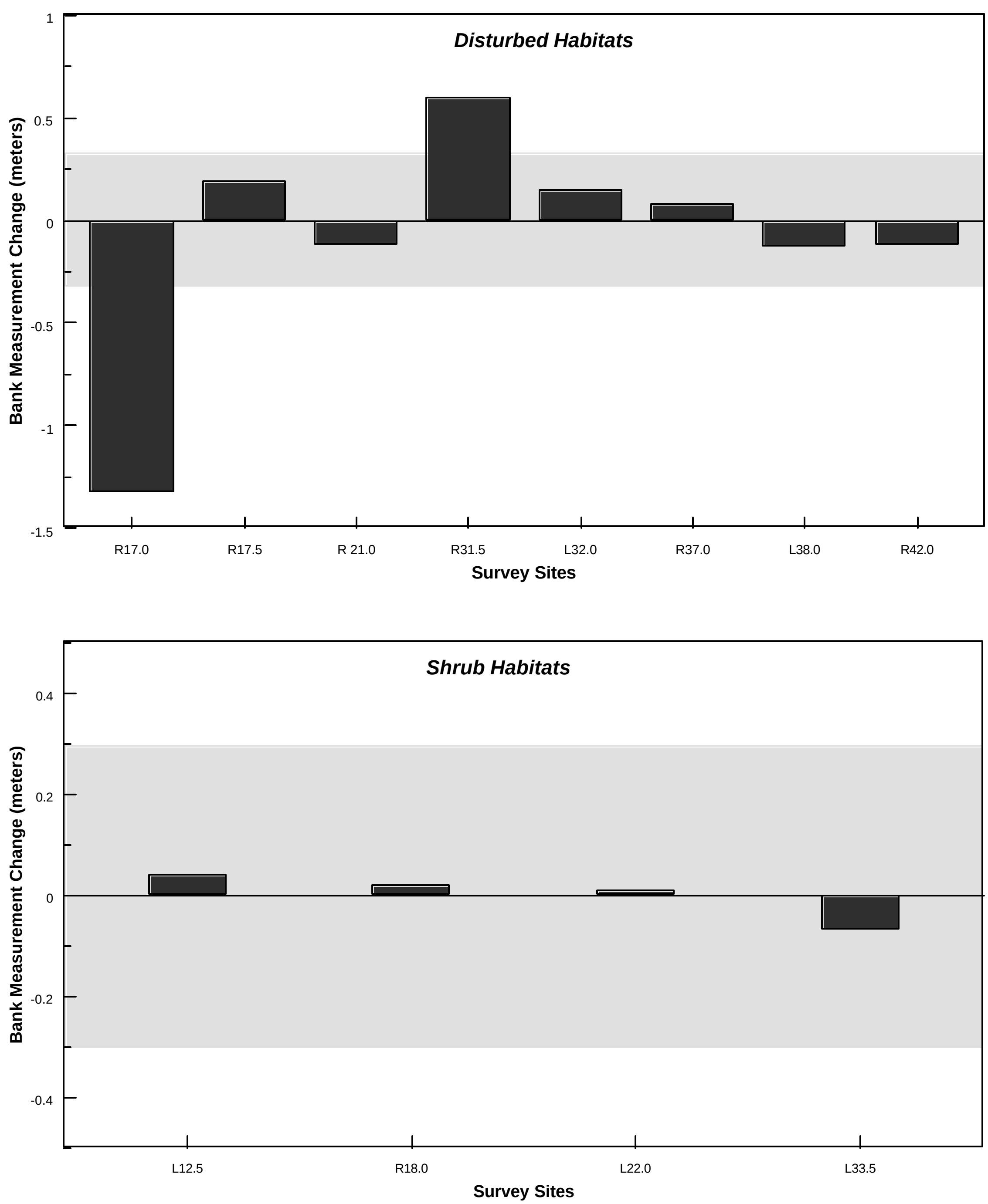
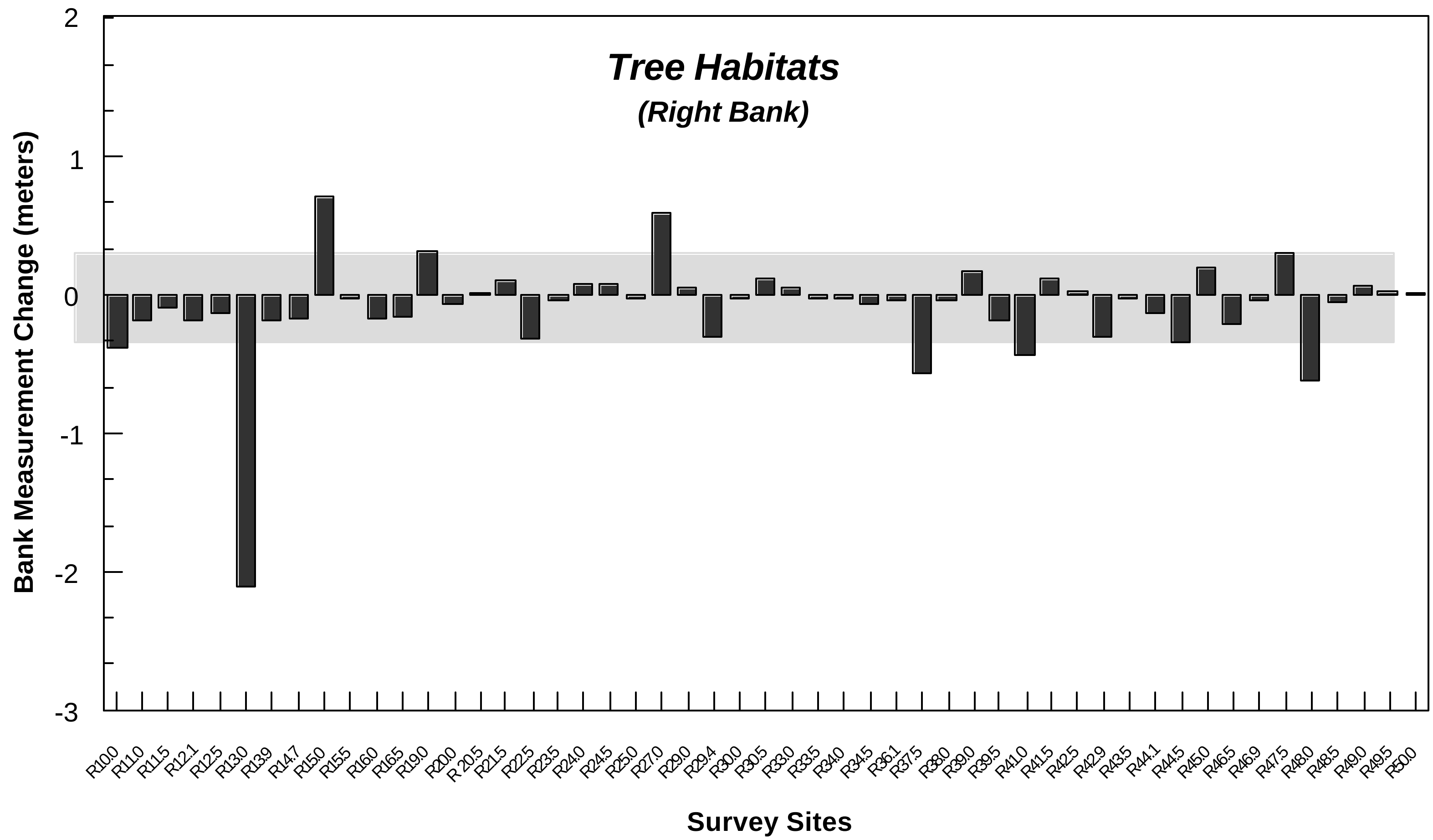


Figure 8.-Change in bank measurements (June 1999–June 1998) for herbaceous and shrub/herbaceous habitat types, Kenai River.



Note: The shaded area represents an acceptable range for potential measurement error (+/- 0.3 meters) associated with consistently locating the bank edge.

Figure 9.-Change in bank measurements (June 1999–June 1998) for disturbed and shrub habitat types, Kenai River.



Note: The shaded area represents an acceptable range for potential measurement error (+/- 0.3 meters) associated with consistently re-locating the bank edge.

Figure 10.-Change in bank measurements (June 1999–June 1998) at tree habitats (right bank), Kenai River.

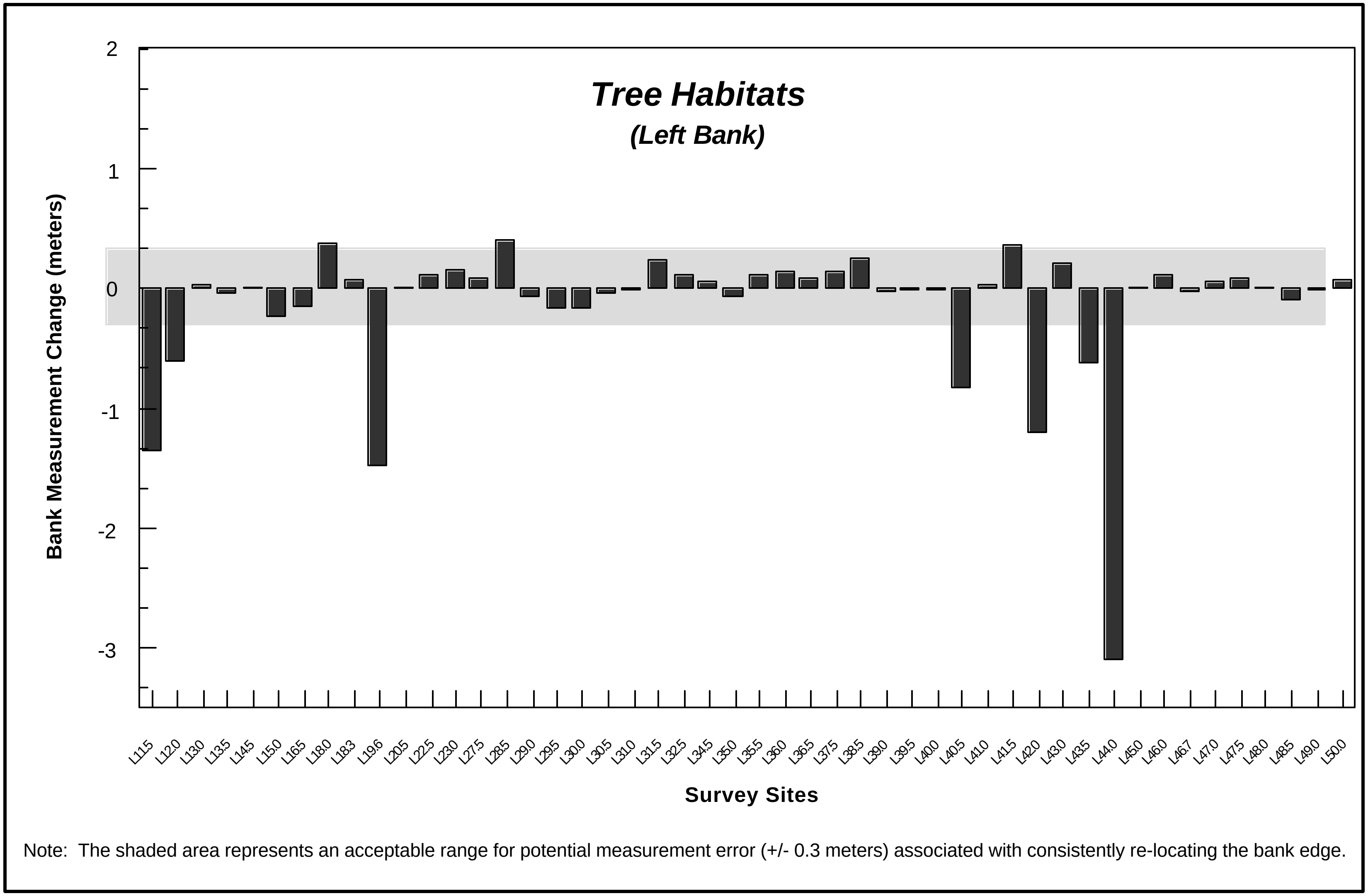


Figure 11.-Change in bank measurements (June 1999–June 1998) at tree habitats (left bank), Kenai River.

Table 6.-Multivariate analyses of variance for effects of angler level of use, stream meander, boat wake level, and habitat type on bank positional change, Kenai River, June 1998 to June 1999. Analyses used the change in distance from benchmark to bank edge for all sites, effort and noneffort.

Source	df	Mean Square	F Value	Pr > F
Habitat Type	4	0.08	0.31	0.87
Angler Level	2	0.01	0.04	0.96
Meander	1	0.33	1.22	0.30
Wake level	1	0.88	3.30	0.07

		Sample Size	Mean	Duncan Grouping
Habitat Type				
	Disturbed	8	0.02	A
	Shrub	4	0.00	A
	Shrub/Herbaceous	29	-0.05	A
	Herbaceous	30	-0.11	A
	Tree	99	-0.12	A
Angler Level				
	Medium	17	-0.05	A
	High	17	-0.08	A
	Low	136	-0.10	A
Meander				
	Inside	25	0.00	A
	None	95	-0.08	A
	Outside	50	-0.17	A
Wake Level				
	Low	112	-0.04	A
	High	58	-0.20	A

Summary

During the process of taking bank measurements, the most challenging task was returning to a site and trying to consistently relocate the bank edge used for taking the original distance measurement from benchmark to bank edge. As a first year program in 1998, we assumed an error of +/- 0.3 m as indicated by the shaded areas in Figures 8-11. Measurements that exceeded this observer error were likely representative of bank change. In 1999, few sites exceeded or minimally exceeded this error zone. Sites with noticeable measured bank loss included intertidal areas (such as herbaceous site R6.0 and treed site L11.5) where increased erosion might be expected, and sites with observed documentation of calving by crewmembers. Sites having measurements that showed a large gain (greater than 0.3 m) in bank were likely a result of observer error in consistently relocating the bank edge. When returning to a bank that had "rolled over" since the previous visit, confusion may have existed in relocating the bank edge. An attached but "rolling" bank may indicate bank growth when measured. Also, since measurements were taken from the top of the bank, not near waterline, the likelihood of having soil accretion is small. Accretion of sediments will generally occur as a result of deposition at or near the waterline rather than at the top of a defined bank. To address the error associated with the bank measurement process, we implemented an observer measurement error program in 1999. Results are in Appendix B1.

It should be noted that there will always be difficulty in correlating the level of angler use with the amount of bank erosion. This is due to angler behavior and the physical characteristics of a bank location. For example (case 1), there may be a high count of anglers at a particular bank location and a low level of bank erosion. This may be due to angler behavior: anglers access the water at specific locations and stay in the water their entire fishing period. This would minimize habitat impacts and likely result in lesser amounts of bank erosion. Sometimes the physical characteristics of a bank (rocks, overhanging vegetation, steep banks, etc.) may limit angler movement and thus reduce angler impacts. On the other hand (case 2), at bank locations where the anglers can freely access the water and do so several times during their fishing trip, the same number of anglers as in case 1 could cause considerably more habitat impacts resulting in increased bank erosion. The correlation of the level of angler use with bank erosion is further confounded by other factors such as boat wakes and natural stream dynamics.

BANK LOSS AND ANGLER EFFORT

Bank measurements were collected at 40 angler effort sites during June. The mean bank positional change from August 1998 to June 1999 ranged from a gain of 0.89 m to a loss of 0.71 m (Appendix C2). Individual distance measurements from the transect line to the riverbank ranged from a gain of 1.82 m to a loss of 3.18 m.

