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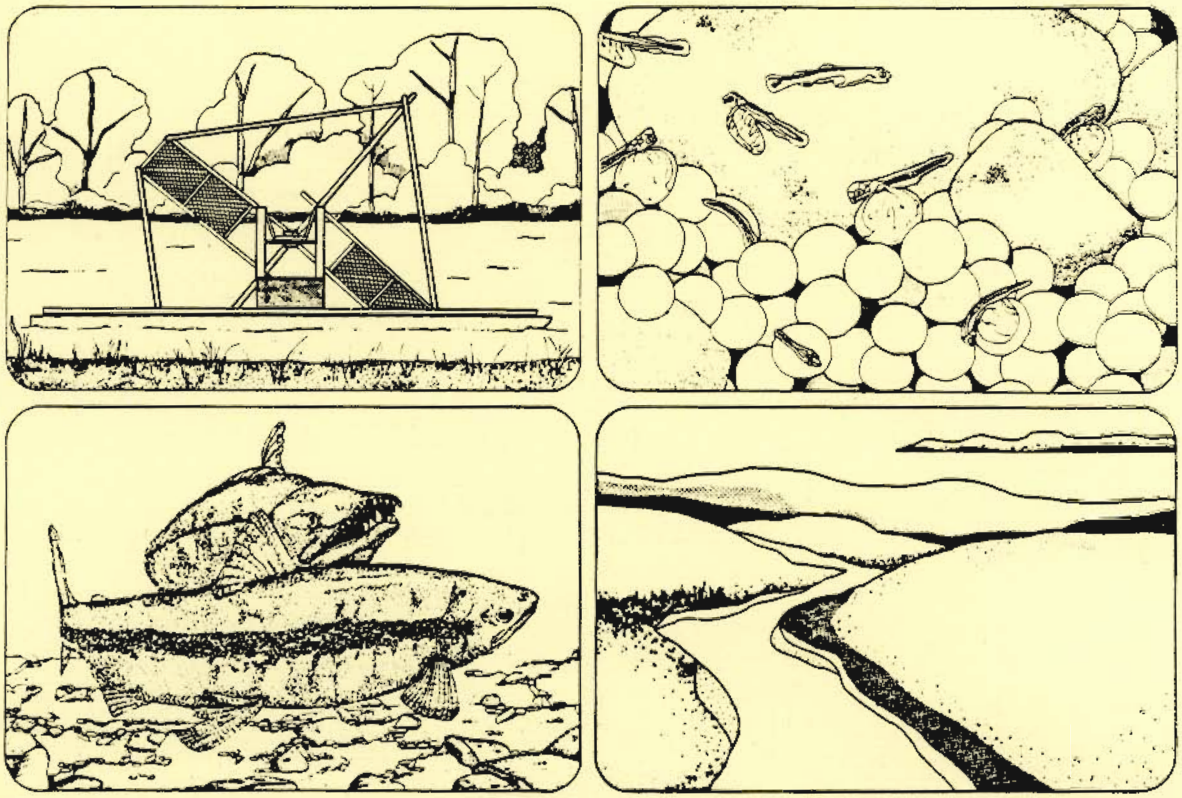

REPORT No. 2
(RESIDENT & JUVENILE ANADROMOUS FISH - - - .)

Part 2.

The Distribution and Relative Abundance of Juvenile Salmon in the Susitna River Drainage above the Chulitna River Confluence

ADFG/SU HYDRO
PROVISIONAL DATA
DATE MAY 0 8 1984

ALASKA DEPARTMENT OF FISH AND GAME
SUSITNA HYDRO AQUATIC STUDIES REPORT SERIES

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THE DISTRIBUTION AND RELATIVE ABUNDANCE
OF JUVENILE SALMON
IN THE SUSITNA RIVER DRAINAGE
ABOVE THE CHULITNA RIVER CONFLUENCE

1984 Report No. 2, Part 2 **PROVISIONAL DATA**

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ABSTRACT

The Juvenile Anadromous Habitat Study was undertaken to determine the seasonal distribution and abundance of juvenile salmon by macrohabitat type in the Susitna River drainage between the Chulitna River confluence and Devil Canyon. Thirty-five sites representing four macrohabitat types were sampled from May through September, 1983; limited sampling was conducted in October and November. Side channels and tributaries were found to be important rearing areas for juvenile chinook salmon with tributaries important early in the summer and side channels of the mainstem Susitna increasing in importance as the summer progressed. Coho salmon were most abundant in tributaries and upland sloughs. Natal side sloughs and backwater areas provided rearing areas for chum and sockeye salmon fry. Upland sloughs, the most lake-like environment, had concentrations of sockeye and coho salmon juveniles. Macrohabitat type and time of year were found to be significantly related to the distribution of all species.

