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FEASIBILITY OF ESTIMATING WINTER DISTRIBUTION AND HABITAT PREFERENCE FOR JUVENILE SALMONIDS IN THE MAINSTEM KENAI RIVER, ALASKA, 1986-1987[1]

By

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ABSTRACT

Techniques for fish habitat and population sampling were tested within the lower 80.5 kilometers of the Kenai River to evaluate their effectiveness in assessing winter (October to March) fish habitat preference and distribution and estimating populations. Sampling for overwintering juvenile fish was conducted in various macrohabitats of the mainstem Kenai River using a hand-held beach seine, baited minnow traps, and a modified substrate sampler. A total of 10,490 juveniles representing 16 species and nine families of freshwater, marine, and anadromous fish were captured. Juvenile members of the family *Salmonidae* accounted for 50 percent of the catch. Coho salmon *Oncorhynchus kisutch* accounted for 41 percent of the entire catch.

Beach seines captured the greatest number and diversity of juvenile fish. Minnow traps were the least effective capture gear. The substrate sampler indicated inter-substrate overwintering behavior for nine species of juvenile fish and provided data on species diversity, apportionment, and density within a limited range of substrate sizes. Due to a variety of limitations, each gear could only be used within a narrow range of habitats in the lower Kenai River.

The catch of juvenile coho salmon by age class was not independent of gear type. Analysis of variance testing for differences between juvenile salmon fork length between gear types indicated that chinook, coho, and sockeye salmon captured by beach seine were significantly larger than those captured by substrate sampler and minnow traps.

Potential sources of variation in habitat preference were examined using multivariate analyses of covariance of transformed catches of juvenile salmon as affected by cover, substrate, depth, and velocity. No significant effects of either cover and substrate types, or depth and velocity levels on transformed minnow trap catches were found. At sites with no object cover, transformed beach seine catches were significantly related to the level of depth sampled. Transformed substrate sampler catches were significantly related to substrate type, depth, and velocity. The importance of depth, velocity, and substrate type varied with cover availability.

Information is presented on the general distribution of overwintering juvenile fish within the study area based on the upper and lower limits of their capture. The diversity of species, based on the composition of catches, decreased with distance upstream from the mouth. The greatest diversity occurred in the intertidal reach of the Kenai River delta.

Habitat diversity in the lower Kenai River is substantially reduced during winter months. Low winter flows reduce the amount of cover, turbidity, depth, and stream margin available to juvenile fish. Turbidity in the intertidal reach, rubble substrates in the middle river, and areas with intermittent aquatic vegetation appear to provide the most abundant cover for overwintering juvenile fish. Sympatric populations of juvenile salmon are segregated during winter months in the Kenai River; however, a considerable amount of overlap in habitat use occurs.

KEY WORDS: Kenai River, juvenile fish, habitat preference, overwintering behavior, cover, substrate, minnow trap, substrate sampler, beach seine, sampling techniques, coho salmon, chinook salmon, sockeye salmon, habitat.

INTRODUCTION

The Kenai River (Figure 1), located in Southcentral Alaska on the Kenai Peninsula, has developed into one of the most intensively used river systems in Alaska. Abundant Pacific salmon *Oncorhynchus* spp. runs, road accessibility, and the proximity of the Kenai River to major population centers have contributed to a dramatic increase in private, recreational, and commercial developments within and adjacent to the Kenai River. During 1986, anglers expended over 330,000 angler-days of effort in the Kenai River making this the largest freshwater fishery in Alaska (Mills 1987).

Along the mainstem Kenai River below Skilak Lake, approximately 66% of the adjacent river land is in private ownership, 15% is owned by the cities of Soldotna and Kenai or the Kenai Peninsula Borough, 15% is in state ownership, and 4% is in federal ownership (Alaska Department of Natural Resources 1986). Developments adjacent to the river include businesses, permanent and seasonal residences, and recreational facilities; while instream developments include boat docks, launching facilities, canals, boat basins, groins, and several types of revetments. Road construction, draining and filling of wetlands, and the removal of instream debris and riparian vegetation have accompanied the development of the Kenai River.

Public concern that uncontrolled development and use of the Kenai River will increase rates of erosion and degrade habitats required to support fish resources prompted the formation of the Kenai River Special Management Area (KRSMA) by the Alaska State Legislature in 1984. The KRSMA encompasses all state owned lands along the river and is managed by the Alaska Department of Natural Resources (ADNR). As a result of KRSMA legislation, the recommendations of a special advisory board, and a series of public meetings held throughout the region, the ADNR adopted the <u>Kenai River Comprehensive Management Plan</u> in 1986. The plan addresses development concerns of private land owners and public agencies and identifies goals and objectives for future use of the river. Implementation of the plan is contingent upon cooperative efforts by agencies, local governments, and private land owners. A major impediment to the entire process is the lack of fundamental resource information for the Kenai River.

Little information is currently available on the early life history, behavior, distribution, or abundance of juvenile fish in the Kenai River. Investigations to date have been undertaken during the summer months and have relied on catch data using baited minnow traps to estimate fish abundance, behavior, and habitat utilization (Burger et al. 1983; Elliott and Finn 1984; Litchfield and Flagg 1986; Estes and Kuntz 1986). A comprehensive scheme has not been formulated to classify and inventory the overall range of seasonally available instream macrohabitats in the Kenai River; thus, previous studies have been confined to evaluating microhabitat characteristics within a narrow range of macrohabitats that have been considered important for rearing chinook and coho salmon during the open-water season. Virtually no information is available for the winter season in the Kenai River. In addition to the lack of habitat classification and inventory data, previous investigators have employed a variety of sample designs and methodologies, which produced results that are difficult to compare.

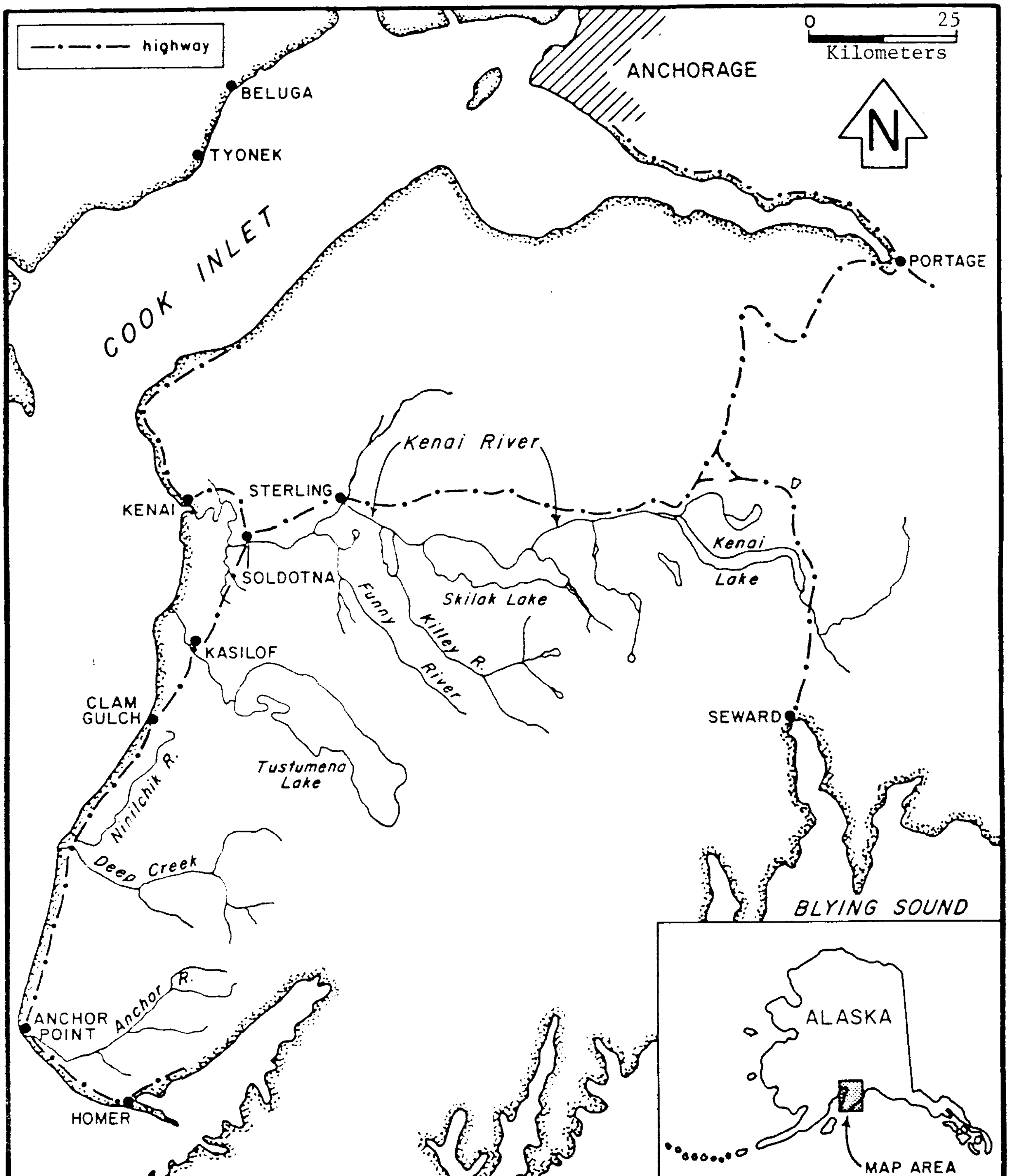

Figure 1. Kenai River basin, Kenai Peninsula, Alaska.

