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HABITAT UTILIZATION

BY FISHES IN THE TANANA RIVER NEAR

FAIRBANKS, ALASKA

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by

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ABSTRACT

This study evaluated summer habitat utilization of fishes and the effects of floodplain developments on fish and aquatic habitat in the glacially-fed Tanana River near Fairbanks, Alaska. Aquatic habitats were quantitatively described on the basis of water velocity, depth, and clarity, and substrate, cover and vegetation. Lake chub and longnose sucker were abundant in all habitats. Whitefishes, juvenile salmon, and northern pike were captured most frequently in areas with high water clarity. Burbot preferred deeper, turbid waters. Young-of-the-year of lake chub and longnose sucker preferred shallow, silty backwaters; juvenile lake chub demonstrated no habitat preferences; and adult lake chub, juvenile longnose sucker, and juvenile/adult slimy sculpin preferred gravel riffles. Bank stabilization activities have significantly modified aquatic habitat and fish communities of Tanana River backwaters. In general, free-flowing sidechannels have become blocked-off sloughs resulting in reduced turbidities and lower flows.

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INTRODUCTION

Most of the information concerning habitat requirements of Alaskan stream fishes has come from studies on clear-runoff streams. Little is known about the habitat requirements of fish in large, braided, glacial-runoff rivers such as the Tanana River in interior Alaska. Few formalized studies have been conducted on such river types, and their ecological value is poorly understood, especially in a quantitative sense. Yet, these streams are known to act as important migration routes and are thought to provide overwintering habitat for migratory fish species (Van Hyning 1976; Francisco and Dinneford 1977; Van Hyning 1978). But the key habitat characteristics and their range of values preferred by certain fish species must be known in order to mitigate the effects of habitat alteration. Activities such as damming, diverting, dredging, and filling have resulted in the permanent loss of fish habitat in scores of rivers in the continental U.S. A prime example is the middle Mississippi River where navigation and flood control activities have reduced the total water surface area by 40 percent since 1881 with most of these losses occurring in ecologically rich wetlands, sidechannels, and backwaters (Rasmussen 1979). Also in this period, the water surface of the Missouri River has been reduced by as much as 67 percent due to construction and maintenance of the 2.7 m (nine-foot) navigation channel (Morris et al. 1968). Channelization of the river has resulted in a reduction in the size and variety of aquatic habitat by destroying many productive areas. Although more limited in scope, the same kinds of activities have recently begun on the Tanana River, especially near Fairbanks, and more can be expected in the near future.

The purposes of this study were to describe the habitat utilization by fishes in the Tanana River near Fairbanks and to evaluate the effects of floodplain developments on the fishes and their habitat in the study area. To fulfill the study purposes I prepared quantitative and qualitative descriptions of habitat types in the Tanana River; determined the relative importance of these habitats to the life stages of various species; developed habitat suitability indices for selected fish species and life stages; compared composition and relative abundance of fish in unmodified backwaters with those modified by floodplain developments; and developed a habitat classification scheme for Tanana River fishes.

Financial support and equipment were provided by the U.S. Fish and Wildlife Service (USFWS) through the Alaska Cooperative Fishery Research Unit (ACFRU). In addition, I was supported during my final semester of study by a grant from the University of Alaska, Fairbanks, through the Office of the Vice Chancellor for Research and Advanced Studies.

I appreciate the support and cooperation of my committee members. My major advisor, Dr. James B. Reynolds, provided overall guidance for for the study and critically edited the manuscript. Mr. Robert H. Armstrong, Dr. Mark W. Oswood, and Dr. Samuel J. Harbo reviewed the manuscript and supplied valuable advice.

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Finally, I thank my wife Barbara for financial and moral support, typing countless manuscripts, and field assistance on numerous occasions. Without her endless sacrifices none of this would have been possible.

AREA DESCRIPTION

The Tanana River drains approximately 115,000 km^2 of eastern interior Alaska (Figure 1). This braided, constantly shifting river is the largest tributary of the Yukon River discharging over 215 million m^3 per year. Flowing through a broad alluvial valley, the Tanana is fed primarily by glacial rivers draining the Alaska Range to the south and by non-glacial streams to the north comprising 85 and 15 percent, respectively, of the total basin discharge.

The Tanana River basin lies within the spruce-birch forest of the western extension of the North American boreal forest. Undisturbed vegetation along the river floodplain consists primarily of sedges, resin birch, ericaceous shrubs, willow, alder, black spruce, paper birch, tamarack, balsam poplar, and white spruce. Succession on disturbed areas follows a pattern of willow and alder, balsam poplar, white spruce, and black spruce and tamarack with stands of white spruce dominating. Various natural features of the Tanana River basin have been described by Anderson (1970), Viereck (1970), Selkregg (1974), Shallock and Lotspeich (1974), USACE (1980), and Collins (1981).

Fairbanks, the largest city in the drainage basin, is located at the confluence (elevation, 425 m above mean sea level) of the Chena and Tanana Rivers, 400 km by highway northeast of Anchorage and 161 km south of the Arctic Circle. The climate of the Fairbanks area is characterized by long, cold winters and short, warm summers

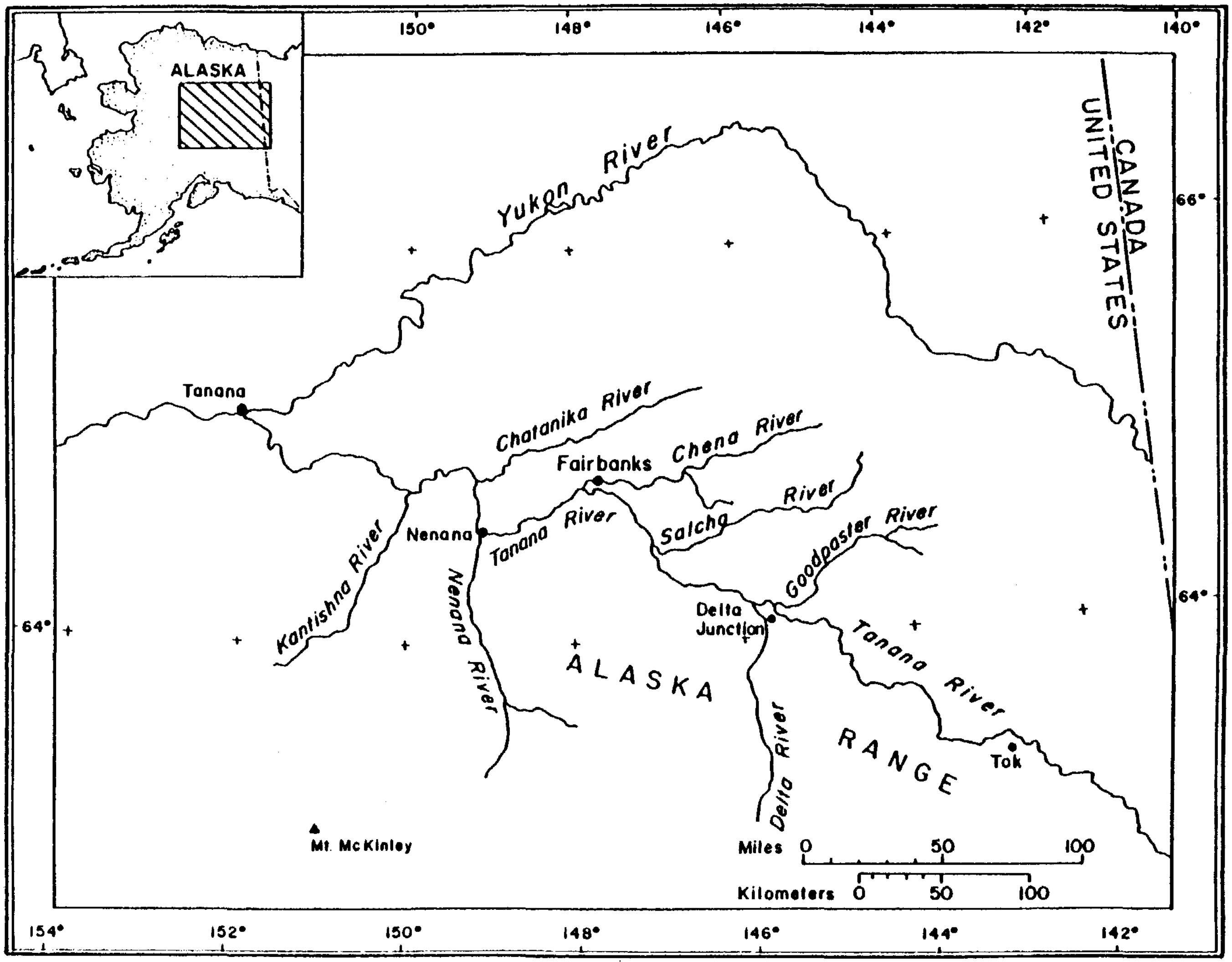

Figure 1. The Tanana River drainage.

with an annual average temperature of -3.5 C and extremes of -54 C and 37 C. Precipitation averages 250 to 560 mm of water equivalent per year with 760 to 1500 mm of snow.

Upstream from Fairbanks, the Tanana River has a braided pattern with unstable banks and a steep shallow course with multiple channels. Near Fairbanks it changes to a meandering river consisting primarily of a single channel with bends in a more or less regular series; in this area, the active floodplain width is between 600 and 900 m. The study area, which lies within this zone of transition, encompassed a section of the Tanana River from 2.9 km below to 2.2 km above the Chena River confluence (Figure 2). Study site locations are given in reference to the Chena Pump Campground (CPC). Within the study area were four primary and four supplemental study sites. Primary sites were selected for intensive sampling and habitat mapping and to evaluate the effects of bank stabilization activities on fish communities and aquatic habitat. Supplemental study sites allowed: comparisons of fish communities in main channel versus backwater habitats; sampling in areas affected by floodplain developments; and sampling during high water periods.

Primary study sites were Morgan Island slough, Airport side channel, Byers Island sidechannel, and Wenrich Island sidechannel hereafter referred to as Morgan, Groin 1, Byers, and Wenrich respectively (Figure 2). Morgan is a modified clearwater slough 2.2 km upstream from CPC. Once a major sidechannel of the Tanana,

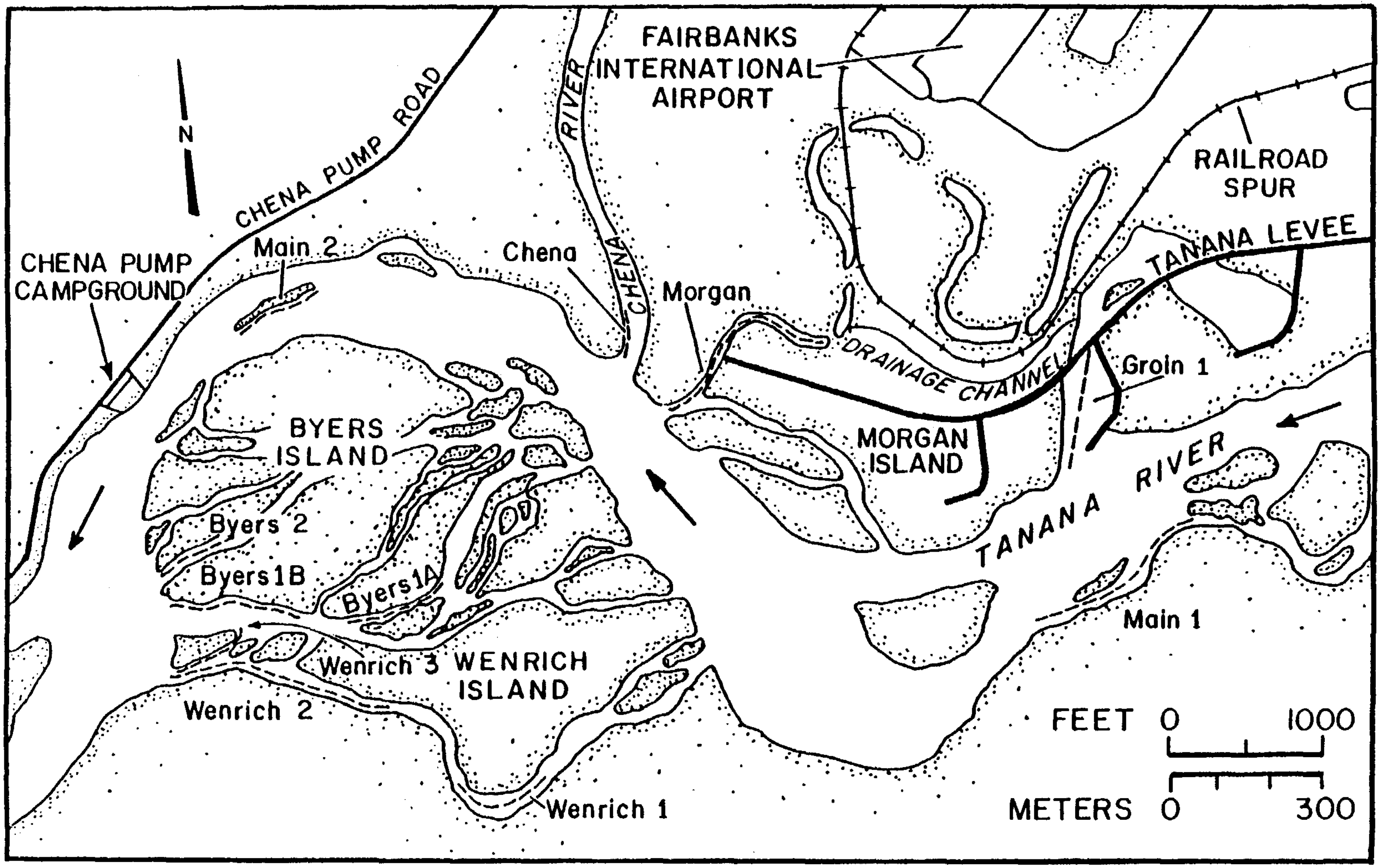

Figure 2. Tanana River study area near Fairbanks, Alaska. Dashed lines indicate extent of sampling sites.

it was diked in 1960 to permit expansion of the Fairbanks International Airport. Originally 4.2 km long, only the lower 1.0 km of Morgan presently connects with the main channel. Upstream 4.9 km from CPC, Groin 1 is a large, deep, lake-like backwater created by an L-shaped current deflection structure (groin) associated with the Chena River Flood Control Project. This area will eventually become filled with silt and invaded by terrestrial vegetation (USACE, 1980). Morgan and Groin 1 were considered as treatment sites because of habitat alterations. Selected as a control for Groin 1, Byers is a large free-flowing sidechannel 0.5 km downstream from CPC. Sampling occurred only in the lower 1.1 km. As a control for Morgan, Wenrich is a longer and narrower sidechannel just downstream from CPC. Wenrich was sampled from the mouth upstream 1.4 km.

Supplemental study sites and their respective abbreviations are Chena River mouth (Chena), Byers Island sidechannel 2 (Byers 2), and a main channel backwater (Main 1) and sandbar (Main 2). Main 1 and Chena were not sampled in 1982 due to time constraints. All sites are designated on the study area map (Figure 2). Chena is a wide, deep river mouth at the confluence of the Tanana and Chena Rivers. It is located 2.1 km above CPC and was sampled from the confluence upstream 100 m. Byers 2, a small, shallow, intermittent sidechannel was sampled only in the lower 500 m. Main 1 is a main channel backwater 4.8 km above CPC. Sampling was limited to a 200 m portion of the main channel shoreline. Upstream from CPC 0.7 km, Main 2 is a large, main channel sandbar that constantly changes shape as with changes in river levels and discharges. Sampling occurred along the entire southern edge.

METHODS

During the 1981 field season, point measurements of habitat variables at each fish collection site were emphasized. Efforts in 1982 were directed more at describing the fish communities and physical and chemical characteristics of major habitat types and the effects of bank stabilization activities. In addition, the use of measurements and gear types that gave highly variable results or were particularly non-productive in terms of explaining fish-habitat relationships was discontinued in 1982.

Seining Stations

Seining stations representing obvious habitat types within study sites were established at Byers and Wenrich. All stations are shown on the study area map (Figure 2). Byers was divided into two stations. Station 1A was from a point 1.1 km upstream from the mouth downstream to the first bend. Station 1B extended from the mouth upstream 500 m. Station 1 at Wenrich was from a point 1.4 km upstream from the mouth to a point downstream 200 m. Station 2 ran from the mouth upstream 700 m. Station 3 consisted of two small, shallow, intermittent sidechannels between Byers and Wenrich.

Fish Sampling

Fish were captured with seines, minnow traps, frame nets, gill nets, and boat electroshocker. Seines were 6.1 m (20 feet) long and 1.2 m (4 feet) wide with 4 mm (0.13 inches) and 6 mm (0.25 inches) mesh. Seines were hauled upstream for 9.1 m. After each haul captured fish were released 10 m downstream to avoid recapture. Measurements of habitat variables were taken after seining was completed.

Minnow traps were made of 6 mm (0.25 inches), galvanized-wire mesh and were 0.4 m (16 inches) long and 0.2 m (8 inches) in diameter. Traps were baited with salmon eggs cured in borax and set along randomly selected transects or at systematic intervals from a randomly selected starting point along the shoreline.

Frame nets were single-throated and 2.4 m (8 feet) long with 25 mm (1 inch) mesh covering five 0.8 m (30 inches) diameter steel hoops and a 0.9 m (3 feet) x 1.5 m (5 feet) rectangular entrance frame with a 10.7 m (35 feet) long by 1.2 m (4 feet) wide lead. Nets were attached to the shore and set as perpendicular to the current as possible with a weight attached to the cod end to keep the net taut.

Sinking, monofilament gill nets were 38.1 m (125 feet) long and 1.8 m (6 feet) wide with 7.6 m (25 feet) long panels of 25, 51, 76, 102, and 127 mm (1, 2, 3, 4, and 5 inches) mesh (stretch measure). Nets were attached with small mesh towards the shoreline and set perpendicular to the current with weights on each end.

The boat-mounted electrofishing gear was powered by a 3500-watt, 60 cycle generator using alternating electrical current. Fishing was usually done at 240 volts and 2 to 5 amperes. Three electrodes made of 9.5 mm (0.38 inches) flexible-steel conduit filled with lead shot were attached to a 2.1 m (7 feet) boom in the front of the boat. Standard procedure was to electrofish against the current for 0.5-hour periods with two persons in the bow collecting fish with long-handled dip nets.

Standard units of effort for passive gear were number of fish captured per 24 hour period; for seines, number captured per 9.1 m haul; and, for electroshocker, number captured per 0.5-hour period. Passive gears were fished for at least 24 hours. It was assumed that catch-per-unit-effort (C/f) of the various methods was a representative measure of relative fish abundance in the different river habitats.

Physical and Chemical Measurements

In 1981, point measurements of depth, velocity, and substrate were taken at the upstream ends of minnow traps and at three equally-spaced intervals along each gill net set. In 1982, these measurements were primarily obtained from concurrent habitat mapping or, in some instances, from point measurements. In both 1981 and 1982, substrate, depth, and velocity were measured at three equally-spaced intervals along transects perpendicular to the direction of flow at the midpoint of each 9.1 m seine haul.

Mean flow velocity was estimated by taking all measurements at 0.6 of total depth for depths less than 0.8 m, and at 0.2 and 0.8 of total depth for depths greater than or equal to 0.8 m. Discharge was estimated at selected stations in conjunction with habitat mapping by procedures described by Trihey and Wegner (1981).

The dominant substrate at sampling points was visually categorized as:

Substrate	Particle Size (mm)	Scale
detritus	-	1
mud (loam)	-	2
silt-clay	< 0.1	3
sand	0.1-1.9	4
fine gravel	2.0-7.9	5
medium gravel	8.0-15.9	6
coarse gravel	16.0-63.9	7
rubble	64.0-129.9	8
cobble	130.0-249.9	9

The amount of vegetation and the amount of cover other than vegetation were recorded as absent, low, moderate, or high. Estimates were based on linear transect measurements at primary sites and seining locations and on visual observations at supplemental study sites.