We conducted 60 angler counts at each angler effort site from 8 July to 10 August (Appendix C3). Mean counts of anglers per site ranged from 0 to 4.5. Estimates of angler effort at these sites during this period ranged from 0 to 2,573 angler hours. Effort exceeded 2,000 angler-hours at two sites (R25.5, 2,131 angler-hours and L17.0, 2,573 angler-hours). Angler use of site R25.5 was uniquely different from other sites because the property was corporately owned, with access during the sport fishery being primarily employees. Onsite security officers enforced a policy that all anglers must fish while standing in the water. This arrangement provided special angling opportunities, attracted large numbers of anglers, and likely reduced the overall habitat impact typically associated with large numbers of shore anglers. Because of these unusual circumstances, data from this site were considered too influential and were excluded from any regression or correlation analysis. On the other hand, site L17.0, which also experienced high levels of angler use (2,573 angler hours), will not be excluded from the 1999 angler effort analyses because there were no extenuating circumstances regulating angler behavior at this site.

Results of analyses (Table 7) test for the effects of 1998 angler effort estimates (King and Hansen 2001), stream meander, boat wake level, and habitat type on bank positional change between August 1998 and June 1999. The 1998 angler effort estimates are used in this analysis because it was the impact of anglers during the 1998 sport fishery that affected any changes

Table 7.-Multivariate analyses for effects of angler effort, stream meander, boat wake level, and habitat type on bank positional change at angler effort sites, Kenai River, August 1998 to June 1999.

Source	df	Mean Square	F Value	Pr > F
Habitat type	1	0.11	1.43	0.24
Total Effort	1	0.14	1.86	0.18
Meander	2	0.18	2.45	0.10
Wake level	1	0.20	2.67	0.11

	Sample Size	Mean	Duncan Grouping
Habitat Type			
Herbaceous	19	0.06	A
Shrub/Herbaceous	19	-0.07	A
Meander			
None	17	0.10	A
Inside	9	-0.03	A
Outside	12	-0.13	A
Wake Level			
High	4	0.26	A
Low	34	-0.03	A

associated with bank position through June of 1999. Results of these analyses showed there were no significant relationships (Table 7 and Figure 12).

Summary

There are two potential sources for problems with these data. First, as described in the Bank Loss section, the greatest potential for error during data collection is the ability to consistently re-locate the bank edge for subsequent measurements. In 1999 we implemented better methods for re-locating the bank edge and conducted observer measurement error tests (Appendix B1) to determine the level of error associated with the bank measurement process. Also, during data analyses, we calculated the mean for all bank positional change measurements at each angler effort site. We felt this mitigated the potential for error. Second, due to problems associated with the old methodology used for taking bank measurements in June 1998, we opted to treat the August 1998 bank measurement data, obtained with the revised and currently used methodology, as the baseline data set. Therefore, analyses of bank change from August 1998 to June 1999 do not include any bank changes that may have occurred during the sport fishery in July 1998. Exclusion of impacts occurring during this period may have reduced the sensitivity of the analyses.

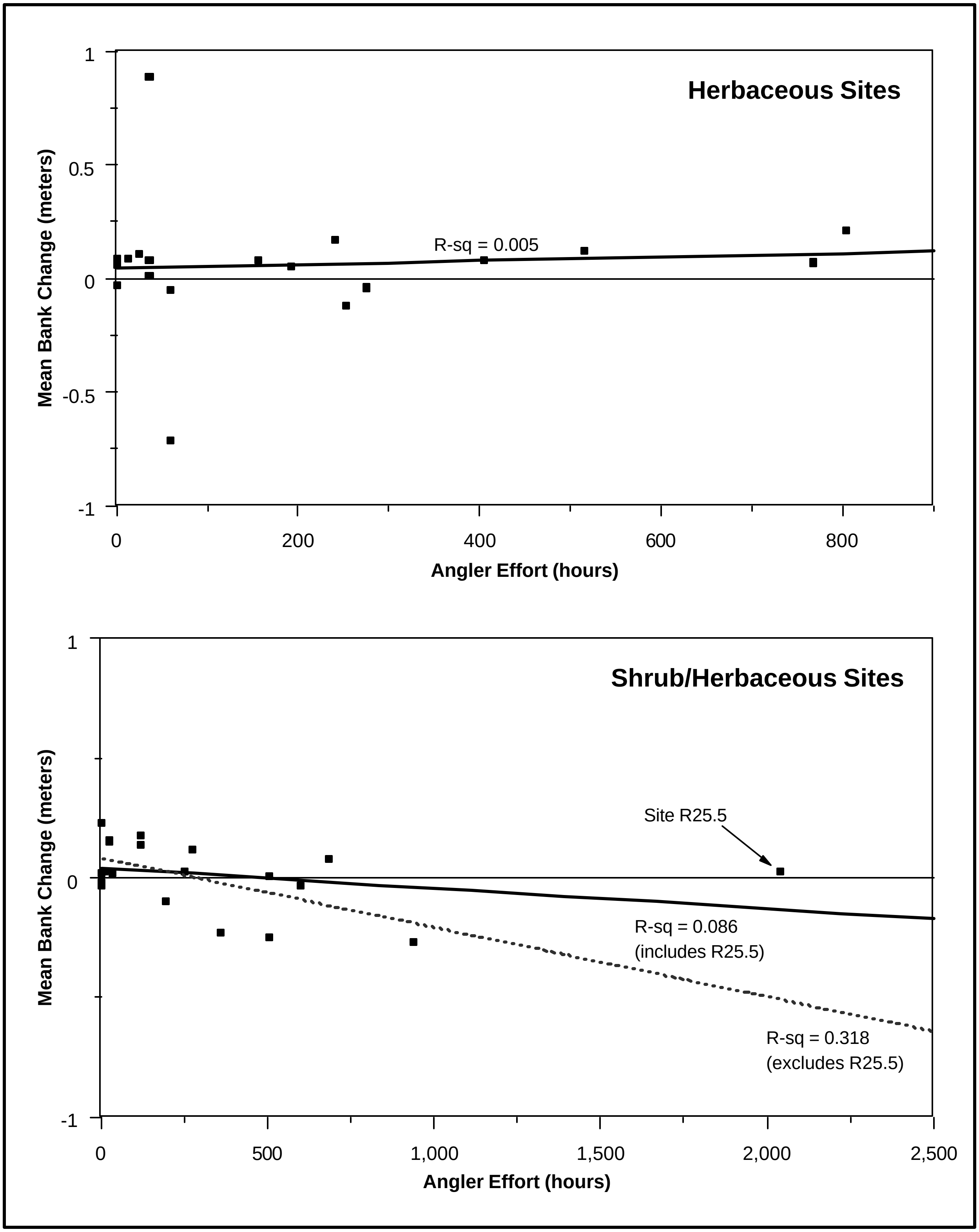


Figure 12.-Correlation of 1998 angler effort with mean change in bank position (August 1998 to June 1999) for herbaceous and shrub/herbaceous habitat sites, Kenai River.

In the future, it may be important to compare bank erosion at sites R25.5 and L17.0. Since both sites receive very high levels of angler effort (in excess of 2,000 angler hours), we could assess how well effective enforcement (limiting access points and insisting that anglers cannot fish while standing on the river bank) minimizes shore angler impacts. Present data for site R25.5 supports the premise that continual presence of enforcement personnel does reduce shore angler impacts.

Again, the difficulty associated with correlating angler effort with bank erosion should be noted. (Refer to cases 1 and 2 in the Summary of the Bank Loss Section.)

Of interest are angler effort site bank positional changes compared by date. Selected sites are presented along with interpretation of bank positional change (Figure 13). Complete explanations of the shaded areas were presented in King and Hansen (2001). Of present interest is that the 1998 measurement errors indicated at sites L36.3 and L19.1 were not repeated in June 1999. Also, at all sites there was minimal change in bank position between August 1998 and June 1999, except at R46.1. The shaded area at this site indicates confusion with consistently relocating the bank edge: the June 1998 and 1999 bank positions overlay, but the August 1998 measurement indicates bank loss. Overall, it appears that our ability to measure bank positional change is improving, becoming more repeatable. We would not have expected large bank positional changes between August 1998 and June 1999. The effects of the 1998 sport fishery and winter impacts (scouring, freezing) will likely become more pronounced on the riverbanks as summer water flow increases and weakened banks react to becoming watered.

TRAMPLING AND ANGLER EFFORT

Vegetation Analysis

Trampling in the nearshore area was evaluated by examining photographs and assessing changes in percent cover for broad cover classes: vegetation, litter, bare ground, and water. Water was a cover class that was added during the assessment process. Due to natural bank curvatures with respect to the transect line, a few vegetation plots actually overhung the river, particularly with increased seasonal water levels.

For the 1999 vegetation assessment, results of the analyses showed that the estimated angler effort had a significant effect on the change in mean percent cover of vegetation ($P < 0.01$), litter ($P < 0.01$), and bare ground ($P < 0.02$) (Table 8). However, the estimated angler effort had no significant effect on mean percent cover of water ($P = 0.65$). There was no significant interaction between habitat type and estimated angler effort for change in mean percent cover, except possibly vegetation ($P = 0.06$). Further analysis showed that as angler effort increased there was a decrease in vegetative cover ($P < 0.01$) and an increase in litter and bare ground cover ($P < 0.01$ for both cover classes) (Table 9, Figures 14-15). The rate of change was greater for mean change in cover for vegetation and litter at herbaceous habitat types. For both habitat types, the rate of change was the same for the mean change in cover of bare ground.

To assess vegetative recovery from sport fishery trampling impacts, we analyzed the relationship between 1998 angler effort estimates and vegetation change from June 1998 to June 1999. A multivariate analysis of variance was used to test if angler effort had a significant impact on mean percent change between prefishery 1998 and prefishery 1999 for each cover class. Results for all four cover classes showed that neither angler effort nor habitat type had any significant effect on the change in mean percent cover (Table 10, Figure 16). Although not significant, a relationship between angler effort and change in mean percent cover appears to be developing at

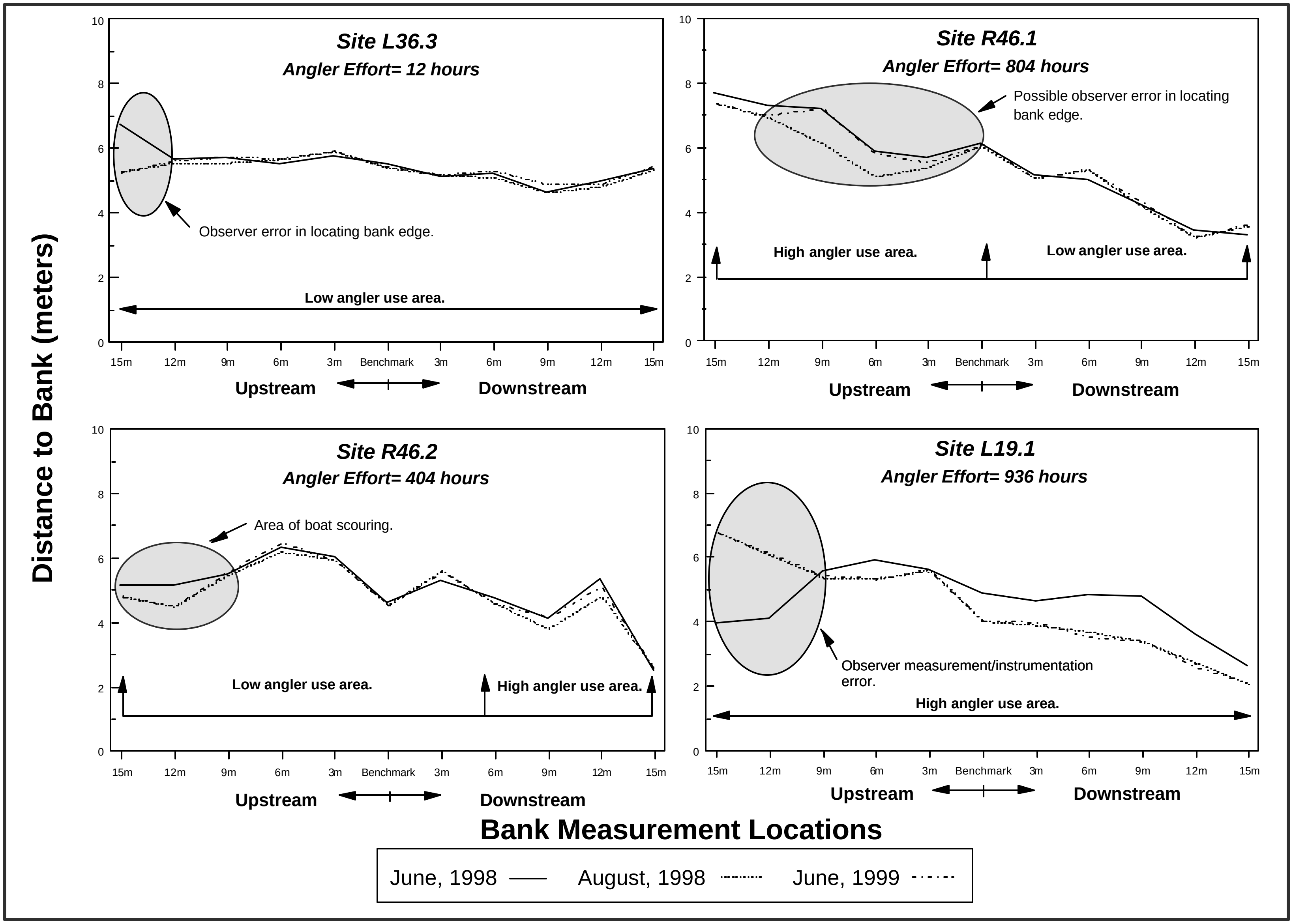


Figure 13.-Bank positional change at selected angler effort sites, Kenai River, 1998-1999.

Table 8.-Multivariate analysis of variance for change in percent cover by cover class from photo imagery analysis of permanent photo plots at habitat survey sites, Kenai River, 1999.

Change in Percent Vegetative Cover

Source	P>F
Estimated angler effort	<0.01
Habitat Type	0.42
Interaction	0.06

Change in Percent Bare Ground Cover

Source	P>F
Estimated angler effort	0.02
Habitat Type	0.71
Interaction	0.99

Change in Percent Litter Cover

Source	P>F
Estimated angler effort	<0.01
Habitat Type	0.97
Interaction	0.17

Change in Percent Water Cover

Source	P>F
Estimated angler effort	0.65
Habitat Type	0.14
Interaction	0.81

Table 9.-Multivariate analysis of variance for change in percent cover of vegetation and litter for permanent vegetation plots at habitat survey sites, assessed by photo imagery analysis, Kenai River, 1999.

