PART 6

Resident Fish Habitat Studies

RESIDENT FISH HABITAT STUDIES

1984 Report No. 2, Part 6

by Paul M. Suchanek, Richard L. Sundet and Mark N. Wenger

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

ABSTRACT

The macrohabitat distribution and microhabitat suitability for rainbow trout, Arctic grayling, round whitefish, and longnose suckers in the Susitna River drainage between the Chulitna River confluence and Devil Canyon were evaluated using electrofishing, beach seine, and hook and line catch data and habitat data collected at radio telemetry relocation sites (rainbow trout and burbot) and spawning sites (round whitefish).

Turbidity had important effects on distribution of both adult and juvenile resident fish. Longnose suckers and juvenile round whitefish were found in highest numbers in turbid water. Adult rainbow trout, Arctic grayling, and round whitefish found clear water more suitable, but used turbidity for cover. Suitability criteria for velocity, depth, and object cover were fit to the distribution of resident fish. The location of radio tagged rainbow trout among macrohabitat types varied greatly by season.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX TABLES

1.0 INTRODUCTION

The Resident Fish Study was initiated in the fall of 1980 to gather preliminary data concerning the following general objectives described in 1979 by the Alaska Department of Fish and Game for the Susitna Hydroelectric project:

A. Define seasonal distribution and relative abundance of resident fish in the Susitna River between Cook Inlet and Devil Canyon.

B. Characterize the seasonal habitat requirements of selected resident fish species within the study area.

During 1981, the primary emphasis was placed upon gathering seasonal distribution and relative abundance data. In 1982, more effort was placed upon characterizing the seasonal habitat requirements. During the 1983 field season, the resident fish studies were refined. We attempted to quantify the important habitat parameters associated with spawning and rearing (growth) of selected resident fish species and measure fish density in spawning and rearing habitats to provide an estimate of habitat quality.

There can be positive or negative effects upon fisheries after the construction of a hydroelectric dam (MDFW&P 1983). Postproject effects may include changes in water temperature, flow, and turbidity. Preproject baseline fisheries data and their correlation to habitat conditions, therefore, are necessary to evaluate the overall potential impact to these fisheries. One of these impacts can be the effect on rearing fish.

Successful rearing of resident fish in the Susitna River is dependent upon a variety of habitat conditions that may be substantially altered under postproject flow regimes (ADF&G 1983c; 1983d). Four major macrohabitats influenced by the mainstem were identified as possible rearing areas in the Susitna River for resident fish (ADF&G 1983e). These four major habitat types are tributary mouths, side sloughs, upland sloughs, and mainstem channels or side channels. Macrohabitat information reported in this report supplements ADF&G (1983e) as much less boat electrofishing was done in 1983.

Microhabitat suitability criteria are one means of quantifying the relationship of a life stage of a fish species to its habitat. The present work develops preliminary suitability criteria by species and river reach for application in incremental simulations of rearing habitat as a function of mainstem flows (see Part 7 of this report). Preliminary data presented for rainbow trout, Arctic grayling, round whitefish, and longnose suckers are univariate functions for cover type, percent cover, depth, and velocity. Frequency distributions by habitat attribute were not generated for other resident fish species such as burbot due to small catches. Differences between distributions in low and high turbidity water were detailed as data permitted.

2.0 METHODS

A two man crew conducted sampling on the Susitna River between the Chulitna River confluence and Devil Canyon from May to October 1983 to capture resident fish for micro- and macrohabitat studies (Figure 1). Sampling was performed largely from a river boat, with occasional use of helicopters. The primary sampling methods were boat electrofishing and hook and line. Habitat data collected included water depth and velocity, cover, substrate, and water chemistry parameters.

2.1 Study Locations

2.1.1 Macrohabitat studies

Relative abundances of selected resident fish species were determined by boat electrofishing at various macrohabitats in the Susitna River from May to October. These macrohabitats included mainstem channels and side channels, upland sloughs, side sloughs, and tributary mouths in the reach of river between the Chulitna River confluence and Devil Canyon.

Also, 26 radio tagged rainbow trout were located in four major macrohabitats in 1983. These macrohabitats included tributaries, upland and side sloughs, tributary mouths, and the mainstem. Radio tagged fish were located at these sites in the Susitna River between RM 100.7 and RM 148.8 from May 19 to October 21, 1983.

2.1.2 Microhabitat studies

Thirteen adult resident microhabitat study sites were sampled from July to October to develop habitat suitability curves. These sites were located between the Chulitna River confluence and Devil Canyon and included six tributary mouths, three tributaries, three side sloughs, and one upland slough (Table 1).

Nine sites at sloughs and tributary mouths were selected for sampling by boat electrofishing because relatively high numbers of adult resident fish exist in these areas (ADF&G 1983b). The nine sites were sampled with boat electrofishing gear twice a month from mid-July to October. The upper reaches of four tributaries were irregularly sampled by hook and line in conjunction with rainbow trout population estimates or studies of radio tagged rainbow trout. (Presented in Part 5 of this report).

Juvenile and a few adult resident fish were captured incidentally at 35 sites sampled during the juvenile anadromous studies reported in parts 2 and 3 of this report.

Microhabitat was also measured at relocation sites of 24 radio tagged rainbow trout and burbot. These data were recorded at tributary mouths, sloughs and sites in the mainstem Susitna River between RM 100.8 and RM 148.7 and at three tributaries.

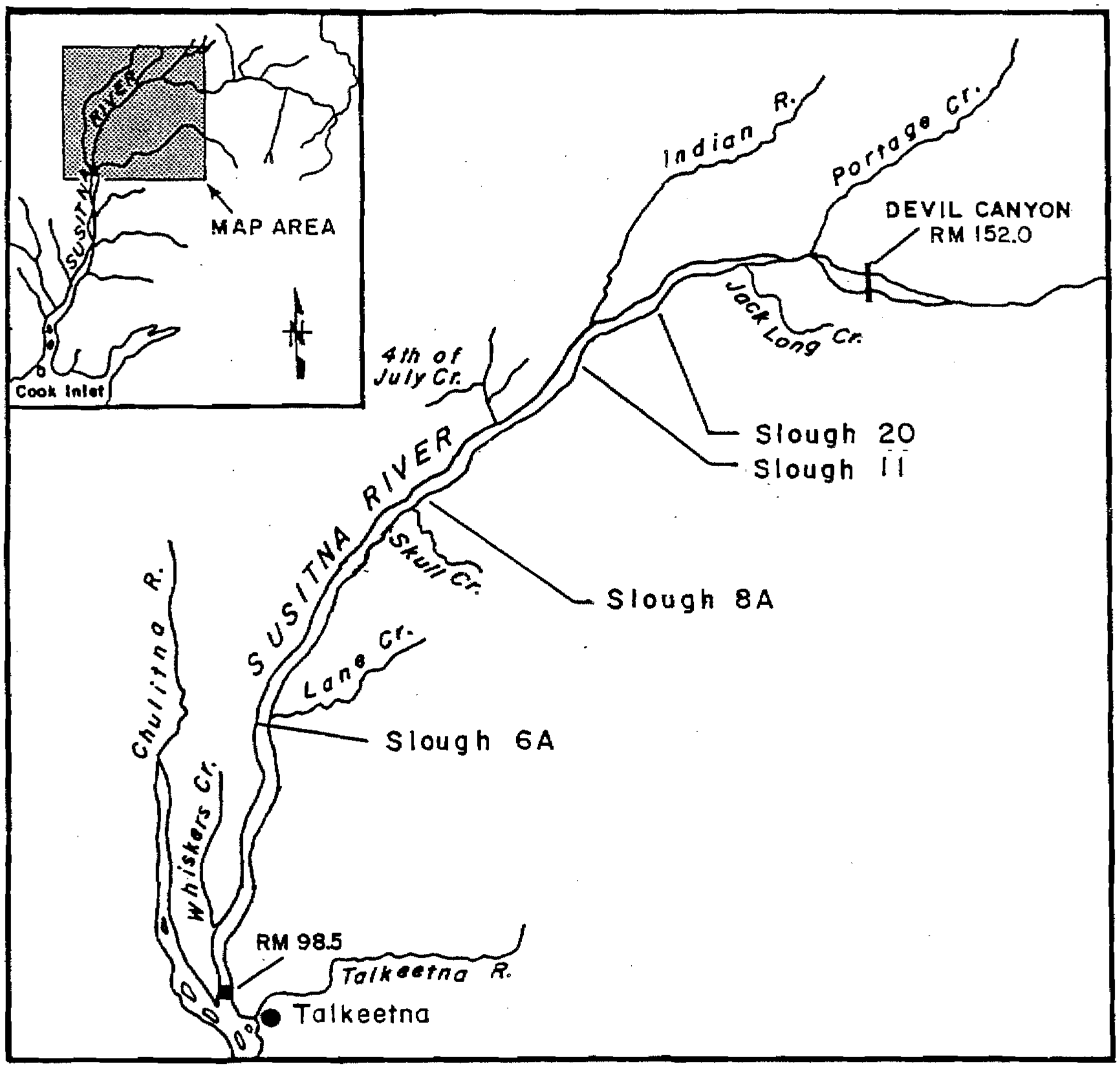

Figure 1. Map of the Susitna River from the Chulitna River confluence to Devil Canyon showing major tributaries and sloughs, 1983.

Table 1. Adult resident fish microhabitat study sites on the Susitna River between the Chulitna River confluence and Devil Canyon, 1983.

Location	River Mile (RM)	Sampling Method: Hook & line	Sampling Method: Boat Electro-fishing
Whiskers Creek Slough	101.2		X
Whiskers Creek - Mouth	101.4	X	
Slough 6A	112.3		X
Lane Creek - Mouth	113.6		X
Lane Creek - TRM [a] 0.6	113.6	X	
Slough 8A - Mouth	125.3		X
Fourth of July Creek - Mouth	131.1		X
Fourth of July Creek - TRM 0.8	131.1	X	
Slough 11 - Mouth	135.3		X
Indian River - Mouth	138.6		X
Indian River - TRM 1.5	138.6	X	
Jack Long Creek - Mouth	144.5		X
Portage Creek - Mouth	148.8		X

a/TRM = tributary river mile

2.2 Field Data Collection

2.2.1 Biological

Adult and a few juvenile (under 200mm) resident fish were captured at accessible locations in the Susitna River with a boat mounted electrofishing unit. Electrofishing equipment consisted of a Coffelt, model VVP-3E, boat electrofishing unit powered by a 2500 watt Onan portable generator. Boat electrofishing procedures are described in ADF&G (1983a). Adult resident fish were also captured by hook and line in tributaries. Juvenile resident fish at upland slough, side slough, mainstem and tributary sites were collected with beach seines and backpack electroshockers.

All resident fish were identified to species. Biological data collected included length, sex, and sexual maturity. Ages were determined by reading scale samples. All healthy adult resident fish were tagged with a Floy anchor tag and released in continuance of a resident fish migrational study described in part 5 of this report. Spawning sites of resident fish species were determined when captured female fish expelled eggs upon slight palpation of the abdomen.