Information on erosional and depositional areas, 1:24,000 scale aerial photography, and river cross-sections was obtained from CRREL. River discharge and cross-sectional information was obtained from USGS.

Techniques, equipment specifications, units, and accuracy for various physical and chemical measurements are listed in Table 1.

Table 1. Accuracy of equipment used for physico-chemical measurements.

Parameter	Instrument	Accuracy
pH	Hach DR - EL/4 Portalab	0.1 unit
Alkalinity	Hach DR - EL/4 Portalab	0.1 mg/l
Hardness	Hach DR - EL/4 Portalab	0.1 mg/l
Dissolved Oxygen	Hach DR - EL/4 Portalab	0.1 mg/l
Turbidity	Hach Model 201 Turbidimeter	2.0 NTU
Water Clarity	200 mm Secchi Disc	5.0 mm
Temperature	Pocket Thermometer	1.0 C
Conductivity	Hach Model 17250 Mini-Conductivity Meter	10.0 micromhos/cm
Water Velocity	Marsh-McBirney Model 201 Current Meter	2.0 cm/s
Depth	Surveyor Level Rod	0.1 m

Habitat Mapping

General fish habitat characteristics of primary sites were quantified by the transect method of stream habitat inventory (Dunham and Collotzi, 1975). Because this technique was developed for smaller streams, some modifications were necessary. For example, transects were placed at 110 m intervals rather than the recommended 15 m. The transect method employs cross-channel, tape-measured lines called transects to quantify habitat variables. The first transect at each study site was randomly selected within the first 50 m of the upstream station boundary at each site. Distances between transects were determined to the nearest 1 m with a range-finder and marked with wooden stakes and flagging tape above the high water mark on each bank. At each transect, a pre-stretched polypropylene rope marked at 1 m intervals was pulled taut with a 1000 kg hand winch between two steel fenceposts driven into the bank at each high water mark.

Depths were recorded to the nearest 1 cm at 1 m intervals up to 10 m from each bank and then at 5 m intervals. Average depth was found by summing the number (n) of individual depth measurements and dividing the sum by n + 2. This gave weight to zero depths at bank points. Channel width was the distance between high water marks and total width, the width of the water surface.

Substrate samples were taken at each depth interval with a Ponar dredge attached to a boat mounted boom and 5000 kg hand winch. Velocities were measured at 1 m intervals and discharge estimated for at least one transect at each primary site. Vegetation, cover, and substrate were recorded over the distance of a transect and expressed as percent of total width.

Data Analysis

Velocity, depth, and substrate habitat suitability indices (HSI) were calculated from seining information for young-of-the-year (YOY), juvenile, and adult lake chub; YOY and juvenile longnose sucker; and juvenile and adult slimy sculpin according to procedures developed by Bovee and Cochnauer (1977), USFWS (1980, 1981), Orth et al. (1981) and Orth and Maughn (1982). Terms used to distinguish life stages were taken from Balon (1980) and Morrow (1980). Young-of-the-year are fish in the 0+ age group. Juvenile is "a small adult from appearance of all definitive structures to the first maturation of gametes." Sexually mature fish beyond the juvenile stage are termed adults. Separation of individuals into the various life stages was done on the basis of length frequency information from Pierce (1977) for longnose sucker, from Sonnichsen (1981) for slimy sculpin and from length frequencies calculated from data collected during this study and unpublished information (personal communication, Willard Barber, University of Alaska, Fairbanks, Alaska) for lake chub. Chi-square goodness-of-fit (Conover, 1980) was used to test the null hypothesis that the distribution of frequency of capture (C/f) was the same as that for the amount of habitat sampled. Intervals for which observed values were greater than expected indicated preferences by fish for the habitat characteristics. Independence of life stage and habitat variables was tested with chi-square tests of independence (Conover, 1980).

For each interval of values of a habitat interval, the number of fish captured was divided by the amount of area sampled to obtain absolute density (number/area). Suitability indices were then calculated by dividing the absolute density for a given interval by the density within the optimum interval. The optimum interval was arbitrarily assigned a value of 1.0 and was defined as the highest density for each habitat variables.

Differences in C/f for each species and gear type among study sites and/or sampling stations were tested with Kruskal-Wallis (K-W chi-square) nonparametric one-way analysis of variance (Conover, 1980). Only those species occurring in four percent or greater of the total catch for a given gear type were considered in the analysis. Kruskal-Wallis ANOVA was also used to test the null hypothesis of no difference in point measurements of habitat variables at primary and supplemental study sites in 1981 and at seining stations (1981 and 1982 combined). Differences in C/f or habitat characteristics were considered significant only if p-values (the probability of observing a value of the test statistic at least as extreme as an observed value when the null hypothesis is true) were less than or equal to $\alpha/2c$ where α equals 0.05 and c equals the number of species or variables being tested. This was done to compensate for experiment-wise error rate (Conover, 1980). If the Kruskal-Wallis test was significant, a multiple comparison procedure (Conover, 1980) was employed to examine all possible pairwise differences in C/f or habitat variables among sites or stations. All analyses were conducted using BMDP program packages (Dixon and Brown, 1981).

AQUATIC HABITAT CHARACTERISTICS

Results

Differences in water quality were observed among study sites (Table 2). Dissolved oxygen concentrations were lower at Morgan and Groin 1 than at other sites on both spring and fall sampling dates. Highest dissolved oxygen concentrations occurred at Main 2. None of the dissolved oxygen concentrations observed at any site represented levels harmful to fish. The differences observed were due to the higher turbulence and mixing in sidechannels and the main channel than in modified backwaters.

Hardness and pH values were higher at Morgan than at any other site (Table 2). All other sites were similar with respect to these parameters. The primary source of water input for Morgan Island slough is groundwater seepage and surface runoff whereas all other sites are fed primarily from the main channel. This factor probably is responsible for the observed differences.

Current velocities varied among study sites (K-W chi-square = 88.3, 5 df, $p < 0.001$; Table 3). Velocities were significantly higher at Wenrich and Byers and lower at Groin 1 and Morgan than velocities at all other sites. The highest range of velocities was observed for Chena while velocities were much less variable at Morgan and Groin 1 (Figure 3). Velocities ranged from 15 to 30 cm/s at Wenrich and Byers and from 5 to 15 cm/s at Chena and Main 1.

Table 2 - Physico-chemical characteristics at primary and supplemental study sites in 1981.

Area	Date	Water Temperature (C)	Dissolved Oxygen (mg/l)	Hardness (mg $CaCO_3$/l)	pH
Morgan	6-20	17.2	6.8	185	8.4
	8-25	16.0	8.5	171	8.1
Groinl	6-20	18.0	7.4	140	7.9
	8-25	12.0	8.2	151	7.6
Byers	6-20	15.0	9.4	120	7.3
	8-25	15.0	9.7	136	7.6
Wenrich	6-20	15.0	9.3	125	7.2
	8-25	14.0	9.4	137	7.5
Mainl	6-20	13.0	10.5	120	7.4
	8-25	9.5	11.3	137	7.6

Table 3. Averages of physical measurements at primary and supplemental study sites in 1981. Extremes observed are in parentheses.

Area	Current Velocity (cm/s)	Depth (m)	Substrate Size	Water Clarity (mm)	Water Temperature (C)	Specific Conductance (micromhos/cm)
Byers	20 (4 - 28)	2.1 (0.7 - 3.5)	3 (3 - 6)	64 (40 - 120)	13.6 (9.4 - 18.3)	502 (210 - 700)
Wenrich	21 (4 - 30)	1.9 (1.2 - 3.1)	4 (3 - 6)	73 (50 - 130)	14.0 (10.0 - 16.7)	511 (210 - 680)
Mainl	8 (0 - 30)	1.4 (1.0 - 2.5)	3 (3 - 4)	68 (40 - 95)	12.6 (8.0 - 16.1)	372 (200 - 570)
Groinl	0 (0 - 0)	2.9 (1.3 - 3.9)	3 (3 - 4)	128 (60 - 210)	14.9 (10.6 - 20.6)	511 (270 - 760)
Chena	16 (8 - 39)	2.1 (1.2 - 3.5)	3 (3 - 3)	898 (250 - 1750)	12.2 (7.2 - 16.7)	394 (220 - 615)
Morgan	1 (0 - 8)	2.2 (0.9 - 3.6)	3 (3 - 4)	1138 (300 - 2600)	14.5 (9.5 - 19.4)	735 (310 - 1120)

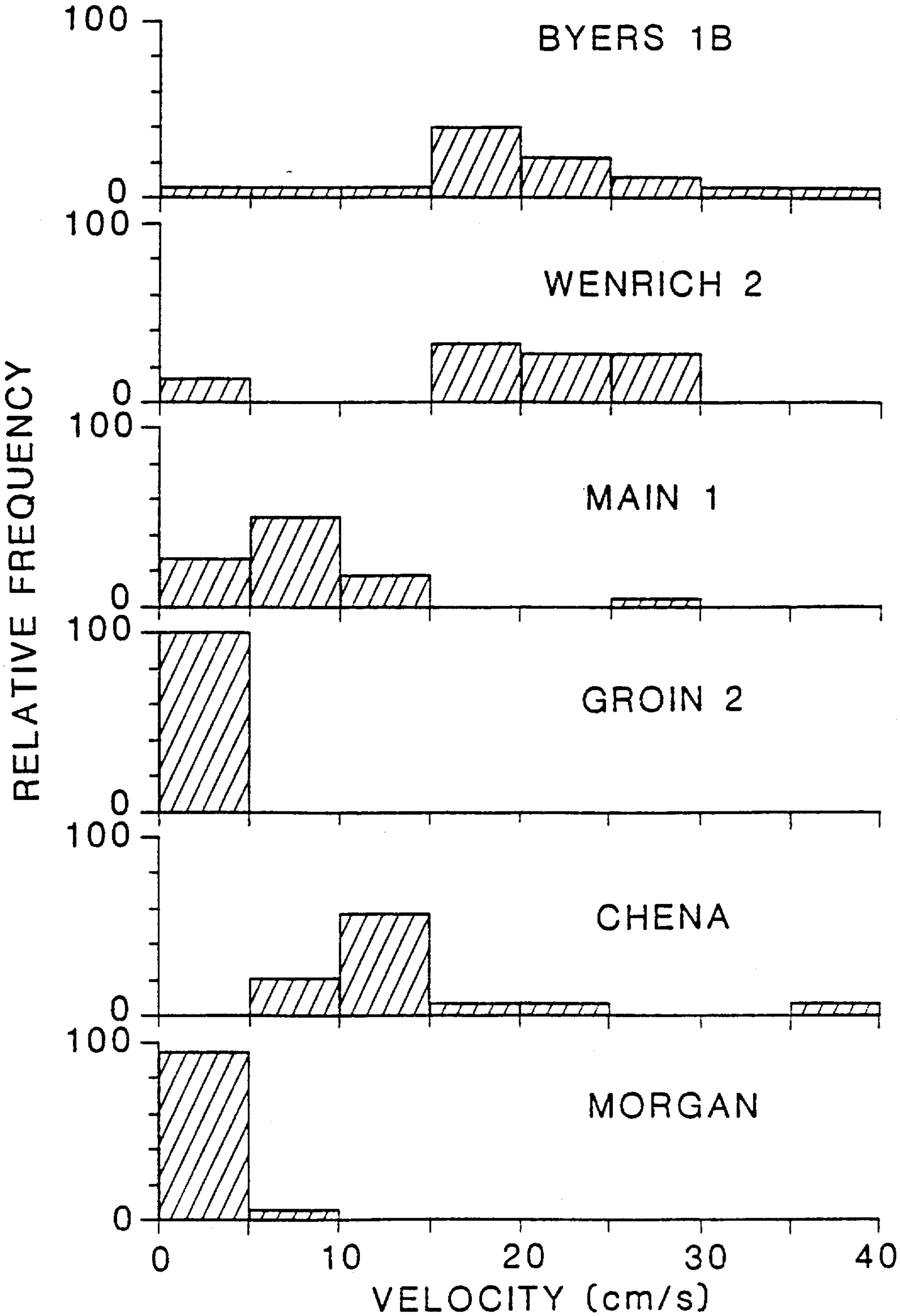

Figure 3. Relative frequency of point measurements in each velocity category at primary and supplemental study sites in 1981.

Depths also differed among sites (K-W chi-square = 60.2, 5 df, $p < 0.001$). Main 1 was shallower and Groin 1 deeper than all other sites (Table 3). No differences were observed among the other four sites. The largest depths were observed at Groin 1 and Morgan (Figure 4).

Size of substrate varied (K-W chi-square = 53.1, 5 df, $p < 0.001$) between study sites. Substrates at Wenrich and Byers were primarily sand and gravels while substrates at other sites were mainly silt with little or no gravels (Table 3; Figure 5).

Water clarity was significantly different between study sites (K-W chi-square = 81.2, 5 df, $p < 0.001$). The highest water clarities were recorded at Morgan and Chena. Water clarities at these sites averaged 1138 mm and 898 mm respectively and were significantly higher than those at all other sites. Water clarities at Groin 1 were also higher than those at Main 1, Byers and Wenrich; water clarity did not vary among the the latter three sites. The lower turbulence at Groin 1 and the separate water sources for Chena (clearwater tributary) and Morgan (groundwater seepage) contributed to the observed differences (Table 3).

Surface water temperatures were higher at some sites than at others (K-W chi-square = 26.5, 5 df, $p < 0.001$). Lowest temperatures were recorded at Main 1 and Chena (Table 3) and the highest at Morgan and Groin 1. Reduced heat dissipation in the more stagnant waters of these sites was responsible.

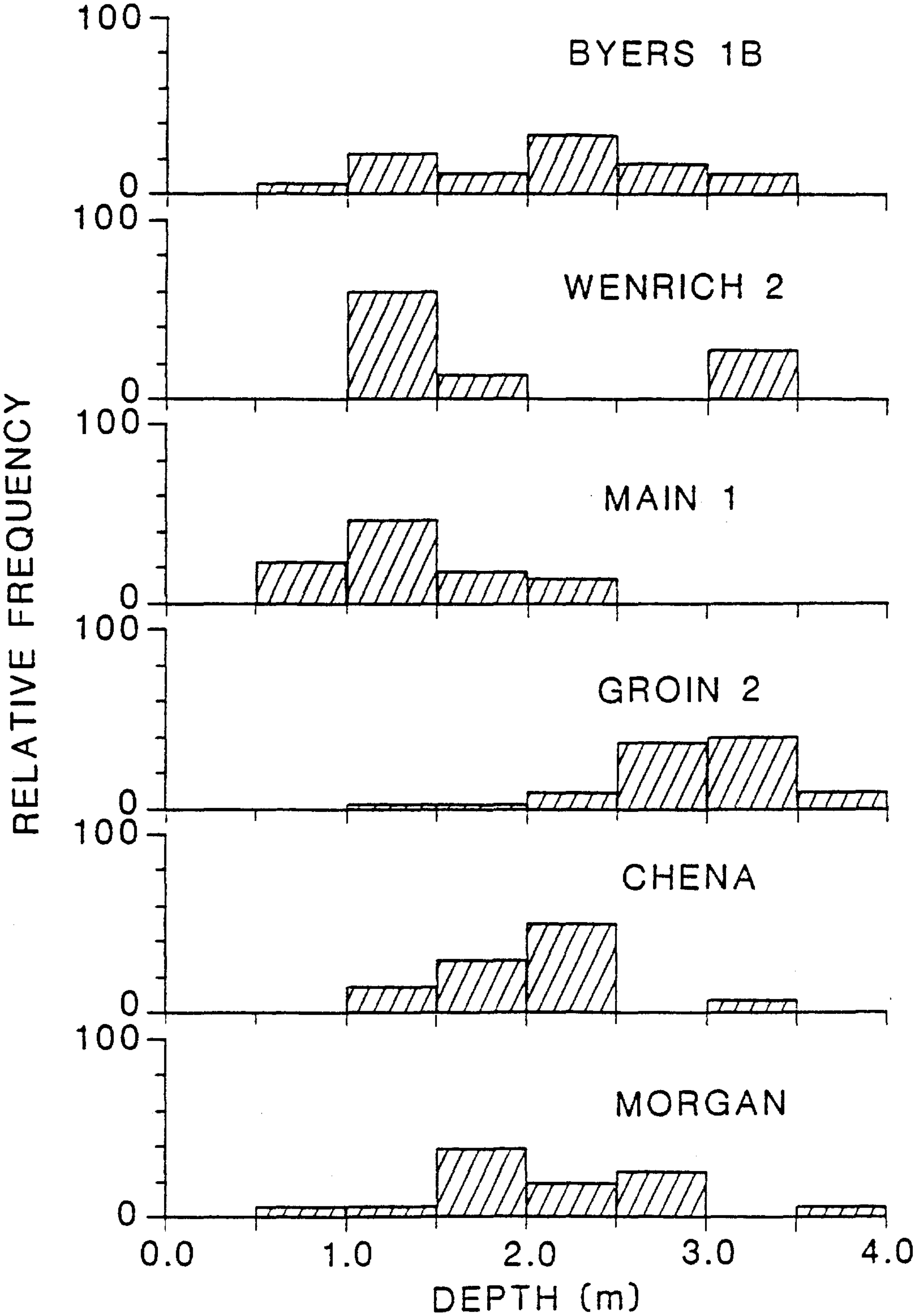

Figure 4. Relative frequency of point measurements in each depth category at primary and supplemental study sites in 1981.

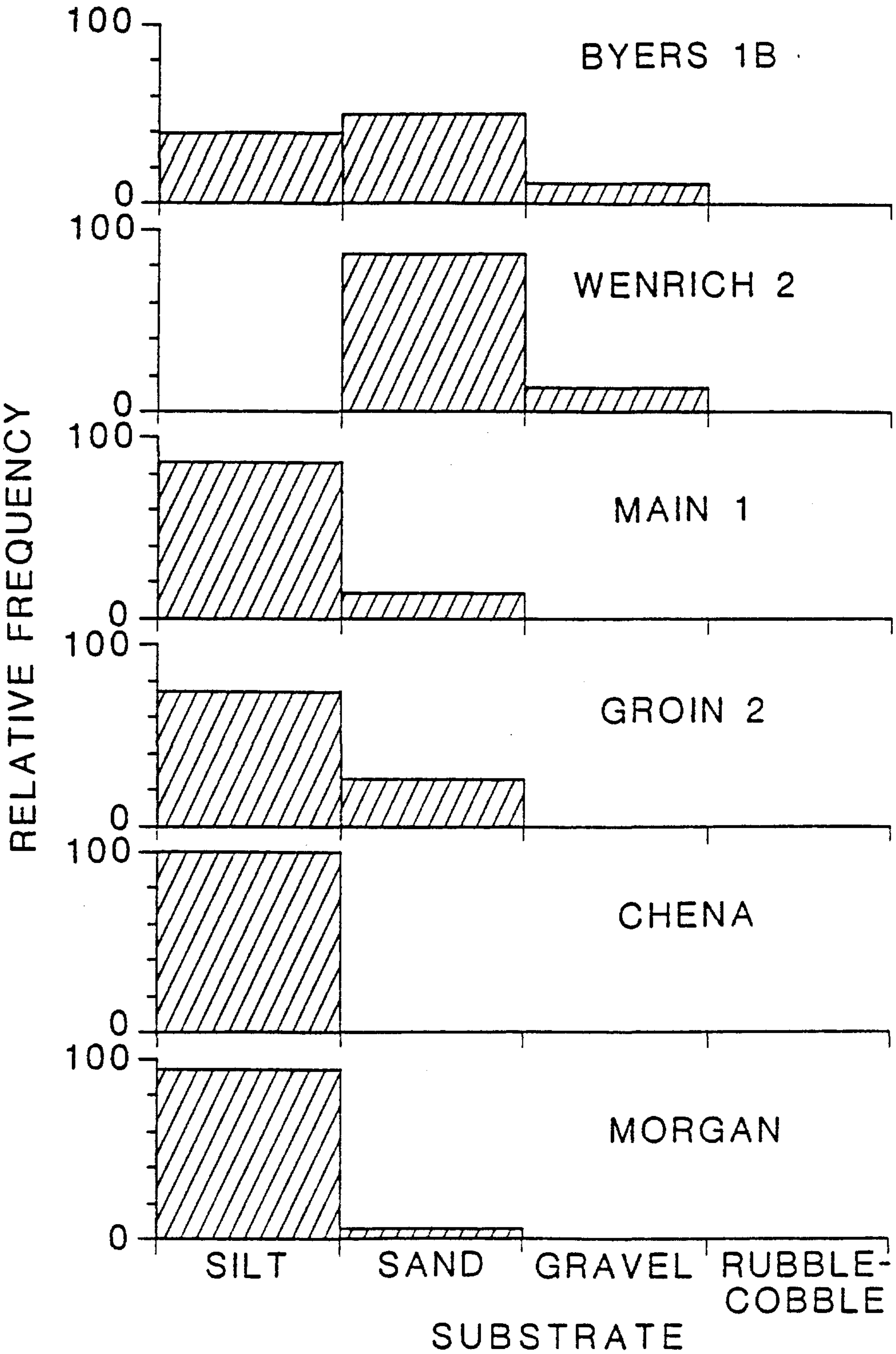

Figure 5. Relative frequency of point measurements in each substrate category at primary and supplemental study sites in 1981.