Change in Percent Vegetative Cover

Parameter	Estimate	SE	P>T
intercept	-1.17	6.94	0.85
slope	-0.06	0.01	<0.01

Change in Percent Litter Cover

Parameter	Estimate	SE	P>T
intercept	0.69	4.84	0.89
slope	0.03	<0.01	<0.01

Change in Percent Bare Ground Cover

Parameter	Estimate	SE	P>T
intercept	-2.69	3.91	0.50
slope	0.02	<0.01	<0.01

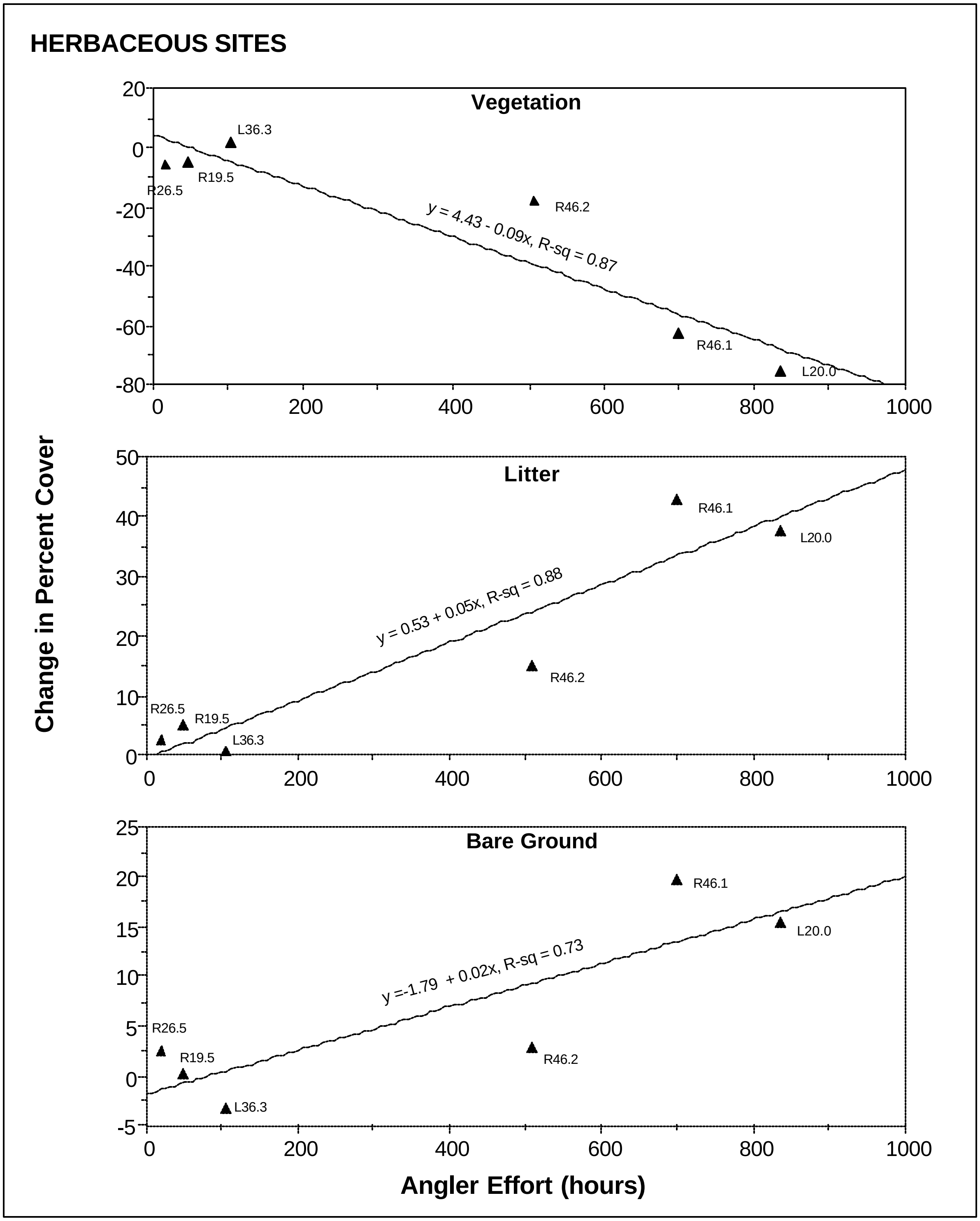


Figure 14.-Relationship of angler effort to change in percent cover (vegetation, litter, and bare ground) for permanent vegetatio n plots at herbaceous habitat types, Kenai River, 1999.

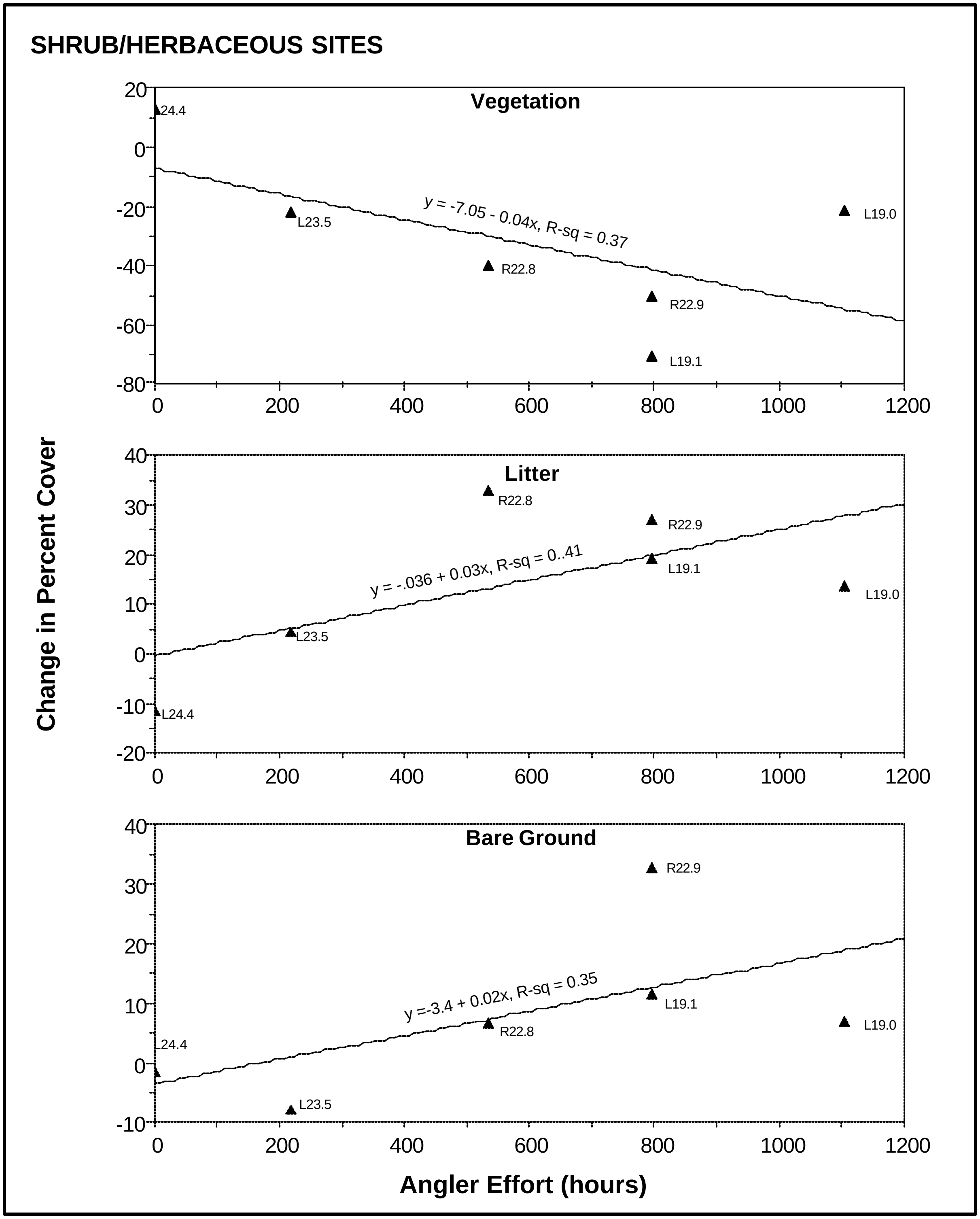


Figure 15.-Relationship of angler effort to change in percent cover (vegetation, litter, and bare ground) for permanent vegetation plots at shrub/herbaceous habitat types, Kenai River, 1999.

Table 10.-Multivariate analysis of variance for mean change in percent cover by cover class for permanent vegetation plots at habitat survey sites, Kenai River, prefishery 1998 vs. prefishery 1999.

Change in Percent Vegetative Cover		Change in Percent Bare Ground Cover	
Source	P>F	Source	P>F
Estimated angler effort	0.53	Estimated angler effort	0.44
Habitat Type	0.54	Habitat Type	0.57
Interaction	0.10	Interaction	0.29

Change in Percent Litter Cover		Change in Percent Water Cover	
Source	P>F	Source	P>F
Estimated angler effort	0.98	Estimated angler effort	0.88
Habitat Type	0.25	Habitat Type	0.10
Interaction	0.14	Interaction	0.44

herbaceous habitats: with increasing angler effort there is a decrease in cover for vegetation and an increase in cover for litter and bare ground.

Photos of plot 3 at site L19.1 (Figure 17) demonstrate shore angler impacts from June 1997 to August 1999. For each year, there is a visible, as well as measured, loss of standing vegetation and a gain in the amount of litter and bare ground for pre- and postfishery photos. Between years (June to June), there is 26.1% loss in vegetation for June 1998, but by June 1999 vegetative cover (80.5%) has returned to levels similar to June 1997 (87.7%). This would appear to be good recovery; however, closer examination of the photos indicates occurrence of plant succession. In June 1997 grass *Calamagrostis* is the dominant plant species in the photo. In the June 1998 photo *Calamagrostis* is present, but to a much lesser extent; and, dandelions *Taraxacum officiniale* are becoming established. By June 1999, dandelions had become the dominant plant species in this plot. This species of dandelion is very cosmopolitan and occurs in waste areas and along roadsides (Hulten 1968). Although we are observing adequate recovery by measuring total vegetation cover, plant succession is occurring and a change in species composition may also be occurring. The more dominant, naturally-occurring species may be less tolerant to heavy foot traffic and are being replaced by plant species more tolerant of heavy foot traffic as well as being able to thrive in disturbed soil conditions. The unanswered question is whether or not these newly established plant species provide good soil stabilization and, therefore, strong bank integrity. Members of the genus *Calamagrostis* propagate through rhizomes, forming tussocks (Hulten 1968) which provide good ground cover and stabilize the soil, much like a vegetative mat. Plants in the genus *Taraxacum* are solitaire plants with a taproot system. This type of plant tends to be an invading species in marginal soil conditions and serves to stabilize soil in denuded areas until such time that the soils allow establishment of other less tolerant plant species. This simple analysis indicates that even though we may be observing adequate recovery, this may be occurring at the expense of changes in species composition. And, the transition may be to plant complexes that contribute less to bank integrity and possibly the overall riparian ecology.

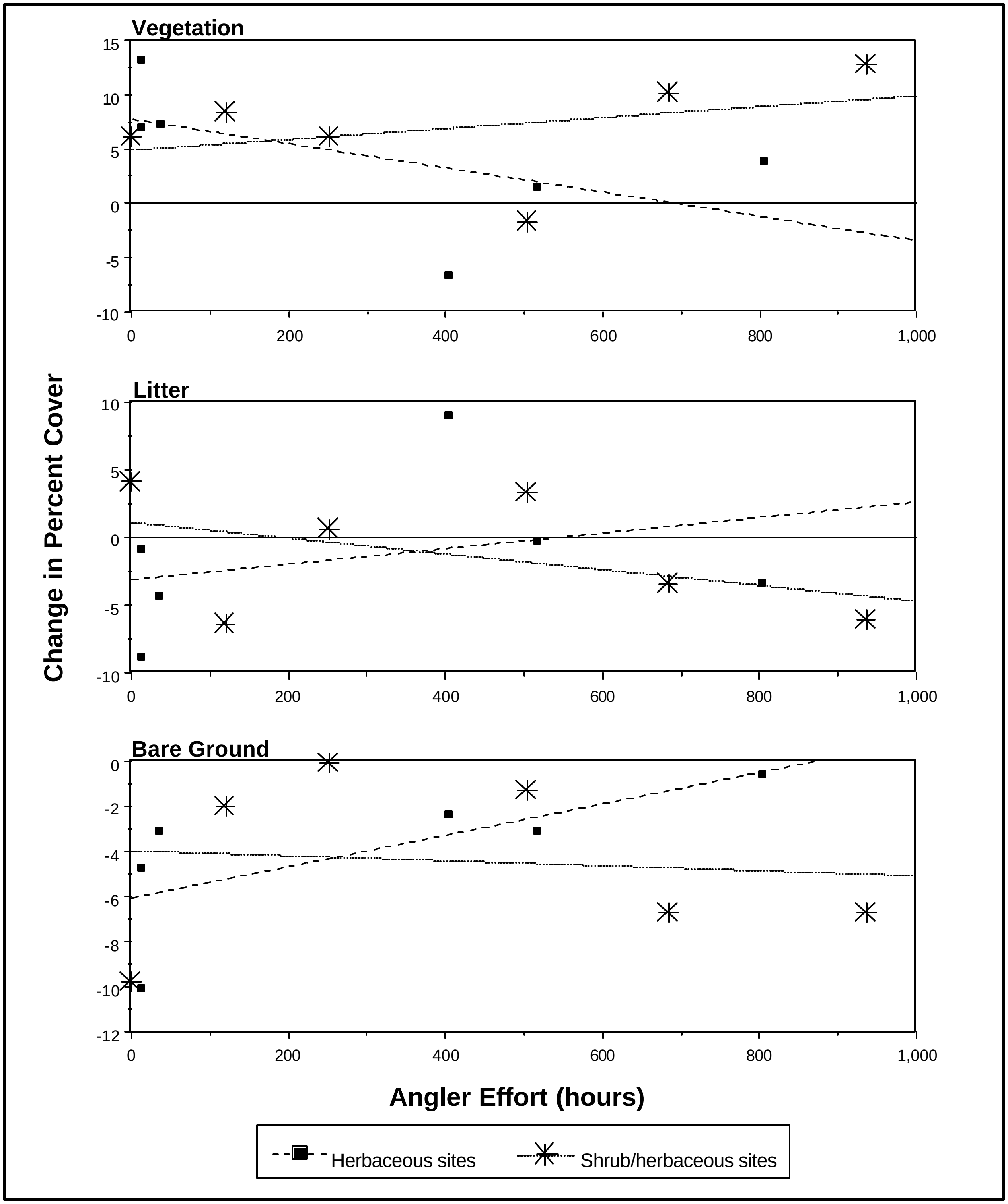


Figure 16.-Relationship of angler effort to mean change in percent cover (vegetation, litter, and bare ground) for permanent vegetation plots at habitat survey sites, Kenai River, prefishery 1998 vs. prefishery 1999.

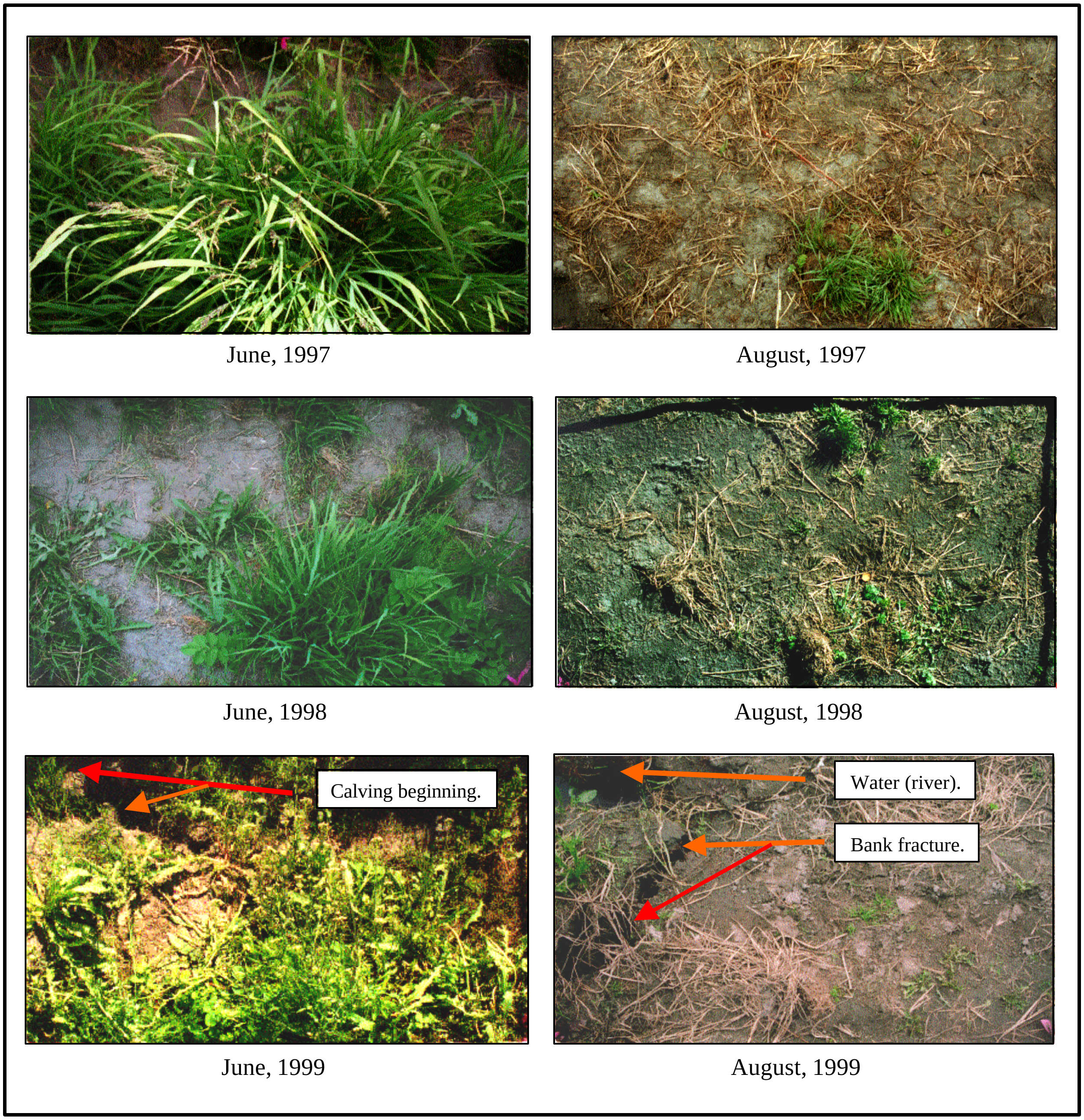


Figure 17.-Vegetation plot 3 at site L19.1 (June 1997 to August 1998), Kenai River.