Juvenile resident fish were captured incidentally during juvenile anadromous sampling of cells and grids located at a greater diversity of sites. Techniques differed somewhat as beach seining and backpack electrofishing were used (see Part 2 of this report for details on collection methods).

Microhabitat data were collected from relocations of four burbot and 20 rainbow trout radio tagged in 1983. Tagging techniques are presented in ADF&G (1981, 1983a) and part 5 of this report. Radio tagged fish were tracked from airplanes and boats. A summary of capture and tracking locations of the tagged fish are presented in Part 5 of this report. Habitat measurements were taken after a radio tagged fish was relocated by boat to an area of no greater than 30 feet by 30 feet. In some cases, radio tagged fish were observed.

2.2.2 Habitat

Each microhabitat study location was divided into one to three grids. Grids were located so that the water quality within them was as uniform as possible and so that the grids would encompass a variety of habitat types. At tributary mouths, one grid was located in the mainstem Susitna River above the confluence of the tributary, another grid was set up within or below the confluence where the tributary was the primary water source, and a third grid was situated where the mainstem and tributary waters mixed (Figure 2). Sites located in sloughs and tributaries had one to three grids depending on the water quality within the slough. Since grid location was dependent upon specific hydraulic characteristics, grid locations were redetermined during each sampling trip based on differences in turbidity and water chemistry readings.

Grids were subdivided into cells. Cells were rectangular and the length and width of each cell varied. The length boundaries of cells within

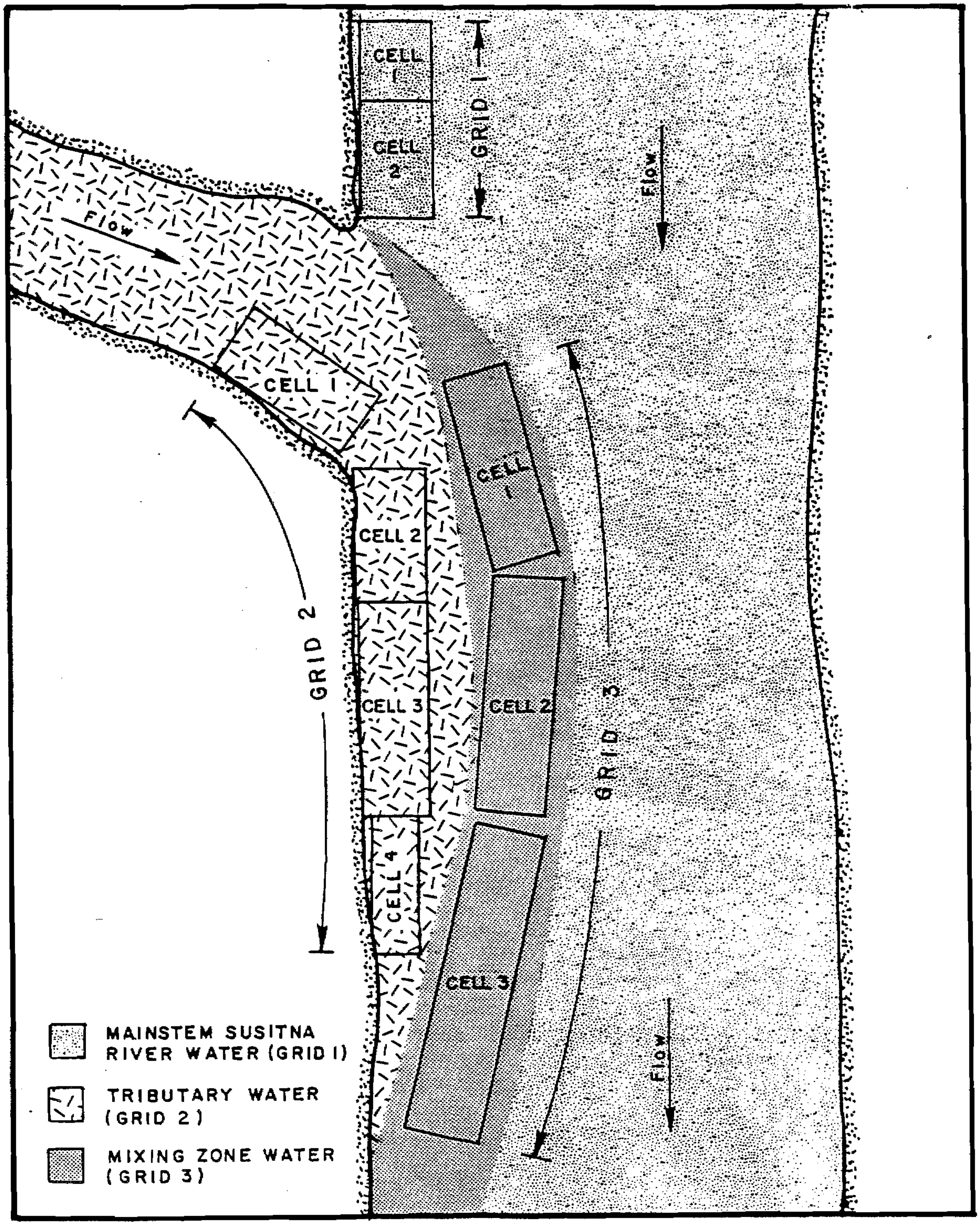

Figure 2. Arrangement of grids and cells at a hypothetical adult resident fish macrohabitat study site.

each grid were marked with orange flagging prior to sampling. The width of cells in tributaries, which were sampled by hook and line, was the width of the stream. Cell widths at sloughs and tributary mouths, which were sampled by boat electrofishing, were determined to be five feet or a multiple of five feet. Five feet was chosen as a standard cell width because it is the average effective capture width of the boat electrofishing equipment used.

This method of sampling was designed to approximate the method that the "instream flow incremental methodology" uses to generate estimates of usable habitat (Bovee 1982, also see Part 7 of this report). The correlation of fish occurrence in cells with a particular set of physical parameters can be compared with the calculated usability of the habitat.

Habitat parameters measured within cells and at radio tagged fish relocations included dissolved oxygen, specific conductance, pH, turbidity, water temperature, water velocity, and water depth. Substrate type, cover type, and percent cover were estimated (Table 2). Intragravel temperatures were also recorded at all spawning sites.

Table 2: Substrate, cover, and percent cover classifications used for resident fish microhabitat studies.

Substrate	Cover Type	% Cover
Silt	No Cover	0 - 5%
Sand	Emergent Vegetation	6 - 25%
Small Gravel (1/8" - 1")	Aquatic Vegetation	26 - 50%
Large Gravel (1" - 3")	Debris/Deadfall	51 - 75%
Rubble (3" - 5")	Overhanging Riparian	76 - 95%
Cobble (5" - 10")	Undercut Banks	96 - 100%
Boulder (> 10")	Large Gravel 1" - 3"	
	Rubble 3" - 5"	
	Cobble or Boulder > 5"	

The mean depth of cells and radio tagged fish relocation sites was measured to the nearest tenth of a foot with a topsetting wading rod. The mean velocity was measured with a Price Model AA velocity meter. Turbidity measurements were made with an HF Instrument Model DRT-15 turbidometer in Nephelometric Turbidity Units (NTU's). Water quality measurements were taken with a Hydrolab model 4001 multi parameter meter.

Habitat parameters were recorded for each cell at resident fish microhabitat study sites. However if the water quality within a grid were relatively constant, only one measurement was taken to represent all cells within that grid. Specific data collection methodology is summarized in ADF&G (1984).

2.3 Data Analysis

2.3.1 Macrohabitat studies

Biological and catch per unit effort (CPUE) data were compiled by macrohabitat type from boat electrofishing sampling data recorded in conjunction with distribution and relative abundance studies presented in Part 5 of this report. Macrohabitat CPUE data were also compiled by pooling the catch from all the cells at microhabitat study sites sampled by boat electrofishing. The macrohabitat type of radio tagged fish relocation sites was also recorded.

Catch data recorded by Juvenile Anadromous Habitat Study (JAHS) crews were also compiled by macrohabitat type for incidentally captured juvenile resident fish. Mean CPUE's were calculated by macrohabitat type, summed, and then each CPUE by type was expressed as a percentage of the total to equalize sampling effort. These percentages were then used to analyze distribution by macrohabitat type. Macrohabitat types were defined with the discharge based classification scheme discussed in Part 2 of this report.

An analysis of variance (ANOVA) was run to determine whether macrohabitat type had a significant effect on the relative abundance of juvenile round whitefish (see Part 2 of this report for further details).

2.3.2 Microhabitat studies

2.3.2.1 Adult resident fish

Biological, habitat and catch data were recorded at microhabitat study sites according to ADF&G (1984). Adult fish microhabitat studies used two gear types, boat electrofishing and hook and line. Hook and line was used in tributaries, while boat electrofishing was used elsewhere. Hook and line data were analyzed separately from boat electrofishing data since the area each gear type sampled was very different in water quality and habitat characteristics.

Values of habitat attributes measured had to be pooled for analysis because of small sample sizes. Groupings for the boat electrofishing and hook and line data are detailed in Table 3. Groupings for the rainbow trout hook and line catch data were somewhat different than the boat electrofishing data because of small sample sizes and different cover types sampled.

Turbidity values were also grouped into three categories to determine the effects of low, moderate and high turbidities on resident fish distribution. The three turbidity groupings used were: 1 to 9 NTU, 10 to 30 NTU and greater than 30 NTU. Turbidity inflection points at 9 NTU and at 30 NTU were used because light penetration changes considerably at these points in other glacial systems in Alaska (Jeffery Koenings, pers. comm.) and because chinook salmon fry used turbidities of greater than 30 NTU for cover (see Part 3 of this report).

Table 3. Habitat attribute groupings for analysis of boat electrofishing and hook and line data.

Boat Electrofishing Habitat Attribute Groupings

No.	Velocity Grouping (ft/sec)	Depth Grouping (ft)	Percent Cover	Cover type	Substrate
1	0	0.7-2.0	0-5%	No cover	Silt - 1"
2	0.2-1.0	2.1-2.9	6-25%	Emergent or aquatic vegetation	1-3"
3	1.1-2.0	3.0-4.4	26-50%	Debris or overhanging riparian vegetation	3-5"
4	2.1-3.0	4.5 +	51+%	Large gravel (1-3")	5"+
5	3.1 +			Rubble (3-5")	
6				Cobble or boulder (5"+)	

Hook and Line Habitat Attribute Groupings

No.	Velocity Grouping (ft/sec)	Depth Grouping (ft)	Cover type
1	0-0.5	0.5-1.0	No cover
2	0.6-1.0	1.1-2.0	Debris, under cut banks or overhanging riparian vegetation
3	1.1-1.5	2.1 +	Cobble or boulder (5"+)
4	1.6 +		

Percent cover and substrate groupings same as for boat electrofishing data.

After habitat attribute values were grouped, Kendall rank-order correlation coefficients were calculated between the habitat attributes and catch for the resident species for both the boat electrofishing and hook and line data. Since cells varied significantly in size, catch was put on an area basis as catch per 1000 ft^2 of surface area. Density of fish was assumed to be a function of catch per 1000 ft^2. Suitability of habitat was reflected by this number as fish density can be assumed to reflect fish habitat suitability.