Sites also differed in specific conductance of the surface waters (K-W chi-square = 62.4, 5 df, $p < 0.001$). The highest conductance values were found at Morgan and the lowest at Main 1 and Chena (Table 3); remaining sites showed no differences.

Seining stations differed with respect to current velocity, depth, substrate, and water clarity. Water temperature and specific conductance were not measured at these stations. I assumed that temperature and conductance were similar among stations at Byers and Wenrich.

The null hypothesis of no difference in current velocities among stations was rejected (K-W chi-square = 117.7, 6 df, $p < 0.001$) and pairwise comparisons revealed that velocities at Wenrich 1 were higher than at any other station. The highest values and greatest range of current velocities occurred at the main channel station, Main 1 (Table 4). Velocities at Byers 1A, Byers 1B, Wenrich 2, and Main 2 were not different and usually ranged between 20 and 25 cm/s. Velocities at Byers 2 and Wenrich 3 were significantly lower than those at other stations, ranging mainly from 0 to 10 cm/s (Figure 6).

Depths varied significantly (K-W chi-square = 84.9, 6 df, $p < 0.001$) among seining stations. Wenrich 2 depths were greater and Byers 2 depths shallower than at other stations. No other pairwise differences were noted. Average depth at Wenrich 2 equalled 0.35 m, at Byers 2 0.11, and at all other stations averages were near 0.20 m (Table 4; Figure 7). Differences were also observed in

Table 4. Averages of physical measurements at seining stations in 1982. Extremes observed are in parentheses.

Area	Current Velocity (cm/s)	Depth (m)	Substrate Type	Water Clarity (mm)
Byers1A	25 (3 - 82)	0.17 (0.06 - 0.43)	7 (3 - 10)	8 (5 - 13)
Byers1B	25 (2 - 53)	0.19 (0.07 - 0.45)	6 (3 - 10)	7 (5 - 10)
Byers2	7 (5 - 10)	0.11 (0.02 - 0.24)	5 (3 - 9)	13 (10 - 14)
Wenrich1	35 (6 - 69)	0.18 (0.07 - 0.41)	8 (7 - 9)	9 (6 - 18)
Wenrich2	20 (13 - 30)	0.38 (0.15 - 0.65)	4 (3 - 4)	10 (5 - 16)
Wenrich3	7 (0 - 36)	0.19 (0.03 - 0.51)	7 (3 - 9)	13 (10 - 16)
Main2	21 (0 - 49)	0.17 (0.06 - 0.91)	8 (3 - 10)	10 (5 - 21)

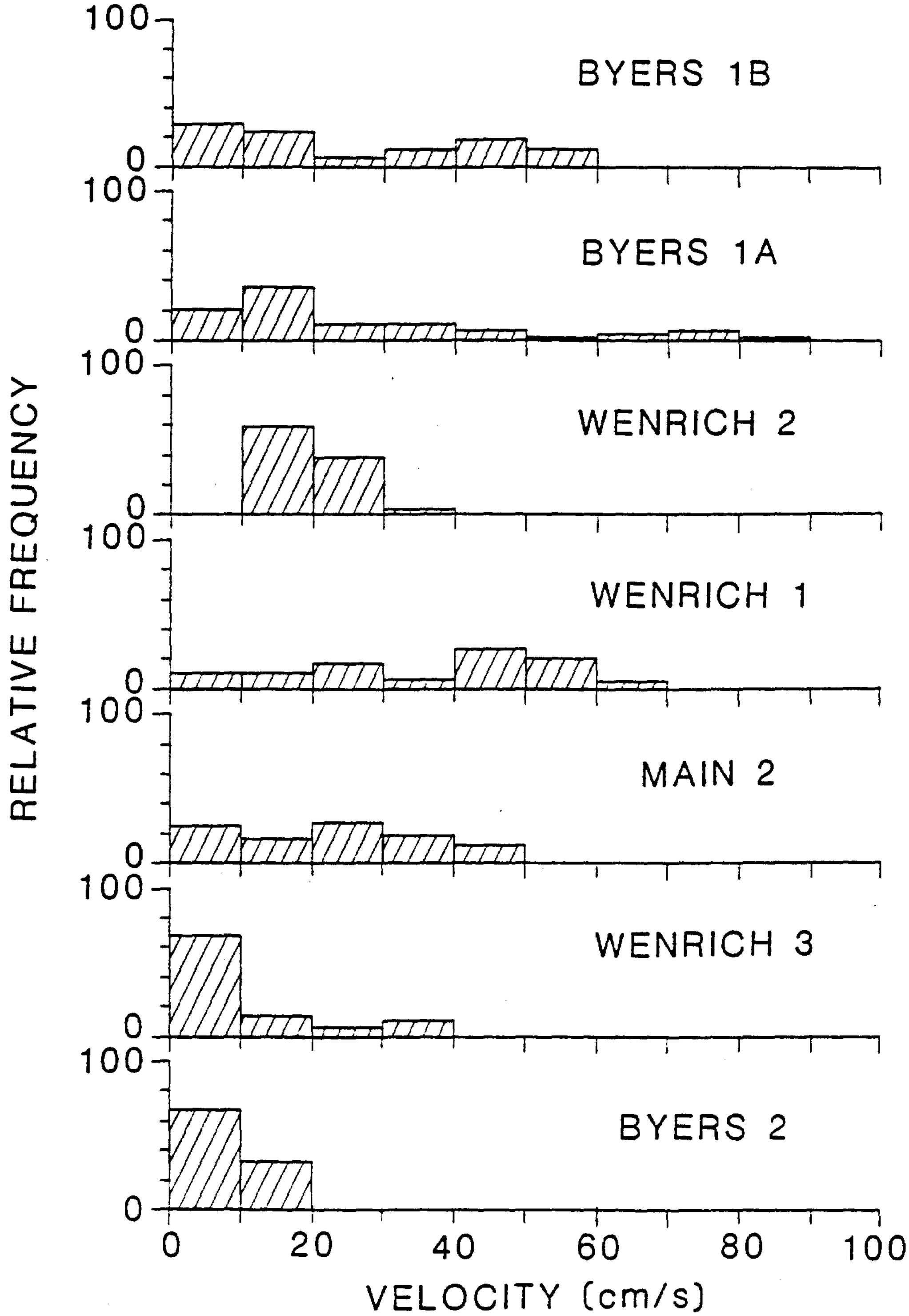

Figure 6. Relative frequency of point measurements in each velocity category at seining stations in 1982.

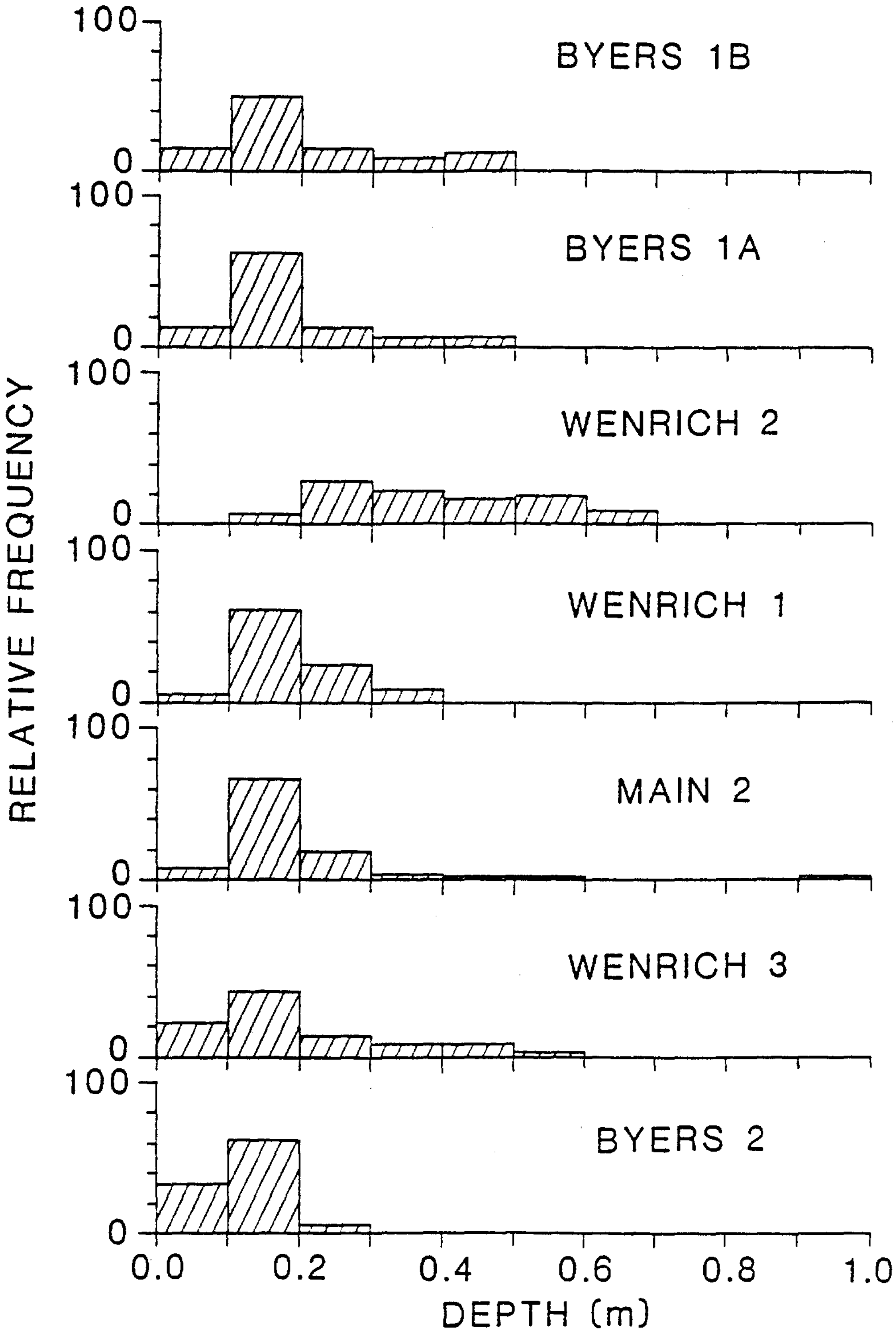

Figure 7. Relative frequency of point measurements in each depth category at seining stations in 1982.

the size of substrate at seining stations (K-W chi-square = 84.9, 6 df, $p < 0.001$). Substrate size was significantly greater at Main 2 and smaller at Byers 2 than it was at other stations. The average substrate size was coarse gravel at Wenrich 1 and Main 2; fine gravel at Byers 1B, Byers 1A and Wenrich 3; sand at Byers 2; and, silt at Wenrich 2 (Table 4; Figure 8).

Water clarity varied significantly (K-W chi-square = 103.4, 6 df, $p < 0.001$) among stations. Water clarities at Byers 2 and Wenrich 3 were higher and were lower at Byers 1B and Byers 1A than those at other stations. The widest range of water clarities occurred at Main 1 (Table 4). Water clarities were not significantly different between Main 1, Wenrich 2 and Wenrich 1.

Discussion

Aquatic habitat in the Tanana River near Fairbanks can be classified into 10 separate and distinct types (Table 5). This classification is primarily derived from observed qualitative and quantitative differences in habitat variables at primary and supplemental study sites but also from classifications developed for other large, turbid river systems. Rasmussen (1979) identified six major habitats in the upper Mississippi River: main channel, main channel border, tailwater, sidechannels, river lakes, and sloughs. Habitats identified by Kallemyn and Novotny (1977) on the Missouri River were main channel, main channel border, main channel sandbar, chutes (sidechannels), backwaters (sloughs), marshes, and five modified

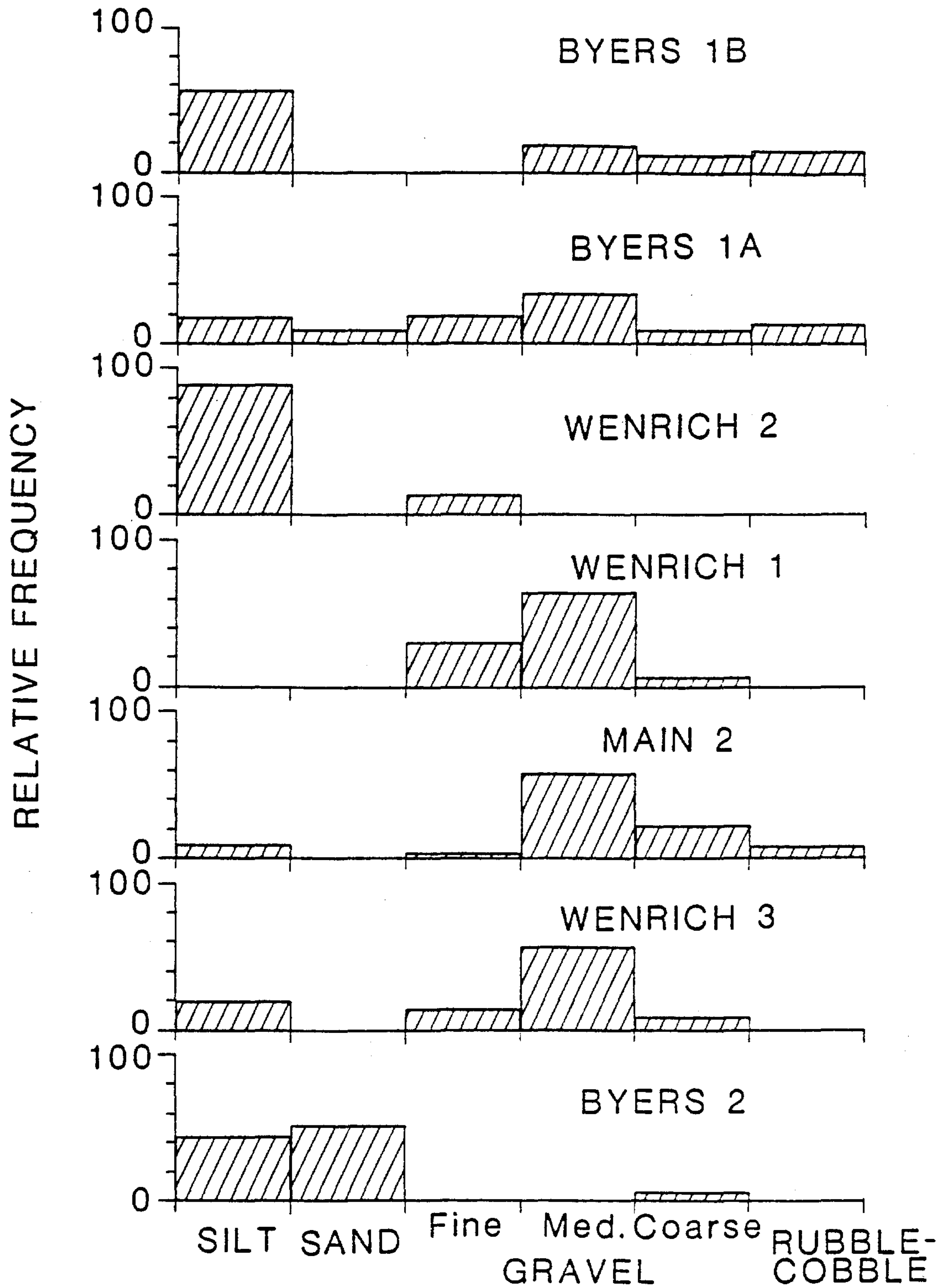

Figure 8. Relative frequency of point measurements in each substrate category at seining stations in 1982.

Table 5. Classification of aquatic habitat in the Tanana River near Fairbanks, Alaska.

Habitat Type	Flow	Average Current (cm/s)	Average Depth (m)	Dominant Substrate	Water Clarity (mm)	Aquatic Vegetation	Cover Influence
Mainstem							
Main Channel	Permanent	160	2.2	Rubble	<100	Absent	Low
Border	Permanent	8	1.4	Silt	<100	Absent	Moderate
Sandbar	Permanent	20	0.2	Gravel	<100	Absent	Low
Sidechannel							
Gravel Bar	Permanent	30	0.2	Gravel	<100	Rare	Low
Lower	Permanent	20	2.1	Silt/Sand	<100	Rare	Low
Side Slough	Temporary	7	0.1	Gravel	100-160	Common	Moderate
Intermittent	Temporary	7	0.2	Sand	100-150	Rare	Moderate
Modified							
Slough	Temporary	1	2.2	Silt	>1000	Abundant	High
Groin	Temporary	0	2.9	Silt	100-200	Absent	Moderate
Tributary							
Mouth	Permanent	16	2.1	Silt	>1000	Rare	High

habitats created by bank stabilization structures. More recently the Alaska Department of Fish and Game, Su Hydro (1983) classified riverine habitats on the large, glacially-fed Susitna River in southcentral Alaska into mainstem, sidechannel, side-slough, upland-slough, tributary, and tributary mouth categories.

The main channel is characterized by perennial flow and is the deepest, swiftest portion of the river. Since no study site was established in the main channel, information on physical habitat was taken from Burrows et al. (1981) and CRREL (1982). Conspicuous features of the main channel include extremely high current velocities (usually greater than 150 cm/s), deep waters which sometimes exceed 8 m, a bottom type dominated by coarse gravels and rubble, and a high degree of bed erosion and scouring. Lateral shifts of 165 m in the main channel over a two season period have been observed. Apparently, these drastic changes in bed profile are common in braided, gravel-bed rivers and represent the complex adjustments needed to maintain a consistent relationship of channel size to total discharge.

Although commonly considered as part of the main channel the main channel border or shoreline represents a separate and distinct aquatic habitat for fisheries purposes. For this study it is defined as the narrow border, no more than 30 m wide along the banks, and away from the main channel. It is distinguished from the main channel by the greatly reduced current, shallower depth, and the presence of submerged cover provided by trees, brush and other debris that fall into the channel from eroding, unstable banks.

Main channel sandbars are islands formed in the slower depositional parts of the main channel. They are defined as the area immediately adjacent to an exposed riverbar where depths are less than 0.5 m. Conditions are quite variable and fluctuate widely with changes in river stage.