Results of tests for observer measurement error associated with the photo imagery analysis process are presented in Appendix B1.

Soil Analysis

For the 12 habitat survey sites assessed during 1999, the range for mean change in soil penetrability measurements at a depth of 1 in was –21.50 to 31.75 psi; at a depth of 3 in, the range was –31.25 to 41.00 psi; and at a depth of 6 in, the range was –29.00 to 50.00 psi (Table 11). Results of a two-sample T-test showed no significant change between pre- and postfishery measurements in soil penetrability at all soil depths (Table 11, Figure 18). Analysis of mean

Table 11.-Summary statistics for soil penetrability measurements at 12 habitat survey sites, Kenai River, 1999.

Depth	Survey Site	Habitat [a] Type	Mean Penetrability (psi) Jun 1999	Aug 1999	SE Jun	SE Aug	Difference in Means	T statistic	P	Significant	1998 Angler Effort
1 in	L24.4	SH	35.75	33.25	3.60	4.53	2.50	0.43	0.33	No	0.0
	R26.5	H	82.00	50.25	8.83	6.43	31.75	2.91	0.00	Yes	19.2
	R19.5	H	13.75	20.50	4.12	4.70	-6.75	-1.08	0.86	No	48.0
	L36.3	H	23.00	21.50	4.65	4.09	1.50	0.24	0.40	No	105.6
	L23.5	SH	59.25	49.50	10.02	11.06	9.75	0.65	0.26	No	220.8
	R46.2	H	75.25	61.00	10.55	8.46	14.25	1.05	0.15	No	508.8
	R22.8	SH	69.75	80.25	7.90	8.01	-10.50	-0.93	0.82	No	537.6
	R46.1	H	65.25	70.50	7.47	6.14	-5.25	-0.54	0.70	No	700.8
	L19.1	SH	33.50	32.00	4.01	4.76	1.50	0.24	0.41	No	796.8
	R22.9	SH	104.75	79.25	9.07	9.45	25.50	1.95	0.03	No	796.8
	L20.0	H	78.00	99.50	8.07	9.43	-21.50	-1.73	0.95	No	835.2
	L19.0	SH	34.75	43.50	4.81	4.59	-8.75	-1.32	0.90	No	1,104.0
3 in	L24.4	SH	63.25	69.00	7.50	7.17	-5.75	-0.55	0.71	No	0.0
	R26.5	H	171.75	130.75	11.48	12.62	41.00	2.40	0.01	No	19.2
	R19.5	H	81.50	85.00	6.74	5.40	-3.50	-0.41	0.66	No	48.0
	L36.3	H	54.75	45.25	5.46	4.31	9.50	1.37	0.09	No	105.6
	L23.5	SH	128.25	104.50	18.80	18.17	23.75	0.91	0.18	No	220.8
	R46.2	H	150.75	114.75	11.71	8.22	36.00	2.52	0.01	Yes	508.8
	R22.8	SH	95.00	115.75	10.95	13.83	-20.75	-1.18	0.88	No	537.6
	R46.1	H	145.75	112.75	10.82	8.53	33.00	2.40	0.01	No	700.8
	L19.1	SH	68.00	69.00	7.18	6.78	-1.00	-0.10	0.54	No	796.8
	R22.9	SH	134.00	131.50	9.09	11.25	2.50	0.17	0.43	No	796.8
	L20.0	H	144.50	175.75	10.55	8.28	-31.25	-2.33	0.99	No	835.2
	L19.0	SH	97.75	98.25	8.49	8.08	-0.50	-0.04	0.52	No	1,104.0
6 in	L24.4	SH	69.75	90.50	6.10	10.51	-20.75	-1.71	0.95	No	0.0
	R26.5	H	148.00	117.25	8.34	8.11	30.75	2.64	0.01	Yes	19.2
	R19.5	H	110.00	103.75	5.07	3.87	6.25	0.98	0.17	No	48.0
	L36.3	H	83.50	65.25	8.16	4.48	18.25	1.96	0.03	No	105.6
	L23.5	SH	117.90	112.00	10.29	16.54	5.90	0.30	0.38	No	220.8
	R46.2	H	154.00	104.00	10.59	6.16	50.00	4.08	0.00	Yes	508.8
	R22.8	SH	86.00	110.25	11.74	11.86	-24.25	-1.45	0.92	No	537.6
	R46.1	H	172.75	125.50	10.90	8.28	47.25	3.45	0.00	Yes	700.8
	L19.1	SH	79.50	64.00	7.31	4.68	15.50	1.79	0.04	No	796.8
	R22.9	SH	110.50	99.50	13.39	10.44	11.00	0.65	0.26	No	796.8
	L20.0	H	129.00	156.75	11.44	13.10	-27.75	-1.60	0.94	No	835.2
	L19.0	SH	106.25	135.25	9.93	52.57	-29.00	-0.54	0.70	No	1,104.0

[a] H = herbaceous, SH = shrub/herbaceous.

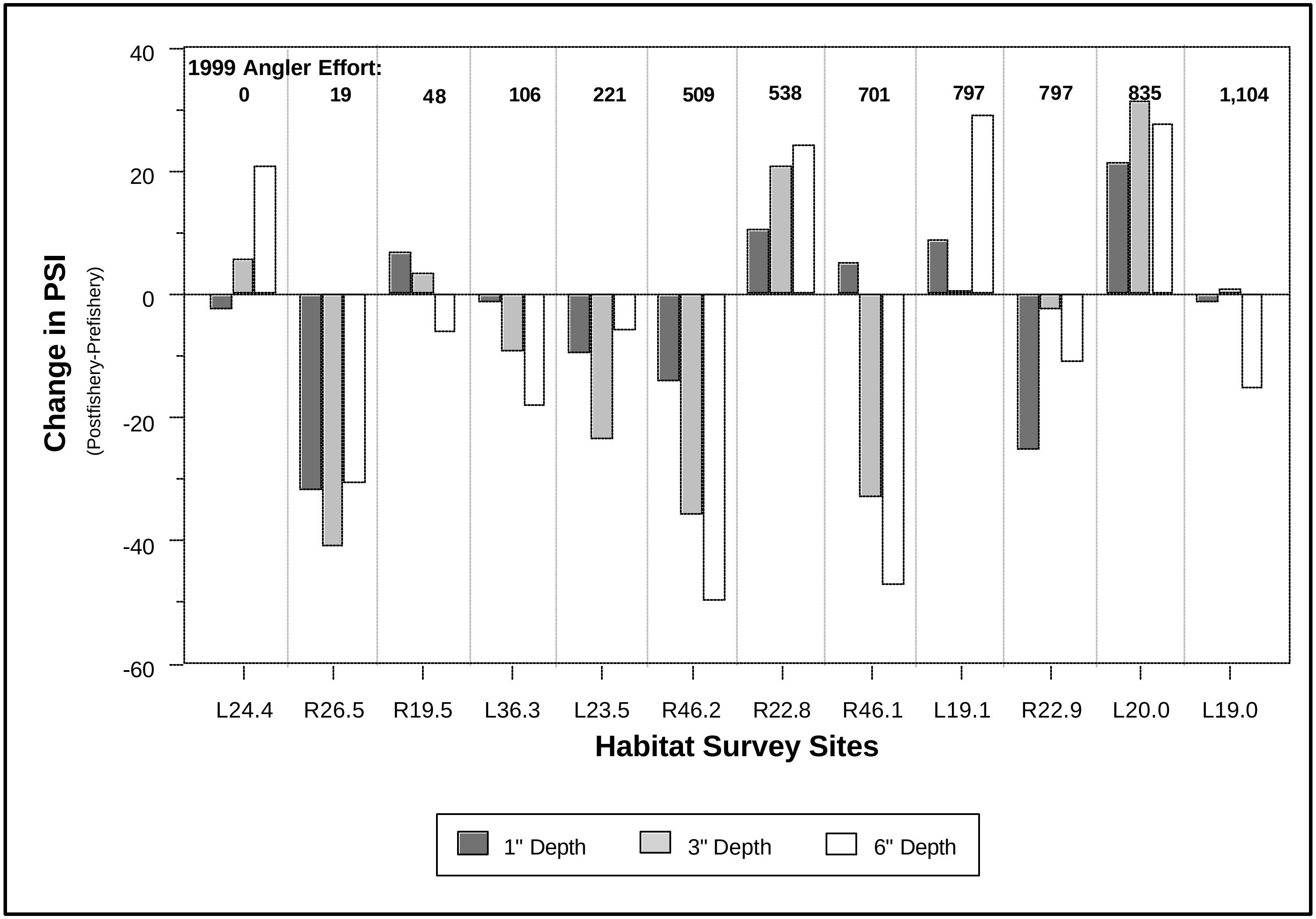


Figure 18.-Change in mean soil penetrability measurements (psi) at three soil depths for habitat survey sites, Kenai River, 1999.

change in soil penetrability between years (prefishery 1998 to prefishery 1999) also showed no significant change in soil penetrability at all soil depths (Table 12, Figure 19).

Because of different soil types at each habitat survey site, it is not possible to directly correlate change in penetrability with angler effort.

Summary

Effects of human foot traffic, categorized as trampling, can be measured by assessment of vegetation and soil compaction changes. With higher levels of foot traffic, one would expect a decrease in vegetative cover that would result in increases of cover for litter and bare ground, individually or combined. The 1997 (King and Hansen 1999), 1998 (King and Hansen 2001), and 1999 inseason changes for cover support this expectation. Angler effort was found to have a significant effect on percent cover of vegetation, litter, and bare ground. More specifically, as angler effort increased there was a decrease in percent cover for vegetation and an increase in percent cover for litter and bare ground. These data strongly support that, inseason, there are negative impacts to vegetation as a result of angler foot traffic. The question to be answered is "what is the permanence of this vegetation loss?" Data analysis to detect levels of permanent vegetation change over time (prefishery 1998 vs. prefishery 1999) showed no significant change in cover by cover class. Ideally, we would have looked at the additive effects of angler effort (summing the 1997 and 1998 angler effort estimates) and correlating with total cover changes from June 1997 to June 1998. However, there were problems associated with the 1997 angler effort estimates making it inappropriate to conduct this analysis. A comparison of cover change in a 1-year period may not detect change; it may take several years of human impact before change in vegetative cover is detected. Also, this assessment process does not address changes in species composition and diversity. Less hardy plant species may not survive constant trampling, but these species may be replaced by more tolerant species. Therefore, percent cover of vegetation may remain unchanged but species diversity may be reduced. The importance of this to the riverbank and fish habitat is not clearly understood.

Results of the observer measurement error tests associated with assessing cover using the photo imagery analysis process were very acceptable (Appendix B1). The 5% error associated with percent cover of vegetation is excellent and actually represents the level of error for the combined assessment of percent cover of litter and bare ground. We know that when vegetation is lost due to trampling, the result is increased cover of litter and bare ground, hence the error would be the same if we only had two cover classes. By using three cover classes, we increase the error relative to separating litter (19% error) from bare ground (22% error). But, this does allow us to more specifically identify changes. The assessment of cover for water is very accurate and consistent with an error of 0% for 1997 and 1% for 1998 and 1999.

For soil compaction changes, using soil penetrability as a standard for measurement, we found no significant inseason (1999) or annual (June 1998 to June 1999) changes at any of the measured depths for each habitat survey site. Previous studies (Kuss 1983; Dotzenko et al. 1967) have shown that effects of human foot traffic are found within the first 3 inches of soil, and to a lesser extent down to 6 inches. Because the foot traffic associated with just the sport fishery occurs in a narrow window of time, about 6 weeks of the year, significant soil compaction may not be occurring at our habitat survey sites. We also have been unable to correlate soil penetrability changes with angler effort. To do this, we need to analyze soil composition at the habitat survey sites. Sites with similar soil composition could be grouped together to correlate angler effort with soil penetrability.

Table 12.-Summary statistics for comparison of soil penetrability measurements at 12 habitat survey sites, Kenai River, 1998 and 1999.