The distributions of mean catches by species were examined for the habitat attributes of velocity, depth, cover type, and percent cover. Velocity was thought to be an important determinant of distribution and therefore suitability criteria were fit by hand using professional judgement to the distributions of catch by grouped velocity interval for all four species. Since we had no data for velocities greater than 4.3 ft/sec, we assumed that suitability for all species was 0 for velocities greater than 4.5 ft/sec.

Depth was not thought to be as important a determinant of distribution and therefore we did not fit suitability criteria to any of the depth distributions. Depth, however, may be important in limiting distribution on the shallow end. Wesche (1976), for example, reported that adults of three trout species preferred depths greater than 0.5 ft. Raleigh et al. (1984) reported that rainbow trout found depths of less than 1.5 ft less suitable than greater depths. We conservatively set depth suitability to 1.0 for all depths greater than 0.6 ft and suitability to 0 for depths less than 0.5 ft.

Percent cover and cover type both were believed to have potential importance in determining adult fish distribution, however, sample sizes limited us to consider only cover type. We believed the cover type data were most reliable and also these data showed clear differences in usability of the different cover types. Since the turbidity data indicated that as turbidity increased, suitability of no cover cells increased, we integrated these data into suitability indices for cover type by turbidity level. Cover type suitability indices for both clear ($<$ 10 NTU) and turbid ($>$ 30 NTU) conditions were developed. The suitability of "no cover" cells (cells without object cover) at these two levels was different. The suitability of the "no cover" cells was set as a minimum, therefore if other cover types had mean catches less than those of the no cover cells then suitability for these types were changed to the suitability value for the no cover cells. Since there were no boat electrofishing data for the cover type, undercut banks, we assumed that undercut banks had a suitability equal to that for overhanging riparian vegetation and debris which provide a somewhat similar type of cover.

2.3.2.2 Juvenile resident fish

Only round whitefish juveniles were captured in sufficient numbers at the juvenile salmon study sites to warrant development of microhabitat suitability indices. The habitat attributes of velocity, depth, percent cover and cover type were examined for criteria development. Beach seining data from water over 30 NTU in turbidity were used in the analysis as catches were highest for this gear type at this turbidity level.

Due to small sample sizes, groupings of velocity values were by 0.3 ft/sec increments and depths by 0.5 ft increments. Cover type analysis was only qualitative due to small sample sizes and the inefficiency of beach seines in different cover types. Round whitefish suitability was measured as mean catch per cell, as this number was assumed to reflect density because cell size was constant at 300 ft^2. In general, analysis was the same as that used to develop criteria for juvenile chinook salmon in turbid water (see Part 3 of this report).

An analysis of variance (ANOVA) was run to determine the effect of the site parameters: mean depth, mean velocity, mean percent cover, water temperature, and turbidity on the relative abundance of juvenile round whitefish (see Part 2 of this report for further details on the methods used).

3.0 RESULTS

3.1 Macrohabitat Distribution

3.1.1 Adult resident fish

Boat electrofishing catch and catch per unit effort (CPUE) for five resident fish species in three types of macrohabitats was determined in 1983 (Table 4). Since sampling was not as intensive in 1983 as in 1982, the category "sloughs" includes both upland sloughs and side sloughs. Sampling effort in 1983 (45.9 boat electrofishing hours) was small in comparison to 1982 efforts (177.6 total boat electrofishing hours, with 63.9 hours above the Chulitna River confluence).

Radio telemetry was used to study movements of rainbow trout among macrohabitat types. Movements of adult rainbow trout in the Susitna River can be placed into three major categories based on their annual life history, those associated with spawning (April-June), those associated with summer rearing (July-September) and those associated with overwintering (October-March). Distribution of radio tagged rainbow trout in or at the mouths of tributary streams and at mainstem areas changed with season (Figure 3). Radio tagged rainbow trout were located in tributaries and at tributary mouths more often during spawning and summer rearing periods than during the winter. Between April and June, 67% of the radio tagged rainbow trout locations were associated with tributaries, the majority being in tributaries (52%). During July through September, 61% of the radio tagged rainbow trout were associated with tributaries, the minority being located in tributaries. By October 1, all radio tagged rainbow trout had outmigrated from tributaries and sloughs into mainstem influenced areas. About 33% of the radio tagged rainbow trout remained at tributary mouths from October to December. Besides the high incidence of rainbows using tributaries from April to September, about 10% used Slough 9 (RM 128.3), Slough 8A (RM 125.3), Slough A (RM 124.7), and Moose Slough (RM 123.5) during July through September.

Often radio tagged rainbow trout moved from one tributary or slough to another tributary or slough (refer to Part 5 of this report for individual trout movements). For example, five radio tagged rainbow trout migrated 7.5 miles downriver from the mouth of Indian River (RM 138.6), to the mouth of Fourth of July Creek (RM 131.1). In addition, a rainbow trout moved 6.5 miles upriver from the mouth of Skull Creek (RM 124.7) to the mouth of Fourth of July Creek, and then 2.6 miles downriver to Slough 9. Another rainbow trout spent over one week in two different sloughs (8A and A) before holding in Moose Slough for over three weeks. Finally, a rainbow trout outmigrated from Fourth of July Creek (TRM 1.5) and moved 7.5 miles upriver to Indian River where it was last located at TRM 4.5.

3.1.2 Juvenile resident fish

Incidental catches of juvenile and a few adult resident fish were made during juvenile anadromous habitat study (JAHS) sampling (Table 5). Large differences in the distribution of juvenile fish by macrohabitat

Table 4. Boat electrofishing catch and catch per unit effort (CPUE) of five resident fish species by three types of macrohabits. Resident fish species sampled are rainbow trout, burbot, Arctic grayling, round whitefish, and longnose suckers. CPUE is in parentheses, and the units are catch per minute.

MACROHABITAT TYPE	MAY 16-31	JUN 1-15	JUN 16-30	JUL 1-15	JUL 16-31	AUG 1-15	AUG 16-31	SEP 1-15	SEP 16-30	OCT 1-15	TOTAL
RAINBOW TROUT											
MAINSTEM	6(.0)	5(.0)	1(.0)	0(0.0)	1(.0)	0(0.0)	----(----)	7(.0)	13(.0)	8(.0)	41(.0)
SLOUGH	4(.1)	2(.0)	1(.0)	1(.0)	3(.0)	1(.0)	1(.1)	0(0.0)	1(.1)	2(.1)	16(.0)
TRIBUTARY MOUTH	7(.0)	7(.1)	9(.1)	4(.1)	11(.2)	3(.0)	4(.3)	19(.2)	16(.2)	14(.2)	94(.1)
TOTAL	17(.0)	14(.0)	11(.1)	5(.0)	15(.1)	4(.0)	5(.2)	26(.1)	30(.1)	24(.1)	151(.1)
BURBOT											
MAINSTEM	6(.0)	3(.0)	0(0.0)	0(0.0)	4(.0)	1(.0)	----(----)	9(.0)	7(.0)	1(.0)	31(.0)
SLOUGH	1(.0)	0(0.0)	0(0.0)	4(.1)	6(.0)	1(.0)	0(0.0)	1(.0)	1(.1)	0(0.0)	14(.0)
TRIBUTARY MOUTH	0(0.0)	2(.0)	3(.0)	0(0.0)	3(.1)	8(.1)	0(0.0)	0(0.0)	0(0.0)	1(.0)	17(.0)
TOTAL	7(.0)	5(.0)	3(.0)	4(.0)	13(.0)	10(.0)	0(0.0)	10(.0)	8(.0)	2(.0)	62(.0)
ARCTIC GRAYLING											
MAINSTEM	63(.2)	78(.4)	40(1.1)	0(0.0)	28(.3)	32(.6)	----(----)	99(.4)	195(.7)	19(.1)	554(.4)
SLOUGH	23(.3)	22(.4)	1(.0)	1(.0)	5(.0)	1(.0)	5(.3)	4(.1)	17(1.3)	2(.1)	81(.2)
TRIBUTARY MOUTH	50(.3)	26(.2)	31(.3)	18(.3)	56(.9)	24(.2)	7(.5)	66(.6)	87(1.1)	14(.2)	379(.4)
TOTAL	136(.3)	126(.4)	72(.4)	19(.1)	89(.3)	57(.2)	12(.4)	169(.4)	299(.8)	35(.1)	1014(.4)

- = No effort.
.0 = Trace.

Table 4 continued.

MACROHABITAT TYPE	MAY 16-31	JUN 1-15	JUN 16-30	JUL 1-15	JUL 16-31	AUG 1-15	AUG 16-31	SEP 1-15	SEP 16-30	OCT 1-15	TOTAL
ROUND WHITEFISH											
MAINSTEM	25(.1)	82(.4)	21(.6)	0(0.0)	31(.3)	20(.4)	----(----)	147(.6)	101(.4)	78(.4)	505(.4)
SLOUGH	7(.1)	11(.2)	3(.1)	45(.6)	142(1.0)	8(.2)	3(.2)	15(.4)	7(.5)	8(.4)	249(.5)
TRIBUTARY MOUTH	26(.2)	45(.4)	36(.4)	61(1.2)	71(1.2)	72(.5)	5(.3)	108(1.0)	66(.8)	75(1.0)	565(.6)
TOTAL	58(.1)	138(.4)	60(.4)	106(.7)	244(.8)	100(.4)	8(.3)	270(.7)	174(.5)	161(.6)	1319(.5)
LONGNOSE SUCKER											
MAINSTEM	1(.0)	3(.0)	5(.1)	0(0.0)	29(.3)	13(.2)	----(----)	65(.3)	16(.1)	3(.0)	135(.1)
SLOUGH	2(.0)	13(.2)	9(.3)	33(.4)	51(.4)	16(.4)	0(0.0)	7(.2)	4(.3)	0(0.0)	135(.3)
TRIBUTARY MOUTH	0(0.0)	4(.0)	15(.1)	4(.1)	10(.2)	56(.4)	0(0.0)	18(.2)	23(.3)	2(.0)	132(.1)
TOTAL	3(.0)	20(.1)	29(.2)	37(.3)	90(.3)	85(.4)	0(0.0)	90(.2)	43(.1)	5(.0)	402(.1)