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PROVISIONAL DATA

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX TABLES

1.0 INTRODUCTION

PROVISIONAL DATA

The Resident and Juvenile Anadromous Fish Studies (RJ) have been directed toward accomplishing the general objectives described in 1979 by the Alaska Department of Fish and Game for the Susitna Hydroelectric Project (ADF&G 1979). These objectives are stated below:

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

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

Five species of Pacific salmon spawn in the reach of the Susitna River between the Chulitna River confluence and Devil Canyon. With the exception of pink salmon, substantial freshwater rearing and growth occur in this reach of river.

The Resident and Juvenile Anadromous Fisheries Studies began in November 1980 with general surveys of the Susitna River mainstem and associated habitats between Cook Inlet and Devil Canyon conducted during the open water season of 1981. Beginning in the winter of 1981 and the spring and summer of 1982, the studies concentrated on those areas of the mainstem and associated habitats that may be most affected by the development of the Susitna Hydroelectric Project.

The data collected during 1981 and 1982 outlined the general distribution patterns of these species and their habitat utilization (ADF&G 1981b, 1981c, 1983c). The 1982 studies also investigated the response of selected macrohabitat areas to mainstem discharge changes and demonstrated species differences in the use of "hydraulic zones" (ADF&G 1983d). These zones were subsections of the slough and tributary mouth areas that were affected by backwater of the mainstem Susitna River, mixing areas of the mainstem with slough or tributary flow, and free-flowing tributary or slough water above the back water. The relative use of the hydraulic zones by each species of juvenile salmon was analyzed to provide an incremental index of habitat availability for each species. This analysis provided evidence that the relative use by juvenile salmon of these macrohabitat areas was affected by changes in mainstem flow. During the course of the 1982 study, observations of the distribution of juvenile salmon indicated certain microhabitat parameters within the zone may respond to discharge changes at a higher rate than does zone surface area. These microhabitat factors include cover and turbidity, with depth and velocity having a somewhat lesser importance.

The objectives of the 1983 Juvenile Anadromous Habitat Study (JAHS) program were to correlate juvenile salmon habitat use to microhabitat parameters and further document the seasonal distribution and relative abundance of juvenile salmon (except pinks) in macrohabitat types (tributaries, upland sloughs, side sloughs and side channels) associated with the Susitna River above the Chulitna River confluence. Pink salmon are not discussed because of the short time they spend in this reach of the river between emergence and outmigration. The purpose of this paper is to present the data on spatial and seasonal distribution and relative abundance for each species and to discuss the causative factors behind the observed distributions.

Juvenile salmon distribution and abundance data will be used to determine the proportion of the population using the macrohabitats associated with the mainstem river. In addition, the data can be used in the assignment of dam flows throughout the summer to minimize the effects on life stages of different juvenile anadromous species. Furthermore, the data will be integrated into macrohabitat indices compiled by E.W. Trihey and Associates which project the percentages of suitable rearing habitat for each juvenile salmon species over a range of mainstem flows between 9,000 cfs and 23,000 cfs. Distribution and abundance data were also used in conjunction with microhabitat studies including the juvenile salmon habitat suitability functions (Part 3 of this report), the juvenile salmon habitat modelling (Part 4), and the IFG-4 modelling (Part 7).

2.0 METHODS

2.1 Field Sampling Design

Two Juvenile Anadromous Habitat Study (JAHS) field crews, of two biologists each, collected distribution and abundance data at rearing habitats used by juvenile salmon. Selected side sloughs, upland sloughs, tributaries and mainstem side channels of the Susitna River between the Chulitna River confluence (RM 98.5) and Portage Creek (RM 148.8) were sampled during the open water season. Crews operated out of tent camps and used river boats for transportation with helicopter support when necessary.