Depth	Survey Site	Habitat[a] Type	Mean Penetrability (psi) Jun 1999	Jun 1998	SE 99	SE 98	Difference in Means	T statistic	P	Significant	1998 Angler Effort
1 in	L24.4	SH	35.75	59.50	3.6	3.8	-23.8	-4.52	1.00	No	0.0
	R26.5	H	82.00	136.50	8.8	9.2	-54.5	-4.28	1.00	No	19.2
	R19.5	H	13.75	21.25	4.1	8.0	-7.5	-0.83	0.79	No	48.0
	L36.3	H	23.00	12.80	4.7	3.3	10.2	1.79	0.04	No	105.6
	L23.5	SH	59.25	97.75	10.0	14.8	-38.5	-2.15	0.98	No	220.8
	R46.2	H	75.25	126.50	10.6	15.9	-51.3	-2.68	0.99	No	508.8
	R22.8	SH	69.75	87.50	7.9	12.0	-17.8	-1.24	0.89	No	537.6
	R46.1	H	65.25	85.00	7.5	10.1	-19.8	-1.57	0.94	No	700.8
	L19.1	SH	34.75	72.50	4.8	3.9	-37.8	-6.08	1.00	No	796.8
	R22.9	SH	104.75	134.25	9.1	9.9	-29.5	-2.20	0.98	No	796.8
	L20.0	H	78.00	84.50	8.1	8.6	-6.5	-0.55	0.71	No	835.2
	L19.0	SH	33.50	42.50	4.0	7.0	-9.0	-1.12	0.86	No	1,104.0
3 in	L24.4	SH	63.25	79.50	7.5	8.4	-16.3	-1.44	0.92	No	0.0
	R26.5	H	171.75	164.75	11.5	11.4	7.0	0.43	0.33	No	19.2
	R19.5	H	81.50	91.50	6.7	4.9	-10.0	-1.20	0.88	No	48.0
	L36.3	H	54.75	44.70	5.5	6.6	10.1	1.18	0.12	No	105.6
	L23.5	SH	128.25	145.50	18.8	16.3	-17.3	-0.69	0.75	No	220.8
	R46.2	H	150.75	143.75	11.7	13.0	7.0	0.40	0.35	No	508.8
	R22.8	SH	95.00	84.00	10.9	9.3	11.0	0.76	0.22	No	537.6
	R46.1	H	145.75	133.25	10.8	10.9	12.5	0.81	0.21	No	700.8
	L19.1	SH	97.75	124.75	8.5	7.5	-27.0	-2.38	0.99	No	796.8
	R22.9	SH	134.00	170.75	9.1	10.8	-36.8	-2.60	0.99	No	796.8
	L20.0	H	144.50	140.75	10.6	8.1	3.8	0.28	0.39	No	835.2
	L19.0	SH	68.00	74.75	7.2	6.6	-6.8	-0.69	0.75	No	1,104.0
6 in	L24.4	SH	69.75	72.00	6.1	5.9	-2.3	-0.26	0.60	No	0.0
	R26.5	H	148.00	128.75	8.3	8.3	19.3	1.63	0.06	No	19.2
	R19.5	H	110.00	101.25	5.1	4.9	8.8	1.24	0.11	No	48.0
	L36.3	H	83.50	54.45	8.2	10.6	29.1	2.17	0.02	No	105.6
	L23.5	SH	117.90	103.00	10.3	5.1	14.9	1.30	0.10	No	220.8
	R46.2	H	154.00	117.00	10.6	8.3	37.0	2.74	0.00	Yes	508.8
	R22.8	SH	86.00	82.50	11.7	8.6	3.5	0.24	0.41	No	537.6
	R46.1	H	172.75	137.75	10.9	6.1	35.0	2.81	0.00	Yes	700.8
	L19.1	SH	106.25	100.50	9.9	7.7	5.8	0.46	0.32	No	796.8
	R22.9	SH	110.50	95.00	13.4	6.2	15.5	1.05	0.15	No	796.8
	L20.0	H	129.00	121.75	11.4	7.4	7.3	0.53	0.30	No	835.2
	L19.0	SH	79.50	77.00	7.3	7.7	2.5	0.24	0.41	No	1,104.0

[a] H = herbaceous, SH = shrub/herbaceous.

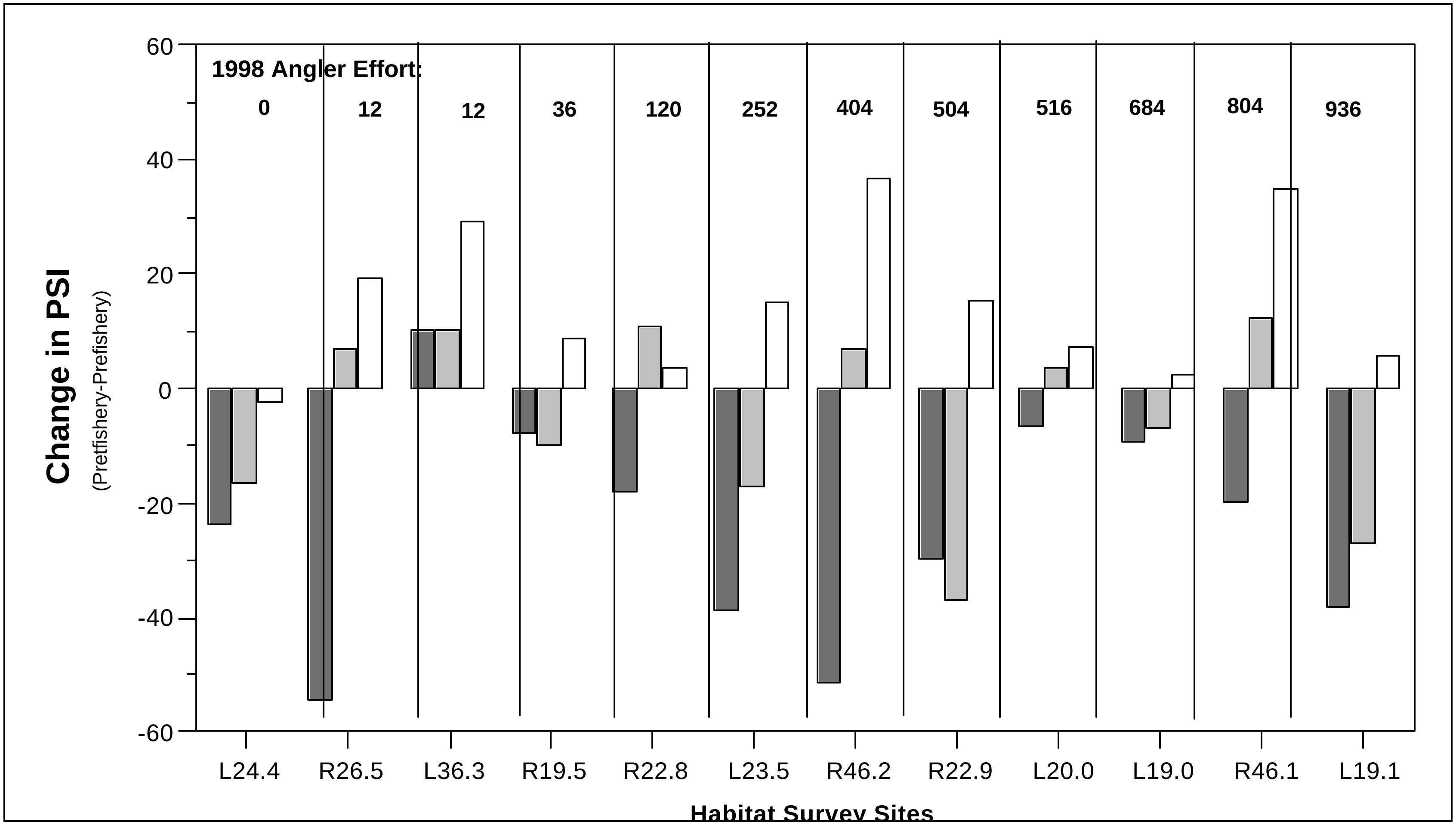


Figure 19.-Change in mean soil penetrability measurements (psi) at three soil depths for habitat survey sites, Kenai River, prefishery 1998 and prefishery 1999.

RECOMMENDATIONS

Assessment of shore angler impacts to Kenai River riparian habitats has been ongoing since 1996. During this time, project personnel have implemented and tested various methods to best assess shore angler impacts. This has been the second year for the project in its current design. We feel that the techniques incorporated from previous years (angler distribution surveys, vegetation assessment using photo imagery analysis, and soil compaction assessment) as well as the more recent bank erosion measurement program (1998 and 1999) are providing useful information, representative of shore angler impacts to the riparian zone of the Kenai River. We continue to strive toward modifying our methods to improve the repeatability of the process and, therefore, the accuracy of the data.

The angler distribution surveys have been ongoing since 1995. Each year we have modified methods by altering the count schedule by: (1) the number of days sampled; (2) the sample design as being random or systematic; and (3) the number of counts per day. The currently recommended sample design has 12 counts during the sport fishery, occurring on every third day, with some days having two counts in order to achieve a total of 12. These surveys have provided good information as to angler use of public and private lands and allowed managers to look at shifting trends of angler behavior.

In 1997 we introduced a survey, as a part of the angler distribution counts, to ascertain angler fishing locations (main bank, island, boardwalks, in water, etc.). This has been a good tool for determining whether anglers are attempting to minimize their impacts to the bank by remaining in the water while fishing or fishing from a provided structure rather than trampling vegetation. However, because of limited and often poor access to the river and improper use of the banks while moving from one fishing location to another, there is still much generally "observed" damage occurring to the vegetation in the nearshore area during the fishery. It is the challenge of this project to document the permanence of those perceived impacts. More public education on low impact shore angling techniques and improved enforcement at areas closed to bank fishing would help to address this problem.

Continuation of these angler distribution counts will allow the Department to monitor trends in fishery participation, as well as changes in participation due to bank angling closures ordered by the Department to protect critical and damaged habitats. Angler counts can be used to determine bank locations receiving high angler use for evaluating if the level of angler use is sufficient to warrant regulatory action. For example, when the state purchased private lands we used the angler distribution maps to assist in determination if it was necessary to close these banks to shore angling. In one case there was minimal fishing effort, so we opted to not close the bank to shore angling, thus not shifting those anglers to other locations. Such locations can be re-evaluated annually.

Through time, it will be important to observe bank change at specific sites, such as L19.1. Figure 20 shows a series of photos depicting bank change at the downstream end of site L19.1. When technicians were at this site in June 1997, they collected various data and took photos of the riverbank. Upon returning in August 1997, they observed a large area of calved bank which had revealed a large rock, previously not visible. They estimated over 1 m of bank loss at this location. In following years, we measured bank loss in proximity to the rock, finding little change. However, immediately upstream of the rock large areas calved: 1.39 m between June

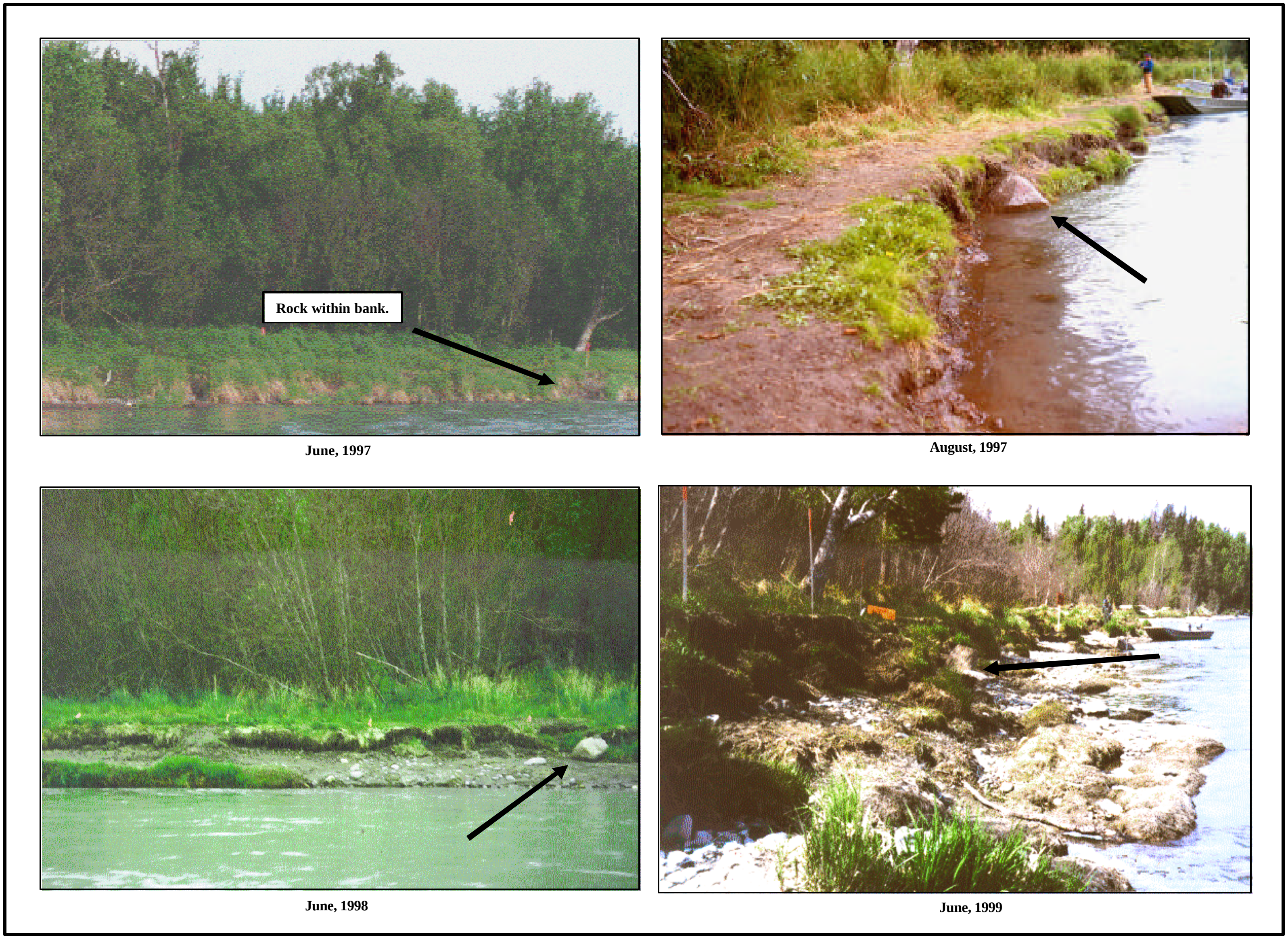


Figure 20.-Bank erosion at site L19.1 (June 1997 to June 1999), Kenai River.

and August 1998; and 2.81 m between August 1998 and June 1999. The June 1999 photo (Figure 20) clearly shows the amount of bank loss since August 1997. This site is located on the outside of a meander, receives high levels of angler use, and is in an area of much boating activity. All of these contribute to the accelerated levels of bank erosion occurring at this site. In situations such as this, it would be beneficial for involved land managers to implement ways to minimize erosion. This might involve alterations to angler conduct as well as power boat activity.

The assessment of vegetation using photo imagery analysis continues to provide good information on impacts of trampling related to shore anglers. Within season, we were able to detect a significant relationship of increased angler effort with a decrease in mean percent cover of vegetation and an increase in mean percent cover of litter and bare ground. These results did not hold true for between season analyses. Continued monitoring of vegetation using this method may eventually provide information regarding plant tolerance to human foot traffic and at what point annual recovery is significantly reduced. However, this assessment does not address changes in plant species diversity and composition resulting from trampling and how that may affect the riparian zone, ultimately affecting fish habitat.

The precision and accuracy for the angler effort estimates was improved in 1999 by increasing the number of counts per day from four to five. Presently, the angler effort estimates are not stratified. By analyzing past data, we may find that stratifying the angler day may provide better estimates of angler effort. This may improve the correlation analyses with vegetation changes, as well as changes in other habitat variables.

Changes in soil penetrability over time have been insignificant for the most part. To better understand the relationship between shore angler impacts and soil penetrability we need to be able to correlate angler effort with soil penetrability changes. This can only be done if we know that soil composition is similar between sites. We recommend analyzing soil composition at each of the 12 habitat survey sites and then grouping sites according to their similar soil composition. We can then do correlation analyses using the corresponding angler effort estimates for the grouped habitat survey sites. Knowing that increased soil resistance can limit plant development, this type of analysis could improve our understanding of angler impacts to the riparian area.

This was the second year for the bank loss monitoring program. This year we implemented an annual program, collecting bank measurements prior to the sport fishery for late-run sockeye salmon rather than pre- and postfishery. Impacts of human perturbations to the integrity of the riverbank may not be fully realized immediately after completion of the sport fishery for late-run sockeye salmon. The increased pressure on the bank may have caused fractures that in time would lead to calving. We felt monitoring these changes would be better accomplished on an annual cycle by taking measurements each June, prior to the fishery. Analyzing only one cycle of bank measurements (June 1998 to June 1999 for all bank sites; August 1998 to June 1999 for angler effort sites) did not show any significant correlation with angler use or angler effort estimates. Again, it may be the correlation of cumulative bank change with angler effort that, over time, becomes significant.

This program can be improved by reducing measurement error by using better equipment and improved methodology. Currently, we coordinate the use of two pieces of equipment to take measurements from the benchmark to the bank edge. After a manually operated surveyor's transit is positioned, a crewmember systematically places a hand-held electronic distance measuring device in a specific location and then shoots the distance. This system gets the job done, but error can occur in consistently reading the vernier on the transit and consistently placing the electronic distance measuring device. A total station surveyor's transit would completely eliminate these errors since the total station provides electronic digital readout and has an internal distance measuring device.