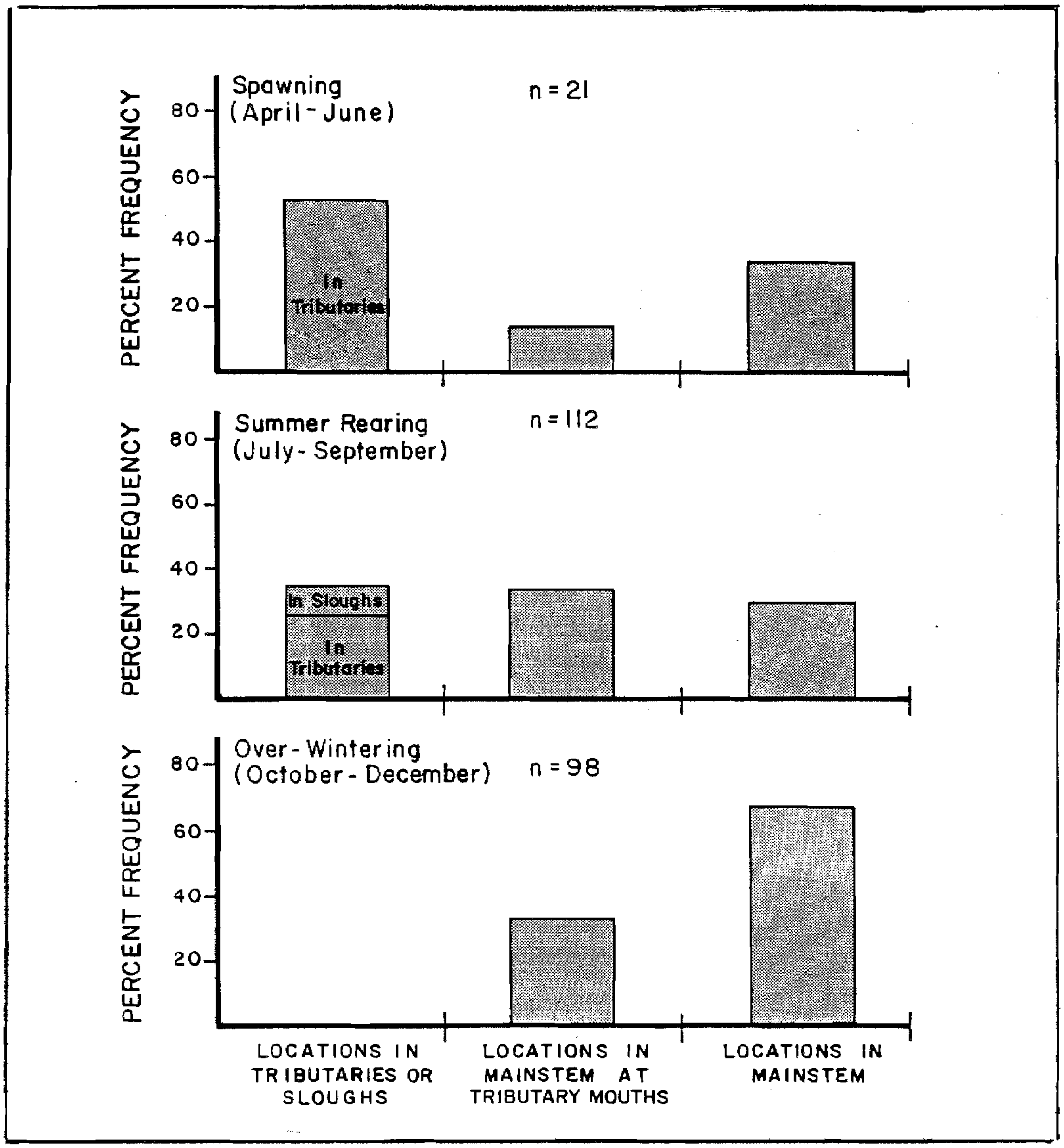

Figure 3. Frequency distribution of radio tagged rainbow trout locations in tributaries, at tributary mouths, and in the mainstem Susitna River during 1983.

Table 5. Incidental catch of juvenile resident fish in cells by macrohabitat sites on a mainstem discharge basis during Juvenile Anadromous Habitat Study sampling.

Species	Tributaries	Upland Sloughs	Side Sloughs	Mainstem Side-channels	Total
Rainbow trout	6	3	1	1	11
Arctic grayling	1	-	-	20	21
Round whitefish	1	20	7	601	629
Longnose sucker	-	20	33	66	119
Dolly Varden	21	-	-	-	21
Burbot	9	3	-	6	18
Humpback whitefish	-	-	-	11	11
Effort (cells fished)	236	131	455	463	

Table 6. Percent catch per unit effort (CPUE) by macrohabitat type on a mainstem discharge basis for juvenile resident fish species for which at least 20 specimens were captured.

	Tributaries	Upland Sloughs	Side Sloughs	Mainstem Side-channels
Arctic grayling (n=21)	8.9%	0.0%	0.0%	91.1%
Round whitefish (n=629)	0.3%	10.4%	1.0%	88.3%
Longnose sucker (n=119)	0.0%	41.5%	19.7%	38.8%
Dolly Varden (n=21)	100.0%	0.0%	0.0%	0.0%

type are evident in this table. The analysis of variance of round whitefish distribution showed that macrohabitat type does have a significant ($p < 0.01$) effect on distribution. In order to adjust for differences in sampling effort among the macrohabitat types, CPUE on a percentage basis was calculated for the four species for which more than 20 individuals were captured (Table 6). Arctic grayling and round whitefish juveniles were most numerous at mainstem side channels while Dolly Varden were captured only in tributaries. Longnose suckers were distributed primarily in upland sloughs and mainstem side channels although they were also caught in side sloughs.

3.2 Microhabitat Suitability

3.2.1 Adult resident fish

Boat electrofishing catches of rainbow trout, Arctic grayling, round whitefish, and longnose suckers were sufficient to be analyzed for microhabitat suitability criteria development. Hook and line catches of rainbow trout were also sufficient. Total catches by species and number of cells fished are listed in Table 7. Additional measurements of microhabitat were taken at telemetry locations of 20 rainbow trout and four burbot and these are available at the ADF&G Susitna Hydro Aquatic Studies office. These telemetry data cannot be used for criteria development but they supplement our knowledge of microhabitat use.

Kendall rank-order correlation coefficients between grouped habitat attributes and fish catches are listed in Table 8. Since substrate is partially a subset of cover type and also was highly correlated (tau=0.61) with velocity, it was dropped from consideration for further analysis.

Turbidity was the habitat attribute most highly correlated with longnose sucker mean catch. Graphs of turbidity level versus mean catch indicated turbidity has an influence on distribution of rainbow trout, round whitefish, Arctic grayling, and longnose suckers (Figure 4). Plots of catch in the "no cover" cells by turbidity value also suggest that these four species use turbidity for cover. Mean rainbow trout, Arctic grayling, and round whitefish catches per 1000 ft^2 were lower in turbid waters, however.

3.2.1.1 Rainbow trout

Rainbow trout were typically captured by boat electrofishing in cells with water velocities less than 1.5 ft/sec (Figure 5). Favored cover types included rocks with diameters over 3", and secondarily, debris and overhanging riparian vegetation. Rainbow trout used cells with 6 to 25% and greater than 50% object cover in the highest densities.

Hook and line sampling data suggested that rainbow trout preferred pools with velocities less than 0.5 ft/sec and depths greater than 2.0 ft (Figure 6). Rainbow trout captured by hook and line sampling used debris, undercut banks, and riparian vegetation more than they did cobble or boulders. An abundance of cover also appeared to be tied to rainbow distribution.

Table 7. Catches and effort for boat electrofishing and hook and line sampling of adult resident fish.

Boat electrofishing sampling

No. of cells sampled = 176

Species	Catch
Rainbow trout	44
Arctic grayling	138
Round whitefish	384
Longnose sucker	157
Burbot	18
Humpback whitefish	15
Dolly Varden	2

Hook and line sampling

No. of cells sampled = 79

Species	Catch
Rainbow trout	99
Arctic grayling	2

Table 8. Kendall correlation coefficients (tau) between grouped habitat variables and resident fish catches.

Boat Electrofishing Data (n = 176)

	Turbidity	Percent Cover	Cover Type	Velocity	Depth	Substrate	Rainbow Trout	Arctic Grayling	Longnose Sucker
Percent cover	-0.07	1.00							
Cover type	-0.22**	0.45**	1.00						
Velocity	-0.08	0.10*	0.45**	1.00					
Depth	-0.27**	0.16**	0.43**	0.34**	1.00				
Substrate	-0.16**	0.33**	0.61**	0.54**	0.32**	1.00			
Rainbow Trout	-0.14*	0.21**	0.22**	0.11	0.11	0.20**	1.00		
Arctic grayling	-0.13	0.18**	0.36**	0.33**	0.27**	0.29**	0.20**	1.00	
Longnose sucker	0.34**	0.19**	-0.15*	-0.25**	-0.22**	-0.25**	-0.04	-0.07*	1.00
Round whitefish	0.05	0.19**	0.20**	0.10	0.11	0.10	0.15*	0.34**	0.18**

Hook and Line Data (n = 79)

	Percent Cover	Cover Type	Velocity	Depth	Substrate
Cover type	-0.10				
Velocity	-0.30**	0.38**			
Depth	0.59**	-0.09	-0.42**		
Substrate	-0.04	0.53**	0.28**	-0.02	
Rainbow Trout	0.42**	0.04*	-0.29**	0.35**	0.08

* Significantly different from 0 at $p < 0.05$
** Significantly different from 0 at $p < 0.01$

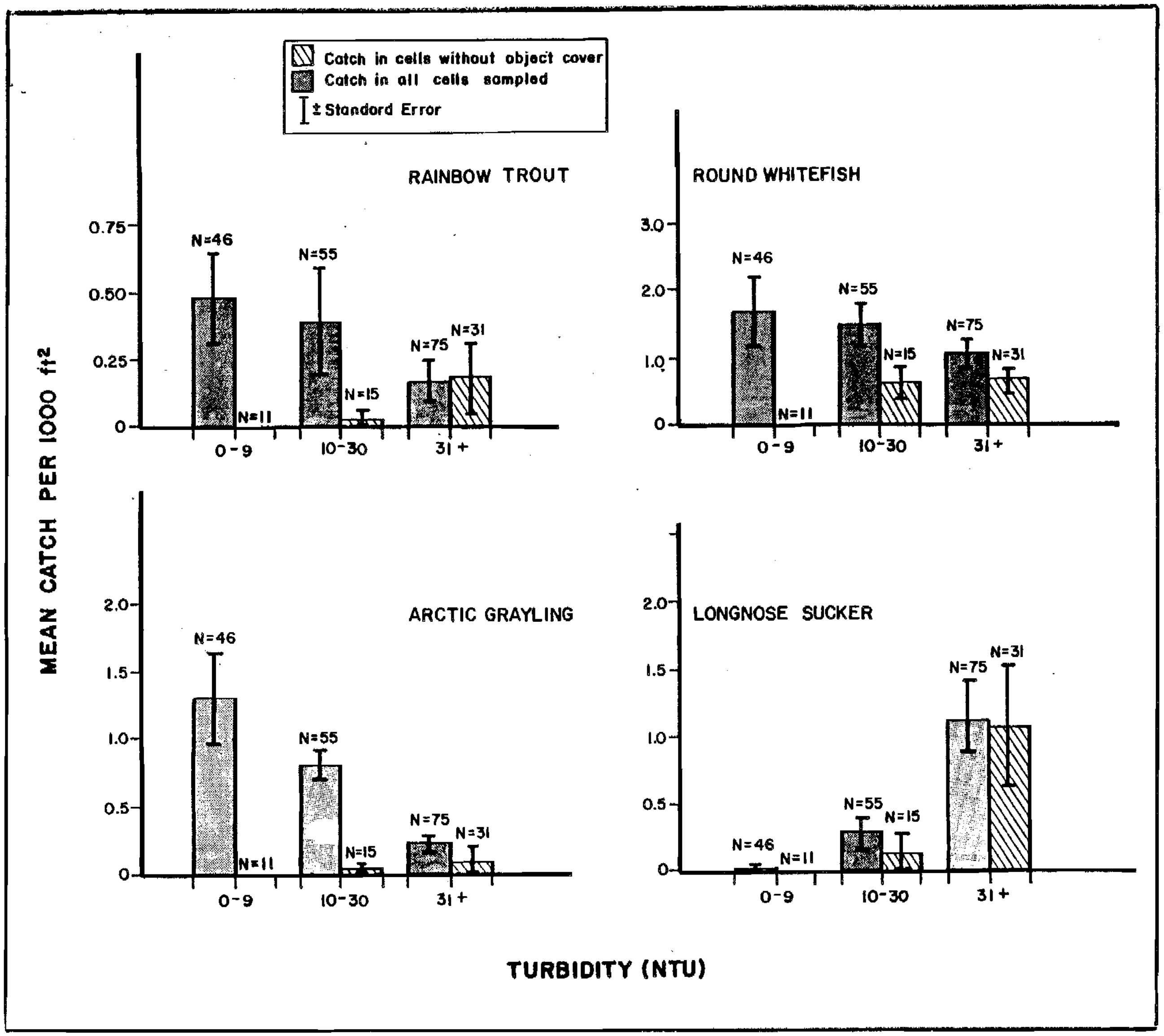

Figure 4. Rainbow trout, round whitefish, Arctic grayling, and longnose sucker boat electrofishing mean catch per 1000 ft² in cells without object cover and all cells sampled by turbidity