2.1.1 Study site locations and selection criteria

Thirty-five study locations on the Susitna River and its major tributaries between the Chulitna River confluence and Devil Canyon were sampled (Table 1). Rearing habitats at thirteen of the sites was modelled using either RJHAB (Part 4) or an IFG model (Part 7). Sites sampled more than three times are shown in Figure 1.

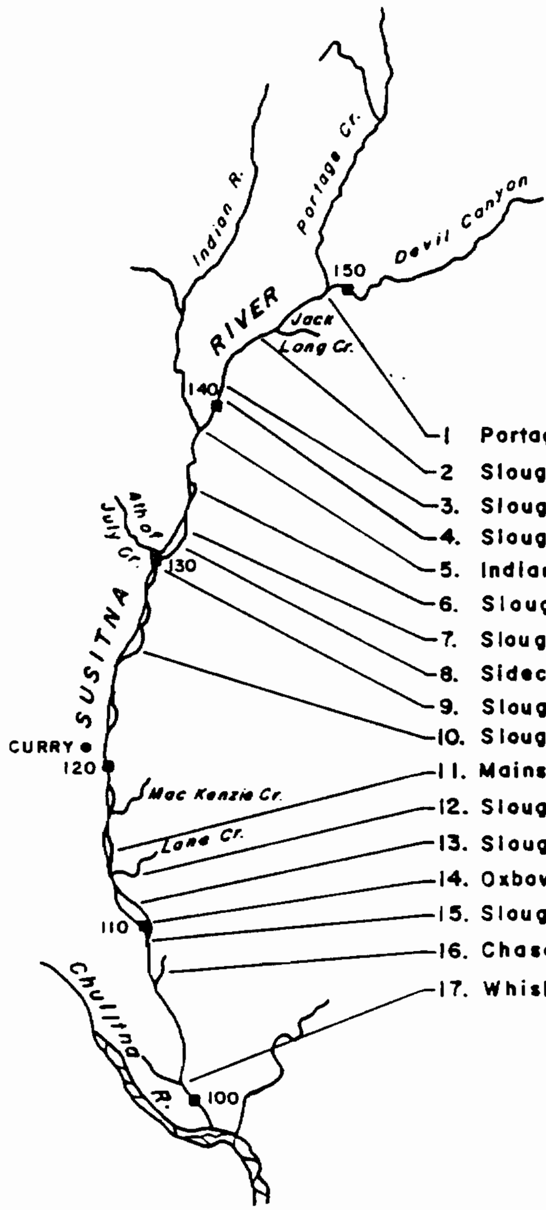
Sites selected for study included: (1) sites that had large numbers of spawning adult salmon in 1982 (ADF&G 1983b), (2) sites where large numbers of rearing juvenile salmon were observed or collected in 1981 and 1982, and (3) sites representing macrohabitat types associated with the Susitna River that are affected by changes in mainstem flow.

Table 1. Juvenile Anadromous Habitat Study (JAHS) sites sampled on the Susitna River between the Chulitna River confluence and Devil Canyon, May through November 1983.

Site	River Mile	Macro-habitat Type a)	Fish Distri-bution Site	RJ Model-ing Site	IFG-4 Model-ing Site
Whiskers Creek Slough	101.2	SS/SC	X	X	
*Whiskers Creek	101.2	T	X		
*Slough 3B	101.4	SS	X		
*Mainstem at head of Whiskers Creek Slough	101.4	SC	X		
Chase Creek	106.9	T	X		
Slough 5	107.6	US	X	X	
Oxbow I	110.0	SC/SS	X		
Slough 6A	112.3	US	X	X	
*Mainstem above Slough 6A	112.4	SC	X		
*Lane Creek	113.6	T	X		
Slough 8	113.6	SS	X	X	
Mainstem II	114.4	SC/SS	X		
*Lower McKenzie Creek	116.2	T	X		
*Upper McKenzie Creek	116.7	T	X		
*Side Channel below Curry	117.8	SC	X		
*Oxbow II	119.3	SC/SS	X		
Slough 8A	125.3	SS	X		X
Side Channel 10A	127.1	SC	X	X	
Slough 9	129.2	SS/SC	X		X
Slough 10 Side Channel	133.8	SC/SS	X		X
*Slough 11 Lower Side Channel	134.6	SC	X		X
Slough 11	135.3	SS	X		
*Slough 11 Upper Sidechannel	136.2	SC	X		X
Indian River - Mouth	138.6	T	X		
Indian River -	138.6	T	X		
*Slough 19 TRM 10.1	140.0	US	X		
*Slough 20	140.1	SS/SC	X		
Slough 21 Side Channel	140.6	SC			X
Slough 21	142.0	SS/SC			X
Slough 22	144.3	SS/SC	X	X	
*Jack Long Creek	144.5	T	X		
Portage Creek Mouth	148.8	T	X		
Portage Creek TRM 4.2	148.8	T	X		
Portage Creek TRM 8.0	148.8	T	X		
			35	6	7