Sidechannels are departures from the main channel in which there is flow from May to October. During the low flows of winter, sidechannels are usually dewatered. They exhibit wide variation in length, depth, current, and width ranging from shorter, fast-flowing chutes to larger, slough-like sidechannels. In general, velocities are greater, depths shallower, and substrates larger in the upper reaches of sidechannels near the point of departure from the mainstem than in the lower reaches of sidechannels. This habitat is analogous to the riffle areas of smaller streams but is designated as a sidechannel gravel bar for the purposes of this study. In the lower reaches of sidechannels, depths increase and velocities and substrate size decrease. This area is also considered a distinct habitat type and is termed lower sidechannel.

Intermittent side-sloughs are overflow channels that act as backwaters connecting larger sidechannels and have little or no flow during low to moderate river stages. Apart from their more temporary nature, side-sloughs are distinguished from other sidechannel

Table 5. Classification of aquatic habitat in the Tanana River near Fairbanks, Alaska.

		Variable					
Habitat Type	Flow	Average Current (cm/s)	Average Depth (m)	Dominant Substrate	Water Clarity (mm)	Aquatic Vegetation	Cover Influence
Mainstem							
Main Channel	Permanent	160	2.2	Rubble	<100	Absent	Low
Border	Permanent	8	1.4	Silt	<100	Absent	Moderate
Sandbar	Permanent	20	0.2	Gravel	<100	Absent	Low
Sidechannel							
Gravel Bar	Permanent	30	0.2	Gravel	<100	Rare	Low
Lower	Permanent	20	2.1	Silt/Sand	<100	Rare	Low
Side Slough	Temporary	7	0.1	Gravel	100-160	Common	Moderate
Intermittent	Temporary	7	0.2	Sand	100-150	Rare	Moderate
Modified							
Slough	Temporary	1	2.2	Silt	>1000	Abundant	High
Groin	Temporary	0	2.9	Silt	100-200	Absent	Moderate
Tributary							
Mouth	Permanent	16	2.1	Silt	>1000	Rare	High

the Alaska Department of Fish and Game, Su Hydro (1983) classified habitats by much shallower depths, slower velocities and higher water clarities. In addition these side-sloughs are one of the few riverine areas where emergent aquatic vegetation is common.

Dewatered during all but moderate to high river stages, intermittent sidechannels are differentiated from side-sloughs by their predominantly sand substrate. And, while side-sloughs are influenced by and connected with larger, more permanent sidechannels, intermittent sidechannels are influenced only by the floodwaters of the mainstem.

Bank stabilization activities have resulted in two distinct types of modified aquatic habitat. A modified slough is a former sidechannel that has been blocked by a dike or other closing structure resulting in a change of water source from mostly riverine to groundwater seepage and local rainwater runoff. The resultant clear waters and lower, more stable flows have allowed growth of rooted and submerged aquatic macrophytes not found in other riverine habitats.

Groins are L-shaped current deflection dikes designed to divert the main channel away from floodplain developments such as the Fairbanks International Airport. Behind the groin a deep, lake-like backwater forms in which flows are imperceptible and water clarity is increased. Banks are steep-sided and lined with coarse gravel or quarried stone.

Tributary mouth habitat consists of the deep backwater such as that formed at the Chena River-Tanana River confluence. It is distinguished from other habitats by the very high water clarities and perennial flow.

This habitat classification only pertains to the May to October sampling period. A totally different set of conditions exists during winter when water clarity greatly increases and the flow coalesces into a single main channel. Also, it is somewhat subjective in that sites were initially selected because, from a qualitative standpoint, they appeared to represent obvious habitat types. However, the large number of significant differences in quantitative measurements of habitat variables seems to support this *a priori* classification. A larger number of randomly selected locations could have been sampled to eliminate or reduce this bias. Unfortunately logistical constraints precluded this type of experimental design.

In any case, it is important to understand and document the aquatic habitats that occur in glacial rivers such as the Tanana River. Apart from the theoretical considerations, this information will be useful in the development of management objectives designed to reduce or mitigate the impacts of present and future floodplain modifications resulting from industrial, residential, and flood control activities.

FISH COMMUNITY STRUCTURE AND HABITAT

Results

Fish community structure was evaluated from species composition data combined for all fish sampling gear, sites, stations, and study periods (1981 and 1982). A total of 15 fish species were captured in the study area. These were lake chub (*Couesius plumbeus*), longnose sucker (*Catostomus catostomus*), humpback whitefish (*Coregonus pidschian*), round whitefish (*Prosopium cylindraceum*), burbot (*Lota lota*), northern pike (*Esox lucius*), slimy sculpin (*Cottus cognatus*), Arctic grayling (*Thymallus arcticus*), chum salmon (*Oncorhynchus keta*), chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), Arctic lamprey (*Lampetra japonica*), sheefish (*Stenodus leucichthys*), broad whitefish (*Coregonus nasus*), and least cisco (*Coregonus sardinella*). Dolly Varden char (*Salvelinus malma*) and ninespine stickleback (*Pungitius pungitius*) although known to occur in the Tanana River drainage, were not captured in the study area.

A total of 14 species were captured at Groin 1, 13 at Morgan, 11 at Wenrich and at Chena, 10 from Byers, and 9 at Main (Table 6). Lake chub, longnose sucker, humpback whitefish, round whitefish, burbot, grayling and YOY chinook salmon occurred in samples from all sites. One broad whitefish was captured over the two-season study period. This 585 mm, 2750 g, ripe female was captured in a gill net set at Groin 1 in late June, 1981. Broad whitefish, although common in the lower Tanana and Yukon Rivers, are generally

Table 6. Number and precentage composition of fishes captured by all gear types combined at primary and supplemental study sites in 1981 and 1982.

Species	AREA Morgan #	%	Wenrich #	%	Byers #	%	Groinl #	%	Main #	%	Chena #	%	Total #	%
Lake Chub	818	41.1	634	52.1	532	35.6	47	17.8	213	60.2	53	19.9	2297	41.1
Longnose Sucker	265	13.3	341	28.0	742	49.6	69	26.1	92	26.0	59	22.1	1568	28.1
Humpback Whitefish	452	22.7	20	1.6	69	4.6	24	9.1	13	3.7	86	32.2	664	11.9
Round Whitefish	35	1.8	26	2.1	27	1.8	5	1.9	13	3.7	25	9.4	131	2.3
Broad Whitefish	-	0.0	-	0.0	-	0.0	1	0.4	-	0.0	-	0.0	1	<0.1
Burbot	2	0.1	43	3.5	38	2.5	28	10.6	5	1.4	1	0.4	117	2.1
Slimy Sculpin	71	3.6	87	7.1	35	2.3	4	1.5	4	1.1	-	0.0	201	3.6
Sheefish	-	0.0	-	0.0	-	0.0	5	1.9	-	0.0	1	0.4	7	0.1
Northern Pike	14	0.7	-	0.0	-	0.0	4	1.5	-	0.0	2	0.7	20	0.4
Least Cisco	4	0.2	-	0.0	1	0.1	1	0.4	-	0.0	1	0.4	7	0.1
Grayling	2	0.1	1	0.1	4	0.3	1	0.4	5	1.4	3	1.1	16	0.3
Lamprey	2	0.1	4	0.3	-	0.0	22	8.3	-	0.0	-	0.0	28	0.5
Chum Salmon (YOY)	129	6.5	45	3.7	27	1.8	-	0.0	4	1.1	-	0.0	205	3.7
Chum Salmon (Adult)	2	0.1	-	0.0	14	0.9	42	15.9	1	0.3	9	3.4	68	1.2
Chinook Salmon (YOY)	140	7.0	14	1.2	6	0.4	10	3.8	4	1.1	25	9.4	199	3.6
Chinook Salmon (Adult)	-	0.0	-	0.0	1	0.1	1	0.4	-	0.0	2	0.7	4	<0.1
Coho Salmon (Juvenile)	54	2.7	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0	54	1.0
Coho Salmon (Adult)	-	0.0	2	0.2	-	0.0	-	0.0	-	0.0	-	0.0	2	<0.1
Total	1990		1217		1496		264		354		267		5588	

not observed upstream of Fairbanks. Juvenile coho salmon were only captured at Morgan and adult coho salmon only at Wenrich. Northern pike were captured only at Morgan, Groin 1, and Chena and sheefish only at Groin 1 and Chena.

Lake chub, longnose sucker, and humpack whitefish were the most abundant species caught in the Tanana River near Fairbanks from mid-May to early October. Each of these three species comprised 10 percent or more of the total catch (Table 6). Species comprising between 1 and 10 percent of the total catch were round whitefish, burbot, slimy sculpin, YOY and adult chum salmon, and YOY chinook salmon. Making up less than one percent of the total catch were broad whitefish, sheefish, northern pike, least cisco, Arctic grayling, Arctic lamprey, adult chinook salmon, and juvenile and adult coho salmon.

Lake chub and longnose sucker made up a large percentage of the catch at all study sites. Humpback whitefish comprised a large portion of the catch at Morgan (23 percent) and Chena (32 percent) but were not abundant elsewhere. Burbot were rarely captured at Morgan and Chena (< 1 percent). YOY and juvenile salmon (chum, chinook, and coho) were very abundant at Morgan comprising 16 percent of the total catch but were much less abundant or absent at other study sites.

Catch rates (C/f) and percentage compositions of fishes were also evaluated for each gear type, study site, and study period to determine relative abundance and importance of fishes in different habitat types. Gill nets captured 630 fish of 12 species at primary and supplemental study sites during 1981 (Table 7). Humpback whitefish were dominant in the catch from all sites at 34.9 percent followed by longnose sucker (30.6 percent), adult chum salmon (10.6 percent), lake chub (9.4 percent), round whitefish (5.2 percent), and burbot (4.0 percent). These six species comprised 94.7 percent of the total gill net catch. Lake chub, longnose sucker, and humpback whitefish were found at all sites while burbot were absent from samples at Morgan and round whitefish from samples at Byers 1B and Wenrich 2.

Kruskal-Wallis tests of the null hypothesis of equal C/f for a given species between sites demonstrated that lake chub (K-W chi-square = 27.9, 5 df, $p < 0.001$), longnose sucker (K-W chi-square = 24.6, 5 df, $p < 0.001$), humpback whitefish (K-W chi-square = 65.4, 5 df, $p < 0.001$), and round whitefish (K-W chi-square = 49.0, 5 df, $p < 0.001$) catch rates varied significantly among study sites. Multiple pairwise comparisons indicated significantly higher C/f at Morgan and Chena than at all other sites for lake chub, longnose sucker, and humpback whitefish. Round whitefish C/f was higher at Chena than at all other sites.

Catch rates for burbot (K-W chi-square = 7.70, 5 df, $p > 0.10$) and adult chum salmon (K-W chi-square = 8.33, 5 df, $p > 0.10$) did not vary among sites. However mean C/f was higher at Byers, Wenrich and Groin 1 for burbot and higher at Byers, Groin 1, and Chena for adult chum salmon (Table 8). Mean C/f for all species combined was

Table 7. Number and percentage composition of fishes captured by gillnets at primary supplemental study sites from June 1 to September 1, 1981.

Species	Area													
	Morgan		Wenrich		Byers		Groinl		Mainl		Chena		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Lake chub	29	12.9	2	6.9	1	3.4	2	2.2	12	20.0	13	6.5	59	9.4
Longnose sucker	70	31.3	20	69.0	7	24.1	5	5.6	34	56.7	57	28.6	193	30.6
Humpback whitefish	110	49.1	3	10.3	2	6.9	11	12.4	9	15.0	85	42.7	220	34.9
Round whitefish	3	1.3	-	0.0	-	0.0	4	4.5	1	1.7	25	12.6	33	5.2
Broad whitefish	-	0.0	-	0.0	-	0.0	1	1.1	-	0.0	-	0.0	1	0.2
Sheefish	-	0.0	-	0.0	-	0.0	5	5.6	1	1.7	1	0.5	7	1.1
Least cisco	3	1.3	-	0.0	-	0.0	1	1.1	-	0.0	1	0.5	5	0.8
Burbot	-	0.0	3	10.3	4	13.8	15	16.9	2	3.3	1	0.5	25	4.0
Northern pike	6	2.7	-	0.0	-	0.0	2	2.2	-	0.0	2	1.0	10	1.6
Chum salmon (adult)	2	0.9	-	0.0	14	48.3	41	46.1	1	1.7	9	4.5	67	10.6
Chinook salmon (adult)	-	0.0	-	0.0	1	3.4	1	1.1	-	0.0	2	1.0	4	0.6
Grayling	1	0.4	1	3.4	-	0.0	1	1.1	-	0.0	3	1.5	6	1.0
Total	224		29		29		89		60		199		630	

Table 8. Mean C/f for the six most abundant species and all species combined captured by gill nets at primary and supplemental study sites during 1981.

	Area					
Species	Byers	Wenrich	Mainl	Groinl	Chena	Morgan
Lake chub	0.06	0.13	0.55	0.06	0.93	1.81
Longnose sucker	0.39	1.33	1.55	0.14	4.07	4.38
Humpback whitefish	0.11	0.20	0.41	0.31	6.07	6.88
Round whitefish	0.00	0.00	0.05	0.11	1.79	0.19
Chum salmon (adult)	0.78	0.00	0.05	1.17	0.64	0.13
Burbot	0.22	0.20	0.09	0.43	0.07	0.00
All species	1.61	1.93	2.73	2.54	14.21	14.00

approximately seven times higher at Chena and Morgan than at any other site. Although this difference may be partly due to higher efficiency of gill nets in slower-moving waters I believe it is primarily a function of higher fish abundance.

Minnow traps captured a total of seven fish species in 1981 at the various sites (Table 9). Lake chub, longnose sucker, and YOY chinook salmon combined to make up 97.6 percent of the catch from all sites. Catch rates did not differ significantly for lake chub (K-W chi-square = 5.1, 5 df, $p > 0.25$) or longnose sucker (K-W chi-square = 5.5, 5 df, $p > 0.25$) between sites but were slightly higher at Morgan, Chena and Byers (Table 10). Catches of YOY chinook salmon were significantly higher (K-W chi-square = 37.0 , 5 df, $p < 0.001$) at Morgan and Chena than at other sites. Except for one capture at Byers, YOY chinook salmon were observed only at sites with higher water clarity.

Fyke nets fished at primary sites in 1982 resulted in the capture of 1019 individual fish representing 11 species (Table 11). Humpback whitefish, lake chub, longnose sucker, round whitefish, and burbot comprised 97.3 percent of the total captures from all sites combined. Catch rates varied among sites for lake chub (K-W chi-square = 38.9, 3 df, $p < 0.001$), humpback whitefish (K-W chi-square = 34.7, 3 df, $p < 0.001$) and burbot (K-W chi square = 15.7, 3 df, $p < 0.002$) but not for longnose sucker (K-W chi-square = 10.7, 3 df, $p > 0.10$) or round whitefish (K-W chi-square = 7.4, 3 df, $p > 0.10$). Lake chub and humpback whitefish were most abundant

Table 9. Number and percentage composition of fishes captured by minnow traps at primary and supplemental study sites in 1981.

Species	Morgan #	Morgan %	Wenrich #	Wenrich %	Byers #	Byers %	Groin1 #	Groin1 %	Main1 #	Main1 %	Chena #	Chena %	Total #	Total %
Lake Chub	85	35.9	35	92.1	37	46.8	17	29.8	6	54.5	40	58.8	220	44.9
Longnose Sucker	10	4.2	2	5.3	39	49.4	40	70.2	5	45.5	2	2.9	96	19.6
Slimy Sculpin	-	0.0	-	0.0	3	3.8	-	0.0	-	0.0	-	0.0	3	0.6
Humpback Whitefish	3	1.3	-	0.0	-	0.0	-	0.0	-	0.0	1	1.5	4	0.8
Round Whitefish	3	1.3	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0	3	0.6
Chinook Salmon (YOY)	136	57.4	1	2.6	-	0.0	-	0.0	-	0.0	25	36.8	162	33.1
Total	237		38		79		57		11		68		490	

Table 10. Mean C/f for the three most abundant species and all species combined captured by minnow traps at primary and supplemental study sites during 1981.

	Area					
Species	Byers	Wenrich	Mainl	Groinl	Chena	Morgan
Lake chub	2.64	1.35	0.50	0.47	4.00	3.70
Longnose sucker	2.79	0.08	0.42	1.11	0.20	0.42
Chinook salmon (YOY)	0.00	0.04	0.00	0.00	2.50	5.91
All species	5.64	1.46	0.92	1.58	6.80	10.30

Table 11. Number and percentage composition of fishes captured by frame nets at primary study sites during 1982.

Species	Morgan #	Morgan %	Wenrich2 #	Wenrich2 %	Byers 1B #	Byers 1B %	Groin1 #	Groin1 %	Total #	Total %
Lake chub	165	24.2	11	9.8	56	28.0	-	0.0	232	22.8
Longnose sucker	116	17.0	47	42.0	52	26.0	10	38.5	225	22.1
Humpback whitefish	305	44.8	8	7.1	54	27.0	3	11.5	370	36.3
Round whitefish	23	3.4	13	11.6	6	3.0	-	0.0	42	4.1
Burbot	1	0.1	31	27.7	28	14.0	12	46.2	72	7.1
Least cisco	-	0.0	-	0.0	1	0.5	-	0.0	1	0.1
Northern pike	8	1.2	-	0.0	-	0.0	-	0.0	8	0.8
Grayling	1	0.1	-	0.0	3	1.5	-	0.0	4	0.4
Lamprey	1	0.1	-	0.0	-	0.0	-	0.0	1	0.1
Chum salmon (adult)	-	0.0	-	0.0	-	0.0	1	3.8	1	0.1
Coho salmon (juvenile)	50	7.3	-	0.0	-	0.0	-	0.0	50	4.9
(adult)	-	0.0	2	1.8	-	0.0	-	0.0	2	0.2
Slimy sculpin	11	1.6	-	0.0	-	0.0	-	0.0	11	1.1
Total	681		112		200		26		1019	

and burbot least abundant at Morgan. Mean C/f was highest at Morgan for all species except for burbot which were most abundant at Byers (Table 12). Mean C/f for all species was lowest at Groin 1 where steep-sided banks were not conducive to effective fyke netting.

Six species were respresented in 1982 minnow trap catches from primary sites with lake chub (87.9 percent), longnose sucker (5.9 percent), and slimy sculpin (5.7 percent) by far the most abundant (Table 13). The null hypothesis of no difference in minnow trap catch rates was rejected for lake chub (K-W chi=square = 70.0, 3 df, $p < 0.001$), longnose sucker (K-W chi-square = 12.8, 3 df, $p < 0.006$), and slimy sculpin (K-W chi-square = 34.4, 3 df, $p < 0.001$). Pairwise comparisons demonstrated that C/f was higher at Morgan for these species than at other primary sites (Table 14).

Boat electroshocker samples contained 11 species of which YOY chum salmon, lake chub, longnose sucker, humpback whitefish, slimy sculpin and lamprey were most abundant (Table 15). Burbot were captured at all sites but were most abundant at Wenrich (Table 16). YOY chinook salmon were captured only at Morgan and Groin 1 and YOY chum salmon only at Morgan. Since electrofishing occurred at Morgan during outmigration of YOY chum salmon and after outmigration at other sites, no tests of equal catch rates of YOY chum salmon were performed. Lamprey (K-W chi-square = 20.4, 3 df, $p < 0.001$) and burbot (K-W chi-square = 12.5, 3 df, $p < 0.001$) catch rates differed among sites. Pairwise comparisons showed burbot to be more abundant at Wenrich and lamprey more abundant at Groin 1 than at other

Table 12. Mean C/f for the five most abundant species and all species combined captured by frame nets at at primary and supplemental study sites during 1982.