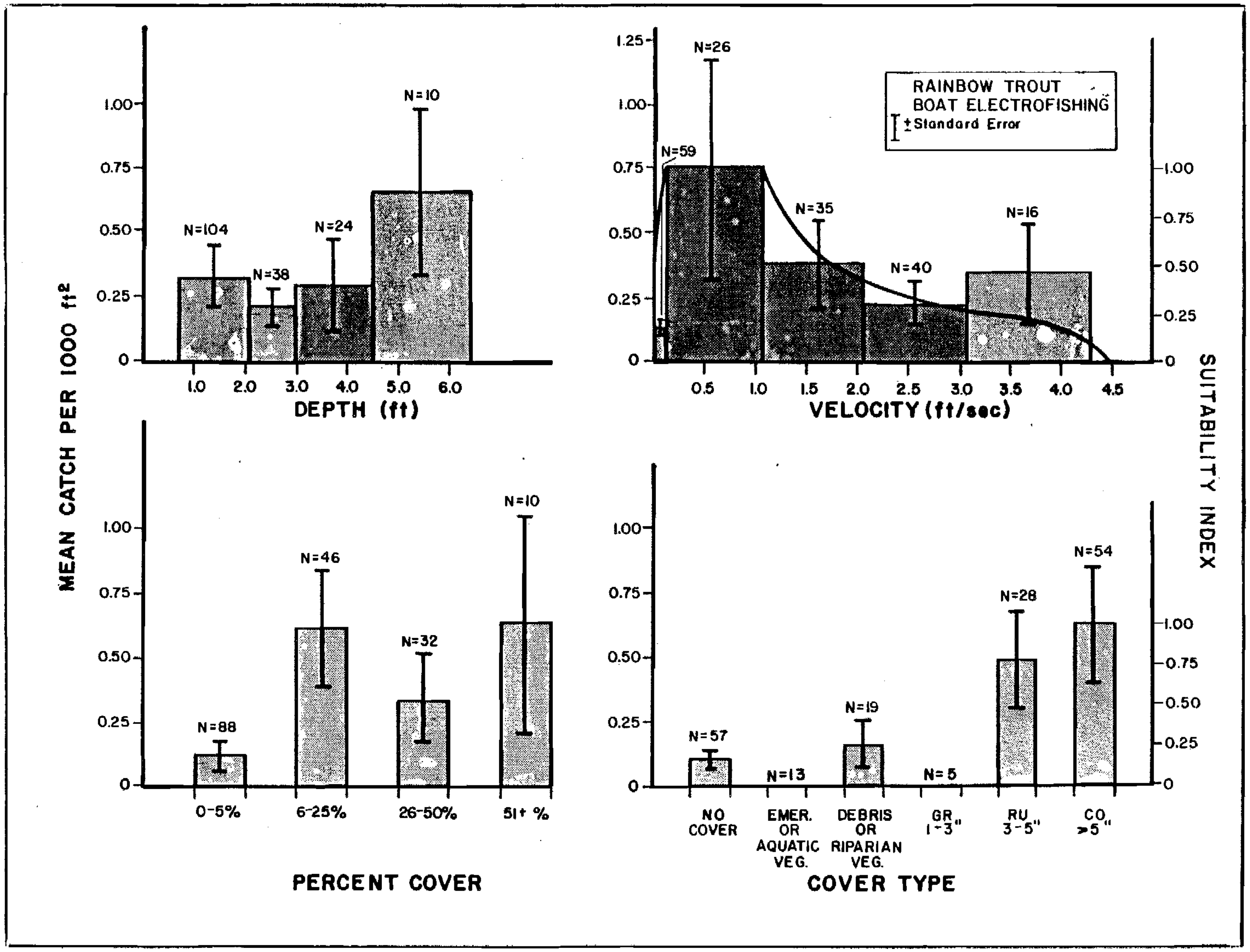

Figure 5. Rainbow trout boat electrofishing mean catch (bars) per 1000 ft² by habitat attribute values of depth, velocity, percent cover, and cover type. Suitability index (line) for velocity

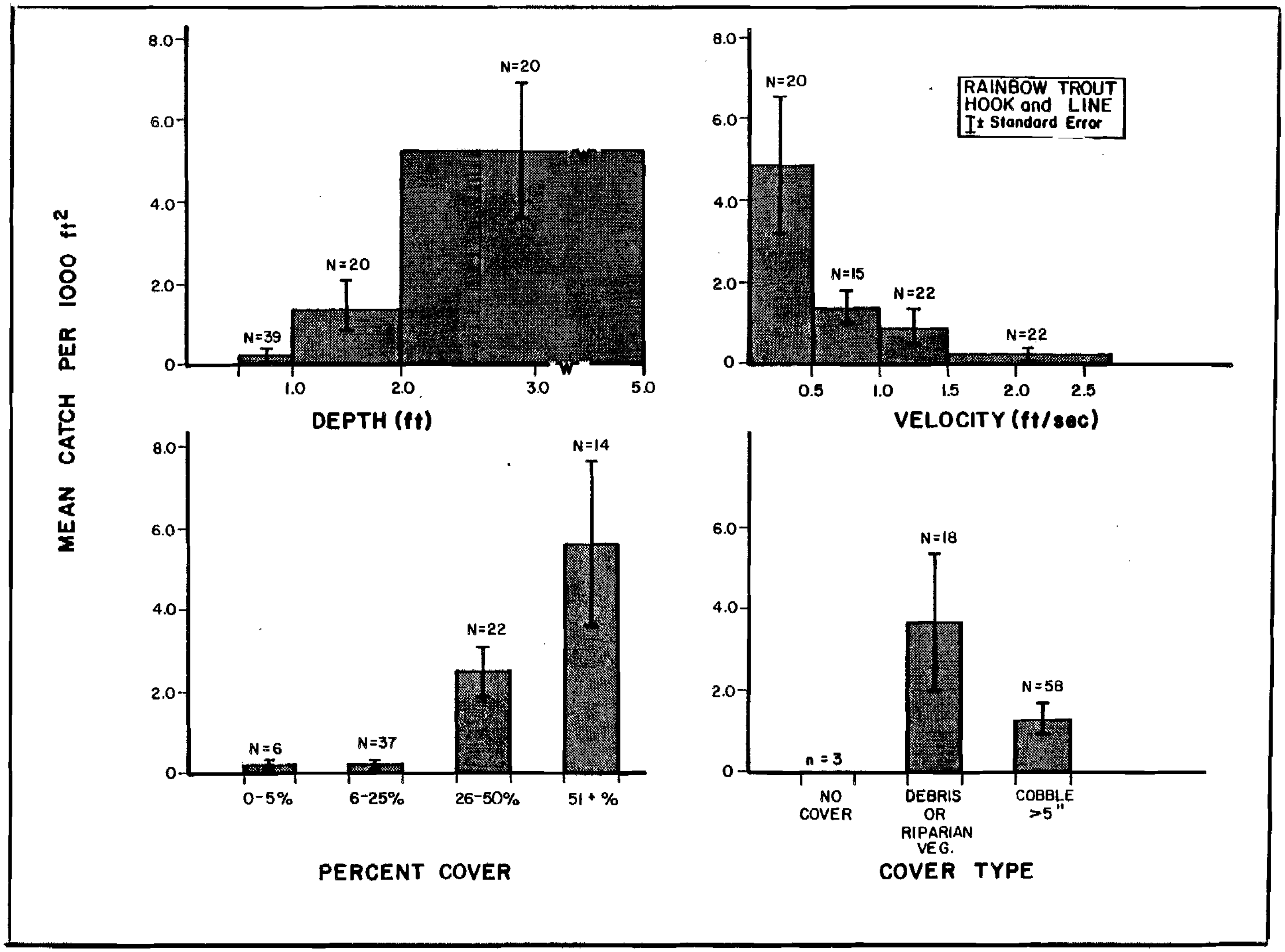

Figure 6. Rainbow trout hook and line mean catch per 1000 ft² by habitat attribute values of depth, velocity, percent cover, and cover type.

Since electrofishing data were collected at more cells in a wider variety of habitat types, velocity and cover type suitability indices were fit to the boat electrofishing data (Figure 4). Since the hook and line data suggested that cover types of debris, overhanging riparian vegetation, and undercut banks were more suitable than cobble or boulders (Figure 5), suitabilities for these cover types were changed to the suitability of cobble and boulders which was 1.0. A listing of suitability criteria point values for rainbow trout (along with all other suitability criteria developed in this report) is contained in Appendix Table A-1.

3.2.1.2 Arctic grayling

Adult Arctic grayling often used rocks for cover and water with high velocities and deep depths (Figure 7). Arctic grayling may avoid high turbidity waters and make little use of turbidity for cover (Figure 4). Suitability criteria were fit to the velocity and cover type distributions of catch (Figure 7 and Appendix Table A-1).

3.2.1.3 Round whitefish

Distribution of round whitefish was influenced by turbidity as they used it for cover (Figure 4). Round whitefish also used object cover in the form of cobble or boulders, debris, and overhanging riparian vegetation most highly (Figure 8). The hydraulic attribute of velocity was not strongly tied to distribution, although optimum velocities ranged from two to three ft/sec. Suitability criteria were fit to the velocity and cover type distributions of catch (Figure 8 and Appendix Table A-1).

Seven spawning sites for round whitefish were found in October 1983. Three of the sites were at tributary mouths while the other four sites were in the mainstem. Microhabitat data collected at these sites are presented in Appendix B, along with a brief discussion of round whitefish spawning in the Susitna River.

3.2.1.4 Longnose suckers

Longnose suckers often used turbid water for cover (Figure 4), but they also used emergent or aquatic vegetation, debris and overhanging riparian vegetation cover (Figure 9). Shallow depths and waters of low velocity were most suitable for longnose suckers. Suitability criteria were fit to the velocity and cover type distributions of catch (Figure 9 and Appendix Table A-1).