The other source for error is in consistently re-locating the bank edge, i.e., using the same location used for previous measurements. This year we addressed this problem by taking good photo documentation of the stadia rod at the bank edge at the time of measurement and also placing a small, but permanent, metal marker in the bank just onshore from the bank edge. Our inseason measurement error test provided very good results for repeatability and accuracy of the bank measurement. The test of the process will be in returning to the sites in June 2000 and re-locating the markers: Will the markers still be in place (not tampered with being the biggest concern)? If the bank has calved more than 6 in, the marker will be gone but the photo documentation should assist in identifying this amount of bank loss. We will continue to design methods which minimize the problem with re-location of the bank edge.

The primary goal of this habitat study has been to determine if bank anglers cause significant loss of riparian habitat, realizing that this can negatively impact the fisheries resource. It continues to be a very challenging task because of the dynamics of fluvial geomorphology and riparian ecology, not to mention other human induced perturbations. Kenai River riparian habitats have certainly been altered due to shorebased angling. The question is how much change (loss?) of riparian habitat is directly attributed to bank anglers? Are bank angler impacts only a piece of a bigger problem related to habitat loss? Studies conducted by USGS (Dorava and Moore 1997) have already documented increased bank erosion due to boat wakes. Bank loss in non-motorized reaches of the river was approximately 75% less than in high use motorized reaches and 33% less than in low use motorized reaches. There is another boat wake study planned for the summer of 2000. This may shed further light on the relationship of boat wakes to bank erosion. Urbanization and structural development within the flood plain have also influenced changes in riparian habitat. Structures placed along the bank or directly in the river (such as rip-rap, gabions, jetties, various dock and deck structures) have contributed to loss of habitat. The increase in structures is due to landowners trying to access the river or reduce bank erosion. Recognition of processes negatively impacting riparian habitat and assessment of their respective impact would allow researchers and managers to better direct efforts to reduce habitat loss.

Assessment of habitat change requires a long-term commitment. We have been attempting to measure habitat changes that are relatively small inseason and may still be small between seasons. It may take several years of data collection to actually detect significant, permanent change. Results of these studies may provide information to develop a shore angling management scenario. For example, we may find that it takes 4 years to measure significant change in habitat variables. We may then wish to implement a rotational approach to management of shore anglers during the sport fishery for late-run sockeye salmon. This would entail identifying heavily impacted areas and closing some of these annually for a period of years to allow vegetation recovery. After a 2-year closure, if functional native vegetation has been re-established, these sites could be re-opened. Once the program is established, certain sites would be closed each year while other sites would be re-opened. This rotational approach to management may reduce the sprawl of anglers to riparian habitats not yet impacted while still allowing adequate access to the fishery. Due to the high angler participation in this fishery, it is necessary to find creative ways to continue to provide angler access. With various bank closures occurring, either due to the Department employing its regulatory authority for critical habitat protection or due to private land owners taking a more vested interest in prohibiting anglers from fishing from their property, shore anglers are already voicing concerns for provision of public access to this fishery. With appropriate management strategies, the Department may be able to allow the conduct of this fishery while minimizing riparian habitat impacts.

ACKNOWLEDGMENTS

We would like to express our gratitude to those individuals who assisted with data collection and analysis. Dave Atcheson was the crew leader for the field season, supervising project personnel and coordinating daily operations. Dave and the other dedicated field personnel (Jason Pawluk, Peter Reynoldson, Tom Rhyner, Cindy Weeks, and Ted Ragains) contributed greatly to the overall success of the project by collecting bank erosion data, conducting shore angler counts, entering data, and cataloging site photos. Pam Russell conducted the photo imagery analysis on the vegetation plots. Support provided by local staff, Tim McKinley and Mike Bethe, was greatly appreciated.

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APPENDIX A: KENAI RIVER MANAGEMENT PLANS

Appendix A1.-5 AAC 21.360. Kenai River Late Run Sockeye Salmon Management Plan.

(a) The department shall manage the Kenai River late-run sockeye salmon stocks primarily for commercial uses in order to provide commercial fishermen with an economic yield from the harvest of these salmon resources based on abundance. The department shall also manage the commercial fisheries to minimize the harvest of Northern District coho, late-run Kenai River chinook, and Kenai River coho salmon stocks in order to provide personal use, sport, and guided sport fishermen with a reasonable opportunity to harvest salmon resources, as specifically set out in 5AAC 21.357, 5AAC 21.358, and 5AAC 21.359.

(b) The Kenai River late-run sockeye salmon commercial, sport, and personal use fisheries shall be managed to

(1) meet an optimum escapement goal (OEG) range of 500,000 - 1,000,000 late-run sockeye salmon;

(2) achieve inriver goals as established by the board and measured at the Kenai River sonar counter located at river mile 19; and

(3) distribute the escapement of sockeye salmon evenly with the OEG range, in proportion to the size of the run.

(c) Based on preseason forecasts and inseason evaluations of the total Kenai River late-run sockeye salmon return during the fishing season, the run will be managed as follows:

(1) at run strengths of less than 2,000,000 sockeye salmon, the department shall manage for an inriver goal range of 600,000 - 850,000 sockeye salmon past the sonar counter at river mile 19 as follows:

(2) at run strengths of 2,000,000 - 4,000,000 sockeye salmon, the department shall manage for an inriver goal range of 750,000 - 950,000 sockeye salmon past the sonar counter at river mile 19 as follows:

(3) at run strengths greater than 4,000,000 sockeye salmon, the department shall manage for an inriver goal range of 850,000-1,100,000 sockeye salmon past the sonar counter at river mile 19 as follows:

(d) The sonar count levels established in (b)(2), (c)(1), and (c)(2) of this section may be lowered by the board if noncommercial fishing, after consideration of mitigation efforts, results in a net loss of riparian habitat on the Kenai River. The department will, to the extent practicable, conduct habitat assessments on a schedule that conforms to the Board of Fisheries (board) triennial meeting cycle. If the assessments demonstrate a net loss of riparian habitat caused by noncommercial fishermen, the department is requested to report those findings to the board and submit proposals to the board for appropriate modification of the Kenai River late-run sockeye salmon inriver goal.

Appendix A2.-5 AAC 56.065. Riparian Habitat Fishery Management Plan.

(a) The Board of Fisheries (board) finds that freshwater fisheries in upper Cook Inlet, including the Kenai Peninsula Area, subject to access limitations of federal, state, and local landowners, are a recognized use of the fishery resources of upper Cook Inlet. The board also finds that, in some situations, freshwater fisheries are negatively impacting riparian habitats of upper Cook Inlet.

(b) The board recognizes the importance of maintaining the structural and functional integrity of upper Cook Inlet riparian habitats. Given this, the board will consider, as part of its deliberations, avoidable impacts to upper Cook Inlet riparian habitats related to recreational fishing.

(c) If the commissioner determines that freshwater fisheries are likely to result in riparian habitat loss that could negatively affect the fishery resources of upper Cook Inlet, the commissioner may close, by emergency order, those riparian areas to fishing. This authority extends only to riparian areas in which there is a state, federal, or municipal property interest. The commissioner may reopen, by emergency order, those riparian areas to fishing if the commissioner determines that such openings will not compromise the integrity of the riparian habitats the emergency order is designed to protect. During seasons in areas opened by emergency order, fishing is only open at times selected by the commissioner at the commissioner's discretion, and fishing is only open from the following, selected at the commissioner's discretion:

(1) boats;

(2) boardwalks or similar structures;

(3) docks;

(4) gravel bars;

(5) natural formations identified by the commissioner; or

(6) other areas identified by the commissioner as areas where use for fishing will not compromise the integrity of the habitat the closure is designed to protect.

(d) *(Note: This section lists 24 bank locations along the Kenai River that are closed to fishing.)*

(e) For purposes of this section, “riparian habitat” means all areas within 10 feet in either direction from the Kenai River waterline.

APPENDIX B: OBSERVER MEASUREMENT ERROR ANALYSES

Appendix B1.-Observer measurement error analyses.

Measurement of environmental conditions is very difficult due to bias associated with observer errors which are compounded by normal fluctuations in physical and biological conditions. In *Methods for Evaluating Stream, Riparian, and Biotic Conditions*, Platts et al. (1983) discuss the many problems associated with precision and accuracy when collecting environmental data, to include repeatability of sampling within and between observers. The inability to repeat a procedure which defines a measurement can lower precision; such as, when measuring bank edge, an observer may not consistently locate the reference points which define the measurement, thus obtaining a different measurement when the bank may not have changed at all. In evaluating the precision associated with collecting habitat measurements, Platts et al. (1983) rated measurements based upon their confidence intervals: (1) poor = confidence interval over ±21%, (2) fair = confidence interval ±11% - 20%, (3) good = confidence interval ±5% - 10%, and (4) excellent = confidence interval less than 5%.

Subjective observations most often provide low precision. Factors which can lower precision include: using different observers over time, observers changing their thinking from year to year, the ability of the methods to measure the attributes, weather conditions at time of measurement, size of stream, amount and type of experience and training, and degree of stream bank stability (Platts et al. 1983). When conducting their research, they used personnel with advanced degrees in fisheries or related fields, provided extensive training, and used good to excellent equipment. In the Kenai River habitat study, personnel had mixed educational backgrounds, were provided short training which evolved with the field season, and used relatively good equipment. In 1999, all field personnel returned to the project which improved the consistency in data collection.

During the 1999 project we conducted measurement error analyses on the vegetation assessment for trampling and on bank measurements as related to consistently relocating the bank edge. Observer error tests conducted on the soil penetrability measurements in 1997 showed an average error of 5%, well within an acceptable range so this was not repeated.

METHODS

Bank Measurements

Reader variability was estimated for measurements taken for the distance to the bank from the benchmark at 29 habitat survey sites. Using the established protocol, four readers obtained six measurements at each site – two of the readers took a second measurement. The first two measurements were taken by each member of a two-person crew during the normal bank sampling schedule. Rather than taking all six measurements at the same time, we felt measurement error would be more representative if the crewmembers returned to each site after a week or more time had elapsed. This would reduce the ability of crewmembers to remember characteristics at the site that they had previously used to identify bank edge for the measurement. Measurement error between readers was estimated as:

$$BR = \frac{\sum_j \left(\frac{\left| R_{ij} - \overline{R}_j \right|}{\overline{R}_j} * 100 \right)}{n_j}, \qquad \text{(B1.1)}$$

where:

$BR =$ within reader variability,

$R_{ij} =$ measurement by reader i at site j,

$\overline{R}_j =$ average measurement at site j,

$n_j =$ number of measurements at site j,

Measurement error within a reader was measured as:

$$WR = \frac{\sum_k \left(\frac{\sum_j \left(\frac{\left| R_{ijk} - \overline{R}_{ij} \right|}{\overline{R}_{ij}} * 100 \right)}{n_j} \right)}{n_k}, \qquad \text{(B1.2)}$$

where:

$WR =$ within reader variability,

$n_j =$ number of measurements at site j,

$R_{ijk} =$ measurement by reader i at site j on trial k,

$\overline{R}_{ij} =$ average measurement by reader i at site j,

$n_k =$ number of trials by reader i at site j.

Trampling

To measure the variability in the determination of trampling and percent cover, 16 (8 from each habitat type) assessment study photographs were randomly selected and evaluated for trampling and percent cover in random order, re-randomized and evaluated a second then a third time. Measurement error within a reader was measured for each variable using equation B1.2.

RESULTS AND DISCUSSION

Bank Measurements

Within reader variability for the technician locating the bank edge was estimated to be:

Technician	Bank Measurement (cm)	Percent Error
Dave	4	0.6
Jason	6	1.3
Pete	4	0.5
Tom	6	1.3

Since the technicians worked in pairs when collecting bank measurement data, the between reader error was estimated in two ways: (1) between team error, and (2) within team error. The reader errors were estimated to be:

Team	Bank Measurement (cm)	Percent Error
Between Team	4.7	1.1
Within Team: Dave & Tom	<0.1	0.3
Tom & Dave	<0.1	0.4
Pete & Jason	<0.1	0.3
Jason & Pete	<0.1	0.6

In all cases the reader errors were highly acceptable with the bank measurement error being less than 6 cm and the percent error always less than 1.5. Since we implemented a new method in 1999 for marking the bank edge (placing nails near the bank edge measurement location), the true test of this method will be our ability to locate these bank edge markers each June. If we can, then we will have greatly improved the repeatability of the process as well as increasing the credibility for the accuracy of the annual measurements.

Trampling

Within reader variability was estimated for each cover class to be:

	Average Measurement Error (%)		
Cover Class	1997	1998	1999
Vegetation	7	6	5
Litter	27	23	19
Bare ground	45	29	22
Water	0	1	1

The reader errors for the three main cover classes (vegetation, litter, and bare ground) have improved steadily since 1997. The most marked improvement has been associated with bare ground (22%). During photo imagery analysis, pixels are assigned to each cover class in a specified order. The protocol recommends assessment of vegetation first and bare ground last. Once the number of pixels for vegetation, litter, and water have been assigned, bare ground is calculated by subtracting the sum of those from the total number of pixels for the photo. This method was shown to always bias high the percent cover for bare ground and likely make it the more variable since it is dependent upon pixel assignment to the other cover classes. Measurement error for water and vegetation coverage was very good due to the ease in discerning these cover types. Separating litter from bare ground can be highly variable when using color enhancement. This step is much more subjective. In the photo imagery process described by Dietz et al. (1996) litter and bare ground were lumped together. To assess effects of trampling, it is necessary to separate the two cover classes. Therefore, both litter and bare ground are more likely to have greater measurement errors. Although percent cover of litter and bare ground may have high variabilities, these are relative to the error associated with percent cover of vegetation and water.

Overall, the reader error associated with photo imagery analysis process for assessing percent cover is very good, well within acceptable ranges.