	Area			
Species	Byers	Wenrich	Groinl	Morgan
Lake chub	2.95	0.35	0.00	8.25
Longnose sucker	2.74	1.52	0.67	5.80
Humpback whitefish	2.84	0.26	0.20	15.25
Round whitefish	0.32	0.42	0.00	1.15
Burbot	1.47	1.00	0.80	0.05
All species	10.53	3.61	1.73	34.05

Table 13. Number and percentage composition of fishes captured by minnow traps at primary study sites during 1982.

Species	Morgan		Wenrich		Byers		Groinl		Total	
	#	%	#	%	#	%	#	%	#	%
Lake chub	475	88.0	13	65.0	24	96.0	27	96.4	539	87.9
Longnose sucker	29	5.4	6	30.0	-	0.0	1	3.6	36	5.9
Round whitefish	-	0.0	-	0.0	1	4.0	-	0.0	1	0.2
Slimy sculpin	35	6.5	-	0.0	-	0.0	-	0.0	35	5.7
Chinook salmon	1	0.2	-	0.0	-	0.0	-	0.0	1	0.2
Burbot	-	0.0	1	5.0	-	0.0	-	0.0	1	0.2
Total	540		20		25		28		613	

Table 14. Mean C/f for the three most abundant species and all species combined captured by minnow traps at primary and supplemental study sites during 1982.

	Area			
Species	Byers	Wenrich	Groinl	Morgan
Lake chub	0.27	0.16	0.19	2.18
Longnose sucker	0.00	0.08	0.01	0.13
Slimy sculpin	0.00	0.00	0.00	0.16
All species	0.28	0.25	0.20	2.48

Table 15. Number and percentage composition of fishes captured by boat electroshocker at primary study sites during 1982.

Species	Morgan #	Morgan %	Wenrich2 #	Wenrich2 %	Byers 1B #	Byers 1B %	Groin1 #	Groin1 %	Total #	Total %
Lake chub	64	20.8	4	18.2	10	55.6	1	1.6	79	19.2
Longnose sucker	40	13.0	7	31.8	4	22.2	13	20.3	64	15.5
Humpback whitefish	34	11.0	2	9.1	1	5.6	10	15.6	47	16.8
Slimy sculpin	25	8.1	-	0.0	-	0.0	4	6.3	29	10.4
Lamprey	1	0.3	-	0.0	-	0.0	22	34.4	23	8.2
Chinook salmon (YOY)	3	1.0	-	0.0	-	0.0	10	15.6	13	4.7
Coho salmon (juvenile)	4	1.3	-	0.0	-	0.0	-	0.0	4	1.0
Chum salmon (YOY)	129	41.9	-	0.0	-	0.0	-	0.0	129	31.3
Burbot	1	0.3	8	36.4	2	11.1	1	1.6	12	4.3
Round whitefish	6	1.9	1	4.5	1	5.6	1	1.6	9	3.2
Northern pike	-	0.0	-	0.0	-	0.0	2	3.1	2	0.7
Least cisco	1	0.3	-	0.0	-	0.0	-	0.0	1	0.4
Total	308		22		18		64		412	

Table 16. Mean C/f for the seven most abundant species and all species combined captured by boat electroshocker at primary and supplemental study sites during 1982.

	Area			
Species	Byers	Wenrich	Groinl	Morgan
Lake chub	2.00	0.67	0.25	5.82
Longnose sucker	0.80	1.17	3.25	3.64
Slimy sculpin	0.00	0.00	1.00	2.27
Humpback Whitefish	0.20	0.33	2.50	3.09
Lamprey	0.00	0.00	5.50	0.09
Burbot	0.40	1.33	0.25	0.09
Chum salmon (YOY)	0.00	0.00	0.00	11.73
All species	3.60	3.67	16.00	28.00

sites. Catch rates were not different among sites for lake chub (K-W chi-square = 9.65, 3 df, $p > 0.01$), longnose sucker (K-W chi-square = 1.82, 3 df, $p > 0.50$), humpback whitefish (K-W chi-square = 10.7, 3 df, $p > 0.01$), and slimy sculpin (K-W chi-square = 9.58, 3 df, $p > 0.01$). Mean C/f for the seven most abundant fish species in electroshocker samples was much higher at Morgan and Groin 1 than at Byers and Wenrich (Table 16).

A total of 10 species were captured by seines at the seven seining stations in 1981 and 1982 (Table 17). Lake chub, longnose sucker, and slimy sculpin were the most abundant species at 49.2 percent, 39.5 percent and 4.7 percent of the overall catch respectively. Less abundant species were round and humpback whitefish, YOY of chum and chinook salmon, burbot, and lamprey. Mean C/f for all species combined was highest at Byers 1A and lowest at Wenrich 2. Other sites had similar combined mean C/f values (Table 18).

In addition to catch rate comparisons between stations, habitat suitability indices (HSI) were developed for the various life stages of lake chub, longnose sucker, and slimy sculpin. The null hypothesis of equal catch rates among seining stations was rejected (K-W chi-square = 41.6, 6 df, $p < 0.001$) for YOY lake chub. Catch rates were greater at Byers 2, Wenrich 3, and Byers 1B than at other stations. YOY lake chub were captured most frequently in shallow backwaters over silt and sand substrates at velocities from 0 to 9 cm/s and at depths from 0.00 to 0.09 m (Tables 19, 20, and 21; Figure 9). Although a few individuals were captured at all sampled

Table 17. Number and percentage composition of fishes captured by seines during 1981 and 1982.

Species	Area															
	Byers1A		Byers1B		Wenrich1		Wenrich2		Main2		Wenrich3		Byers2		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Lake chub	247	26.3	157	77.0	386	60.1	58	68.2	195	68.7	125	48.3	152	57.4	1,320	49.2
Longnose sucker	615	65.4	25	12.3	151	23.5	13	15.3	53	18.7	95	36.7	108	40.8	1,060	39.5
Slimy sculpin	27	2.9	5	2.5	47	7.3	7	8.2	4	1.4	33	12.7	3	1.1	126	4.7
Round whitefish	15	1.6	4	2.0	11	1.7	-	0.0	12	4.2	1	0.4	1	0.4	44	1.6
Humpback whitefish	-	0.0	12	5.9	-	0.0	2	2.4	4	1.4	5	1.9	-	0.0	23	0.9
Chum salmon (YOY)	27	2.9	-	0.0	36	5.6	-	0.0	4	1.4	-	0.0	-	0.0	67	2.5
Chinook salmon (YOY)	5	0.5	1	0.5	11	1.7	1	1.2	4	1.4	1	0.4	1	0.4	24	0.9
Burbot	4	0.4	-	0.0	-	0.0	-	0.0	3	1.1	-	0.0	-	0.0	7	0.3
Grayling	1	0.1	-	0.0	-	0.0	-	0.0	5	1.8	-	0.0	-	0.0	6	0.2
Lamprey	-	0.0	-	0.0	-	0.0	4	4.7	-	0.0	-	0.0	-	0.0	4	0.1
Total	941		204		642		85		284		259		265		2,681	

Table 18. Mean C/f for six most abundant species and all species combined captured by seines at seining stations in 1981 and 1982.

	Location						
Species	Byers1A	Byers1B	Byers2	Wenrich1	Wenrich2	Wenrich3	Main2
Lake Chub	5.49	4.62	3.80	4.49	1.76	3.57	2.87
Longnose Sucker	13.67	0.74	2.70	1.76	0.39	2.71	0.78
Slimy Sculpin	0.60	0.15	0.08	0.55	0.21	0.94	0.06
Round Whitefish	0.33	0.12	0.03	0.13	0.00	0.03	0.18
Humpback Whitefish	0.00	0.35	0.00	0.00	0.06	0.14	0.06
Chinook Salmon (YOY)	0.11	0.03	0.03	0.13	0.03	0.03	0.06
All Species	20.91	6.00	6.63	7.47	2.58	7.40	4.18

Table 19. Velocity interval (cm/s), area sampled (m^2), catch frequencies, and densities (number/m^2) for YOY, juvenile, and adult lake chub. All probabilities associated with T values (chi-square goodness-of-fit) are less than 0.001 with 6 degrees of freedom.

Velocity	Area	YOY		Juvenile		Adult	
		Frequency	Density	Frequency	Density	Frequency	Density
0-9	7,190	191	0.027	162	0.023	164	0.023
10-19	4,849	47	0.010	99	0.020	149	0.031
20-29	2,800	38	0.014	75	0.027	46	0.016
30-39	1,728	2	0.001	12	0.007	34	0.020
40-49	2,049	2	0.001	13	0.006	86	0.042
50-59	1,226	0	0.000	13	0.011	68	0.055
60-90	543	0	0.000	6	0.011	33	0.061
Total	20,385	280		380		580	
T		160.4		59.0		92.3	

Table 20. Depth interval (m), area sampled (m^2), catch frequencies, and densities (number/m^2) for YOY, juvenile, and adult lake chub. All probabilities associated with T values (chi-square goodness-of-fit) are less than 0.001 with 6 degrees of freedom.

Depth	Area	YOY		Juvenile		Adult	
		Frequency	Density	Frequency	Density	Frequency	Density
0.00-0.09	2,453	103	0.042	78	0.032	89	0.036
0.10-0.19	10,869	150	0.014	238	0.022	389	0.036
0.20-0.29	3,874	16	0.004	43	0.011	72	0.019
0.30-0.39	1,422	4	0.003	13	0.009	24	0.017
0.40-0.49	962	3	0.003	5	0.005	2	0.002
0.50-0.59	516	3	0.006	3	0.006	4	0.008
0.60-0.90	293	1	0.003	0	0.000	0	0.000
Total	20,389	280		380		580	
T		193.5		67.2		86.4	

Table 21. Substrate interval, area sampled (m^2), catch frequencies, and densities (number/m^2) for YOY, juvenile, and adult lake chub. All probabilities associated with T values (chi-square goodness-of-fit) are less than 0.001 with 5 degrees of freedom.

Substrate	Area	YOY		Juvenile		Adult	
		Frequency	Density	Frequency	Density	Frequency	Density
Silt	5,713	131	0.023	140	0.025	134	0.023
Sand	1,338	41	0.031	18	0.013	18	0.013
Gravel							
Fine	2,717	10	0.004	22	0.008	28	0.010
Medium	7,623	83	0.011	158	0.021	302	0.040
Coarse	2,118	12	0.006	21	0.010	62	0.029
Rubble-Cobble	878	3	0.003	21	0.024	36	0.041
Total	20,387	280		380		580	
T		104.4		40.0		85.4	

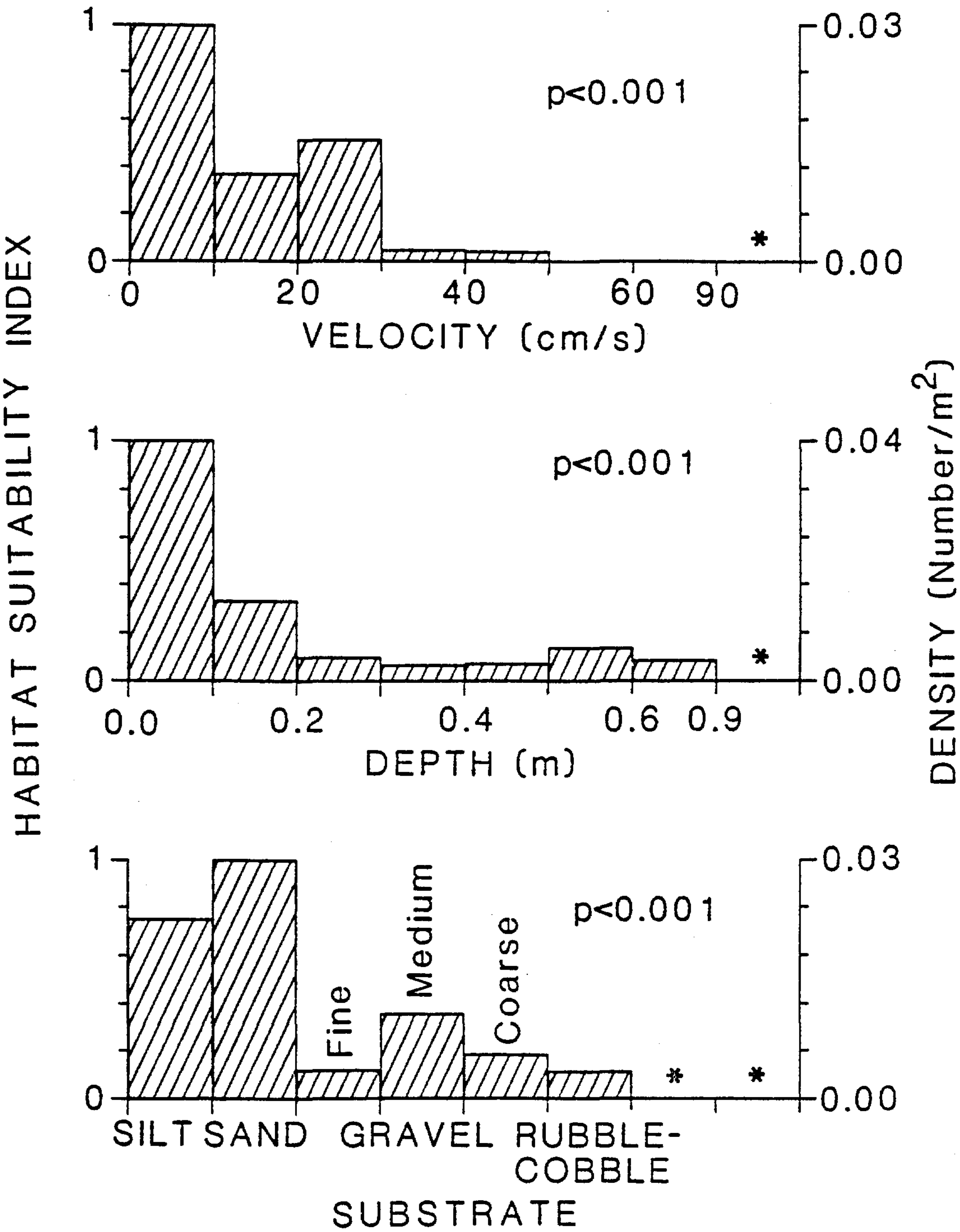

Figure 9. Habitat suitability indices and densities for YOY lake chub (N = 280, average TL = 39 mm) based on measurements of velocity, depth, and substrate. Asterisks indicate categories not measured.

ranges of depths and substrates, no YOY were found in velocities greater than 50 cm/s. The null hypothesis that densities did not vary over the sampled range of habitat was rejected ($p < 0.001$) for each variable.

Catch rates of juvenile lake chub were not significantly different among seining stations (K-W chi-square = 13.3, 6 df, $p > 0.01$). Individuals were present in moderate numbers throughout the sampled range of each habitat variable. Still, some ranges were preferred over others and densities varied significantly over each habitat variable (Tables 19, 20 and 21; Figure 10). Observed values were greater than would be expected under the null hypothesis for velocities from 0 to 29 cm/s with 20 to 29 cm/s optimum and for depths from 0.00 to 0.29 m with 0.00 to 0.09 optimum. Although the null hypothesis that densities did not vary over the sampled range of substrate was rejected ($p < 0.001$), no clear pattern was evident. Juvenile lake chub were captured more often over silt, medium gravel, and rubble-cobble than over other substrates. An assignment of an HSI of 1.0 to all substrate ranges is probably appropriate.

Catch rates for adult lake chub did vary significantly (K-W chi-square = 17.2, 6 df, $p < 0.001$) among seining stations. Pairwise comparisons revealed that catches at Byers 1A were higher than at Byers 1B, Byers 2, and Wenrich 2. Wenrich 2 catch rates were lower than at Byers 1A, Wenrich 1, Main 2, and Wenrich 3. Shallow riffle areas over gravel and rubble-cobble substrates were preferred.

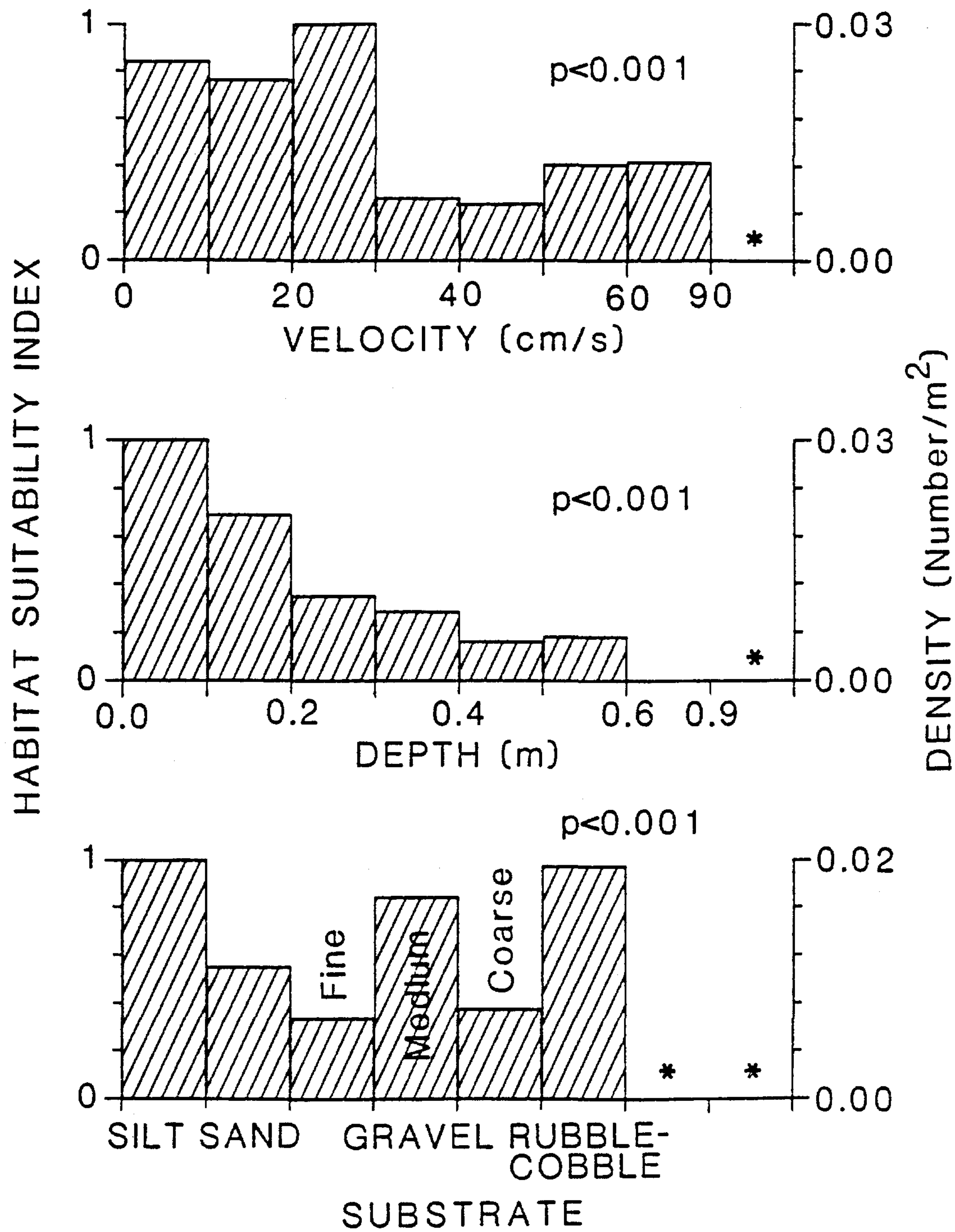

Figure 10. Habitat suitability indices and densities for juvenile lake chub (N = 380, average TL = 60 mm) based on measurements of velocity, depth, and substrate. Asterisks indicate categories not measured.