3.2.1.5 Burbot

Burbot prefer areas of moderate to high turbidities since catch data show they are always in the mainstem during the summer (ADF&G 1983e). Telemetry data also showed they were always found in the mainstem. While in these mainstem areas, radio tagged burbot appeared to prefer low velocities (under 1.5 fps) and shallow depths (approximately 2.5 feet). They also appeared to prefer areas with rubble or cobble substrate, however, nearly all of the mainstem river between the Chulitna River confluence and Devil Canyon, where the radio tagged fish were found, has a predominately rubble or cobble substrate.

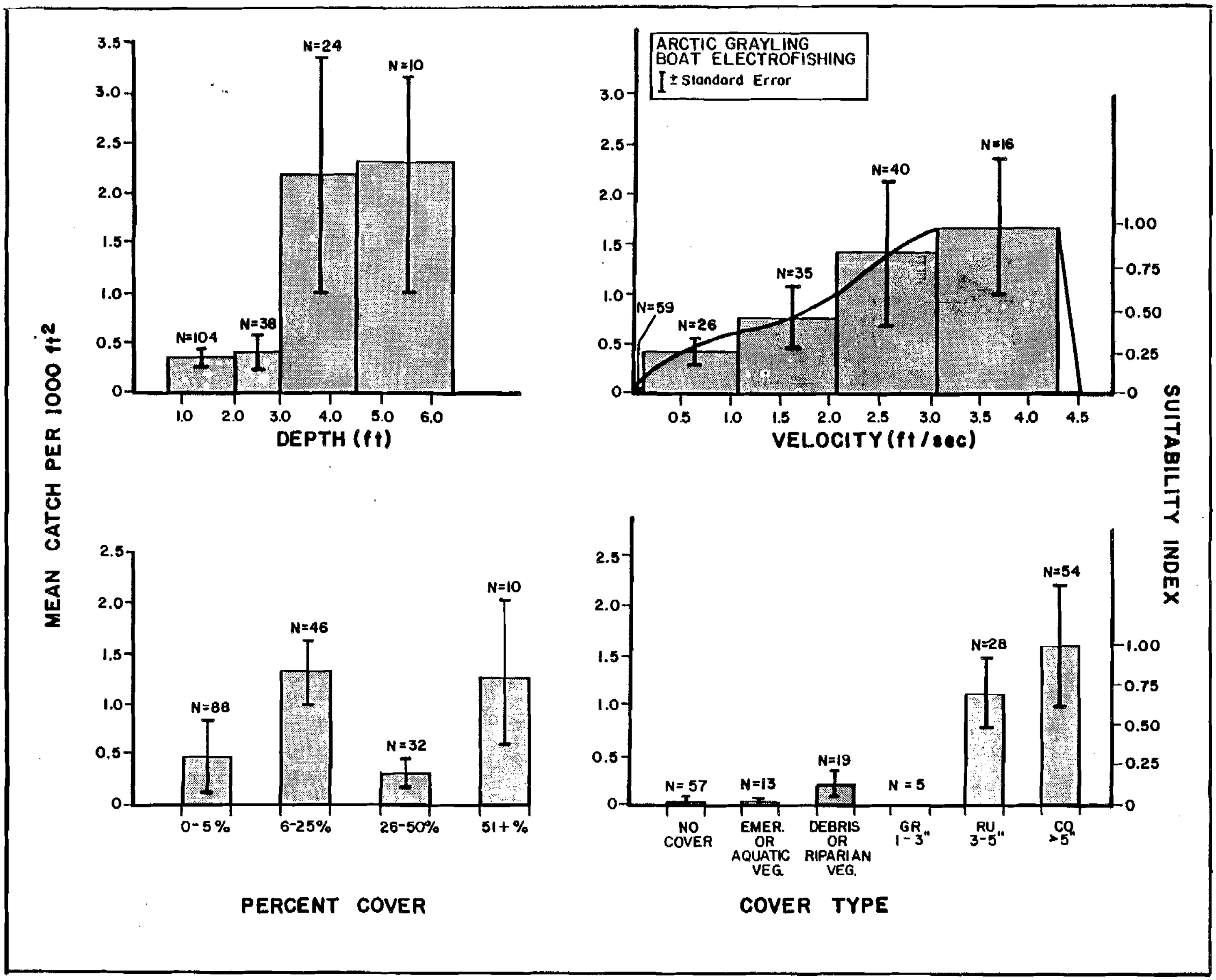

Figure 7. Arctic grayling boat electrofishing mean catch (bars) per 1000 ft² by habitat attribute values of depth, velocity,

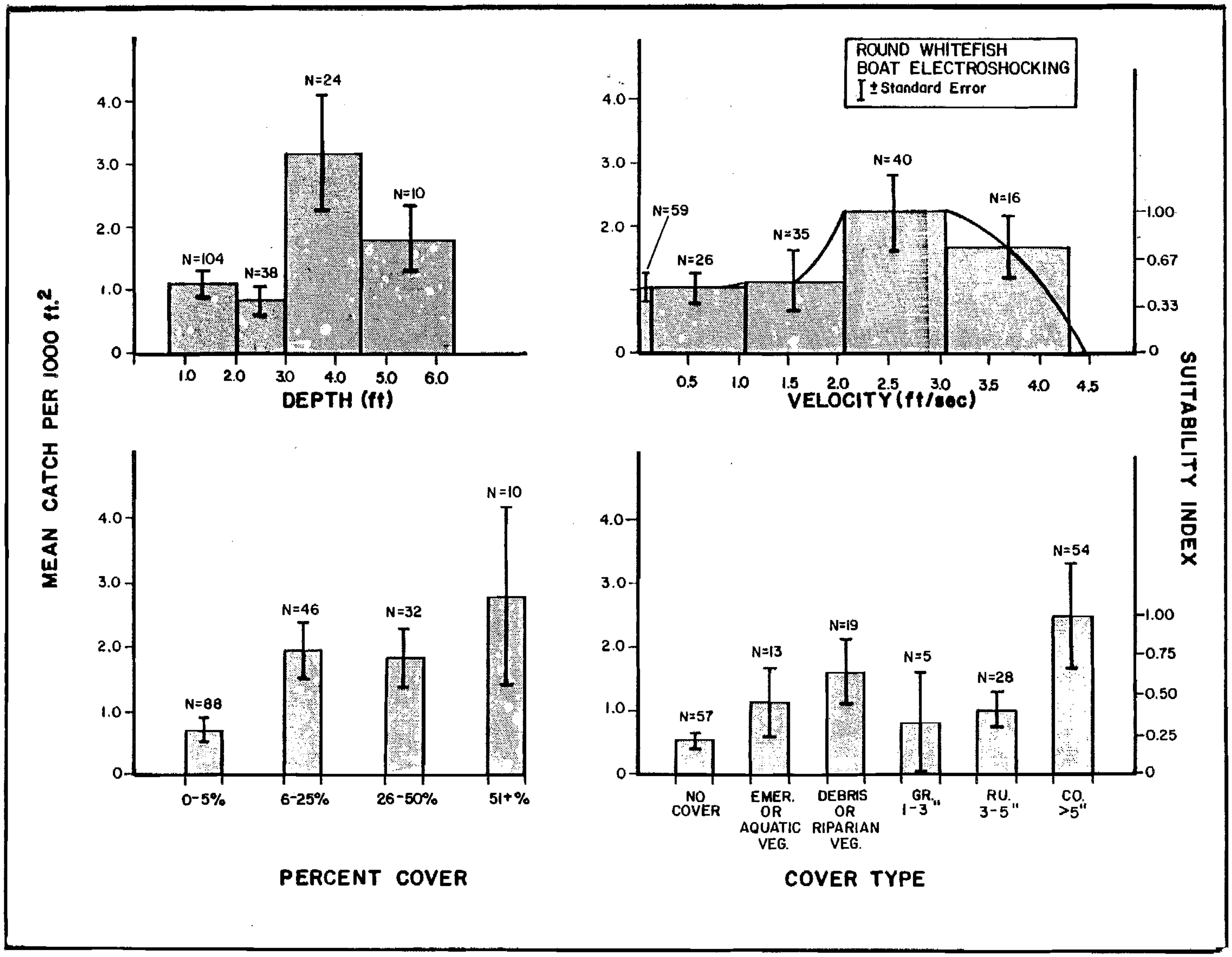

Figure 8. Round whitefish boat electrofishing mean catch (bars) per 1000 ft² by habitat attribute values of depth, velocity, percent cover, and cover type. Suitability index (line) for

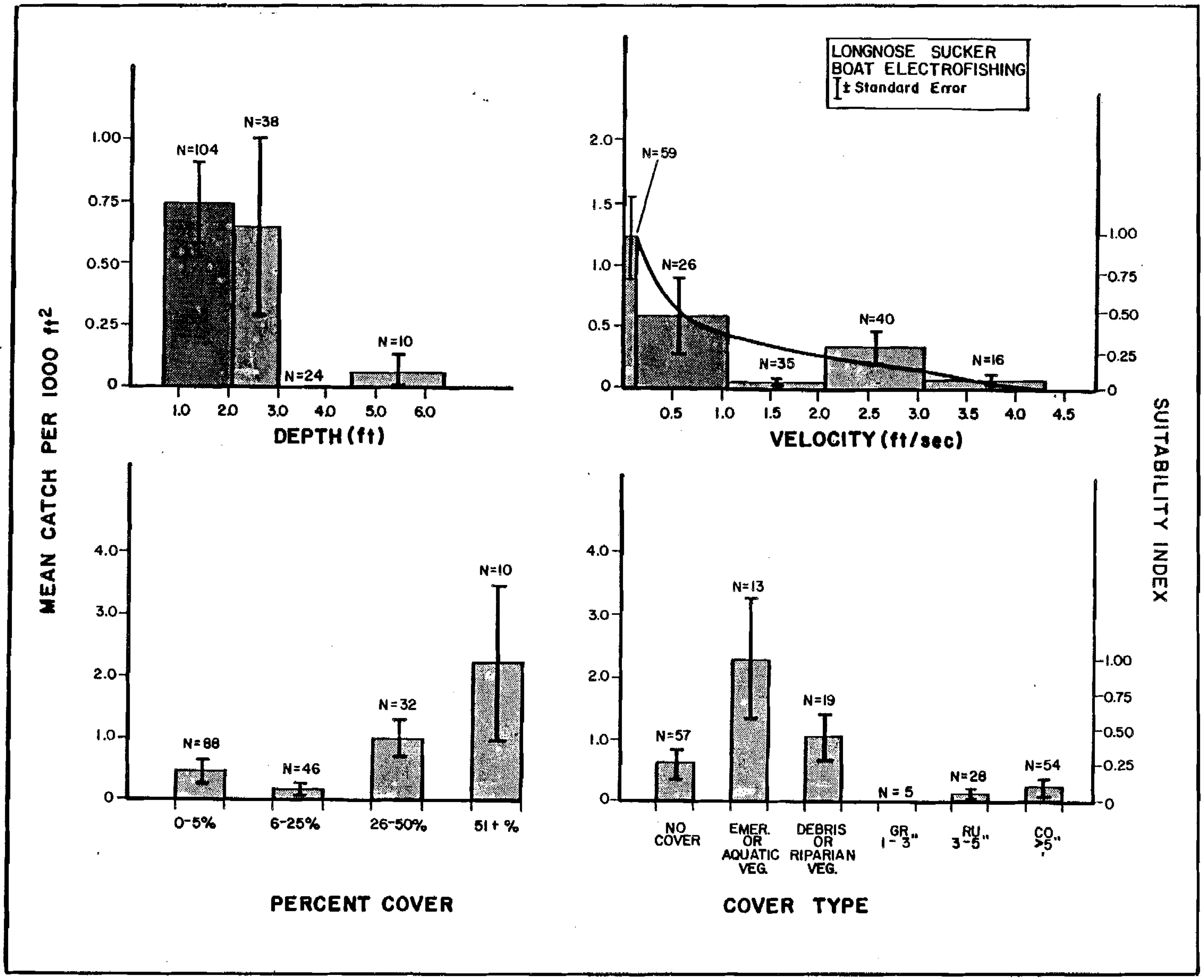

Figure 9. Longnose sucker boat electrofishing mean catch (bars) per 1000 ft² by habitat attribute values of depth, velocity,

3.2.2 Juvenile resident fish

The analysis of variance showed that turbidity had a significant ($p < 0.01$) effect on the relative abundance of juvenile round whitefish. Catch rates in water with a turbidity less than 30 NTU were extremely low.