The relationship of riparian and instream habitat conditions to the production of fish and wildlife habitat has been identified as one of the most important informational gaps. Towards this end, the Alaska Department of Fish and Game (ADF&G) entered into a multi-year cooperative effort with the U.S. Soil Conservation Service (SCS), the U.S. Fish and Wildlife Service, the ADNR, the U.S. Corps of Engineers, the Kenai Peninsula Borough, and the U.S. Geological Survey to obtain this and related information requirements (SCS 1987).

To address these fishery related informational needs, the Sport Fish Division of the ADF&G initiated sampling for baseline habitat and biological data necessary to formulate developmental policies for the Kenai River. The primary focus of the ADF&G effort to date has been to collect summer fish habitat and population data and to obtain low level color infrared aerial photography of the river corridor. A most urgent informational gap was identified as a lack of understanding of overwintering habitat distribution, preference, and timing (Estes and Kuntz 1986). The limited amount of previous winter investigations do not provide sufficient background knowledge required for designing sampling procedures and schedules. Specific objectives for this study, therefore, were to:

1) Evaluate techniques for capturing juvenile fish in the Kenai River during the winter months (October through March).

2) Describe the composition and distribution of overwintering juvenile fish captured in the Kenai River.

3) Investigate potential sources of variation in juvenile fish habitat preference including water depth, water velocity, turbidity, air temperature, water temperature, conductivity, salinity, cover characteristics, and substrate.

METHODS

Measurement of Fish Population Variables

Sampling for juvenile fish in the lower 80.5 km (study area) of the Kenai River was conducted during the period 1 October 1986 to 31 March 1987. Three capture techniques were used to test which method or combination of methods were effective under varying conditions: hand-held beach seine; baited minnow traps; and modified substrate sampler. Methods for estimating depth, velocity, and other habitat characteristics at each sample site varied for each gear. An effort was made to sample the study area once monthly which usually required 3 to 4 days of sampling with each gear. Sample sites were chosen each month that did not conflict with the inherent limitations of the different gears. For instance, the seine was deployed in areas with no ice, gradually sloping beaches, and little object cover; minnow traps were deployed in areas of low velocity; and the substrate sampler was used in shallow water that was ice-free.

Each sample site was identified by a date, accession number, river mile and gear type. A photograph was taken of each site and a sketch was drawn showing the sampling stations within the site and the general features of the macrohabitat reach which contained the site.

It was not possible to repeatedly sample the same site during different periods due to changes in shore ice accumulation, bank configuration, and declining water levels throughout the study period. All sample sites were located in mainstem habitats and water depths of 1.2 m or less.

Gear Deployment

Minnow traps, a seine, and a substrate sampler were deployed in the macrohabitats in the lower 80.5 km of the Kenai River. Minnow traps and seines were chosen for use in this study because of their wide use for fish assessment studies in Alaska, portability, and manpower constraints associated with the project. The substrate sampler was developed to capture fish inhabiting interstitial substrate spaces. The frequency of sampling was determined by budget and manpower constraints. Specific deployment procedures are describe in the following sections.

Minnow Traps:

Minnow traps measuring 48 x 20 x 0.6 cm and baited with approximately 85 g of borax cured salmon roe were set within 61 m long reaches of shoreline to attract and capture fish inhabiting the water column. A standard sampling effort at each site consisted of 12 traps set for 30 minutes each. An effort to equalize the soak time of all traps was made by positioning the traps along the beach adjacent to each station followed by rapid deployment of all twelve traps. This process was reversed following the 30 minute soak period. Fish captured by minnow trap were aggregated for a total catch at each site. Specimens were identified, counted, and released.

Sites sampled by minnow trap were typically heterogeneous with respect to substrate size, depth, and velocity. Cover, including undercut banks, overhanging riparian vegetation, and deadfalls was usually abundant. Minnow traps attract fish from an undetermined area that is influenced by the bait; thus, a random sampling procedure was used to estimate depth and velocity at each site without regard to the specific location of each trap. Eight stations were randomly selected along each 61 m minnow trap site. At each station, depth and velocity were measured 0.6 m from shore and 1.2 m from shore providing a total of 16 measurements for each parameter at each site.

Beach seine:

Seining was conducted using a 15 x 1.8 m x 0.6 cm hand-held beach seine to capture fish inhabiting the water column. A standard effort consisted of a single 30.5 m haul that began and terminated along the shoreline. The width of each haul was determined by the slope of the beach out to the 1.2 m depth contour. Sites sampled by seine were relatively homogeneous with a uniform substrate size and a gradual, unobstructed slope to the beach. A systematic grid procedure was used to estimate depth and velocity at each seine site. The length and width of the 30.5 m reach that was seined was divided into thirds. A depth and velocity measurement was taken at the eight grid intersections.

Substrate sampler:

A modified substrate sampler (Figure 2) was used to capture fish overwintering in the river substrate or in dense mats of rooted aquatic vegetation. A metal frame enclosure covered with 0.6 cm nylon mesh and having a downstream cod end and a 2 m^2 skirted opening on the bottom was placed over the substrate that was to be sampled. A gasoline powered portable egg pump was mounted on a floating platform supported by an inner tube. The egg pump venturi was inserted through an opening in the top of the frame and the substrate was thoroughly disturbed by a jet of water and air. Juvenile fish displaced by the process escaped to the water column and were captured in the cod end of the frame enclosure. A standard sampling effort at each site included pumping six 2 m^2 plots of substrate. Depth and velocity were measured in the center of each plot that was pumped. Additional habitat characteristics (turbidity, conductivity, temperature) were measured for all plots at a single point within the site.

<u>Measurement of Habitat Variables</u>

The following physical parameters were measured and recorded for each sample site:

Macrohabitat:

A mainstem macrohabitat matrix was developed for winter discharge conditions in the lower 80.5 kilometers of the Kenai River based on reconnaissance field observations and Scott (1982) (Appendix Table 1). The river was categorized into four distinct reaches or zones (Figure 3) based on physiographic or morphologic characteristics: (1) intertidal, (2) transition, (3) entrenched, and (4) upper.

The intertidal zone (0.0 to 18.5 km) is characterized by tidal fluctuations in water level, current velocity, and salinity. It has a single meandering channel, low relative surface slope, extensive flood plain, and high relative turbidity (>10 NTU). The predominant substrate is silt and sand. The transition zone (18.5 to 35.4 km) has the greatest physiographic diversity of the four study area zones. It has single, multiple, meandering, and sinuous channel patterns. It includes the areas of transition between tidal and non-tidal influences, extensive to absent flood plain, wide point bars to entrenched channel, silt to rubble substrate, and relatively low to high surface slope. The entrenched zone (35.0 to 63.5 km) is the longest and most homogeneous reach within the study area. It has a single sinuous entrenched channel, predominantly rubble substrate, and relatively high surface slope. The upper zone (63.5 to 80.5 km) has single and multiple meandering channel patterns, gravel substrate, and relatively low surface slope.

Each zone was subdivided into four instream habitat categories: main channel, side channel, island, and tributary. Each habitat category was identified as

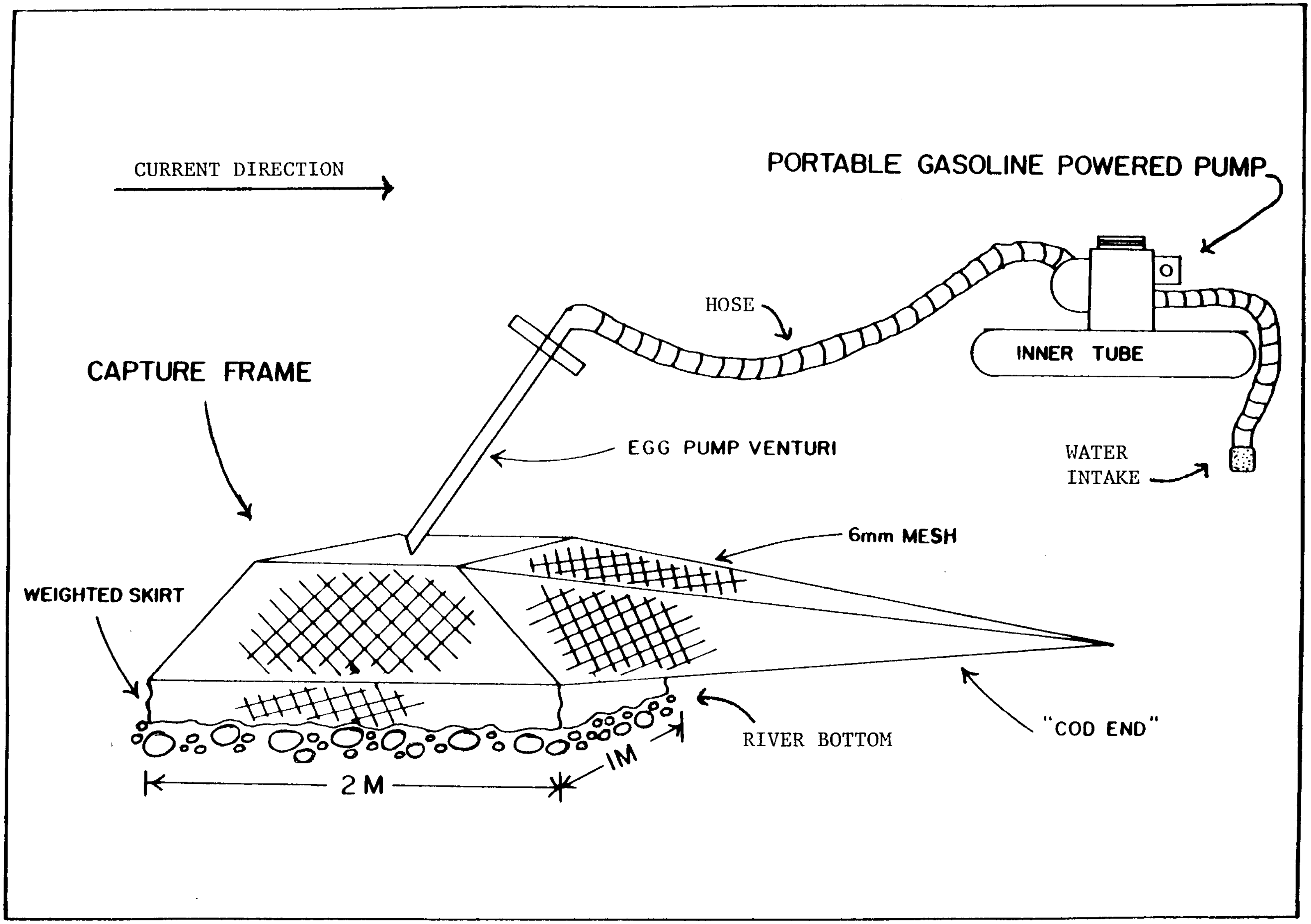

Figure 2. Modified substrate sampler and net frame used to capture juvenile fish overwintering within substrates.