Densities varied significantly over the sampled range of habitat variables ($p < 0.001$) and were highest at 50 to 59 cm/s velocities, 0.00 to 0.09 depths, and for rubble-cobble substrates (Tables 19, 20 and 21; Figure 11). Observed values were greater than expected for velocities greater than 40 cm/s, depths less than 0.4 meters and for substrates of medium gravel and larger.

The null hypothesis of independence of life stage and habitat was rejected ($p < 0.001$) for each variable. YOY and juveniles of lake chub were captured more frequently than expected at velocities less than 30 cm/s while adults were found at velocities greater than 30 cm/s more frequently than would be expected if capture velocities were independent of life stage (Table 22).

YOY of lake chub were captured at depths from 0.00 to 0.09 m, juveniles from 0.20 to 0.49 m and adults from 0.10 to 0.39 m more frequently than expected (Table 23). Substrate at capture locations was also not independent of life stage ($p < 0.001$). YOY of lake chub were found over silt and sand, juveniles over silts, gravel and rubble-cobble and adults over medium gravel to rubble-cobble substrates more frequently than expected (Table 24).

Catch rates of YOY longnose sucker differed among seining stations (K-W chi-square = 74.2, 6 df, $p < 0.001$). Pairwise comparisons indicated that YOY were more abundant at Byers 2 than they were at all other stations except Byers 1A. Byers 1A catch rates were higher than those at all sites except Wenrich 3 and Byers 2. Catch rates were lowest at Byers 1B and Wenrich 2.

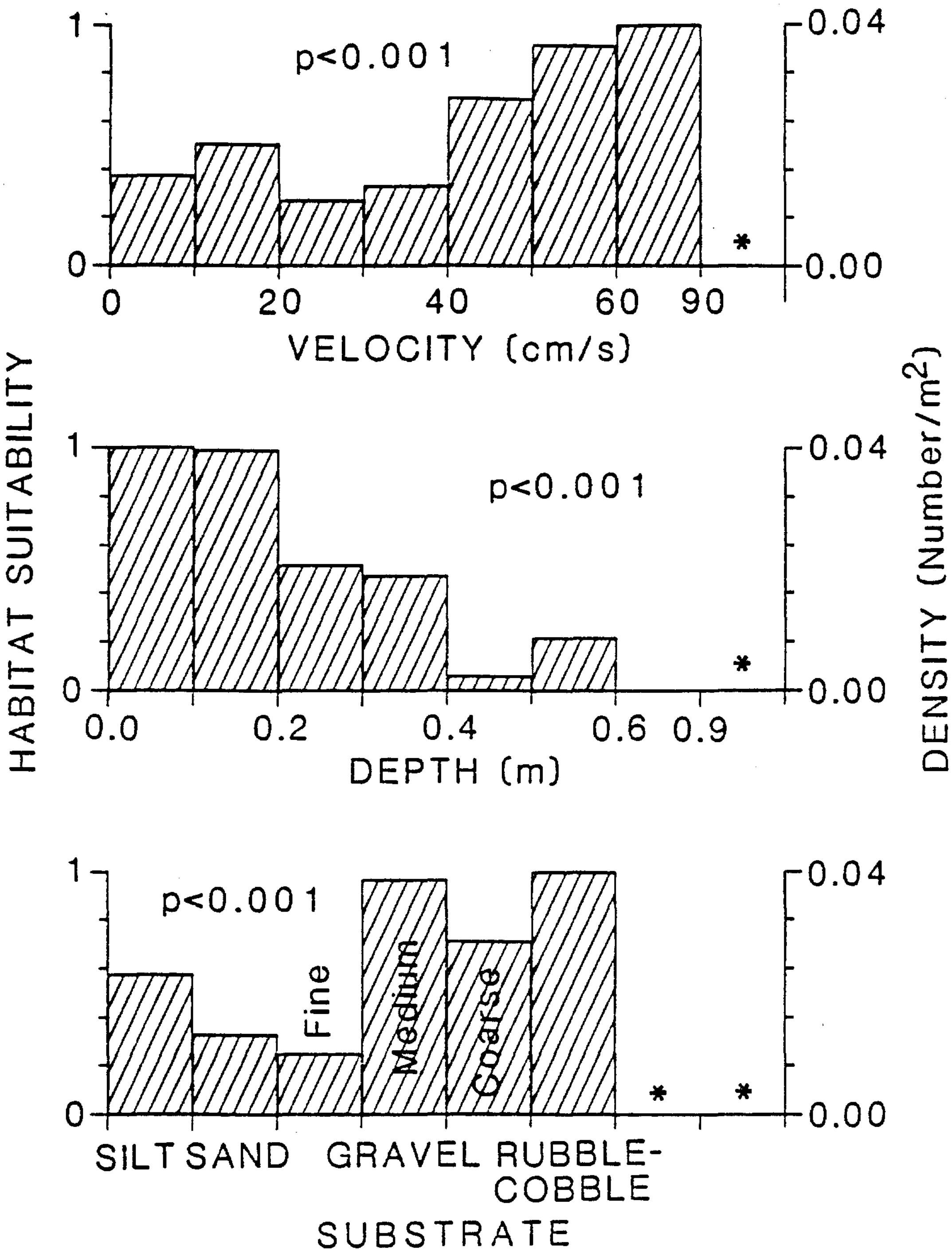

Figure 11. Habitat suitability indices and densities for adult lake chub (N = 580, average TL = 95 mm) based on measurements of velocity, depth, and substrate. Asterisks indicate categories not measured.

Table 22. Observed frequencies of lake chub and expected frequencies (in parentheses), assuming independence of fish length and water velocity at capture locations.

Life stage	Water velocity (cm/s)							Totals
	0-9	10-19	20-29	30-39	40-49	50-59	60-90	
YOY	191	47	38	2	2	0	0	280
	(116.7)	(66.6)	(35.9)	(10.8)	(22.8)	(18.3)	(8.8)	
Juvenile	162	99	75	12	13	13	6	380
	(158.4)	(90.4)	(48.7)	(14.7)	(31.0)	(24.8)	(12.0)	
Adult	164	149	46	34	86	68	33	580
	(241.8)	(138.0)	(74.4)	(22.5)	(47.2)	(37.9)	(18.2)	
Totals	517	295	159	48	101	81	39	1,240

$T = 251.3$, 12 df, $p < 0.001$

Table 23. Observed frequencies of lake chub and expected frequencies (in parentheses), assuming independence of fish length and water depth at capture locations.

Life stage	Water depth (m)							Totals
	0.00-0.09	0.10-0.19	0.20-0.29	0.30-0.39	0.40-0.49	0.50-0.59	0.60-0.90	
YOY	103	150	16	4	3	3	1	280
	(61.0)	(175.6)	(29.6)	(9.3)	(2.3)	(2.3)	(0.2)	
Juvenile	78	238	43	13	5	3	0	380
	(82.7)	(238.1)	(40.1)	(12.6)	(3.1)	(3.1)	(0.3)	
Adult	89	389	72	24	2	4	0	580
	(126.3)	(363.4)	(61.3)	(19.2)	(4.7)	(4.7)	(0.5)	
Totals	270	777	131	41	10	10	1	1,240

$T = 65.5$, 12 df, $p < 0.001$

Table 24. Observed frequencies of lake chub and expected frequencies (in parentheses), assuming independence of fish length and substrate at capture locations.

Life stage	Substrate						Totals
	Silt	Sand	Fine gravel	Medium gravel	Coarse gravel	Rubble-cobble	
YOY	131	41	10	83	12	3	280
	(91.5)	(17.4)	(13.5)	(122.6)	(21.5)	(13.5)	
Juvenile	140	18	22	158	21	21	380
	(124.1)	(23.6)	(18.4)	(166.4)	(29.1)	(18.4)	
Adult	134	18	28	302	62	36	580
	(189.4)	(36.0)	(28.1)	(254.0)	(44.4)	(28.1)	
Totals	405	77	60	543	95	60	1,240

$T = 125.7$, 12 df, $p < 0.001$

YOY longnose sucker were most abundant in shallow backwaters. Densities were highest at velocities from 0 to 9 cm/s, 0.00 to 0.09 m depths and over silt substrates (Tables 25, 26 and 27; Figure 12). The null hypothesis that densities did not vary over the sampled range of habitat variables was rejected ($p < 0.001$). Observed values were greater than expected under the null hypothesis only for optimum ranges of each variable. The null hypothesis of equal catch rates between seining stations was rejected (K-W chi-square = 20.9, 6 df, $p < 0.003$) for juvenile longnose sucker. Pairwise comparisons revealed that catch rates were higher at Byers 1A than at all other sites expect Byers 2. Catch rates were significantly lower at Wenrich 2 than at any other site. No other pairwise differences were observed. Juvenile longnose sucker preferred velocities greater than 40 cm/s with 60 to 90 cm/s optimum, depths from 0.00 to 0.09 m, and sand to medium gravel substrates with fine gravels most preferred (Tables 25, 26 and 27; Figure 13). Densities varied significantly ($p < 0.001$) over the sampled range of each habitat variable.

The null hypothesis that velocity, depth, and substrate at capture locations was independent of life stage of longnose sucker was rejected for each variable ($p < 0.001$). YOY of longnose sucker occurred at velocities from 0 to 9 cm/s, depths from 0.00 to 0.09 m, and at silt and sand substrates in greater frequency than expected while juveniles tended to occupy higher velocities, greater depths, and substrates of larger particle size (Tables 28, 29 and 30).

Table 25. Velocity interval (cm/s), area sampled (m^2), catch frequencies, and densities (number/m^2) for YOY and juvenile longnose sucker and juvenile/adult slimy sculpin. All probabilities associated with T values (chi-square goodness-of-fit) are less than 0.001 with 6 degrees of freedom.

Velocity	Area	YOY Sucker		Juvenile sucker		Sculpin	
		Frequency	Density	Frequency	Density	Frequency	Density
0-9	7,190	285	0.040	156	0.022	57	0.008
10-19	4,849	39	0.008	84	0.017	13	0.003
20-29	2,800	5	0.002	56	0.020	5	0.002
30-39	1,728	2	0.001	21	0.012	6	0.003
40-49	2,049	5	0.002	73	0.036	18	0.009
50-59	1,226	1	0.001	44	0.036	6	0.005
60-90	543	0	0.000	32	0.059	3	0.006
Total	20,385	337		466		108	
T		368.8		71.2		28.0	

Table 26. Depth interval (m), area sampled (m^2), catch frequencies, and densities (number/m^2) for YOY and juvenile longnose sucker and juvenile/adult slimy sculpin. All probabilities associated with T values (chi-square goodness-of-fit) are less than 0.001 with 6 degrees of freedom.

Depth	Area	YOY Sucker		Juvenile sucker		Sculpin	
		Frequency	Density	Frequency	Density	Frequency	Density
0.00-0.09	2,453	147	0.060	133	0.054	8	0.003
0.10-0.19	10,869	135	0.012	255	0.023	50	0.005
0.20-0.29	3,874	51	0.013	68	0.018	49	0.013
0.30-0.39	1,422	2	0.001	8	0.006	1	0.001
0.40-0.49	962	1	0.001	0	0.000	0	0.000
0.50-0.59	516	1	0.002	2	0.004	0	0.000
0.60-0.90	293	0	0.000	0	0.000	0	0.000
Total	20,389	337		466		108	
T		338.4		165.8		57.5	

Table 27. Substrate interval, area sampled (m^2), catch frequencies, and densities (number/m^2) for YOY and juvenile longnose sucker and juvenile/adult slimy sculpin. All probabilities associated with T values (chi-square goodness-of-fit) are less than 0.001 with 5 degrees of freedom.

Substrate	Area	YOY Sucker		Juvenile sucker		Sculpin	
		Frequency	Density	Frequency	Density	Frequency	Density
Silt	5,713	218	0.038	96	0.017	12	0.002
Sand	1,338	28	0.021	29	0.022	0	0.000
Gravel							
Fine	2,717	10	0.004	101	0.037	10	0.004
Medium	7,623	63	0.009	203	0.027	79	0.010
Coarse	2,118	17	0.008	29	0.014	7	0.003
Rubble-Cobble	878	1	0.001	8	0.009	0	0.000
Total	20,387	337		466		108	
T		241.9		53.4		62.6	

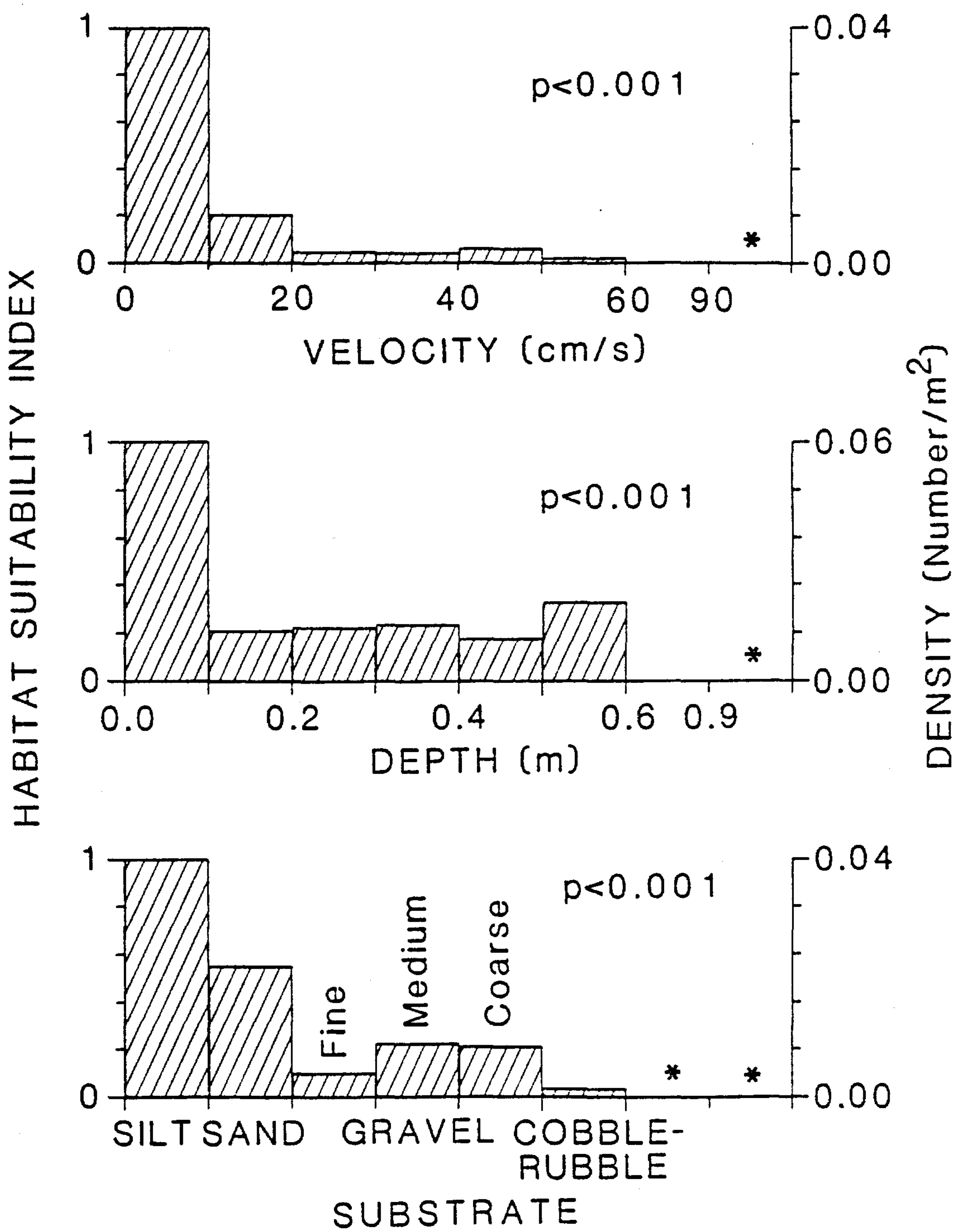

Figure 12. Habitat suitability indices and densities for YOY longnose sucker (N = 337, average TL = 38 mm) based on measurements of velocity, depth, and substrate. Asterisks indicate categories not measured.

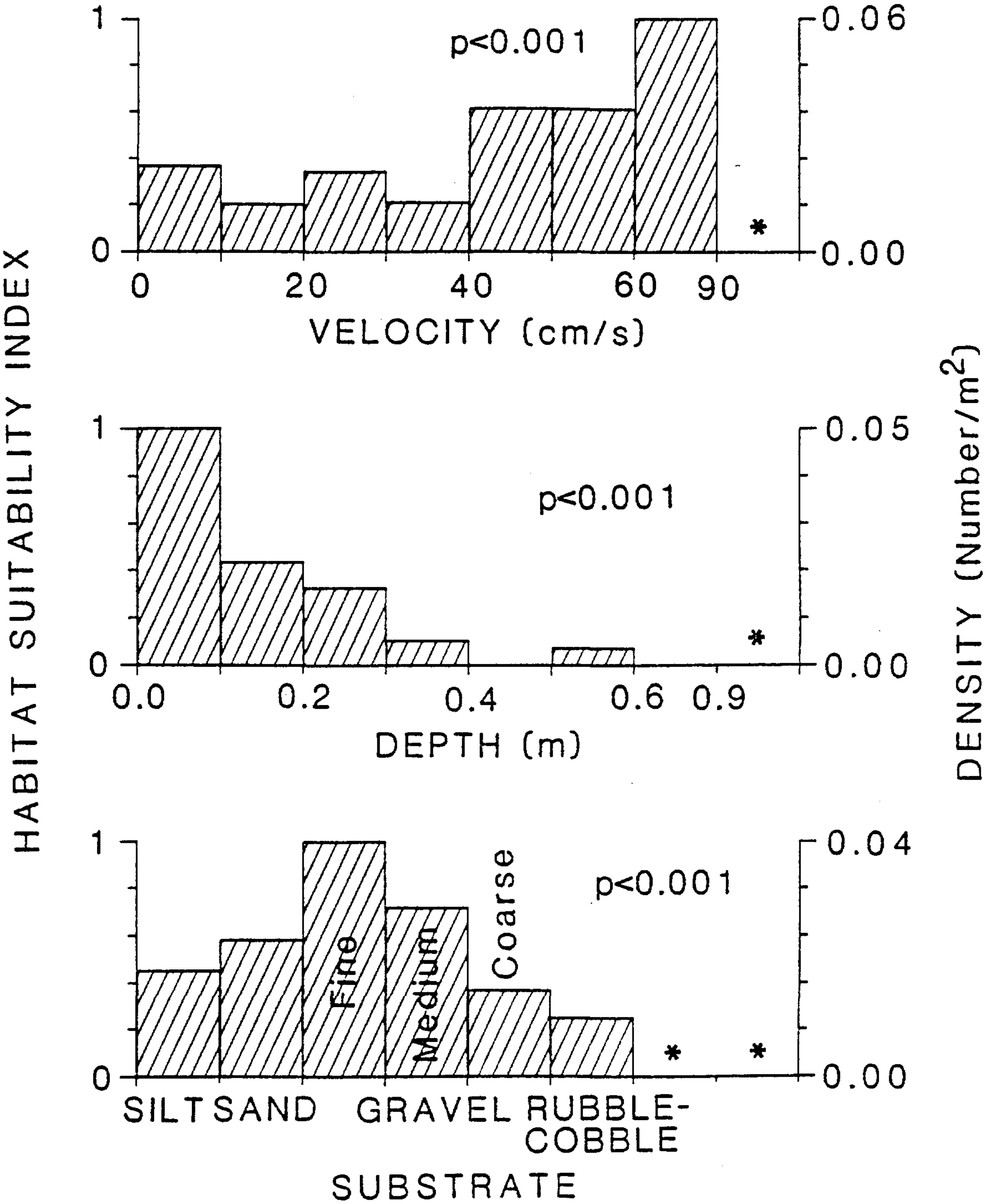

Figure 13. Habitat suitability indices and densities for juvenile longnose sucker (N = 466, average TL = 94 mm) based on measurements of velocity, depth, and substrate. Asterisks indicate categories not measured.