APPENDIX C: SUPPORTING STATISTICS

Appendix C1.-Bank measurements at combined effort and non-effort survey sites, Kenai River, 1999

						Distance from Benchmark to Bank (m)			Inseason Change (m)	Annual Change (m)
	Hab	Wake	AngLev[c]							
Site	Type[a]	Lev[b]	1998	1999	Meander[d]	Jun 1998	Aug 1998	Jun 1999	Aug98-Jun98	Jun99-Jun98
L6.0	H	L	L	L	N	8.61	8.73	8.75	0.12	0.14
R6.0	H	L	L	L	N	11.35	7.29	7.52	-4.06	-3.83
L7.0	H	L	L	L	O	10.08	12.16	12.21	2.08	2.13
R7.0	H	L	L	L	O	9.59	9.80	9.66	0.21	0.07
L7.7	H	L	L	L	N	6.35	5.82	8.35	-0.53	2.00
R8.0	H	L	L	L	N	7.75	7.05	8.35	-0.70	0.60
L9.0	H	H	L	L	N	10.48	8.69	10.86	-1.79	0.38
R9.0	SH	H	L	L	O	6.45	6.51	6.54	0.06	0.09
L10.0	H	H	L	L	I	7.72	7.80	7.79	0.08	0.07
R10.0	T	H	L	L	O	3.72	3.52	3.34	-0.20	-0.38
L11.0	H	H	L	L	I	6.77	6.70	6.47	-0.07	-0.30
R11.0	T	H	L	L	O	4.21	4.14	4.02	-0.07	-0.19
L11.5	T	H	L	L	N	7.40	7.42	6.04	0.02	-1.36
R11.5	T	H	L	L	O	7.30	7.41	7.22	0.11	-0.08
L12.0	T	H	L	L	N	7.95	7.58	7.34	-0.37	-0.61
R12.1	T	H	L	L	N	6.62	6.31	6.43	-0.31	-0.19
L12.5	S	H	L	L	N	5.25	5.31	5.29	0.06	0.04
R12.5	T	H	L	L	N	5.84	5.81	5.70	-0.03	-0.14
L13.0	T	H	L	L	N	7.95	8.01	7.97	0.06	0.02
R13.0	T	H	L	L	N	5.54	3.59	3.45	-1.95	-2.09
L13.5	T	H	L	L	N	7.72	7.84	7.67	0.12	-0.05
R13.5	SH	H	L	L	I	9.57	9.64	9.57	0.07	0.00
R13.9	T	H	L	L	N	8.85	8.76	8.66	-0.09	-0.19
L14.0	H	H	L	L	N	7.87	8.55	8.72	0.68	0.85
L14.5	T	H	L	L	N	5.57	5.48	5.57	-0.09	0.00
R14.7	T	H	L	L	N	5.65	5.29	5.48	-0.36	-0.17
L15.0	T	H	L	L	N	6.43	6.29	6.21	-0.14	-0.22
R15.0	T	H	L	L	N	7.92	8.63	8.64	0.71	0.72
R15.5	T	H	L	L	O	6.05	5.98	6.04	-0.07	-0.01
R16.0	T	H	L	H	I	7.07	6.92	6.90	-0.15	-0.17
L16.5	T	H	L	L	N	7.39	7.32	7.24	-0.07	-0.15
R16.5	T	H	L	L	N	5.40	5.14	5.25	-0.26	-0.15
L17.0	H	H	H	H	N	7.76	7.31	7.27	-0.45	-0.49
R17.0	D	H	L	L	N	7.54	7.25	6.21	-0.29	-1.33
L17.5	SH	H	M	M	N	6.95	7.10	7.17	0.15	0.22
R17.5	D	H	L	M	O	6.28	6.16	6.47	-0.12	0.19
L18.0	T	L	L	L	I	6.46	6.43	6.82	-0.03	0.36
R18.0	S	H	L	L	N	4.85	4.84	4.87	-0.01	0.02
L18.3	T	H	L	L	N	8.34	8.50	8.41	0.16	0.07
R18.5	H	L	L	L	N	7.09	7.08	7.09	-0.01	0.00
L18.8	H	L	H	L	O	6.08	6.19	restored	0.11	
L19.0	SH	L	L	H	O	5.51	5.71	5.65	0.20	0.14
R19.0	T	L	L	L	N	6.32	6.68	6.63	0.36	0.31
L19.1	SH	L	H	H	O	4.90	4.01	4.02	-0.89	-0.88
R19.5	H	L	L	L	N	7.60	7.68	7.74	0.08	0.14
L19.6	T	L	L	L	O	7.36	7.23	5.89	-0.13	-1.47

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Site	Hab Type[a]	Wake Lev[b]	AngLev[c] 1998	AngLev[c] 1999	Meander[d]	Distance from Benchmark to Bank (m) Jun 1998	Aug 1998	Jun 1999	Inseason Change (m) Aug98-Jun98	Annual Change (m) Jun99-Jun98
L20.0	H	L	H	H	N	7.18	7.52	7.39	0.34	0.21
R20.0	T	L	L	M	O	6.44	6.39	6.38	-0.05	-0.06
L20.5	T	L	H	H	N	7.60	7.57	7.61	-0.03	0.01
R 20.5	T	L	H	M	O	6.48	6.56	6.50	0.08	0.02
L21.0	H	L	L	L	N	8.84	9.53	9.52	0.69	0.68
R 21.0	D	L	M	M	N	4.99	5.61	4.87	0.62	-0.12
L21.4	SH	L	L	M	N	5.98	6.05	5.98	0.07	0.00
L21.5	H	L	L	L	N	6.96	6.99	7.12	0.03	0.16
R21.5	T	L	H	H	N	7.75	7.85	7.84	0.10	0.09
R21.9	H	L	H	H	N	6.96	6.82	6.88	-0.14	-0.08
L22.0	S	L	L	L	N	7.01	7.03	7.02	0.02	0.01
L22.3	H	L	L	L	I	4.57	4.44	4.47	-0.13	-0.10
L22.5	T	L	L	L	N	6.83	6.85	6.93	0.02	0.10
R22.5	T	L	H	L	N	4.61	4.51	4.30	-0.10	-0.31
R22.8	SH	L	L	H	N	5.43	4.46	4.59	-0.97	-0.84
R22.9	SH	L	H	H	N	4.50	4.51	4.46	0.01	-0.04
L23.0	T	L	L	L	N	5.59	5.76	5.74	0.17	0.15
L23.5	SH	L	L	L	O	6.47	6.48	6.52	0.01	0.05
R23.5	T	L	L	L	N	5.97	5.91	5.94	-0.06	-0.03
L23.6	H	L	L	L	O	6.27	6.07	6.07	-0.20	-0.20
L24.0	SH	L	L	L	I	4.48	4.84	4.56	0.36	0.08
R24.0	T	L	L	L	O	3.35	3.29	3.43	-0.06	0.08
L24.2	H	L	L	L	I	New in 99		6.95		
L24.3	H	L	L	L	I	8.74	8.77	8.70	0.03	-0.04
R24.5	T	L	L	L	N	4.07	4.14	4.15	0.07	0.08
L25.0	SH	L	L	L	N	3.91	4.03	4.01	0.12	0.10
R25.0	T	L	L	L	I	5.94	6.11	5.93	0.17	-0.01
L25.5	SH	L	L	L	N	6.72	6.75	6.75	0.03	0.03
R25.5	SH	L	H	H	N	8.02	7.75	7.72	-0.27	-0.30
R25.6	SH	L	H	H	O	7.80	7.38	7.50	-0.42	-0.30
L25.7	H	L	L	M	O	7.95	8.20	8.20	0.25	0.25
L25.9	SH	L	L	L	N	4.28	4.42	4.39	0.14	0.11
R26.0	H	L	L	L	N	5.36	5.45	5.41	0.09	0.05
L26.5	H	L	L	L	N	5.91	5.96	5.90	0.05	-0.01
R26.5	SH	L	L	L	I	5.08	4.94	5.05	-0.14	-0.03
R26.6	H	L	L	L	I	New in 99		6.87		
L26.9	SH	L	L	L	O	5.10	4.89	5.11	-0.21	0.01
R27.0	T	L	L	L	I	5.30	6.03	5.90	0.73	0.60
L27.5	T	L	L	L	N	4.04	4.19	4.12	0.15	0.08
R27.5	SH	L	L	L	N	5.15	5.13	4.66	-0.02	-0.49
L28.0	SH	L	L	L	N	7.16	7.16	7.06	0.00	-0.10
R28.3	SH	L	L	L	O	8.22	8.19	8.19	-0.03	-0.03
L28.5	T	L	L	L	N	6.24	6.53	6.64	0.29	0.40
L29.0	T	L	L	L	N	6.34	6.34	6.27	0.00	-0.07
R29.0	T	L	L	L	N	4.47	4.78	4.52	0.31	0.05
R29.4	T	L	L	L	I	6.00	5.89	5.70	-0.11	-0.30
L29.5	T	L	L	L	N	6.24	6.22	6.08	-0.02	-0.16

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Site	Hab Type[a]	Wake Lev[b]	AngLev[c] 1998	AngLev[c] 1999	Meander[d]	Distance from Benchmark to Bank (m) Jun 1998	Aug 1998	Jun 1999	Inseason Change (m) Aug98-Jun98	Annual Change (m) Jun99-Jun98
L30.0	T	L	L	L	U	5.98	5.89	5.81	-0.09	-0.17
R30.0	T	L	L	L	N	6.74	6.89	6.73	0.15	-0.01
L30.5	T	L	M	H	N	4.75	4.73	4.71	-0.02	-0.04
R30.5	T	L	L	L	O	7.18	7.20	7.29	0.02	0.11
L31.0	T	L	L	L	N	6.54	6.64	6.53	0.10	-0.01
R31.0	SH	L	L	M	N	6.12	6.15	6.13	0.03	0.01
L31.5	T	L	L	L	N	6.07	6.21	6.31	0.14	0.24
R31.5	D	L	L	L	O	4.46	4.83	5.06	0.37	0.60
L32.0	D	L	L	L	N	5.17	5.31	5.32	0.14	0.15
R32.1	SH	L	L	L	O	6.17	6.55	6.29	0.38	0.12
L32.5	T	L	L	L	N	7.57	7.82	7.67	0.25	0.10
R32.7	H	L	L	L	O	5.86	5.29	5.48	-0.57	-0.38
L32.8	SH	L	L	L	O	6.55	6.44	6.49	-0.11	-0.06
R33.0	T	L	L	M	I	7.98	8.15	8.03	0.17	0.05
L33.5	S	L	L	L	N	5.11	5.20	5.04	0.09	-0.07
R33.5	T	L	L	L	I	3.86	4.11	3.85	0.25	-0.01
L33.9	SH	L	H	M	N	4.72	4.61	4.88	-0.11	0.16
R34.0	T	L	M	M	I	7.01	7.00	6.99	-0.01	-0.02
L34.5	T	L	L	L	O	5.06	4.49	5.12	-0.57	0.06
R34.5	T	L	L	L	N	3.17	3.12	3.11	-0.05	-0.06
L35.0	T	L	M	H	N	8.24	8.15	8.18	-0.09	-0.06
R35.0	SH	L	L	L	O	6.67	6.46	6.63	-0.21	-0.04
L35.5	T	L	L	L	N	3.75	3.76	3.86	0.01	0.11
R35.5	H	L	L	M	N	6.94	7.03	6.94	0.09	0.00
L36.0	T	L	L	L	O	6.02	6.14	6.15	0.12	0.13
R36.1	T	L	L	L	O	3.92	3.72	3.89	-0.20	-0.03
L36.3	H	L	L	L	I	5.50	5.39	5.42	-0.11	-0.08
L36.5	T	L	L	L	N	7.17	7.33	7.26	0.16	0.09
R36.5	H	L	M	L	O	4.39	4.17	4.23	-0.22	-0.16
L37.0	SH	L	L	L	N	4.79	4.91	4.92	0.12	0.13
R37.0	D	L	L	L	O	5.03	5.06	5.11	0.03	0.08
L37.5	T	L	L	L	O	5.88	6.14	6.02	0.26	0.14
R37.5	T	L	L	L	O	7.50	8.43	6.94	0.93	-0.56
L38.0	D	L	L	L	N	6.38	6.27	6.25	-0.11	-0.13
R38.0	T	L	L	L	I	6.50	6.45	6.47	-0.05	-0.03
L38.5	T	L	L	L	N	6.06	6.20	6.32	0.14	0.26
R38.5	SH	L	L	L	O	6.90	6.97	6.86	0.07	-0.04
L39.0	T	L	L	L	O	7.18	7.17	7.15	-0.01	-0.03
R39.0	T	H	H	H	N	5.25	5.37	5.41	0.12	0.16
L39.5	T	H	L	L	N	4.99	4.96	4.98	-0.03	-0.01
R39.5	T	H	L	M	O	7.67	7.57	7.49	-0.10	-0.18
L40.0	T	H	L	L	O	5.87	5.82	5.85	-0.05	-0.02
R40.3	H	H	L	L	I	5.55	5.49	5.50	-0.06	-0.05
L40.5	T	H	L	L	O	4.71	4.75	3.89	0.04	-0.82
L41.0	T	H	L	L	O	9.45	9.40	9.47	-0.05	0.02
R41.0	T	H	L	L	N	3.63	3.22	3.19	-0.41	-0.44
L41.5	T	H	L	L	N	6.18	6.30	6.53	0.12	0.35
R41.5	T	H	L	M	N	3.29	3.21	3.41	-0.08	0.12
L42.0	T	H	L	L	O	4.80	4.16	3.60	-0.64	-1.20
R42.0	D	H	L	L	O	4.55	4.45	4.43	-0.10	-0.12

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Site	Hab Type[a]	Wake Lev[b]	AngLev[c] 1998	AngLev[c] 1999	Meander[d]	Distance from Benchmark to Bank (m) Jun 1998	Aug 1998	Jun 1999	Inseason Change (m) Aug98-Jun98	Annual Change (m) Jun99-Jun98
	SH	H	L	L	N	4.61	4.62	4.68	0.01	0.07
R42.5	T	H	L	L	N	6.76	6.63	6.79	-0.13	0.03
R42.9	T	H	L	L	N	6.53	6.29	6.23	-0.24	-0.30
L43.0	T	H	L	L	O	5.11	4.90	5.31	-0.21	0.20
L43.5	T	H	L	L	O	4.65	4.51	4.03	-0.14	-0.62
R43.5	T	H	L	L	O	4.46	4.38	4.44	-0.08	-0.02
L44.0	T	H	L	L	O	7.41	4.29	4.31	-3.12	-3.10
R44.1	T	H	L	L	I	7.16	7.29	7.02	0.13	-0.14
L44.5	H	H	L	L	I	9.39	10.02	9.34	0.63	-0.05
R44.5	T	H	L	L	O	6.88	6.48	6.54	-0.40	-0.34
L45.0	T	H	L	L	N	6.78	6.77	6.78	-0.01	0.00
R45.0	T	H	H	H	N	3.92	4.09	4.11	0.17	0.19
L45.5	SH	H	L	L	I	9.92	9.81	10.16	-0.11	0.24
L46.0	T	H	L	L	O	5.98	6.05	6.08	0.07	0.10
R46.1	H	L	H	H	I	6.11	6.04	6.10	-0.07	-0.01
R46.2	H	L	H	H	I	4.60	4.55	4.52	-0.05	-0.08
R46.5	T	L	L	L	O	8.07	7.91	7.87	-0.16	-0.20
L46.7	T	L	L	L	I	4.76	4.75	4.73	-0.01	-0.03
R46.9	T	L	L	L	O	6.41	6.37	6.38	-0.04	-0.03
L47.0	T	L	L	L	I	6.04	5.97	6.09	-0.07	0.05
L47.5	T	L	L	L	O	6.90	6.87	6.99	-0.03	0.09
R47.5	T	L	L	L	O	8.59	8.38	8.89	-0.21	0.30
L48.0	T	L	L	L	N	7.86	8.04	7.86	0.18	0.00
R48.0	T	L	L	L	N	5.80	5.80	5.18	0.00	-0.62
L48.5	T	L	L	L	N	5.04	5.01	4.95	-0.03	-0.09
R48.5	T	L	L	L	N	8.09	8.12	8.04	0.03	-0.05
L49.0	T	L	L	L	N	3.45	3.45	3.43	0.00	-0.02
R49.0	T	L	L	L	N	9.24	9.19	9.30	-0.05	0.06
L49.5	H	L	L	L	N	5.02	4.96	4.81	-0.06	-0.21
R49.5	T	L	L	L	N	8.37	8.66	8.40	0.29	0.03
L50.0	T	L	L	L	N	5.80	5.77	5.87	-0.03	0.07
R50.0	T	L	L	L	N	7.08	7.03	7.09	-0.05	0.01

[a] Habitat Types: SH = Shrub/herbaceous, H = Herbaceous, T = Treed,
D = Disturbed. S = Shrub

[b] Wake Level: L = Low, H = High

[c] Angler Use Level: L = Low, M = Medium, H = High

[d] Meander: I = Inside, O= Outside, N = None

Appendix C2.-Bank measurements at angler effort survey sites, Kenai River, 1999.