The total catch of round whitefish by beach seines in turbid (greater than 30 NTU) water was 569, and most of these were 0+ juveniles. Mean catches by velocity, depth and percent cover interval suggest that velocity had the largest effect on distribution in the 320 cells fished (Figure 10). Juvenile round whitefish greatly preferred water without a significant velocity. Catches in cells with little object cover were higher than in cells with large amounts of cover. This suggests that object cover is not very significant in influencing round whitefish habitat use. Beach seining efficiency is greatly reduced, however, by the amount and type of cover present, and therefore catch distribution by cover type has not been presented. The data suggest that round whitefish fry also find shallow depths most suitable.

A suitability index was fit to both the depth and velocity catch distributions by hand using professional judgement. Pearson correlation coefficients between the fitted suitability criteria for depth, velocity, and (depth x velocity) and juvenile round whitefish catch by cell were calculated. The correlations between juvenile round whitefish catch and depth, velocity, and (depth x velocity) were 0.23, 0.42, and 0.50 ($n=320$, $p < 0.001$ for all three), respectively. Since depth was correlated with catch, we decided to use depth as fitted in subsequent habitat modelling. Suitability for turbid water for all cover types was set to 1.0 and suitability for all cover types in clear water was set to 0 (Appendix Figure A-1).

Catches were insufficient for any other species of juvenile resident fish to be analyzed for criteria development.

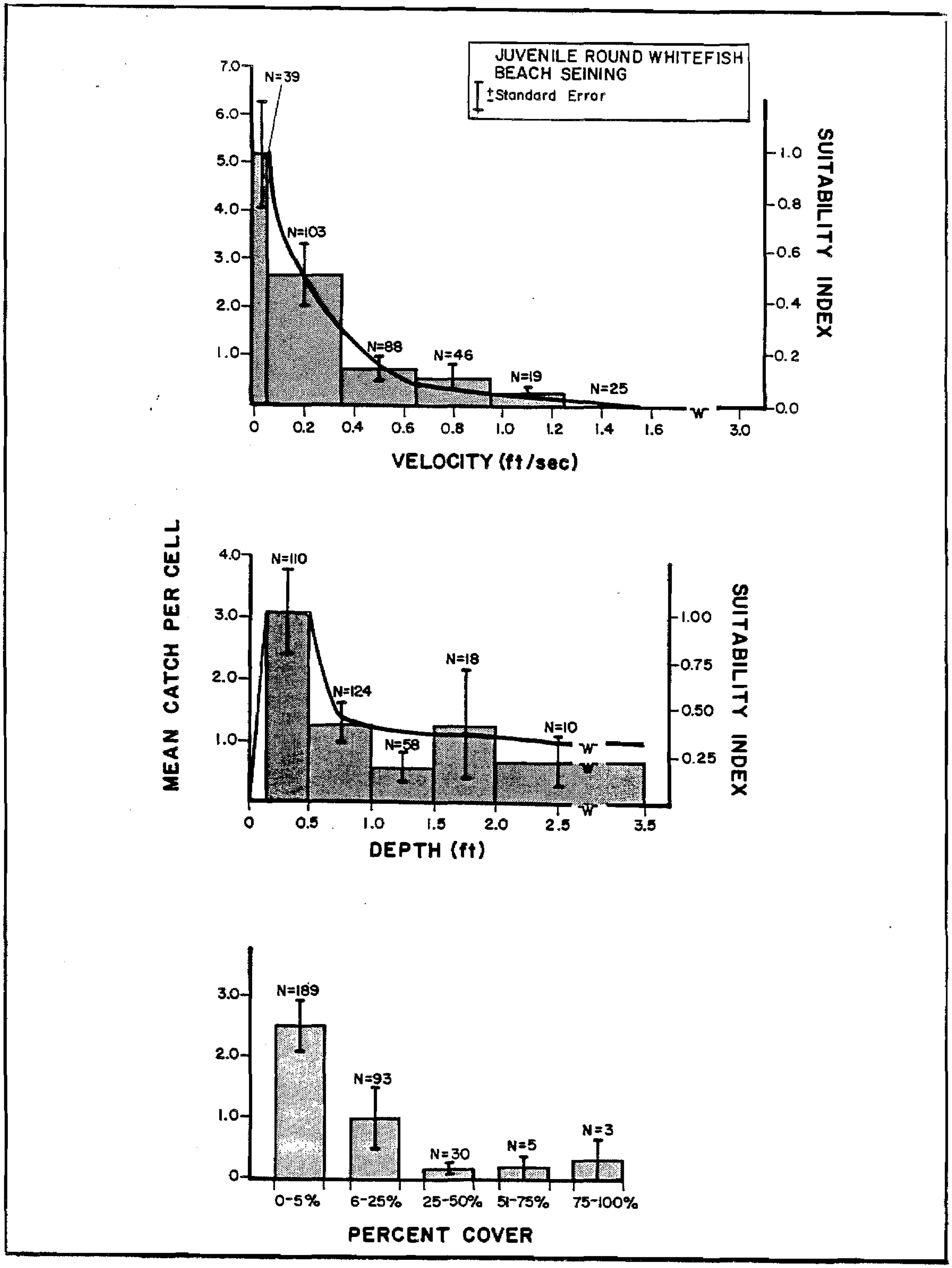

Figure 10. Juvenile round whitefish beach seining mean catch (bars) by habitat attribute values of velocity, depth, and percent cover. Suitability indices (lines) for depth and velocity were fit by hand using professional judgement.

4.0 DISCUSSION

4.1 Adult Resident Fish

Boat electrofishing and hook and line sampling have provided a limited set of data by habitat attribute which were used to generate suitability criteria for adult resident fish. These suitability criteria are preliminary as sampling effort was limited. Since most sampling was done by boat electrofishing a bias toward the capture of large fish was probable. There may have also been some bias in the capture rates of fish in clear versus turbid water because of differences in boat electrofishing efficiency between these two habitat types but it did not appear to be large. The boat electrofishing microhabitat suitability data were collected near tributary and slough mouths during July to October and therefore are applicable only during the open water season. Additional information about rainbow trout and burbot microhabitat distribution was also collected during radio telemetry locations of tagged fish and these data were used to supplement the other data because they were free of sample efficiency bias.

Use of macrohabitats at tributaries and slough mouths could be due to food input in the form of salmon eggs, fry or invertebrates drifting out of the sloughs or tributaries. Species interactions could also play a role in distribution as each species competes best within a niche. All the species showed different responses to the habitat variables and this may be due to these interactions rather than an actual preference. Intercorrelations among habitat variables might also cause apparent preferences as fish might actually be selecting for something else.

Turbidity was an important habitat attribute which had large effects on adult resident fish distribution. Rainbow trout, Arctic grayling, and round whitefish apparently avoided turbid water. Longnose suckers avoided clear water. Turbidity also provided cover for all species and therefore was desirable from this aspect.

Analysis of radio tagged rainbow trout distribution among the macrohabitats of the Susitna River provided insights not obtainable by other sampling methods. These data are not subject to the collection gear bias inherent in other collection methods. Rainbow trout apparently ascend tributary streams from mid-May through early June to spawn. Some rainbow trout remain in the tributaries but others outmigrate to mainstem influenced macrohabitats. Tributary mouths are used heavily for summer rearing especially during periods of salmon spawning. Rainbow trout may also ascend tributaries and move into sloughs while following spawning salmon. Rainbow trout were observed being chased from spawning redds by male chum salmon while presumably feeding on salmon eggs. One radio tagged rainbow trout in Slough A[1] and another in Lane Creek were observed milling around spawning pink and chum salmon. The mainstem, per se, is probably used mainly as a migration path between tributaries and sloughs at this time. By mid-September, however, all radio tagged trout which had been in tributaries had descended to the mouths. The occurrence of this outmigration during a short time period makes rainbow trout in the upper Susitna River extremely vulnerable to sport fishing. Local anglers take advantage of the outmigration at the mouth of Indian River (RM 138.6) each fall. As the Susitna River basin continues to develop, the rainbow trout population may suffer from the increased fishing pressure. Most adult rainbow trout apparently overwinter in the mainstem.

Rainbow trout distribution within microhabitat was correlated with velocity and cover (Figures 5 and 6). Lewis (1969) found that rainbow trout populations in pools were most highly correlated with higher velocities, rather than the amount of cover. Shirvell and Dungey (1983) found velocity to be the most important factor determining brown trout position choice but that positions were chosen with optimum combinations of depth and velocity. Observations of radio tagged fish, however, revealed that rainbow trout distribution within microhabitat may be dependent upon food source. In areas where rainbow trout were feeding on salmon eggs, rainbow trout were closely associated with the spawning salmon and therefore used shallow water riffles with cobble substrate for cover. In other areas where there were no adult salmon, rainbow trout were presumably feeding primarily on aquatic insects. In these areas they were found in plunge pools or deep pools using turbulent water and depth, along with rubble/cobble substrate and debris as cover. Turbulent water in plunge pools was observed to be excellent cover.

4.1.2 Juvenile Resident Fish

Juvenile resident fish use of macrohabitat present on the Susitna River during the ice free months was found to vary greatly by species (Tables 5 and 6). Juvenile Dolly Varden, for example, were found only in tributaries while round whitefish juveniles were found most abundantly in mainstem side channels. The tributary sites are not influenced by mainstem discharge so Dolly Varden rearing would be little affected by changes in discharge. Round whitefish, on the other hand, might be affected by changes in discharge. Juveniles of this species apparently find turbid, mainstem conditions most suitable as they infrequently occur in sloughs when the heads are not overtopped. Large numbers of rearing juvenile Arctic grayling and round whitefish have been found during previous Susitna studies to prefer mainstem mixing zones of either sloughs or tributaries and secondarily mainstem waters (ADF&G 1983d). Longnose suckers were found in mainstem waters primarily but data collected during 1983 indicate that juvenile longnose suckers also find upland and side sloughs suitable for rearing.