Table 28. Observed frequencies of longnose sucker and expected frequencies (in parentheses), assuming independence of fish length and water velocity at capture locations.

Life stage	Water velocity (cm/s)							Totals
	0-9	10-19	20-29	30-39	40-49	50-59	60-90	
YOY	285	39	5	2	5	1	0	337
	(185.1)	(51.6)	(25.6)	(9.7)	(32.7)	(18.9)	(13.4)	
Juvenile	156	84	56	21	73	44	32	466
	(255.9)	(71.4)	(35.4)	(13.3)	(45.3)	(26.1)	(18.6)	
Totals	441	123	61	23	78	45	32	803

T = 229.5, 12 df, $p < 0.001$

Table 29. Observed frequencies of longnose sucker and expected frequencies (in parentheses), assuming independence of fish length and water depth at capture locations.

Life stage	Water depth (m)							Totals
	0.00-0.09	0.10-0.19	0.20-0.29	0.30-0.39	0.40-0.49	0.50-0.59	0.60-0.90	
YOY	147	135	51	2	1	1	0	337
	(117.5)	(163.7)	(49.9)	(4.2)	(0.4)	(1.3)	(0.0)	
Juvenile	133	255	68	8	0	2	0	466
	(162.5)	(226.3)	(69.1)	(5.8)	(0.6)	(1.7)	(0.0)	
Totals	280	390	119	10	1	3	0	803

$T = 47.0$, 12 df, $p < 0.001$

Table 30. Observed frequencies of longnose sucker and expected frequencies (in parentheses), assuming independence of fish length and substrate at capture locations.

Life stage	Substrate						Totals
	Silt	Sand	Fine gravel	Medium gravel	Coarse gravel	Rubble-cobble	
YOY	218	28	10	63	17	1	337
	(131.8)	(23.9)	(46.6)	(111.6)	(19.3)	(3.8)	
Juvenile	96	29	101	203	29	8	466
	(182.2)	(33.1)	(64.4)	(154.4)	(26.7)	(5.2)	
Totals	314	57	111	266	46	9	803

$T = 186.4$, 12 df, $p < 0.001$

Catch rates of slimy sculpin varied (K-W chi-square = 18.0, 6 df, $p < 0.001$) across sites. Catches were highest at Wenrich 1 and Byers 1B and lowest at Main 2 and Byers 2. Due to the smaller sample size for slimy sculpin (N = 125) adults and juveniles were combined both for catch rate comparisons and HSI calculations. YOY sculpin were excluded from the analysis and tests of independence of life stage and habitat variables were not performed. Sculpin were found in moderate numbers at all velocity ranges. Densities were highest at 40 to 49 cm/s. Preferences were indicated only for depths from 0.20 to 0.29 m and medium gravel substrates (Tables 25, 26 and 27; Figure 14). The null hypothesis that densities did not vary over the sampled range of habitat was rejected ($p < 0.001$) for each variable.

Discussion

The fishes most frequently captured in the study area from May to October, in decreasing order of abundance, were lake chub, longnose sucker, humpback whitefish, YOY chum and chinook salmon, slimy sculpin, round whitefish, and burbot. Round whitefish were caught most frequently in tributary mouth habitat (Table 31); this species is probably most abundant in clear streams and lakes (Degraaf and Machniak 1977; Hale 1981). YOY chinook salmon were abundant only in tributary mouth and modified slough habitats. YOY chum salmon were abundant only during spring outmigration.

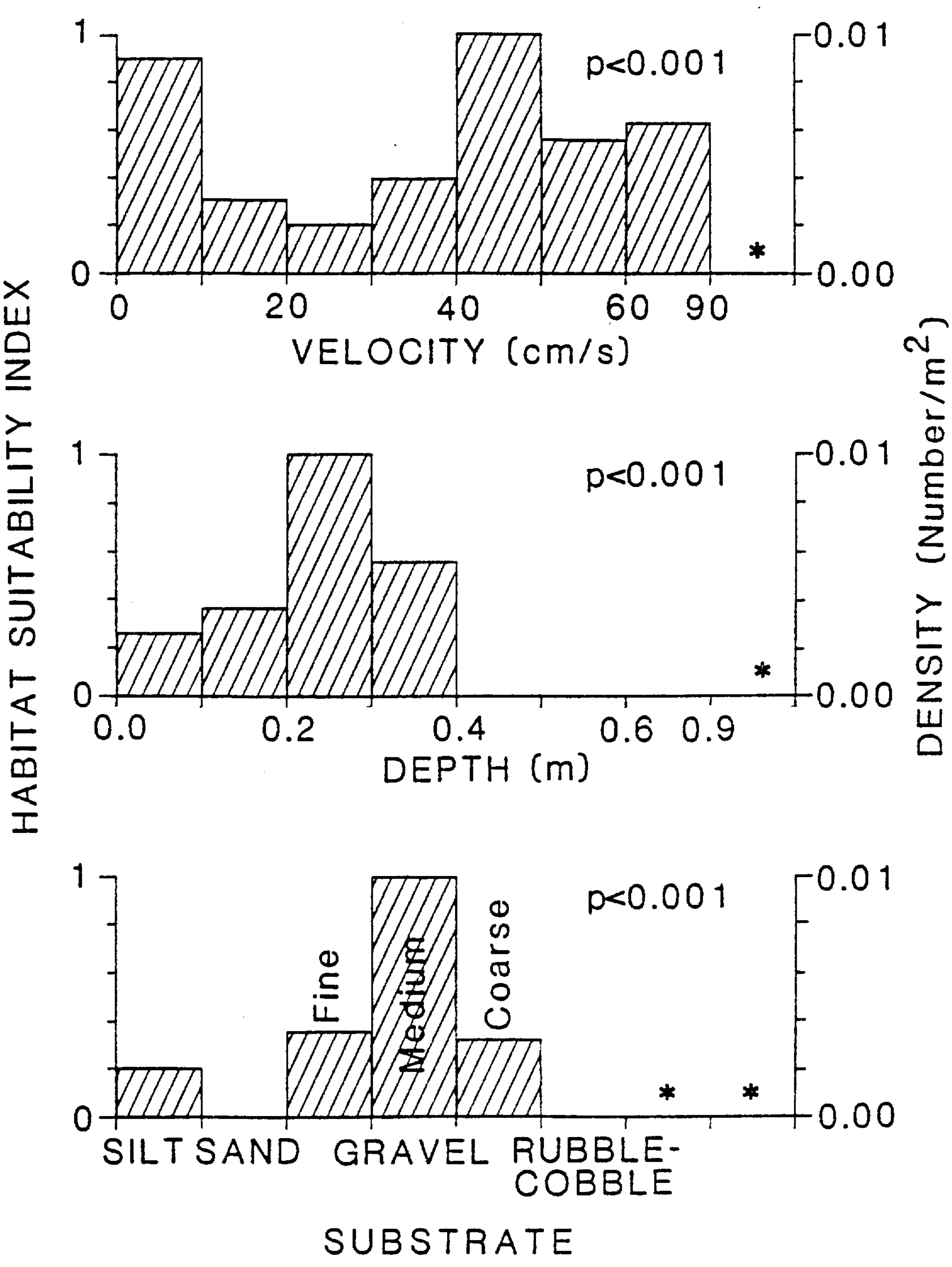

Figure 14. Habitat suitability indices and densities for juvenile/adult slimy sculpin (N = 108, average TL = 44 mm) based on measurements of velocity, depth, and substrate. Asterisks indicate categories not measured.

Table 31. Percentage composition of fishes by habitat type.

Habitat	Lake Chub	Longnose Sucker	Humpback Whitefish	Round Whitefish	Slimy Sculpin	Burbot	Juvenile Salmon	Adult Salmon
	Species							
Main Channel								
Border	20	58	15	2	0	3	0	2
Sandbar	70	19	1	4	1	1	3	0
Sidechannel								
Gravel Bar	40	48	0	2	5	<1	5	0
Lower	34	33	12	4	<1	14	<1	3
Side Slough	48	37	2	<1	13	0	<1	0
Intermittent	57	41	0	<1	1	0	<1	0
Modified								
Slough	41	13	23	2	4	<1	16	<1
Groin	20	30	10	2	2	12	4	18
Tributary								
Mouth	20	23	33	10	0	<1	10	4

The remaining fishes frequently captured in the study area are adapted for benthic feeding: a benthic feeding strategy (as opposed to feeding in the water column) may be an advantage in turbid glacial waters. Humpback whitefish possess an inferior mouth adapted for feeding on benthic invertebrates such as larvae of Trichoptera and Diptera (McPhail and Lindsey 1970; Morrow 1980). Longnose sucker are tactile bottom feeders (Scott and Crossman 1979; Edwards 1983) and possess what may be sensory papillae on ventrally located protrusible mouthparts (Morrow 1980). Both burbot (Chen 1969) and slimy sculpin (Sonnichsen 1980) are benthic dwelling fishes that feed almost entirely on other benthic organisms. Lake chub, although classified as a sight feeder because of large optic lobes, possess subcutaneous taste buds on the pectoral fins as well as muscular folds in the pharyngeal cavity that are useful in sorting food from non-food items (Davis and Miller 1967).

Broad whitefish, least cisco, sheefish, Arctic grayling, northern pike, and lamprey were rarely captured during this study. However some of these species may enter the Tanana River in winter when turbidities therein decrease and the various tributaries offer a less hospitable environment due to icing conditions. For instance, Arctic grayling are thought to move out of the Goodpaster River (Tack 1974), Delta Clearwater River (Pearse 1974), Richardson Clearwater River (Pearse 1974), Five Mile Clearwater River (Hallberg 1980), and several other tributaries (Tack 1980) and overwinter in the Tanana River. Northern pike are known to move from the Minto

Flats area and into the Tanana River to overwinter in the lower Tolovana River-Swanneck Slough area (Cheney 1971, 1972; Hallberg 1983) as do broad whitefish, humpback whitefish, and least cisco (Kepler 1973).

Burbot were captured most frequently in lower sidechannel, groin, and main channel border areas (Table 31). They were rarely captured in the clearer modified slough and tributary mouth habitats and, except during high river stages, were absent from shallow main channel sandbar and sidechannel habitats (Table 31). Chen (1969) found that although burbot occasionally entered clearwater tributaries (particularly during winter spawning migrations) they preferred the heavily silted and deeper portions of glacial rivers.

Northern pike on the other hand, were only captured in tributary mouth, groin, and modified slough habitats. Pike are not adapted to life in swift currents (Inskip 1982) and when present in rivers prefer backwaters. They are often associated with vegetation especially for spawning purposes (Inskip 1982). Most of the pike captured were from the modified slough which was the only location where rooted and submerged aquatic macrophytes were observed. Whitefishes are a preferred prey item in northern pike diets (Cheney 1971) and the areas in which pike were found are those areas where whitefish make up a substantial portion of the fish community (Table 31).

Arctic lamprey were found only in slower, deeper waters at the lower ends of sidechannels and in modified slough and groin habitats. All individuals captured were either the larval anadromous form or possibly a dwarf freshwater form (Morrow 1980). Little is known of the biology of arctic lamprey but larval brook lamprey exhibit a strong preference for areas with low current velocity and stable silt-sand substrates (Malmqvist 1980).

Fish communities of the shallow margins of main channel sandbar and most sidechannel areas were dominated by lake chub, longnose sucker, and to a lesser extent by slimy sculpin. Although each of these species occurred in many habitats, definite preferences were observed. Habitat suitability indices were developed for the different life stages of each species. Lake chub and longnose sucker occupied microhabitats of increasing velocity, depth, and substrate size as they grew. Similar patterns of habitat use by different size classes have been observed for chinook salmon (Lister and Genoe 1970), Colorado River squawfish (Holden 1977), smallmouth bass (Orth and Maughn 1982) and bluegill (Werner et al. 1977, 1983).

Preference for shallow, silty, slow-moving backwaters by YOY fishes may be related to the presence of an abundant food supply, an attempt to avoid the harsher conditions of open channel areas, or to escape predation by adults of the same and other species. Holden (1977) suggests that backwaters are often nutrient rich due both to the silt substrates and warmer water temperatures. They may provide the most suitable habitat for copepods, cladocerans, and small aquatic insects, especially in a river as turbid and swift as the Tanana.

The primary predator in the Tanana River is the burbot. Seining, fyke-netting, and electrofishing indicated that they seldom frequent waters less than 0.5 m deep. Because YOY lake chub and longnose sucker tend to inhabit very shallow backwaters they may, as a result, be less susceptible to predation.

Regardless of the reasons for the observed habitat uses by YOY fishes it is obvious that shallow backwaters act as critical nursery habitat; not only for lake chub and longnose sucker but also for YOY of slimy sculpin and juvenile chinook salmon, round whitefish and humpback whitefish. Vanicek (1967) suggested that shallow backwaters are so important that an abundance or lack of these preferred habitats may increase or decrease the survival of of YOY and juvenile fishes.

Juvenile lake chub were abundant across a wider range of velocities and substrate sizes than were either YOY or adults. Holden (1977) attributed the wider habitat preferences of juvenile Colorado River squawfish to an increased movement between preferred habitats. It is not known if juvenile lake chub follow such a movement pattern.

Preferences for swift, shallow gravel riffle areas particularly at the head of sidechannels by adult lake chub and juvenile longnose sucker may be related to the presence of an abundant food supply. The primary prey organism of these species are aquatic insect larvae (Scott and Crossman 1979) which tend to be more abundant in the riffle areas of streams (Surber 1941). Werner et al. (1983)

demonstrated that while predation influenced habitat use patterns more strongly than feeding strategies in rearing bluegills, the opposite was true for larger size classes.

Slimy sculpin were present over a wide range of velocities but did prefer fairly narrow ranges of depth and substrate. In the upper Chena River Sonnichsen (1981) captured sculpin throughout the sampled ranges of velocity, depth, and substrate. However, she felt that the way in which velocities were measured did not accurately represent the actual water velocities encountered by the benthic dwelling sculpin. Velocities should have been measured at or near the bottom at all sculpin capture locations rather than at 0.6 of total depth. Orth and Maughn (1982) encountered similar difficulties in determining velocity preferences for another benthic stream fish, the freckled madtom. Although Sonnichsen (1981) found sculpin to be distributed randomly across all larger substrates; silt, sand, and smaller gravels were rarely if ever sampled. The wider range of substrates sampled for Tanana River sculpin may present a clearer picture of their habitat preferences in glacial rivers. Sculpin reach their greatest abundance in rocky or gravelly streams (Craig and Wells 1976; Scott and Crossman 1979) and prey almost exclusively on invertebrate bottom fauna which are more abundant in gravel riffle areas.

There are three potential sources of bias in the development of habitat suitability curves or indices (Orth et al. 1981). The first occurs when sample distributions of habitat variables are nonuniform. This bias was reduced by using relative densities based on the area sampled in each habitat interval.

The second type of bias relates to differential sampling efficiencies of gear between habitats. The most common way to alleviate this bias is to develop HSI's based on samples obtained with two or more gear types. Visual observation and electrofishing are preferred methods for developing suitability indices (Bovee and Cochnauer 1977). Unfortunately neither method is practical in the heavily silted Tanana River. Fyke nets, gill nets, and various baited traps and nets are plagued by other types of bias and are generally not recommended (Bovee and Cochnauer 1977). Although using only seining information is not ideal, it proved to be the only practical method available.

The third source of bias arises when habitat use varies among size groups or seasons. Although the bias associated with size groups was overcome, that relating to seasonal changes was not. As temperatures, turbidities, and flows vary, changes in habitat use are likely to occur. However, many authors suggest that fishes exhibit stable patterns of habitat use (Moyle 1973; Mendelson 1975; Hall and Werner 1977). Others believe that stability of habitat use occurs but only in stable environments (Matthews and Hill 1980). Stability of habitat use in the widely fluctuating Tanana River appears unlikely and further investigation in this area is warranted.

Bovee and Cochnauer (1977) present criteria for rating habitat suitability indices. Under this system indices calculated for all life stages of lake chub and longnose sucker can be considered as excellent since more than 200 samples were collected under a wide range of hydraulic conditions. The sculpin HSI is classified as good since more than 100 samples were obtained.

The habitat suitability indices presented here are based on two assumptions. The first assumption is that individual fish prefer certain ranges of one habitat attribute independently of the other attributes. Orth and Maughn (1982) demonstrated that this assumption was invalid for freckled madtom, central stoneroller, and orangebelly darter in Glover Creek, Oklahoma. The use of mathematically more sophisticated procedures, for example, multivariate suitability functions that account for interdependence among variables (Voos 1981) was beyond the scope of this study.

The second assumption is that species abundance as estimated by C/f is positively related to habitat quality. Van Horne (1983) has shown that the relationship of population density to habitat quality is affected by factors such as the availability of critical winter habitat, social interactions, and temporal variation in local population densities, food availability, predator abundance, and abiotic environmental factors. Interspecific interactions such as competition for food and space may exert a strong influence on habitat selection in some species. For example, Dolly Varden and cutthroat trout utilized widely different habitats when sympatric but more completely utilized all available habitat when allopatric; diet followed a similar pattern (Andrusak and Northcote 1971).

Given the problems and limitations associated with the methodology implemented in this study, investigators are urged to exercise caution when applying these models to other river systems.

EFFECTS OF BANK STABILIZATION ON FISHES AND THEIR HABITAT

Results

Water quality differed between modified and unmodified sidechannels (Table 32). Surface water temperature, hardness, and water clarity were higher in modified sidechannels (Morgan and Groin 1) compared to unmodified ones (Byers and Wenrich). Differences were most apparent at Morgan because of the change from riverine to groundwater input.

Discharge estimates were obtained at the first (upstream) and last (downstream) transects at low, moderate, and high river stages in 1982 at Morgan and Wenrich and at low and moderate river stages at Byers. Although some circulation occurs at the mouth of Groin 1, flow is otherwise imperceptible. Discharge ranged from 0 to 5 m^3/s and averaged 1 m^3/s at Morgan; from 3 to 20 m^3/s with a mean of 13 m^3/s at Wenrich; and from 3 to 18 m^3/s at Byers. Average discharge at Byers is higher than estimated because no estimate was obtained during peak river stages.

Habitat mapping (Dunham and Collotzi 1975) revealed differences in physical features of modified and unmodified sidechannels. Byers sidechannel is wider and shallower than Morgan, Wenrich, and Groin 1 (Table 33). Morgan and Wenrich are similar with respect to width and average depth. Greatest depths were observed at Morgan. The main channel may exert a damming effect on Morgan and Groin 1 similar to that observed on the Chena River mouth which would otherwise be much shallower (Buska, CRREL, personal communication).

Table 32. Averages of physico-chemical measurements at modified and unmodified sidechannels of the Tanana River near Fairbanks, Alaska. Extremes observed are in parentheses.

	Modified		Unmodified	
Measurement	Morgan	Groinl	Byers	Wenrich
Temperature (C)	14.5 (9.5-19.4)	14.9 (10.6-20.6)	13.6 (9.4-18.3)	14.0 (10.0-16.7)
pH	8.3 (8.1-8.4)	7.8 (7.6-7.9)	7.5 (7.3-7.6)	7.4 (7.2-7.5)
Dissolved Oxygen (mg/l)	7.7 (6.8-8.5)	7.8 (7.4-8.2)	9.6 (9.4-9.7)	9.4 (9.3-9.4)
Hardness (mg $CaCO_3$)	178 (171-185)	146 (140-151)	128 (120-136)	131 (125-137)
Specific Conductance (micromhos/cm)	735 (310-1120)	511 (270-760)	502 (210-700)	511 (210-680)
Water Clarity (mm)	1138 (300-2600)	128 (60-210)	64 (40-120)	73 (50-130)
Current Velocity (cm/s)	1 (0-8)	0 (0-0)	20 (4-28)	21 (4-30)
Depth (m)	1.5 (0-3.8)	1.5 (0-3.1)	0.8 (0-2.7)	1.4 (0.3.4)
Flow (m^3)	1 (0-5)	0 (0-0)	13 (3-18)	14 (3-20)

Table 33. Morphometry of modified and unmodified sidechannels.