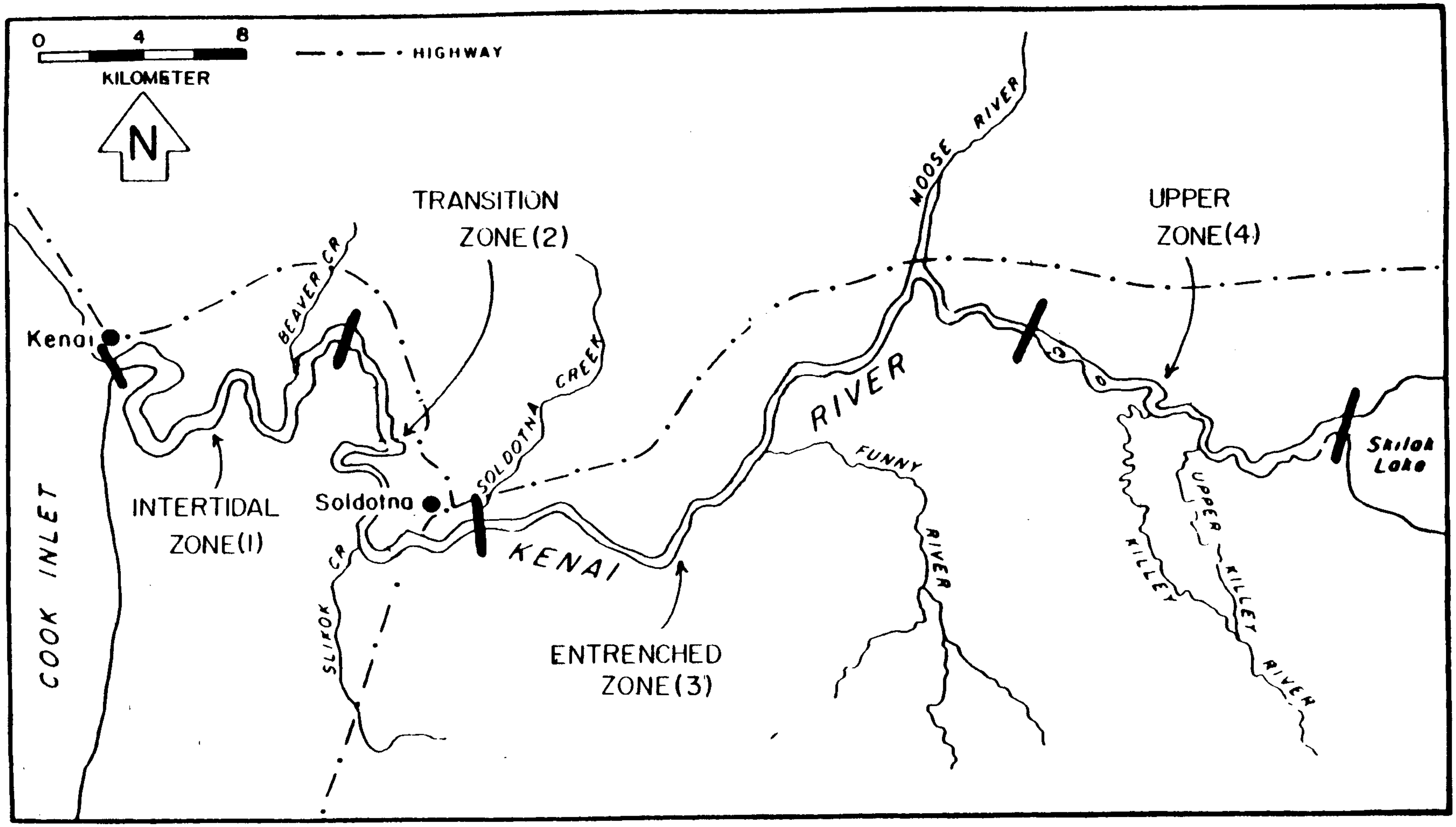

Figure 3. Lower 80.5 kilometers of the Kenai River showing the four macrohabitat subdivisions.

being either modified by development that altered the hydraulic or morphologic characteristics of the natural streambank or unmodified.

Cover:

The following selected categories of cover at each site were subjectively characterized by visual observation and listed in order of predominance:

1) No object cover.

2) Emergent vegetation which consists of riparian grasses and small shrub vegetation that is normally inundated at medium to high flows.

3) Aquatic vegetation which consists of rooted submerged vegetation as well as mats of green and brown algae.

4) Deadfalls including spruce and deciduous trees which have fallen into the river, as well as root wads and stumps.

5) Overhanging riparian vegetation which typically consists of leaning spruce trees and shrub vegetation.

6) Undercut banks which are typically vegetated banks that have undergone erosion resulting in a scalloped surface at the waters edge.

7) Shore-fast ice that is overtopping the water column.

In addition, the availability of cover within the entire study area was subjectively estimated by travelling the river by boat from the mouth to Skilak Lake (0.0 to 80.5 km). An observer visually estimated the type and amount of shoreline cover, and delineated its occurrence on a 10 cm to 1.6 km scale map of the river. The lineal proportions of each cover category were then estimated from the field map.

Substrate:

The substrate at each sample site was classified, based on the following size categories:

1.	Silt - grains indistinguishable
2.	Sand - grains less than 2 cm diameter
3.1	Gravel - 2 cm to 5 cm
3.9	Gravel - 5 cm to 10 cm
4.1	Rubble - 10 cm to 20 cm
4.9	Rubble - 20 cm to 40 cm
5.	Boulders - over 40 cm

In addition, the availability of different sized substrates throughout the study area was estimated by travelling the river by boat from the mouth to Skilak Lake. An observer visually estimated the size of substrate exposed at the water's edge and delineated its occurrence on a 10 cm to 1.6 km scale map of the river. The lineal proportion of each substrate category was then estimated from the field map.

Climatological and Hydrological Measurements:

Air temperature was measured at each site using a hand-held mercury thermometer and recorded in degrees Celsius. Measurements of water temperature, salinity, and conductivity were obtained at each site using a Yellow Springs Instruments STC meter. A water sample was collected for turbidity at each sample site and stored in a clean nalgene bottle. Samples were later analyzed using an HF Instruments model DRT 100 turbidity meter. A Marsh McBirney model 201 portable water current meter was used to measure velocity. A top setting rod was used to determine various depths of measurement and the water column depth. In water depths less than 0.8 m, the mean water column velocity was measured at a single point located 0.6 of the total depth from the surface. In depths of 0.8 m or greater, two velocities, at 0.2 and 0.8 of the total depth from the surface were measured and averaged to estimate mean water column velocity.

Length and Age Samples

A sample of the first 400 juvenile chinook, coho, and sockeye salmon captured was retained for length and age analysis. Catches of each species were labeled according to gear type and date of capture. Samples were placed in plastic bags filled with tap water, and frozen. The desired sample size of 400 fish was not achieved for both chinook and sockeye salmon due to the small numbers of these species encountered in the study. Thawed fish were measured to the nearest millimeter in fork length. A scale smear, placed between glass slides and analyzed under a Bruning 200 micro projector, was used to determine ages.

Analysis Procedures for Juvenile Salmon Catch, Length, and Age Comparisons

Multivariate analyses of covariance (MANACOVA) were used for testing the hypothesis that cover, substrate, depth, and velocity affect the catches of juvenile salmon. The analyses were conducted separately for each of the three gear types used. Standard MANACOVA procedures were followed to test the hypothesis (Morrison 1976). Prior to completing the MANACOVA, elementary exploratory data analysis (EDA) techniques were used to evaluate the sample data for agreement with the underlying assumptions of MANACOVA (Hoaglin et al. 1983; Hoaglin et al. 1985). The initial steps of EDA indicated that the catch statistics needed to be transformed in order to stabilize the variances. Two standard transformations were evaluated. The $\log_e$ of the catches plus one transformation and the inverse hyperbolic sine (Arcsinh) transformation are often useful in stabilizing variances in instances of "contagion" (that is, when the animals come in groups or not at all [e.g., high number of zero catches]) (Zar 1974). The Arcsinh transformation performed successfully in reducing variance instability, and was selected for the MANACOVA. All analyses were conducted utilizing the Statistical Analysis System (SAS 1985a, 1985b).

Comparisons between mean length-at-age for each species among gear types were made using a one way analysis of variance (ANOVA). Two-way comparisons between each gear type were made using a Fisher's protected least significant difference (LSD) testing procedure (Ott 1977). These analyses were conducted utilizing the Statistical Analysis System (SAS 1985a, 1985b). Comparisons between numbers of juvenile coho salmon by age class versus each gear type were made using a chi-square contingency table testing procedure.