a) T - Tributary
US - Upland Slough
SS - Side Slough
SC - Side Channel

*These sites sampled three times or less.



Macrohabitat Type

Site	Tributary	Upland Slough	Side Slough	Mainstem Side Channel
1 Portage Creek	▲			
2 Slough 22			▲	▲
3. Slough 21			▲	▲
4. Slough 21 Sidechannel				▲
5. Indian River	▲			
6. Slough 11			▲	
7. Slough 10 Sidechannel			▲	▲
8. Sidechannel 10A				▲
9. Slough 9			▲	▲
10. Slough 8A			▲	
11. Mainstem 2			▲	▲
12. Slough 8			▲	
13. Slough 6A		▲		
14. Oxbow One			▲	▲
15. Slough 5		▲		
16. Chase Creek	▲			
17. Whiskers Cr. Sl.			▲	▲

Figure 1. Juvenile Anadromous Habitat Study (JAHS) sites sampled more than three times by macrohabitat type, 1983.

In 1982, sampling sites were classified, using site geomorphology as a criterion, into one of four macrohabitat types: tributary, upland slough, side slough, or side channel. Upland sloughs are sites which have heads vegetated with trees and brush that are rarely overtopped. Side sloughs are sites with unvegetated heads that are sometimes overtopped by mainstem flows during the open water season of a normal year. Side channels are sites with heads that are usually overtopped, often by strong flows, during the open water season of a normal year.

Side sloughs are geomorphologically distinct from side channels for several reasons. A mainstem backwater area is frequently present at the mouths of side sloughs. Fewer backwater areas occur at the mouth of side channels because the gradient of the side channels is typically higher than that of sloughs. The infrequency of large flows in the sloughs over the course of several years has caused sloughs to silt in and debris and deadfall to accumulate. Debris and silt is often flushed out of the side channels and sometimes the substrate may become armored. The water in the sloughs is often clear and moving slowly and therefore much more conducive to the growth of aquatic and emergent vegetation.

This year, side sloughs and side channels were distinguished with a discharge-based classification scheme which depends on the status of the head of the site. Under this criterion, sites are classified as side sloughs only when the head is not overtopped by mainstem discharge. When the head is overtopped by the mainstem, these sites are classified as side channels. Classification of upland sloughs did not change.

This is the classification method which was used by E.W. Trihey and Associates to measure the total surface area of each macrohabitat type in this reach of river.

The discharge-based method is useful when considering fish distribution because of the major habitat changes which occur when the head of a slough is overtopped. The geomorphological-based method is useful because the frequency of overtopping has an important influence on the distribution of substrate and object cover which are important to juvenile and spawning salmon. The discharge-based scheme considers an instantaneous effect of mainstem discharge, while the geomorphological-based scheme considers a long-term effect. Both effects are important. The instream methodology being used in other reports in this series considers only the discharge-based assumptions and not the very important effects of discharge on long-term geomorphology of these sites.