	Modified		Unmodified	
Measurement	Morgan	Groinl	Byers	Wenrich
Section Length (m)	770	220	990	1320
Mean Channel Width (m)	45.8	95.2	141.7	50.4
Mean Total Width (m)	44.7	93.9	78.6	47.8
Mean Depth (m)	1.52	1.52	0.78	1.40
Maximum Depth (m)	3.75	3.10	2.70	3.35

Both the relative amount and type of substrate varied between modified and unmodified sidechannels (Table 34). Organic detritus (decaying plant matter) was common at Morgan, less common at Groin 1, and absent or rare at Wenrich and Byers. The dominant substrate was silt at Morgan and Groin 1 while silt-sand (50-50), sand, and gravel were dominant at Byers and Wenrich. Sand and gravel made up a low percentage of the substrate at Morgan and Groin 1. The high percentage of rip-rap (quarried rock) at Morgan and Groin 1 resulted from transects being located next to a revetted culvert at Morgan and to the revetted south and east banks at Groin 1.

Modified and unmodified sidechannels differed in the amount and type of cover present (Table 35). The proportion of flooded vegetation was high at Morgan due partly to high water but also to the stable banks which allow growth of shrubs and grasses near the waters edge. Because of scouring and more widely fluctuating water levels there was a low proportion of flooded vegetation at unmodified sidechannels. Much of the flooded terrestrial vegetation at Groin 1 is dead or dying due to higher water levels resulting from groin construction. Emergent aquatic vegetation (primarily *Juncus alpinus* and *Scirpus* sp.) was similar in relative abundance at Morgan, Byers, and Wenrich and absent at Groin 1. The sidechannels are characterized by a moderate amount of shallow sloping banks where conditions are favorable for emergent aquatic plant growth. In contrast, banks are very steep and covered by rip-rap or coarse gravel at Groin 1.

Table 35. Cover in modified and unmodified sidechannels expressed as percent of total transect distance

	Modified		Unmodified	
Cover	Morgan	Groinl	Byers	Wenrich
Flooded Terrestrial Vegetation	11.9	0.9	0.0	0.4
Emergent Aquatic Vegetation	4.3	0.0	4.7	3.7
Rooted Aquatic Vegetation	14.6	0.0	0.0	0.0
Overhanging Vegetation	7.3	2.7	0.6	5.5
Submerged Debris	12.6	19.0	3.9	4.1
No Cover	49.5	77.4	90.8	86.3

Because of clearer and slower moving waters, a rooted aquatic plant community has developed in Morgan Island sidechannel. No rooted aquatic macrophytes were observed at Byers, Groin 1, or Wenrich because of scouring and/or higher turbidites.

Submerged logs and brush were common at Morgan and Groin 1 but relatively scarce at Byers and Wenrich. The absence of flushing flows during spring and glacial-runoff periods in late summer is responsible for the large amount of debris in these modified sidechannels. Essentially, any brush or trees that fall or are carried into these modified areas are no longer carried away during peak flows and therefore remain to provide instream cover.

The proportion of overhanging vegetation was highest at Morgan and Wenrich and lowest at Byers. Morgan and Wenrich sidechannels are lined on both banks with dense stands of willow and alder. Banks are covered with rip-rap at Groin 1 except for a small portion along the western edge. Overhanging willow and alder occur only along the southern bank at the upstream end of Byers. The northern bank is lower in elevation and is covered with water during high river stage.

The proportion of transect distance not influenced by cover of any type is very high at Byers and Wenrich and still fairly high at Groin 1 due to the revetted banks. Over one half of the transect distance measured at Morgan is influenced by some type of cover. In summary, modified sidechannels within the study area were deeper, dominated more by finer substrates, and had more cover than unmodified sidechannels.

Differences were also seen in relative abundance and composition of fishes in modified and unmodified areas. Whitefishes (humpback, round, least cisco, and sheefish) made up a much larger proportion of the total catch at Morgan and Groin 1 than at Byers and Wenrich (Table 36). Predatory fishes (northern pike and burbot) contributed a low percentage of the overall catch at Morgan but were common at other sites. Of the predatory fishes captured at Morgan only two were burbot. Four northern pike were also captured at Groin 1 while none were found at Byers and Wenrich. The presence of northern pike in modified sidechannels is related to the clearer water, pike are visual predators (Brakevelt 1975) and the large numbers of whitefishes, a preferred prey species for northern pike (Cheney 1971; Morrow 1980). The very low numbers of burbot in Morgan despite the presence of abundant prey is apparently related to their preference for more turbid waters (Chen 1969).

Adult chinook, coho, and chum salmon were infrequently captured at Morgan and Wenrich but were fairly abundant at Byers and Groin 1. This may be due to Morgan and Wenrich being somewhat more isolated from the main channel since spawning salmon generally prefer deeper swifter waters on their upstream migration. Adult chum salmon were commonly captured in gill nets at Groin 1. This groin is immediately adjacent to the swiftest and deepest portion of the main channel (CRREL 1982).

Table 36. Number and percentage composition of major groups of fishes in modified and unmodified sidechannels for combined gear types in 1981 and 1982.

	Modified				Unmodified			
	Morgan		Groinl		Byers		Wenrich	
Group	#	%	#	%	#	%	#	%
Whitefishes	491	24.7	36	13.7	97	6.5	46	3.8
Forage[a] Species	1156	58.1	142	54.0	1309	87.7	1066	87.7
Predator[b] Species	16	0.8	32	12.2	38	2.5	43	3.5
Adult Salmon	2	0.1	43	16.3	15	1.0	2	0.2
Juvenile Salmon	323	16.2	10	3.8	33	2.2	59	4.9

a - humpback whitefish, round whitefish, broad whitefish, least cisco, and sheefish

b - northern pike and burbot

An obvious difference in fish community structure occurred at Morgan. YOY chum, chinook, and juvenile coho salmon made up 16 percent of the total catch in this clearer sidechannel while comprising less than five percent at other more turbid sidechannels. At least a portion of the YOY chum salmon captured were released into Morgan Island sidechannel by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation and Enhancement (FRED) in early spring 1982 (Raymond, ADF&G, FRED, personal communication). However, even if the YOY chum salmon captured are ignored, YOY and juvenile salmon still make up a much larger percentage of the catch at Morgan than at other sites. The abundance of YOY and juvenile salmon at Morgan is most likely related to the clearer waters and abundance of cover.

Discussion

Bank stabilization has altered habitat and water quality characteristics in Tanana River sidechannels. Although dissolved oxygen, hardness, pH, and specific conductance values were dissimilar in modified and unmodified sidechannels these differences are not likely to affect fish relative abundance or distribution. However, it appears that increased water temperatures and water clarity resulting from lower flows and isolation from the more turbid main channel have had a significant impact.

Other sidechannels upstream from the study area that have been blocked or diverted have shown similar changes in hydrology and water quality. In 1945 a diversion dike was constructed at the confluence of Chena Slough and Moose Creek to prevent potential Tanana River floodwaters from threatening the Fairbanks townsite (Collins 1980). Chena Slough was a major sidechannel of the Tanana River that departed the north bank of the main channel approximately 45 km upstream of the Chena River confluence and then flowed in a northwesterly direction for 37 km where it joined the Chena River 16 km east of Fairbanks. At that time residents considered this confluence to be the mouth of the Chena River; the present-day lower Chena River that flows through Fairbanks was regarded as part of the Tanana River (Collins 1980). In fact, an estimated 70 percent of the lower Chena River flow was from Chena Slough. After dike construction, nearly all of the lower Chena River flow was from the Chena River itself. The lower part of Chena Slough (renamed Badger Slough) was reduced in length from 45 km to 27 km, became shallower, and average flow was reduced from 140 m^3/s (Collins 1980) to 0.003 m^3/s (Walker 1983). Badger Slough flows now come from groundwater seepage and local rainwater runoff. The water is probably warmer now than before dike construction; highs of 19 C have been observed (Walker 1983).

The Chena River Flood Control Project (CRFCP) was authorized by the U.S. Congress in 1968 following the disastrous flooding of Fairbanks by the Chena River in 1967. Built by the Army Corps of Engineers the CRFCP consists of a flood control dam across the Chena River at river km 71 (operational in 1980) designed to divert floodwaters along the 11.6 km Moose Creek Floodway south to the Tanana River. An associated 37 km reinforced levee extends from the Moose Creek Floodway downstream along the north bank of the Tanana River. To date, six L-shaped current deflection structures (groins) and a causeway have been emplaced along the levee. The first of these was built in 1975 near North Pole where erosion was threatening the levee (USACE 1980). The second diversion structure consists of a causeway, also constructed in 1975, by the Fairbanks North Star Borough from the northern bank of the Tanana across the northernmost sidechannel for the purposes of gravel mining on a main channel island. In 1979 a diversion groin and pilot channel were constructed to protect the integrity of the southern end of the Moose Creek floodway sill.

The effects of these structural intrusions on the Tanana River are similar and include: increased water clarity and greatly reduced flows behind the groins during low river stages as water input changes from riverine to groundwater seepage; increased bank erosion downstream as the river reestablishes its original length by forming a meander below the groins; and, the invasion of terrestrial vegetation on the gravel bars of the old riverbed blocked by the groins (USACE 1980; CRREL 1982).

The Phase III portion of the CRFCP involved the extension of the Tanana River levee to a point near the mouth of the Chena River just south of the Fairbanks International Airport (FIA). The Groin 1 primary study site is the second of four groins built to protect the levee and, along with a large pilot channel operational in 1981, to direct the main channel of the Tanana southward (CRREL 1982). This construction eliminated a major bend and several associated sidechannels where north bank erosion of up to 30 m per year was threatening the railroad spur associated with the airport. This unusually severe erosion was occurring where the upstream end of Morgan Island Slough was blocked off around 1960. Behind Groin 1 flows have been reduced and water temperatures and water clarity increased. Unlike the three groins near North Pole water input is still primarily from the main channel. However the design of these current deflectors is such that increased silt deposition within and particularly at the mouth of the groin will eventually cut them off during low flows from the main channel.

Bank stabilization has modified other aquatic habitat features besides hydrology and water quality. In both Morgan Island Slough and Badger Slough dense growth of aquatic macrophytes have developed that are completely absent in riverine sidechannels and the main channel. Other types of potential instream cover such as brush, logs and other debris have also increased in modified sidechannels due to reduced and stabilized flows.

The dominant substrate type has shifted from silt-sand, and gravels in riverine sidechannels to a more uniform substrate of fine silt in altered sidechannels. The modifications of aquatic habitat caused by slough blockages and diversions have caused apparent shifts in fish communities in these areas. These changes are most dramatic in Badger Slough and Piledriver Slough (the upper portion of Chena Slough). These waters now support large numbers of YOY and juvenile grayling and significant numbers of spawning grayling are known to utilize Badger Slough in early spring (Tack 1973; Walker 1983). In fact, Badger Slough provides one of the earliest grayling fisheries in interior Alaska with an average annual harvest of 9,540 grayling (Walker 1983). Piledriver Slough is also utilized as a spawning area by chum salmon although the magnitude of the run is unknown (Walker 1983).

Changes in the fish communities of Morgan Island Slough and Groin 1 are not as dramatic as those in Badger and Piledriver Slough primarily because the latter two are more geographically isolated from the Tanana River. Badger Slough functions only as a Chena River tributary. Changes in the fish communities of the modified sidechannels have likely occurred; they include increased numbers of YOY chum and chinook and juvenile coho salmon, whitefish, and northern pike. These fishes usually reach their greatest abundance in clearer waters (Morrow 1980).

At first glance bank stabilization of sidechannels would appear beneficial; in particular because of increases in commercially or recreationally important fish species like grayling, pike, and salmon. Unfortunately the new habitat that these modifications have created is for the most part only temporary. Areas behind stabilization structures generally silt in and are then invaded by terrestrial vegetation. Once these channels are blocked they often, as in the case of Chena Slough, become prime candidates for residential or industrial development. The initial diversion of Morgan Island Slough was stimulated by the need to expand the airport runway and it appears that future development of this area will occur since runway expansion can only occur at the southern end of the airport.

A comparison of historical and recent aerial photography reveals that bank stabilization activities within the study area have artificially reduced the water surface area of Morgan Island sidechannel and Groin 1 sidechannel by approximately 44 ha. More importantly, these losses have occurred in backwater areas. This study has demonstrated the importance of backwater habitat, particularly as nursery areas for YOY and juvenile fishes. Studies on other large turbid rivers such as the Missouri River and Mississippi River have shown that backwaters (sidechannels, sloughs, and marshes) often provide the bulk of larval fish production even though they represent less than 20 percent of the total water surface area (Morris et al. 1968; Kozel 1971; Funk and Robinson 1974; Kallemyn and Novotny 1977). Channelization activities on these rivers reduced the absolute amount and diversity of aquatic habitat with resultant decreases in diversity and abundance of fish populations (Schneberger and Funk 1971; Funk and Robinson 1974; Kallemyn and Novotny 1974; and Rasmussen 1979). Many fish species which occupy many different habitats as juveniles and adults are dependent on a particular habitat for reproductive purposes. And even though some species prefer particular habitats most require several habitats to complete their life cycle. Therefore the removal of a particular habitat from a river ecosystem affects not only its permanent residents but also species that utilize it for only a portion of their life cycle (Kallemyn and Novotny 1977).

Efforts by the Corps of Engineers to restrict and channelize the main channel of the upper Mississippi River have resulted in a significant degradation and lowering of the river bed. In some areas the present main channel is 3 m deeper than it was in the 1800's before the implementation of wing dikes (Rasmussen 1979). Subsequent elevation of sidechannels and lowering of water tables may result in the ultimate destruction of nearly all man-induced and natural sidechannels (Simons et al. 1975). This may also occur on the Tanana River near Fairbanks if the effect of the levee and present and proposed groins is to force the Tanana into a single channel.

The impacts of bank stabilization on overwintering Tanana River fishes is relatively unknown. Only two studies have examined overwintering habitats on the Tanana River (Van Hyning 1978; Smith 1979). In neither case were researchers able to locate overwintering areas or concentrations of fish and no biological conclusions were reached. Although the water surface area of Morgan Island and Groin 1 sidechannels has been reduced by bank stabilization, what remains may be utilized as overwintering habitat by several fish species. Depths at Groin 1 and Morgan Island Slough are greater than 3 m in several locations and groundwater upwelling areas are present at each site. Moulton (1980) found successful overwintering of northern pike, lake chub, slimy sculpin, and burbot in inundated pits deeper than 2.5 m created by gravel mining in main channel islands at two sites on the upper Tanana River near Delta Junction. Groundwater upwellings were also present in these pits. In addition, approximately 300 individuals of lake chub, YOY chinook salmon, and juvenile round whitefish were fin clipped in August 1981 at Morgan Island Slough. Numerous recaptures of lake chub and a few king salmon were obtained during a population estimate during June 1982. In contrast riverine sidechannels such as Wenrich and Byers Island sidechannels are dewatered from November to April due to dropping river levels. If water levels remain stable and fish passage in and out of modified backwaters continues, floodplain modifications may have short-term beneficial effects. Unfortunately these conditions are unlikely to continue in the future as discussed previously.

The effects of increased silt loads during winter months resulting from future construction of proposed additional groins and maintenance of existing facilities on overwintering Tanana River fishes are unknown. The Corps of Engineers has restricted construction activities to late fall or winter to reduce impacts on upstream migrating salmon. Unfortunately, this practice may adversely affect grayling, whitefish, and northern pike that move out of clearwater tributaries to overwinter in the Tanana River.

Both positive and negative impacts have resulted from bank stabilization of the Tanana River near Fairbanks. Negative changes include losses in total water surface area and potential fish habitat, increased sediment deposition, and increased likelihood of development in blocked sidechannels. From a fisheries perspective, positive changes include increases in water temperature, water level stability, water clarity, and cover. Alterations to backwaters generally resulted in shifts from riverine species to those preferring lake-like habitat. If groundwater flow and surface runoff is adequate, the blockage of upper ends of sidechannels may be a way to improve fish habitat and mitigate losses in other areas; good examples are Morgan Island, Badger, and Piledriver Sloughs. Otherwise, backwater areas may eventually fill in and become a permanent part of the developed floodplain.

It is difficult to recommend other mitigation measures without a more complete understanding of the engineering problems associated with their implementation. For example, it is obvious that the deep channels behind groins are utilized by many fish species. Yet, if silt deposition at the mouth of groins is allowed to continue, fish passage will be blocked and entrapment may occur during low river stages. One or more culverts emplaced along the upstream face of groins may alleviate this potential problem by promoting a flushing action at the groin mouth. This raises many questions beyond the scope of this study regarding minimum flows through the culverts, possible detrimental effects on the stability of the groins themselves, and economic feasibility. Proposed construction of several more groins upstream of the study area demonstrates an urgent need for research in this area.

SUMMARY

1. This study related fish community composition and relative abundance of fish species and life stages to major habitat types and specific habitat parameters, and examined the effects of bank stabilization on fish and aquatic habitat in the Tanana River near Fairbanks, Alaska.

2. Aquatic habitat was classified as main channel, main channel border, main channel sandbar, sidechannel gravel bar, lower sidechannel, intermittent sidechannel, intermittent side-slough, modified slough, groin, and tributary mouth. These habitats differed primarily with respect to water velocity, depth, and clarity, and substrate type.

3. Fifteen fish species were collected with gill nets, seines, frame nets, boat electroshocker, and minnow traps. Most species were not abundant in the study area and many were found only in a particular habitat type.

4. Lake chub and longnose sucker were abundant in all habitats. Humpback whitefish, northern pike, and YOY and juvenile chinook salmon were abundant only in modified slough, tributary mouth, and groin areas.

5. Burbot were rarely captured in tributary mouth, modified slough, and shallow riverine habitats, preferring the deeper, more turbid waters of lower sidechannel, groin, and main channel border areas.

6. Habitat suitability indices based on measurements of velocity, depth, and substrate were calculated for YOY, juvenile, and adult lake chub; YOY and juvenile longnose sucker; and juvenile/adult slimy sculpin.

7. Lake chub and longnose sucker occupied microhabitats of increasing velocity, depth, and substrate size as they grew in length. Habitat variables were not independent of life stage. Shallow, slow-moving backwaters over silt and sand substrates were preferred by YOY lake chub and longnose sucker. Adult lake chub and juvenile longnose sucker were most abundant in swifter, gravel riffle areas. Juvenile lake chub did not exhibit preferences for a particular habitat type.

8. Juvenile/adult slimy sculpin were uniformly distributed across all velocity intervals measured but preferences were indicated for moderate depths and gravel substrates.

9. Bank stabilization has significantly modified aquatic habitat in sidechannels of the Tanana River near Fairbanks,

Alaska. Modified sidechannels are characterized by lower dissolved oxygen levels, reduced flows, substrates of finer particle size, and increased pH, hardness, water temperature, specific conductance, and cover. In sidechannels completely blocked-off from the main channel, aquatic macrophytes have become established.

10. Generally, bank stabilization resulted in the conversion of free-flowing sidechannels to lake-like sloughs. From the fisheries perspective, positive changes were increases in water temperature, water clarity, water level stability, and cover. Negative changes were losses in total surface area, increased sediment deposition, and increased likelihood of development in the same area. Alterations to backwaters generally resulted in shifts from riverine species to those preferring lake-like habitat.

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