RESULTS

Habitat Inventory

The surface area proportions of each macrohabitat category for the entire study area have not been delineated at this time due to fiscal and manpower constraints. However, the lineal proportions of the intertidal, transitional, entrenched, and upper zone categories account for 23%, 21%, 35%, and 21% of the study area respectively. Lineal proportions were also estimated for each cover and substrate category within the study area (Figure 4).

Catch and Effort

A total of 10,490 juvenile fish was captured by all gear types (Table 1). Sixteen species representing nine families of freshwater, marine, or anadromous fish were present (Appendix Table 2). Juvenile members of the family *Salmonidae* accounted for 50% of the catch, while *Gasterosteidae* and *Osmeridae* accounted for 25% and 12%, respectively. Juvenile coho salmon, the most frequently captured species, accounted for 41% of the entire catch. Two marine species, Pacific tomcod and snailfish, which were captured in the intertidal reach, were previously unreported for the Kenai River.

Minnow Traps:

Baited minnow traps were fished at 86 sites for a total of 1,433 trap-hours of effort. Water velocities and depths at minnow trap sites ranged from 0 to 70 cm/sec and from 0.06 to 1.2 m, respectively. Turbidity values ranged from 2.6 to 586 NTU. A total of 2,080 juvenile fish, including nine species and representing 3 families were captured using baited minnow traps. Juvenile coho salmon accounted for 91% of the minnow trap catch and were taken at a frequency of 1.32 fish per trap hour (Figure 5).

Multivariate analyses of covariance of the transformed (Arcsinh) minnow trap catches of juvenile chinook, coho, and sockeye salmon as affected by cover, substrate, depth, and velocity were conducted. Due to small sample sizes associated with the original cover and substrate categories, collapsed categories for substrate and cover were developed. The collapsed codes for substrate are:

Collapsed Code	Old Codes	Description
1	1 and 2	silt–sand
2	3.1, 3.9, 4.1, 4.9, and 5	gravel–rubble–boulder

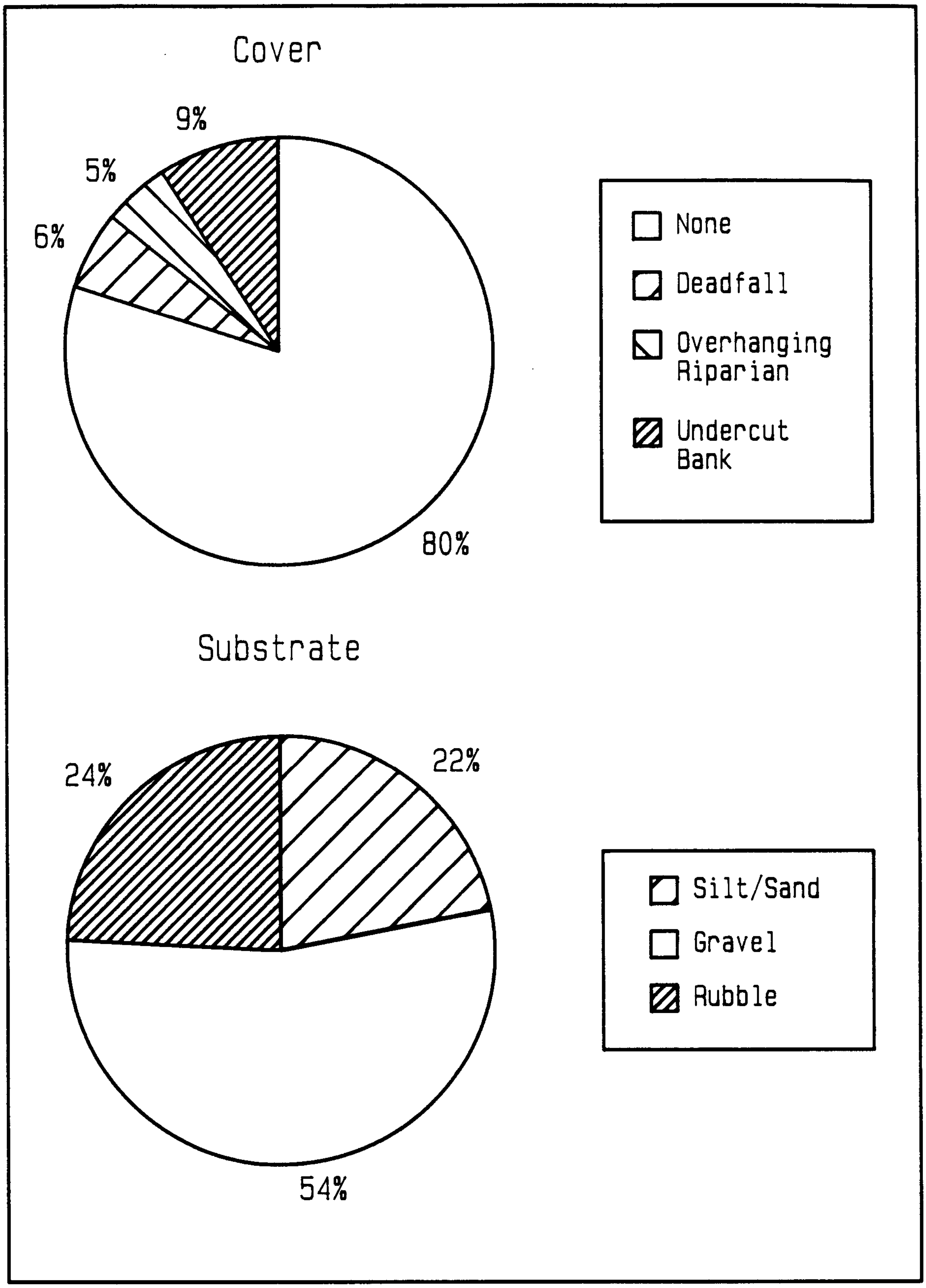

Figure 4. Estimated lineal proportions of selected cover and subtrate categories occurring in the lower 80.5 km of the mainstem Kenai River.

Table 1. Catch composition and numbers of each species captured with three sampling gears in the Kenai River between 8 October 1986 and 14 April 1987.

	GEAR			
Common Name	Minnow Trap	Seine	Substrate Sampler	Total
Chinook Salmon	86	52	273	411
Sockeye Salmon	4	405	35	444
Coho Salmon	1,887	2,033	345	4,265
Rainbow Trout	2	3	11	16
Dolly Varden	15		11	26
Round Whitefish		44		44
Slimy Sculpin	28	284	457	769
Pacific Staghorn Sculpin	2	126		128
Threespine Stickleback	55	2,280	228	2,563
Arctic Lamprey			36	36
Longfin Smelt	8	1,295		1,295
Pacific Herring		8		8
Starry Flounder		337		337
Ninespine Stickleback	1	12	5	18
Pacific Tomcod		128		128
Liparid spp.		2		2
TOTAL	2,080	7,009	1,901	10,490

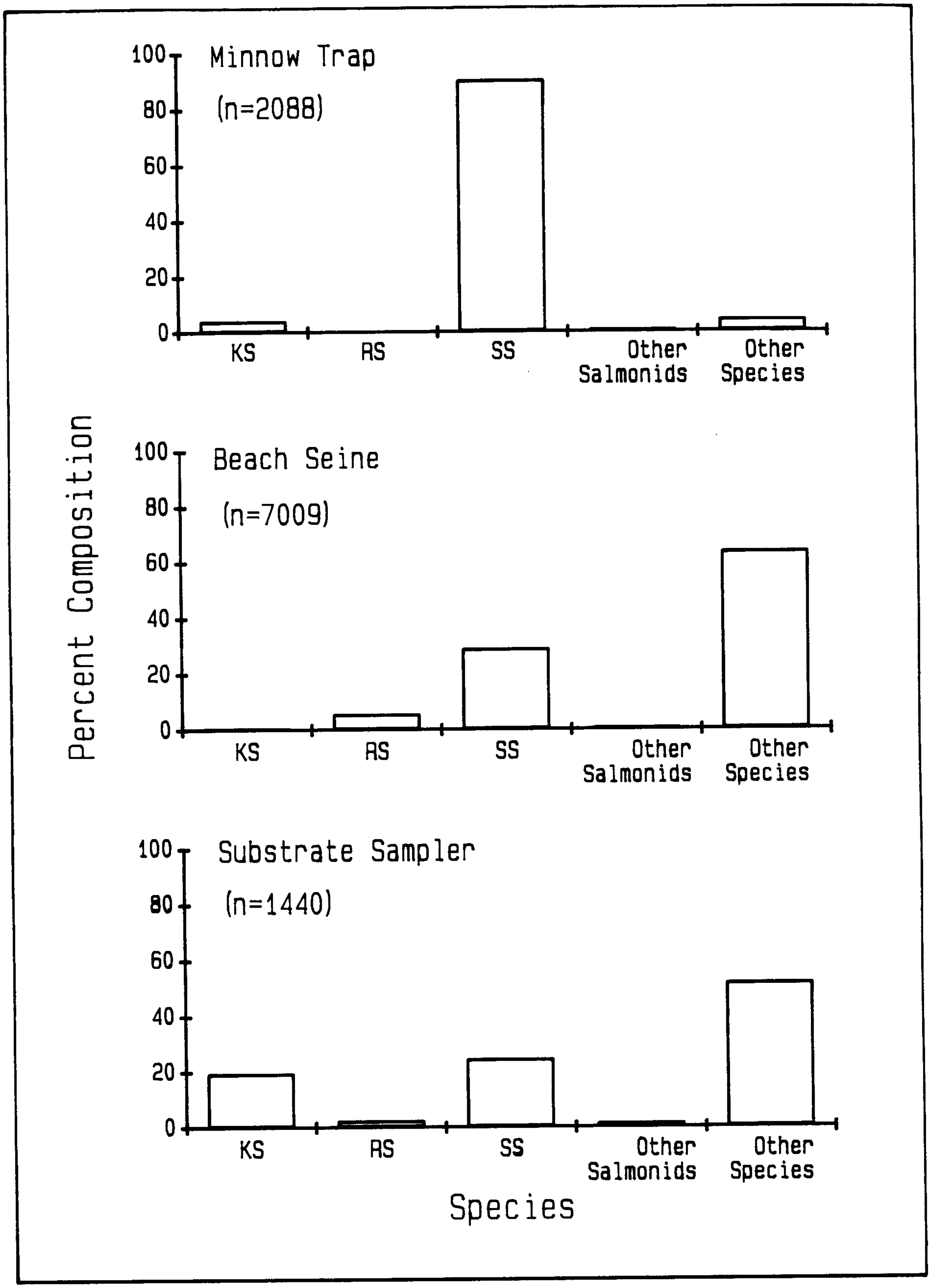

Figure 5. Catch composition of three gear types used in the Kenai River between 14 October 1986 and 2 April 1987.