					Distance Change (m)											Change Statistics:							
					June1999 - August 1998											August 19 - June 19, 1998				June 19, 1999 - Augeust 19, 1998			
Survey Site	HabType[a]	WakeLev[b]	98 AngLev[c]	Meander[d]	BM-D	UBM1-D	UBM2-D	UBM3-D	UBM4-D	UBM5-D	DBM1-D	DBM2-D	DBM3-D	DBM4-D	DBM5-D	Max	Min	Mean	Var	Max	Min	Mean	Var
R13.5	SH	H	L	I	-0.07	-0.12	0.18	0.38	0.82	0.06	-0.09	0.09	-0.32	0.72	0.07	2.17	-0.58	0.47	0.92	0.82	-0.32	0.16	0.12
L14.0	H	H	L	N	0.17	0.16	0.09	-0.07	-0.13	0.23	0.21	-0.02	0.42	-0.35	0.33	2.73	-1.28	0.24	1.30	0.42	-0.35	0.09	0.05
L17.0	H	H	H	N	New site in 1999																		
L17.5	SH	H	M	N	0.07	0.07	-0.09	0.00	-0.06	-1.45	-0.14	0.00	-1.54	0.19	0.38	1.63	-1.54	-0.02	0.80	0.38	-1.54	-0.23	0.41
R18.5	H	L	L	N	0.01	-0.36	-3.18	0.10	-0.18	-0.09	-0.62	-1.13	-0.56	-0.41	-1.44	2.55	-0.12	0.91	0.89	0.10	-3.18	-0.71	0.89
L19.0	SH	L	L	O	-0.06	-0.16	-0.01	0.00	0.04	0.85	0.02	0.13	-0.01	-0.01	0.11	1.29	-1.24	-0.09	0.35	0.85	-0.16	0.08	0.07
L19.1	SH	L	H	O	0.01	-0.06	0.03	0.07	0.06	-0.01	-2.80	-0.17	0.02	-0.12	0.02	2.81	-1.39	0.11	2.19	0.07	-2.80	-0.27	0.71
R19.5	H	L	L	N	0.06	1.82	0.82	1.60	0.49	0.42	0.44	1.75	0.85	0.98	0.52	0.30	-1.34	-0.43	0.19	1.82	0.06	0.89	0.35
L20.0	H	L	H	N	-0.13	0.44	0.18	0.09	0.26	0.15	-0.08	0.13	0.14	0.04	0.12	0.34	-0.32	0.01	0.05	0.44	-0.13	0.12	0.02
L21.0	H	L	L	N	-0.01	0.20	0.02	0.17	0.19	-0.16	-0.01	0.12	0.18	0.23	-0.03	2.43	-0.10	0.84	0.69	0.23	-0.16	0.08	0.02
L21.4	SH	L	L	N	-0.07	0.13	0.05	-0.65	0.06	0.11	0.03	0.08	-0.98	0.12	0.04	0.91	-8.95	-0.57	7.86	0.13	-0.98	-0.10	0.13
L21.5	H	L	L	N	0.13	0.07	0.16	0.01	0.05	0.04	0.12	0.23	-0.10	0.02	0.10	0.21	-0.29	-0.14	0.02	0.23	-0.10	0.08	0.01
R21.9	H	L	H	N	0.06	-0.04	-0.69	-0.10	0.06	-0.01	-0.11	0.84	0.22	0.44	0.05	2.42	-0.79	0.33	0.99	0.84	-0.69	0.07	0.14
L22.3	H	L	L	I	0.03	0.00	0.51	-0.01	-0.04	-0.09	0.06	0.02	-0.01	0.04	-0.01	1.60	-0.92	-0.02	0.37	0.51	-0.09	0.05	0.03
R22.8	SH	L	L	N	0.13	0.05	0.01	0.00	-0.07	0.80	0.97	-0.13	0.13	0.14	-0.01	1.95	-3.01	-0.14	1.78	0.97	-0.13	0.18	0.13
R22.9	SH	L	H	N	-0.05	0.05	-0.11	-0.02	0.11	0.02	0.03	0.10	0.01	-0.03	-0.04	1.29	-0.93	0.12	0.37	0.11	-0.11	0.01	0.00
L23.5	SH	L	L	O	0.04	-0.07	0.03	-0.06	-0.29	0.06	-0.05	0.14	0.05	0.32	0.12	0.19	-1.51	-0.52	0.35	0.32	-0.29	0.03	0.02
L23.6	H	L	L	N	0.00	-0.11	0.02	-0.03	-0.02	0.11	0.05	-0.03	0.10	0.07	-0.03	0.60	-0.62	-0.07	0.12	0.11	-0.11	0.01	0.00
L24.0	SH	L	L	I	-0.28	0.12	-0.06	0.03	0.01	0.12	0.07	-0.05	0.14	0.08	0.05	0.36	-0.18	0.05	0.03	0.14	-0.28	0.02	0.01
L24.3	H	L	L	N	-0.07	-0.15	0.08	0.04	-0.69	-0.17	-0.29	-0.09	-0.05	0.03	0.05	0.10	-1.67	-0.51	0.49	0.08	-0.69	-0.12	0.05
L25.0	SH	L	L	N	-0.02	0.00	-0.03	0.01	0.03	0.07	0.09	0.04	0.02	-0.08	0.05	2.01	-1.94	0.02	0.81	0.09	-0.08	0.02	0.00
L25.5	SH	L	L	N	0.00	-0.03	0.02	0.00	0.06	0.94	0.02	-0.02	0.05	0.04	0.19	0.03	-2.61	-0.64	0.63	0.94	-0.03	0.12	0.08
R25.5	SH	L	H	N	-0.03	0.07	0.20	-0.79	-0.15	1.31	0.01	-0.06	-0.07	-0.26	0.08	0.09	-1.22	-0.20	0.14	1.31	-0.79	0.03	0.25
R25.6	SH	L	H	O	0.12	0.02	-0.08	-0.03	-0.12	-0.15	-0.02	-0.05	0.08	-0.04	-0.05	0.20	-2.06	-0.34	0.43	0.12	-0.15	-0.03	0.01
L25.7	H	L	L	O	0.00	0.06	0.42	0.15	-0.03	0.17	0.21	0.35	0.16	0.24	0.10	0.66	-0.88	0.04	0.19	0.42	-0.03	0.17	0.02
L25.9	SH	L	L	N	-0.03	0.13	0.18	0.08	1.43	1.13	0.15	0.08	-0.82	0.07	0.16	1.31	-0.22	0.36	0.28	1.43	-0.82	0.23	0.35
R26.0	H	L	L	N	-0.04	0.05	0.16	-0.08	-0.24	-0.05	-0.79	0.67	-0.03	0.05	-0.04	1.19	-0.15	0.32	0.22	0.67	-0.79	-0.03	0.12

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					Distance Change (m)											Change Statistics:							
					June1999 - August 1998											August 19 - June 19, 1998				June 19, 1999 - August 19, 1998			
Survey Site	HabType[a]	WakeLev[b]	98 AngLev[c]	Meander[d]	BM-D	UBM1-D	UBM2-D	UBM3-D	UBM4-D	UBM5-D	DBM1-D	DBM2-D	DBM3-D	DBM4-D	DBM5-D	Max	Min	Mean	Var	Max	Min	Mean	Var
R26.5	SH	L	L	I	0.11	0.07	0.05	0.19	0.01	-0.07	0.02	0.05	-0.04	-0.03	0.02	0.55	-0.22	0.03	0.05	0.19	-0.07	0.03	0.01
L26.9	SH	L	L	O	0.22	-0.41	-0.08	0.13	-0.02	0.06	-0.04	0.01	-0.03	-0.08	-0.08	0.45	-0.21	0.09	0.04	0.22	-0.41	-0.03	0.02
R28.3	SH	L	L	O	0.00	-0.05	-0.03	0.00	-0.30	0.10	0.06	0.02	-0.01	-0.03	0.01	0.63	-0.94	-0.06	0.23	0.10	-0.30	-0.02	0.01
R32.7	H	L	L	O	0.19	-0.14	0.00	-0.05	-0.03	-0.06	-0.01	0.32	0.12	0.10	0.18	0.15	-0.57	-0.22	0.05	0.32	-0.14	0.06	0.02
L32.8	SH	L	L	O	0.05	0.10	0.20	0.13	0.33	0.20	0.21	0.17	0.17	0.01	0.04	1.11	-0.52	0.07	0.23	0.33	0.01	0.15	0.01
L33.9	SH	L	H	N	0.27	marsh[e]	-0.05	-0.05	-0.96	-0.69	-0.02	0.03	-0.04	-1.01	-0.02	1.98	-0.42	0.46	0.56	0.27	-1.01	-0.25	0.21
R35.5	H	L	L	N	-0.09	-0.06	creek[e]	0.00	-0.25	0.00	-0.32	-0.12	0.00	0.07	0.38	5.92	-0.63	0.73	4.28	0.38	-0.32	-0.04	0.04
L36.3	H	L	L	I	0.03	-0.01	0.02	0.19	0.08	-0.03	0.01	0.21	0.26	0.09	0.11	0.15	-1.49	-0.18	0.20	0.26	-0.03	0.09	0.01
R36.5	H	L	M	O	0.06	-0.10	0.19	0.45	0.15	0.02	-0.04	0.23	0.15	0.07	0.02	1.20	-2.10	-0.29	0.64	0.45	-0.10	0.11	0.02
R38.5	SH	L	L	O	-0.11	-0.18	-0.06	0.04	-0.22	0.00	-0.09	0.23	-0.17	0.86	1.19	1.91	-0.05	0.47	0.39	1.19	-0.22	0.14	0.21
R40.3	H	H	L	I	0.01	-0.30	-0.05	0.10	0.15	0.08	0.10	-0.60	-0.02	0.04	-0.01	0.18	-0.14	-0.03	0.01	0.15	-0.60	-0.05	0.05
R46.1	H	L	H	I	0.06	0.15	0.71	1.10	0.07	-0.02	0.01	0.02	0.15	0.02	0.06	0.30	-1.06	-0.25	0.16	1.10	-0.02	0.21	0.13
R46.2	H	L	H	I	-0.03	-0.01	0.29	0.09	0.02	-0.04	-0.04	-0.01	0.37	0.29	-0.04	0.28	-0.68	-0.18	0.07	0.37	-0.04	0.08	0.02

[a] Habitat Types: SH = Shrub/herbaceous, H = Herbaceous

[b] Wake Level: L = Low, H = High

[c] Angler use level: L = Low, M = Medium, H = High

[d] Meander: I = Inside, O= outside, N = None

[e] The location of the benchmark or bank edge falls within a creek or marsh and thus the distance is not consistently measureable.

Appendix C3.-Summary of angler counts and effort at angler effort survey sites during the sport fishery for late-run sockeye salmon, Kenai River, 1999.

		Survey Sites:													
Date	Data	L14.0	L17.0	L17.5	L19.0	L19.1	L20.0	L21.0	L21.4	L21.5	L22.3	L23.5	L23.6	L24.0	L24.2
8-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0
11-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0.4	0	0.2	0.6	0	0	0	0.2	0	1	0	0	0
14-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	2	0	0.6	1	0.8	0	0	0	0	0	0	0	0
17-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	4.6	0.4	3.2	1.8	1.6	0	0	0.4	0	0.2	0	0	0
20-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	14	1.6	5.4	4.4	5.2	0	0	0.8	0	0.8	0.2	0	0
23-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.2	9.6	2.6	5	2.8	2.4	0.4	2.6	1.4	0	0.2	0	0	0
26-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	8.8	2	4.8	1.6	3.4	1	3.6	1.8	0.6	1.2	0	0	0
29-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.2	8.4	1.2	0.8	1.2	2	0	0	0	0	0	0.6	0	0
1-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	2.4	0.8	2.2	2.2	1.4	0	0.2	1	0	0.8	0.6	0	0
4-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	1	0	0.4	0.4	0.6	0	0	0	0	0.4	0	0	0
7-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0.4	0	0	0.4	0	0	0	0	0	0	0	0	0
10-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	1.4	0	0.4	0.2	0	0	0.2	0.2	0	0	0	0	0
Total Number of counts		60	60	60	60	60	60	60	60	60	60	60	60	60	60
Mean count		0.0	4.5	0.7	1.9	1.4	1.5	0.1	0.6	0.5	0.1	0.4	0.1	0.0	0.0
Variance of count		0.0	26.5	2.0	6.8	2.9	4.9	0.5	3.0	0.9	0.1	0.9	0.3	0.0	0.0
Angler Hours Effort		19	2,573	413	1,104	797	835	67	317	278	29	221	67	0	0
Variance of Effort		346	81,482	17,132	31,407	25,811	55,917	5,017	23,582	10,738	1,558	9,873	3,459	0	0

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Date	Data	L24.3	L25.0	L25.5	L25.7	L25.9	L26.9	L32.8	L33.9	L36.3	R13.5	R18.5	R19.5	R21.9	R22.8
		Survey Sites:													
8-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0	0	0	0	0.2	0	0	0.2	0	0.2	0
14-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0.4
17-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0	0	0	0	1.4	0	0	0	0	1.4	0.6
20-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	1	0	0.2	1.8	0.4	0	0	0.8	0.8	0	0.2	0	4.2	2.4
23-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.8	0	1.8	1.6	0	0	0	2	0.4	0.8	1	0.6	4.6	1.4
26-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.2	0	0.2	0.2	0	0.2	0	2.2	0	0	0	0	6.8	2.8
29-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0.6	2.2	0	0	0	0.2	1	0	0	0.4	3	3
1-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.4	0	1.2	0.4	0	0	0	0.2	0	0	0	0	0.6	0.4
4-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0	0	0	0.2	1	0	0	0	0	0	0.2
7-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0	0	0	0	0.8	0	0	0	0	0.2	0
10-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0
Total Number of counts		60	60	60	60	60	60	60	60	60	60	60	60	60	60
Mean count		0.2	0.0	0.3	0.6	0.0	0.0	0.0	0.7	0.2	0.1	0.1	0.1	1.8	0.9
Variance of count		0.3	0.0	0.8	1.1	0.0	0.0	0.0	1.3	0.7	0.3	0.2	0.2	8.2	1.9
Angler Hours Effort		115.2	0	192	316.8	19.2	9.6	19.2	422.4	105.6	38.4	67.2	48	1008	537.6
Variance of Effort		5,191	0	12,988	7,481	174	346	692	11,441	12,799	2,770	1,216	2,250	57,162	10,765

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Date	Data	Survey Sites: R22.9	R25.5	R25.6	R26.0	R26.5	R26.6	R28.3	R32.7	R35.5	R36.5	R38.5	R40.3	R46.1	R46.2
8-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0
11-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	1.2	0.8	0	0	0	0	0	0	0.2	0	0	0	0	0
14-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.6	0.2	0	0	0	0	0	0	0.8	0	0	0	0	0
17-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	1.2	2.6	2.2	0	0	0	0	0	0	0	0	0	0.4	0.4
20-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	1.8	9.2	2	0.4	0	0	0	0	1.8	0	0.2	0	1.6	1.6
23-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	3.4	7.6	4	0	0	0	0	0	1.4	0	0.2	0	1.2	1.8
26-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	1	7.8	1.4	0	0	0	0.2	0	1.8	0	1	0	1	0.8
29-Jul	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	1.8	5.2	2.8	0	0.4	0	0	0	2.8	0	0.6	0	3	1.8
1-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.6	4.4	1.4	0	0	0.2	0	0	0.8	0	1.8	0	0.6	2.4
4-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	0.4	4.2	0	0	0	0	0	0	0	0	0	0	2.4	1
7-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	2.8	0.4	0	0	0	0	0.4	0	0	0	0.6	0	1.6	0.2
10-Aug	Number of counts	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean count	1.8	2	0	0	0	0	0	0.2	0	0	0	0	2.8	0.6
Total Number of counts		60	60	60	60	60	60	60	60	60	60	60	60	60	60
Mean count		1.4	3.7	1.2	0.0	0.0	0.0	0.3	0.0	0.8	0.0	0.4	0.0	1.2	0.9
Variance of count		2.4	13.4	3.8	0.1	0.1	0.0	1.0	0.0	2.2	0.0	0.7	0.0	2.1	2.4
Angler Hours Effort		796.8	2131.2	662.4	19.2	19.2	9.6	153.6	9.6	460.8	0	211.2	0	700.8	508.8
Variance of Effort		30,662	60,620	29,129	692	1,384	346	3,164	346	30,625	0	7,109	0	19,246	35,999