Turbidity is the one factor which most distinguishes side slough habitats from mainstem side channel habitats and turbid water increases the suitability of mainstem side channels for such species as juvenile Arctic grayling and round whitefish. Turbidity provides suitable cover in environments which lack large amounts of object or overhead cover. If lack of suitable cover limits rearing of juvenile fish, major decreases in the amount of turbid rearing areas may adversely affect habitat used by juvenile Arctic grayling, round whitefish, and possibly longnose suckers.

Round whitefish fry find turbid, mainstem side channels as the preferred macrohabitat. Within these side channels, they use shallow, slow moving microhabitats. Apparently the turbid water provides all the cover necessary. Little, if any, literature is available concerning juvenile round whitefish rearing microhabitat needs.

Very little data are available concerning the microhabitat preferences of other resident species which make use of mainstem influenced environments for rearing. Juvenile Arctic grayling under 200mm perhaps have microhabitat preferences similar to that of chinook salmon fry or other salmonids. Juvenile longnose suckers probably use microhabitat very similar to that used by juvenile round whitefish as adult longnose suckers also prefer shallow, slow moving, turbid habitats.

5.0 CONTRIBUTORS

Field data were collected by Rich Sundet and Mark Wenger. Larry Dugan, Paul Suchanek, Dave Sterritt, and Bob Marshall collected the juvenile round whitefish data. Dana Schmidt provided the study design.

Data processing was done by Allen Bingham, Gail Heinemann, Donna Buchholz, Kathrin Zosel and Alice Freeman. Figures were drafted by Carol Kerkvliet, Carol Riedner, and Sally Donovan. The typing was done by Skeers Word Processing Services.

6.0 ACKNOWLEDGEMENTS

Funding for this study was provided by the State of Alaska, Alaska Power Authority. We would like to express our gratitude to all the people and organizations that provided information or assistance to the Resident Fish Study during the past year.

We are especially grateful to Carl Burger (USFWS) for his technical expertise and advice on radio telemetry investigations.

We are grateful to the employees at the Palmer ADF&G, Sport Fish office and state veterinarian Burt Gore D.V.M. who showed us several techniques to radio tag fish. We also thank ADF&G, FRED Division personnel at Elmendorf hatchery who provided rainbow trout to us for a radio tag implantation clinic.

7.0 LITERATURE CITED

Alaska Department of Fish and Game (ADF&G). 1981. Phase 1 final draft report. Subtask 7.10. Adult anadromous fisheries project. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

______. 1983a. Aquatic studies procedures manual. Phase II (1982-83). Subtask 7.10. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

______. 1983b. Susitna Hydro aquatic studies phase II basic data report. Volume 3 (2 parts). Resident and juvenile anadromous fish studies on the Susitna River below Devil Canyon, 1982. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

______. 1983c. Susitna Hydro aquatic studies phase II basic data report. Volume 4 (3 parts). Aquatic habitat and instream flow studies, 1982. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

______. 1983d. Influence of habitat parameters on distribution and relative abundance of juvenile salmon and resident species. Appendix F in Susitna Hydro aquatic studies phase II report. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 parts). Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

______. 1983e. Use of major habitat types by juvenile salmon and resident species. Appendix G in Susitna Hydro aquatic studies phase II report, synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 parts). Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

______. 1983f. Susitna Hydro aquatic studies phase II data report. Winter aquatic studies (October 1982 - May 1983). Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

______. 1984. Susitna Hydro aquatic studies May 1983 - June 1984 procedures manual. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Anchorage, Alaska.

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. U.S. Fish and Wildlife Service. FWS/OBS-82/26.

Everhart, W.H., A.W. Eipper, and W.D. Youngs. 1975. Principles of fishery science. Cornell University Press. Ithaca, New York.

Lewis, S. L. 1969. Physical factors influencing fish populations in pools of a trout stream. Transactions of the American Fisheries Society 98(1):14-19.

Montana Department of Fish, Wildlife and Parks (MDFW&P). 1983. Kootenai River fisheries investigations final report 1972-1982. Mont. Dept. Fish, Wildlife & Parks. Kalispell, Mont. 224pp.

Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1984. Habitat suitability information: Rainbow trout. U.S. Fish & Wildlife Service FWS/OBS-82/10.60.

Shirvell, C. S. and R. G. Dungey. 1983. Microhabitats chosen by brown trout for feeding and spawning in rivers. Transactions of the American Fisheries Society 112:355-367.

APPENDIX A

Suitability Indices for Resident Fish Species for Cover, Velocity, and Depth

Appendix Table A-1. Suitability indices for resident fish species for cover, velocity, and depth.

Cover Suitability

Cover type	PHABSIM Code	Adult: Rainbow trout clear	Adult: Rainbow trout turbid	Adult: Arctic grayling clear	Adult: Arctic grayling turbid	Adult: Round whitefish clear	Adult: Round whitefish turbid	Adult: Longnose suckers clear	Adult: Longnose suckers turbid	Juvenile: Round whitefish clear	Juvenile: Round whitefish turbid
No cover	1.	0	0.29	0	0.07	0	0.26	0	0.47	0	1.00
Emergent vegetation	2.	0	0.29	0	0.07	0.47	0.47	1.00	1.00	0	1.00
Aquatic vegetation	3.	0	0.29	0	0.07	0.47	0.47	1.00	1.00	0	1.00
Debris/ deadfall	4.	1.00	1.00	0.14	0.14	0.65	0.65	0.46	0.47	0	1.00
Overhanging riparian vegetation	5.	1.00	1.00	0.14	0.14	0.65	0.65	0.46	0.47	0	1.00
Undercut banks	6.	1.00	1.00	0.14	0.14	0.65	0.65	0.46	0.47	0	1.00
Large gravel (1-3")	7.	0	0.29	0	0.07	0.33	0.33	0	0.47	0	1.00
Rubble (3-5")	8.	0.77	0.77	0.69	0.69	0.41	0.41	0	0.47	0	1.00
Cobble or boulder (> 5")	9.	1.00	1.00	1.00	1.00	1.00	1.00	0	0.47	0	1.00

VELOCITY

Adult: Velocity (ft/sec)	Adult: Rainbow trout suitability	Adult: Velocity (ft/sec)	Adult: Arctic grayling suitability	Adult: Velocity (ft/sec)	Adult: Round whitefish suitability	Adult: Velocity (ft/sec)	Adult: Longnose sucker suitability	Juvenile: Velocity (ft/sec)	Juvenile: Round whitefish suitability
0.00	0.18	0	0.04	0	0.45	0	1.00	0	1.00
0.05	1.00	0.55	0.25	0.55	0.46	0.05	1.00	0.05	1.00
1.05	1.00	1.55	0.46	1.55	0.51	0.55	0.47	0.20	0.52
1.55	0.50	2.55	0.86	2.05	1.00	1.55	0.31	0.50	0.16
2.55	0.33	3.05	1.00	3.05	1.00	2.55	0.20	0.80	0.07
3.55	0.20	4.30	1.00	3.55	0.70	3.55	0.10	1.10	0.04
4.50	0.00	4.50	0.00	4.50	0.00	4.3	0.00	1.40	0.00

DEPTH

Adult: Depth (ft)	Adult: All resident fish suitability	Juvenile: Depth (ft)	Juvenile: Round whitefish suitability
0	0	0	0.00
0.5	0	0.15	1.00
0.6	1.00	0.50	1.00
10.0	1.00	0.75	0.42
		1.25	0.35
		1.75	0.33
		2.50	0.31
		10.0	0.31

APPENDIX B

Round Whitefish Spawning Microhabitat Data

Since 1981, nine locations have been determined to be spawning sites for round whitefish. In 1981 and 1982 one site was found each year at RM 100.8 and RM 102.6, respectively. In 1983 seven sites were found including four mainstem sites: RM 102.0, RM 114.0, RM 142.0 and RM 147.0; and three tributary mouth sites: Lane Creek (RM 113.6), Indian River (RM 138.6) and Portage Creek (RM 148.8) (Appendix Table B-1).

While catch data and the incidence of sexually ripe fish suggest that spawning of round whitefish might occur nearly anywhere in the mainstem, selection of spawning sites may not be random. Anchor ice, water fluctuations and ice cover can all limit egg survival. Due to these reasons, round whitefish in the Susitna River may seek out areas which have adequate ground water. Habitat data taken at one mainstem site (RM 147.0 in 1983) where eight sexually ripe males and females were captured support this hypothesis. Specific conductance was relatively high, 160 umhos/cm, in this area, indicating an area of upwelling. Chum salmon, another mainstem spawning species in the Susitna River, also seek areas of upwelling for spawning (ADF&G 1983c).

Appendix Table B-1. Physical and chemical habitat characteristics of spawning round whitefish in the Susitna River during October 1983.

Area, River Mile	Date	Site	Water depth	Velocity 0.2	Velocity 0.8	Velocity x/0.6	Substrate Primary	Substrate Secondary	Water quality: Turbidity	Water quality: intragravel temp	Water quality: surface temp	Water quality: pH	Water quality: DO	Water quality: specific conductance
Lane Creek (RM 113.6)	Oct 7	1	3.2	1.8	1.6		cobble(5"-10"),	rubble(3"-5")	12.0	-	0.4	-	-	-
		2	2.2			1.5	rubble(3"-5"),	gravel(1"-3")	12.0	-	0.4	-	-	-
Portage Creek (RM 148.8)	Oct 5	1	4.2	1.4	1.2		rubble(3"-5"),	cobble(5"-10")	4.2	-	1.2	7.5	15.1	133
		2	2.2			0.4	rubble (3"-5"),	silt	2.0	-	1.7	7.4	13.7	104
Mainstem (RM 147.0)	Oct 5	1	2.1			0.7	silt,	cobble (5"-10")	14.0	0.6	0.0	7.5	15.1	159.0
		2	1.9			0.7	silt,	cobble (5"-10")	14.0					
		3	2.3			0.7	silt,	cobble (5"-10")	14.0	0.6	0.0	7.5	15.0	160.0
		4	2.2			0.7	silt,	cobble (5"-10")	14.0					
		5	1.8			1.2	cobble(5"-10"),	boulder(over 10")	14.0	0.6	0.0	7.5	15.0	161.0
		6	1.7			1.2	cobble(5"-10"),	boulder(over 10")	14.0					

Document No. 1784
Susitna File No. 4.3.1.6

Part 6
Resident Fish Habitat Studies

ALASKA DEPARTMENT OF FISH AND GAME
SUSITNA HYDRO AQUATIC STUDIES

REPORT NO. 2

RESIDENT AND JUVENILE ANADROMOUS FISH INVESTIGATIONS (MAY - OCTOBER 1983)

Edited by:

Dana C. Schmidt
Stephen S. Hale
Drew L. Crawford
Paul M. Suchanek

Prepared for:

Alaska Power Authority
334 W. Fifth Avenue, Second Floor
Anchorage, Alaska 99501

July 1984