The collapsed codes for cover are:

Collapsed Code	Old Codes	Description
1	1	no object cover
2	2 and 3	instream cover
3	4, 5, 6, and 7	riparian cover

The analyses indicated that there was no significant (at $\alpha = 0.05$) effect of either cover and substrate types, or depth and velocity levels on the transformed catches of juvenile chinook, coho, or sockeye salmon (Table 2).

Beach seine:

A total of 149 sites, located throughout the lower 80.5 km of the Kenai River were sampled by seine. Water velocities and depths at beach seine sites ranged from 0 to 96 cm/sec and from 0 to 1.0 m, respectively. Turbidity values ranged from 4.7 to 590 NTU. A total of 7,009 juvenile fish representing eight families and 14 species was captured by seine (Figure 5). Of the three gear types, beach seines captured the greatest number and diversity of juvenile fish.

Multivariate analyses of covariance of the transformed (Arcsinh) beach seine catches of juvenile chinook, coho, and sockeye salmon as affected by cover, substrate, depth, and velocity were conducted. As in the case of the minnow trap analyses collapsed codes were used for substrate and cover categories. Due to significant interaction effects between cover types and depth ($\rho = 0.0038$) and velocity ($\rho = 0.0021$), analyses were carried out for each cover type separately. A total of 135 sites were categorized as having no object cover (Table 3). The transformed no object cover juvenile salmon beach seine catches were positively and significantly ($\rho = 0.0062$) related to the level of depth sampled. Transformed juvenile chinook and sockeye salmon catches were most affected by depth levels (with slopes = 0.3850 and 0.4860, $\rho = 0.0063$ and 0.0296, and $r^2 = 0.1031$ and 0.0667, for chinook and sockeye salmon, respectively). Transformed juvenile coho salmon catches were only moderately affected by depth levels (with slope = 0.2941, $\rho = 0.0683$, and $r^2 = 0.0474$). Neither substrate category or velocity were significantly (at $\alpha = 0.05$) related to transformed juvenile salmon catches in the no cover sites.

A total of 13 and 1 beach seine sites were categorized as occurring in areas of instream cover and riparian cover, respectively. This small number of samples precluded further analysis of the beach seine data (Table 3).

Substrate Sampler:

A total of 353 two m^2 substrate plots were sampled at 58 sites. Sixty-one percent of the sites were located in areas of rubble substrate in the entrenched reach of the river. The remaining sites were located in gravel reaches of the upper and lower study area. Substrate sampling was not conducted in the silt sediments of the intertidal reach because fine sediments agitated by the pump would plug the cod end of the capture net. Water

Table 2. Minnow trap depth, velocity, and catch statistics of juvenile chinook, coho, and sockeye salmon by collapsed cover and substrate categories for samples from the Kenai River between 8 October 1986 and 14 April 1987.

Cover Category	Substrate Category	Number of Sites Sampled	Depth (cm) Sample Size	Depth (cm) Mean	Depth (cm) S.E.	Velocity (cm/s) Sample Size	Velocity (cm/s) Mean	Velocity (cm/s) S.E.	Chinook Salmon Catch	Chinook Salmon Arcsinh(Catch) Mean	Chinook Salmon Arcsinh(Catch) S.E.	Coho Salmon Catch	Coho Salmon Arcsinh(Catch) Mean	Coho Salmon Arcsinh(Catch) S.E.	Sockeye Salmon Catch	Sockeye Salmon Arcsinh(Catch) Mean	Sockeye Salmon Arcsinh(Catch) S.E.
NO OBJECT COVER	SILT-SAND	7	5	36.9	8.2	5	2.8	2.1	2	0.2	0.2	5	0.3	0.3	0	0.0	0.0
	GRAVEL-RUBBLE-BOULDER	28	22	36.6	3.9	21	12.0	2.8	2	0.1	0.1	14	0.3	0.1	1	<0.05	<0.05
INSTREAM COVER	SILT-SAND	3	2	65.5	22.9	2	21.7	11.7	1	0.3	0.3	2	0.5	0.5	0	0.0	0.0
	GRAVEL-RUBBLE-BOULDER	8	2	31.1	14.6	2	12.2	9.8	46	1.5	0.5	165	2.1	0.8	0	0.0	0.0
RIPARIAN COVER	SILT-SAND	9	8	81.7	9.4	7	5.7	3.4	1	0.1	0.1	407	2.4	0.9	1	0.1	0.1
	GRAVEL-RUBBLE-BOULDER	31	18	45.8	4.2	16	10.7	2.8	34	0.4	0.2	1294	2.0	0.4	2	0.1	0.0

Table 3. Beach seine depth, velocity, and catch statistics of juvenile chinook, coho, and sockeye salmon by collapsed cover and substrate categories for samples from the Kenai River between 8 October 1986 and 14 April 1987.

Cover Category	Substrate Category	Number of Sites Sampled	Depth (cm) Sample Size	Depth (cm) Mean	Depth (cm) S.E.	Velocity (cm/s) Sample Size	Velocity (cm/s) Mean	Velocity (cm/s) S.E.	Chinook Salmon Catch	Chinook Salmon Arcsinh(Catch) Mean	Chinook Salmon Arcsinh(Catch) S.E.	Coho Salmon Catch	Coho Salmon Arcsinh(Catch) Mean	Coho Salmon Arcsinh(Catch) S.E.	Sockeye Salmon Catch	Sockeye Salmon Arcsinh(Catch) Mean	Sockeye Salmon Arcsinh(Catch) S.E.
NO OBJECT COVER	SILT-SAND	50	32	57.0	1.8	32	10.0	2.1	15	0.2	0.1	125	0.6	0.2	263	0.8	0.2
	GRAVEL-RUBBLE-BOULDER	85	39	53.6	2.8	39	29.4	3.3	31	0.2	0.1	376	0.5	0.1	82	0.4	0.1
INSTREAM COVER	SILT-SAND	2	0			0			1	0.4	0.4	1300	3.9	3.9	52	2.3	2.3
	GRAVEL-RUBBLE-BOULDER	11	3	51.7	4.7	3	23.1	12.6	5	0.3	0.2	232	2.6	0.5	8	0.5	0.2
RIPARIAN COVER	SILT-SAND	0															
	GRAVEL-RUBBLE-BOULDER	1	0			0			0	0.0		0	0.0		0	0.0	

velocities and depths at sites ranged from 0 to 104 cm/sec and 0.15 to 1.0 m, respectively. Turbidity values ranged from 2.3 to 61 NTU. A total of 1,401 juvenile fish representing four families and nine species was captured using the substrate sampler (Figure 5). Members of the family *Salmonidae* accounted for 48% of the catch. Slimy sculpins were the most frequently captured species accounting for 33% of the catch, followed by coho salmon (25%) and chinook salmon (19%). Catch rates were highest in substrate category 4 (rubble) and lowest in substrate category 5 (boulders). The density of juvenile fish was greatest in cover category 3 (rooted aquatic vegetation). Catch rates ranged from 0.0 to 43.5 fish/m^2 with an overall density of 1.98 fish/m^2.

Multivariate analyses of covariance of the transformed (Arcsinh) catches of juvenile salmon as affected by cover, substrate, depth, and velocity were conducted. As in the case of the minnow trap and beach seine analyses, collapsed codes were used for substrate and cover categories. Due to significant interaction effects between cover types and depth ($\rho = 0.0013$) and velocity ($\rho = 0.0001$), the analysis was carried out for each cover type separately. A total of 244 sites were categorized as having no object cover (Table 4). All these sites occurred over substrates categorized as gravel-rubble-boulder. The transformed no object cover juvenile salmon catches were significantly related to both depth ($\rho = 0.0476$) and velocity ($\rho = 0.0001$). The effect of depth was positive in slope, whereas transformed catches were negatively related to velocity. Transformed juvenile chinook and coho salmon catches were more affected by depth levels than were transformed sockeye salmon catches (with slopes = 0.2044, 0.1488, and −0.0026, $\rho = 0.0601$, 0.0192, and 0.7801, for chinook, coho, and sockeye salmon, respectively). Transformed juvenile chinook and coho salmon catches were also more affected by velocity levels than were transformed sockeye salmon catches (with slopes = −0.0044, −0.0056, and −0.0001, $\rho = 0.0373$, 0.0001, and 0.4764, for chinook, coho, and sockeye salmon, respectively). The overall models for each species did not "explain" a substantial proportion of the observed variances in transformed catches in the no cover sites ($r^2 = 0.0222$, 0.0820, and 0.0040, for chinook, coho, and sockeye salmon, respectively).

A total of 82 sites were categorized as having instream cover (Table 4). The transformed catches of the three juvenile salmon species were significantly related to both substrate type ($\rho = 0.0006$) and velocity ($\rho = 0.0001$). The effect of velocity upon transformed catches was negative in slope. Transformed juvenile chinook salmon catches were only moderately affected by velocity levels (slope = −0.0121 and $\rho = 0.2494$). Correspondingly, transformed juvenile chinook salmon catches were highly related to substrate category ($\rho = 0.0088$), with mean transformed catches associated with gravel-rubble-boulder substrate being significantly (at $\alpha = 0.05$) higher than those occurring in silt-sand substrates. Transformed juvenile coho salmon catches were significantly related to velocity levels (slope = −0.0572 and $\rho = 0.0001$). Substrate type did not significantly relate to transformed juvenile coho salmon catches ($\rho = 0.0561$). Similarly, transformed juvenile sockeye salmon catches were significantly related to velocity level (slope = −0.0177 and $\rho = 0.0067$), but not to substrate type ($\rho = 0.0535$). Depth was not significantly ($\alpha = 0.05$) related to transformed juvenile salmon catches in the instream cover sites.

Table 4. Substrate sampler depth, velocity, and catch statistics of juvenile chinook, coho, and sockeye salmon by collapsed cover and substrate categories for samples from the Kenai River between 8 October 1986 and 14 April 1987.

Cover Category	Substrate Category	Number of Sites Sampled	Depth (cm)			Velocity (cm/s)			Chinook Salmon			Coho Salmon			Sockeye Salmon		
			Sample Size	Mean	S.E.	Sample Size	Mean	S.E.	Catch	Arcsinh(Catch) Mean	Arcsinh(Catch) S.E.	Catch	Arcsinh(Catch) Mean	Arcsinh(Catch) S.E.	Catch	Arcsinh(Catch) Mean	Arcsinh(Catch) S.E.
NO OBJECT COVER	SILT-SAND	0															
	GRAVEL-RUBBLE-BOULDER	244	244	39.5	0.8	244	25.3	1.4	147	0.4	<0.05	44	0.1	<0.05	1	<0.05	<0.05
INSTREAM COVER	SILT-SAND	44	44	50.5	2.3	44	3.1	0.7	24	0.3	0.1	96	0.9	0.1	6	0.1	<0.05
	GRAVEL-RUBBLE-BOULDER	38	38	40.7	2.2	38	10.5	2.2	99	0.8	0.2	205	1.4	0.2	28	0.4	0.1
RIPARIAN COVER	SILT-SAND	0															
	GRAVEL-RUBBLE-BOULDER	27	27	54.2	1.1	27	13.6	2.3	3	0.1	0.1	0	0.0		0	0.0	

A total of 27 sites were categorized as having riparian cover (Table 4). All these samples were categorized as occurring over gravel–rubble–boulder substrates. Transformed catches of juvenile chinook, coho, and sockeye salmon were not significantly ($\alpha = 0.05$) related to either depth or velocity levels.

Juvenile Salmon Length and Age Analyses

Fork length and age measurements were obtained from a sample of chinook, coho, and sockeye salmon captured using all three gear types. The samples were comprised of the first fish encountered in the study and were not selected in proportion to gear type or habitat category. Procedures for collecting and preserving samples in blocks of ice resulted in usable scales for age determination following up to 6 months of storage. Summary statistics from samples of juvenile salmon used for length and age analyses are presented in Table 5. Multiple age classes were present in the sample of juvenile coho salmon, while chinook and sockeye salmon samples were composed of age-1 fish only. A chi-square contingency table analysis of juvenile coho samples indicated that the catch by age class was not independent of gear type ($\chi^2 = 33.56$, 4 degrees of freedom, and $\rho = 0.0001$). Analysis of variance testing for differences between length-at-age between gear types for juvenile chinook salmon indicated that age-1 chinook salmon captured by beach seine were significantly larger ($\alpha = 0.05$) than those captured by minnow trap or substrate sampler; whereas, juvenile chinook salmon captured by substrate sampler were significantly larger than those captured by minnow trap. Age-1 coho salmon captured by minnow trap were significantly smaller ($\alpha = 0.05$) than those captured by both beach seine and substrate sampler. Age-1 sockeye salmon captured by beach seine were significantly larger ($\alpha = 0.05$) than those captured by substrate sampler. Juvenile sockeye salmon were not present in age-length samples from minnow trap catches.

Juvenile Fish Distributions

The distribution of juvenile fish in the lower 80.5 km of the Kenai River, based on the upper and lower limits of capture using minnow traps, seines, and the substrate sampler, from October 1986 through April 1987, is shown in Figure 6. Juvenile chinook, coho, and sockeye salmon were captured throughout the study area from the intertidal reach, to Skilak Lake. Five species of marine fish and longfin smelt were limited to the intertidal reach, while Arctic lamprey, rainbow trout, Dolly Varden and round whitefish were only captured above the intertidal area. The diversity of species, based on the composition of catches, decreased with distance upstream from the mouth.

DISCUSSION

Winter Habitat Availability

The mean annual flow of the Kenai River, based on 21 years of data measured at Soldotna (U.S. Geological Survey gage # 15266300), is 167 m^3/s (5,800 cfs) (Still, et al. 1987). Typically, summer flows are dominated by melt-water from ice fields in the headwater drainages and range from 142 to 850 m^3/s (5,000 to 30,000 cfs), while winter flows range from 23 to 142 m^3/s (800 to

Table 5. Summary statistics for juvenile chinook, coho, and sockeye salmon used for length and age analysis.

SPECIES	AGE CLASS	GEAR TYPE	SAMPLE COMPOSITION BY GEAR TYPE (%)	FORK LENGTH (mm) N	MEAN	STDERR	MIN	MAX	RANGE	AGE CLASS 0 (%)	1 (%)	2 (%)
CHINOOK SALMON	1	SEINE	9.9	32	79	1.5	60	98	38			
		MINNOW TRAP	13.6	44	64	1.0	47	78	31			
		SUBSTRATE SAMPLER	76.5	248	74	0.4	52	97	45			
		ALL GEARS COMBINED	100.0	324	73	0.4	47	98	51			
SOCKEYE SALMON	1	SEINE	82.8	159	60	0.6	37	81	44			
		MINNOW TRAP	0.0	0								
		SUBSTRATE SAMPLER	17.2	33	52	1.1	42	68	26			
		ALL GEARS COMBINED	100.0	192	58	0.6	37	81	44			
COHO SALMON	0	SEINE	7.9	3	41	0.3	40	41	1			
		MINNOW TRAP	31.6	12	42	0.7	39	48	9			
		SUBSTRATE SAMPLER	60.5	23	41	0.5	34	44	10			
		ALL GEARS COMBINED	100.0	38	41	0.4	34	48	14			
COHO SALMON	1	SEINE	21.2	80	51	0.7	42	77	35			
		MINNOW TRAP	49.2	186	48	0.3	40	67	27			
		SUBSTRATE SAMPLER	29.6	112	50	0.5	40	65	25			
		ALL GEARS COMBINED	100.0	378	49	0.3	40	77	37			
COHO SALMON	2	SEINE	77.8	7	93	4.3	75	110	35			
		MINNOW TRAP	22.2	2	105	<0.05	105	105	0			
		SUBSTRATE SAMPLER	0.0	0								
		ALL GEARS COMBINED	100.0	9	96	3.7	75	110	35			
COHO SALMON	ALL AGES	SEINE	21.2	90	54	1.4	40	110	70	3.3	88.9	7.8
		MINNOW TRAP	47.1	200	48	0.5	39	105	66	6.0	93.0	1.0
		SUBSTRATE SAMPLER	31.8	135	48	0.5	34	65	31	17.0	83.0	0.0
		ALL GEARS COMBINED	100.0	425	49	0.4	34	110	76	8.9	88.9	2.1

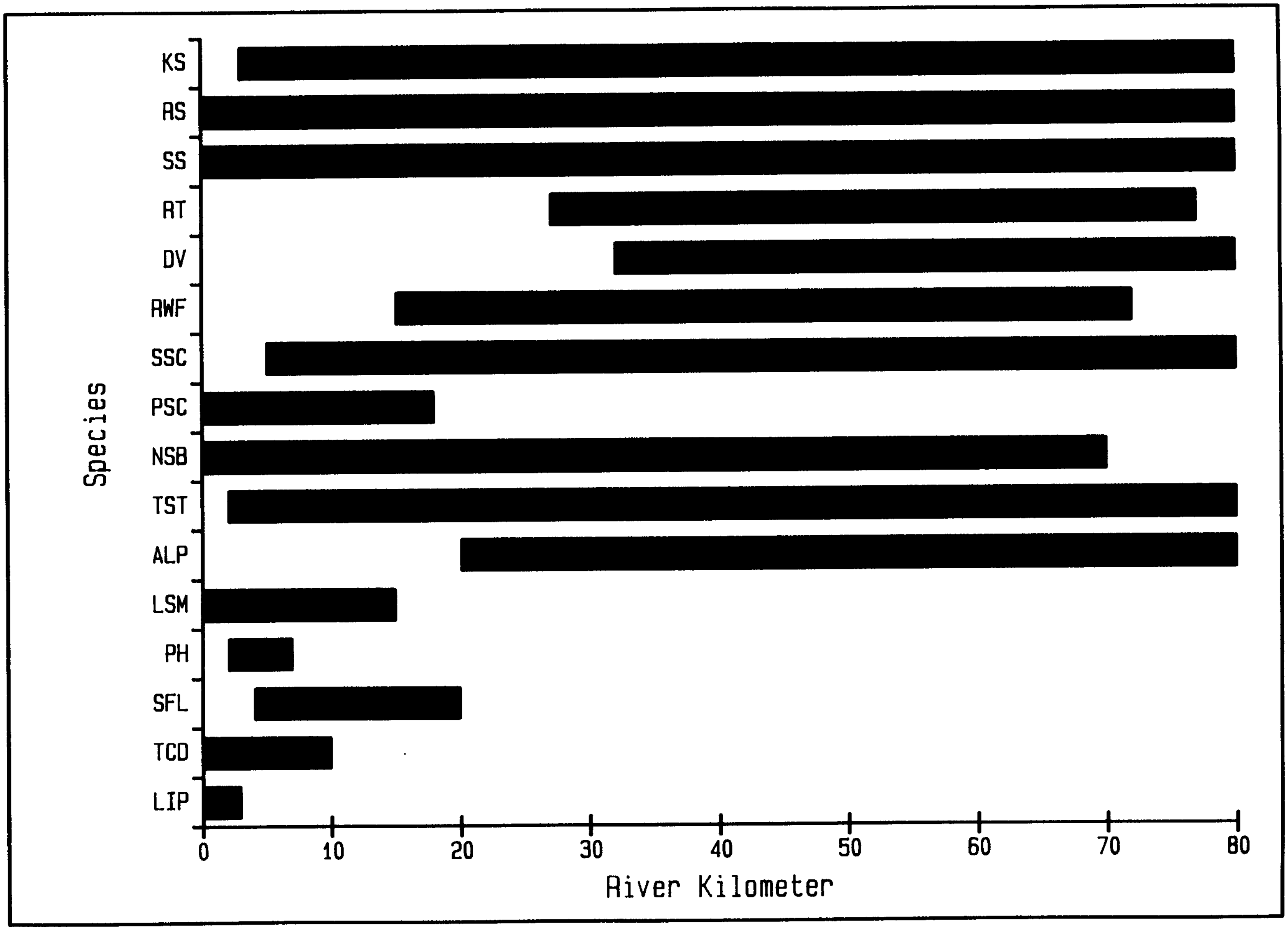

Figure 6. Distribution of juvenile fish in the lower 80.5 km of the Kenai River, based on the upper and lower limits of capture using minnow traps, seines, and a substrate sampler from October 1986 through April 1987.

5,000 cfs). Cover and velocity have been identified as the two most important variables influencing juvenile salmon rearing habitat during the summer months (Burger et al. 1983; Estes and Kuntz 1986). No effort has been made to quantify the type and amount of cover along the river during winter months; however, our study suggests that cover availability in the forms of depth, turbidity, overhanging and instream vegetation undercut banks and instream debris is substantially reduced during periods of low winter flow. Discharge decreased throughout the winter sampling period resulting in a stream margin that was substantially devoid of object cover. Emergent vegetation was not present along the river margin during the winter months. Undercut banks provided the most abundant cover, yet were only available over an estimated 9% of study area. Deadfalls and overhanging riparian vegetation were present over an estimated 6% and 5% of the study area, respectively, and 80% of the study area was judged to have no cover other than substrate and turbidity. Reduced winter flows also decreased the amount of stream margin available to overwintering fish. Shoal areas, side channels, and sloughs were above the wetted perimeter of the river by mid-December. Anabranching reaches of the Kenai between river kilometer 18.3 to 25.4 and 63.7 to 68.7 were reduced to single channel patterns during low winter flows. Turbidity, which is highest in the intertidal reach, rubble substrate which predominates between 35.4 and 63.5 km, and submerged aquatic vegetation which occurs intermittently between the intertidal and Skilak Lake appear to provide the most abundant cover for overwintering juvenile fish.

Gear Limitations

While habitat diversity is substantially reduced during the winter months, it was not possible to sample all locations with a single gear type due to the inherent limitations of each gear. The greatest number and diversity of juvenile fish were captured using a beach seine. Sampling with the seine was limited to habitats that were devoid of cover including deadfalls, undercut banks, large substrates, submerged vegetation, and shore-fast or floating ice. Effective seining was limited to water velocities less than 50 cm/s and depths of 1.0 m or less. Decreased mobility was experienced when seining over silt substrates and fish captured in the process were imbedded in thick mud. Wind velocities experienced on numerous occasions in the Kenai River delta were sufficient to lift the extended seine completely out of the water column. Additionally, tidally exposed beaches of the delta were frozen by mid-winter leaving hard projections of silt and ice that would foul the lead-line on the seine. This limitation was partially eliminated by seining at low tide when most of the sampling could be done below the frozen sections of beach. Within these limitations, seining was conducted effectively in the intertidal zone, and along exposed gravel bars in the transitional and upper zones of the study area. The small number of seine samples obtained in areas of instream and riparian cover precluded detailed analysis of transformed catches and habitat variables. The no object cover juvenile salmon beach seine transformed catches were positively and significantly related to the level of depth sampled. The length of each seine haul was standardized, but the width varied with the slope of the beach (out to the 1.2 m depth contour); thus, the relationship observed between transformed catches and depth may also be a function of effort since more water is filtered through the seine at deeper sites. The lack of significant relationships between juvenile salmon beach seine transformed catches and substrate category or velocity may have resulted from the narrow range of these variables within which the seine could be deployed. Juvenile salmon captured by seine were significantly larger than those captured by either minnow trap or substrate sampler. The relationship between gear type and juvenile salmon size may be a function of the differences between habitats sampled by the various gears. Investigations in Idaho indicate that juvenile chinook salmon progressively increase their distance from cover and occupy faster, deeper water as they increase in length (Hillman et al. 1987). The beach seine was typically deployed in the absence of cover along unobstructed beaches and sampled a greater depth and distance from shore than either minnow traps or the substrate sampler.

Minnow traps were deployed effectively in areas of low velocity and dense cover. Minnow traps would not remain in place when velocities exceeded 40 cm/s. They could be deployed in all cover and substrate categories and depths encountered within the study area. Minnow trapping in the intertidal zone was limited by fluctuations in water level and velocity. During a 30 minute soak period, it was often necessary to reposition the traps one or more times due to decreasing water levels or increases in velocity. Minnow traps were the least effective method of capturing fish during the study period. Age-1 chinook and coho salmon captured by minnow trap were significantly smaller than those captured by beach seine and substrate sampler. Minnow traps caught only nine of the 16 species encountered in the study area and a single species, coho salmon, accounted for 91% of the minnow trap catch. The lack of significant effects of either cover and substrate categories or depth and velocity levels on the minnow trap transformed catches of juvenile salmon suggest that minnow traps were the least effective gear used to investigate potential sources of variation in fish habitat preference. Baited traps catch fish from an undetermined area in which microhabitat measurements more often characterize the trap locations, rather than the habitat occupied by the fish.

The substrate sampler provided quantitative capture data but could only be deployed in a narrow range of habitats. Assuming that the apparatus captured all of the fish that were present in each 2 m^2 sample station, accurate information on the apportionment, diversity, and density of species overwintering within the substrate can be obtained using this gear. The sampler was deployed successfully in velocities up to 100 cm/s and depths of 1 m. Increased depths could be sampled by extending the length of the venturi tube on the pump. Sampling was not successful in the fine sediments of the intertidal area. Sediments agitated in this reach would completely fill the cod end of the capture apparatus. Sampling in boulder substrates was also unsuccessful because a tight seal around the bottom perimeter of the capture net could not be obtained and in large substrates, interstitial spaces provided alternate escape routes. Successful sampling was conducted in substrates ranging from 2.0 cm to 40.0 cm in diameter. During periods of sub-freezing temperatures, ice accretion on the capture frame netting would increase the weight of the apparatus beyond that which was convenient for a single person to handle. The impeller housing on the gasoline powered pump would freeze between intervals of use and would require thawing with an external source of heat. During extended periods of sub-zero temperatures, frazil ice would cover the entire stream bed to a depth of approximately 15 cm. Sampling through this layer of ice was not successful because the dislodged ice would fill the capture net. Multivariate analyses of covariance indicated that of the three gears used, the substrate sampler was most effective for investigating potential sources of variation in juvenile salmon winter habitat preference. The transformed catches of juvenile salmon species were significantly related to substrate type, depth, and velocity. These findings are consistent with observations made during the open water season in the Kenai River (Burger et al. 1983; Estes and Kuntz 1986). Analysis by collapsed cover categories suggest that the importance of depth, velocity, and substrate varies with cover availability. Juvenile salmon captured by substrate sampler were intermediate in size compared to those captured by beach seine and minnow traps.

Overwintering Strategies of Principle Salmon Species

Juvenile coho, sockeye, and chinook salmon overwinter throughout the mainstem of the Kenai River between Skilak Lake and Cook Inlet. Reduced bank cover, turbidity, discharge, and stream margin during the winter season eliminates many of the habitats occupied by these species for rearing and feeding during the summer months. While many fish may enter tributaries such as the Killey River or Skilak Lake to overwinter, investigating those areas was beyond the scope of this study.

Ice accretion throughout the river was intermittent during the study period. The entrenched reach experienced intermittent episodes of shelf ice accretion over shallow margin areas. The transition reach was ice-covered except for the mid-channel areas for most of February and March. The intertidal reach was covered with broken ice from mid-January through March. Temporary jams that backed up significant amounts of ice and water occurred on several occasions in the vicinity of river kilometer 22. When ice jams eroded, the impounded ice was deposited along the stream margins leaving a vertical wall of ice up to 3 m high at the waters edge. These vertical walls of ice eliminated any remaining shoreline cover that may have been utilized by juvenile fish, and extended along both banks from 9.6 to 27.4 km during January through mid-April.

Various size substrates, the open water column, and limited areas of cover including submerged mats of aquatic vegetation are the few remaining habitat components available to rearing fish during the winter months in the mainstem of the lower Kenai River. Large numbers of juvenile salmon, which are readily observed along the stream margin during summer months, were seldom observed during more than 60 days of winter sampling.

Multiple overwintering strategies were indicated for juvenile chinook, coho, and sockeye salmon. All three species were present throughout the sampling period from the outlet of Skilak Lake, downstream to the brackish intertidal reach. If we assume that the seine sampled only the water column in habitats devoid of cover, minnow traps sample margin habitats with cover, and the substrate sampler sampled inter-substrate habitats; an indication of utilization in broad categories of habitat can be obtained by comparing the apportionment of the three species in the catch in each category (Figure 7).

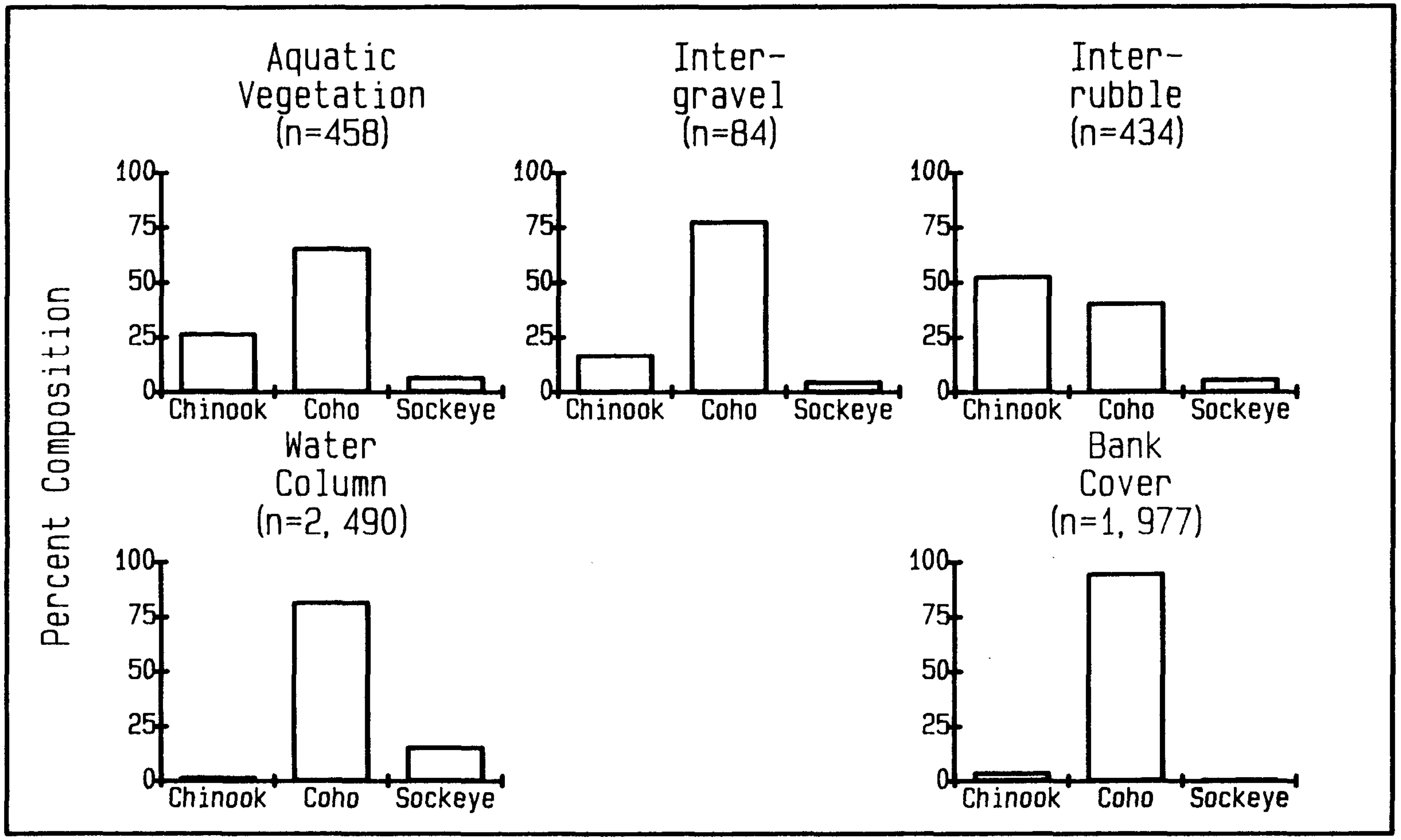

Figure 7. Juvenile salmon percent species composition captured in selected habitat categories in the mainstem Kenai River.

Juvenile coho salmon comprised a high proportion of the salmon catch in all selected categories with the highest proportion found in areas of bank cover and the least in rubble substrates. Juvenile sockeye salmon comprised a relatively small proportion of the salmon catch in all categories, having the highest frequency of capture in the water column with no object cover. Juvenile chinook salmon were intermediate in use of all selected categories but were most frequently captured overwintering within rubble substrates. A chi-square contingency table analysis of the catch of each salmon species by habitat category indicated that species composition was not independent of habitat ($\chi^2 = 1723.98$, 8 degrees of freedom, and $\rho < 0.001$). These data suggest that sympatric populations of juvenile salmon are segregated during winter months in the Kenai River; however, a considerable amount of overlap in habitat use occurs. These general findings are consistent with other investigations of juvenile salmon overwintering behaviors. Bustard and Narver (1975) found juvenile coho salmon utilizing bank cover more readily than rubble cover in a British Columbia study. Everest (1969) found juvenile chinook salmon overwintering within rubble substrates in two Idaho streams and suggested that no juveniles could be found above the substrate when stream temperatures fell below 5^oC. Everest found a mean density of 0.01 chinook/m^2 in a sample of 135 m^2 of substrate. Our density of chinook in substrate category 4 (0.50/m^2) was substantially higher for the Kenai River. Juvenile sockeye salmon typically migrate to nursery lakes located within spawning drainages (Scott and Crossman 1973). Our studies indicate that a small number of juvenile sockeye salmon remain in the lower mainstem of the Kenai River to rear throughout the winter.

Studies conducted during the open water season in the Kenai River have suggested that populations of juvenile chinook salmon are relatively open, indicating significant recruitment of fry occurs into and out of a site over time; while winter studies suggest that distributions of juvenile chinook salmon are relatively stable (Estes and Kuntz 1986; Litchfield and Flagg 1986). Due to inter-substrate overwintering behavior, and the likelihood of stable distributions during winter months, we recommend continued use of the substrate sampler to estimate juvenile salmonid density (fish/m^2) by river reach and macrohabitat category in the mainstem Kenai River.

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APPENDIX

Appendix Table 1. Macrohabitat matrix developed for winter flow conditions in the lower 80.5 km of the mainstem Kenai River.

1. INTERTIDAL 0.0 to 18.5 km
    1. MAIN CHANNEL
        1. Modified
        2. Unmodified
    2. SIDE CHANNEL
        1. Modified
        2. Unmodified
    3. ISLAND
        1. Modified
        2. Unmodified
    4. TRIBUTARY
        1. Modified
        2. Unmodified

2. TRANSITIONAL 18.5 to 35.0 km
    1. MAIN CHANNEL
        1. Modified
        2. Unmodified
    2. SIDE CHANNEL
        1. Modified
        2. Unmodified
    3. ISLAND
        1. Modified
        2. Unmodified
    4. TRIBUTARY
        1. Modified
        2. Unmodified

3. ENTRENCHED 35.0 to 63.5 km
    1. MAIN CHANNEL
        1. Modified
        2. Unmodified
    2. SIDE CHANNEL
        1. Modified
        2. Unmodified
    3. ISLAND
        1. Modified
        2. Unmodified
    4. TRIBUTARY
        1. Modified
        2. Unmodified

4. UPPER 63.5 to 80.5 km
    1. MAIN CHANNEL
        1. Modified
        2. Unmodified
    2. SIDE CHANNEL
        1. Modified
        2. Unmodified
    3. ISLAND
        1. Modified
        2. Unmodified
    4. TRIBUTARY
        1. Modified
        2. Unmodified

Appendix Table 2. List of common names, scientific names, and abbreviations used for fish captured in the lower 80.5 km of the Kenai River between October 1986 and March 1987.

Family Common Name	Scientific Name	Abbreviation
Salmonidae		
Chinook Salmon	*Oncorhynchus tshawytscha* (Walbaum)	KS
Sockeye Salmon	*Oncorhynchus nerka* (Walbaum)	RS
Coho Salmon	*Oncorhynchus kisutch* (Walbaum)	SS
Rainbow Trout	*Salmo gairdneri* Richardson	RT
Dolly Varden	*Salvelinus malma* (Walbaum)	DV
Round Whitefish	*Prosopium cylindraceum* (Pallas)	RWF
Cottidae		
Slimy sculpin	*Cottus cognatus* Richardson	SSC
Pacific Staghorn Sculpin	*Leptocottus armatus* Girard	PSC
Gasterosteidae		
Threespine Stickleback	*Gasterosteus aculeautus* Linnaeus	TST
Ninespine Stickleback	*Pungitius pungitius* (Linnaeus)	NSB
Petromyzontidae		
Arctic lamprey	*Lampetra japonica* (Martens)	ALP
Osmeridae		
Longfin Smelt	*Spirinchus thaleichthys* (Ayres)	LSM
Clupeidae		
Pacific Herring	*Clupea harengus pallasi* Valenciennes	PH
Pleuronectidae		
Starry Flounder	*Platichthys stellatus* (Pallas)	SFL
Gadidae		
Pacific Tomcod	*Microgadus proximus* (Girard)	TCD
Cyclopteridae		
Snailfish	*Liparus* spp.	LIP