2.1.2 Field data collection

Each of the study locations was divided into one or more grids. Grids were located so that water quality within the site was as uniform as possible and so that the site encompassed a variety of habitat types. Each grid consisted of a series of transects which intersected the channels of the study sites at right angles (Figure 2). There were one to three cells (6 ft. in width by 30 ft. in length) at every transect within the grid. An attempt was made to confine uniform habitat within each cell. Further descriptions of the grid system used are detailed in

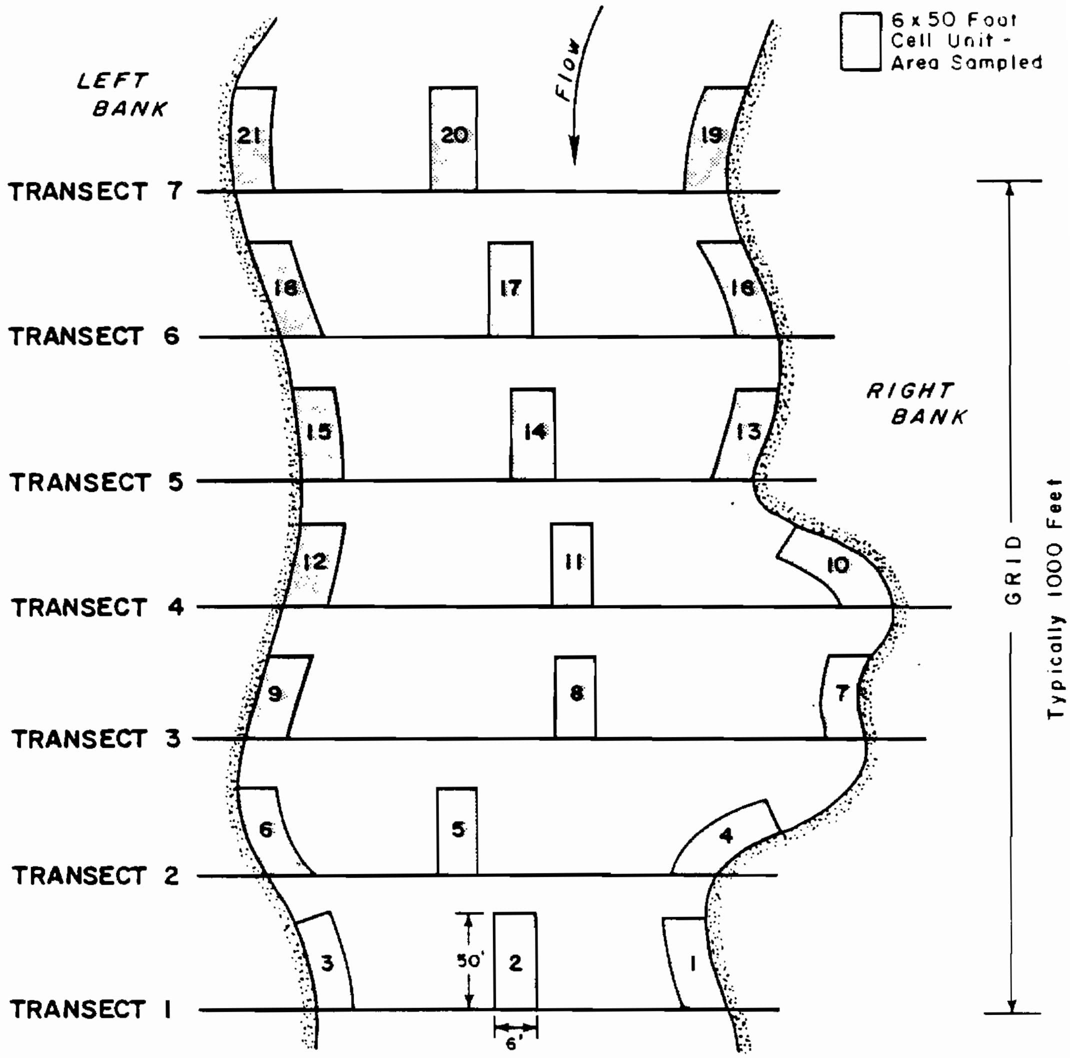


Figure 2. Arrangement of transects, grids, and cells at a Juvenile Anadromous Habitat Study (JAHS) site.

the 1983-84 Procedures Manual (ADF&G 1984). Habitat data collection methods are further described in Parts 3 and 4 of this report.

Backpack electrofishing units (Coffelt, Model BP1C and Smith-Root, Model XVBPG) and beach seines were used to collect fish. Procedures used for sampling with these techniques are described in the 1982-83 Procedures Manual (ADF&G 1983a). Juvenile salmon collected were identified to species, measured for total length in millimeters and released. A few specimens were preserved in 10% formalin for later identification.

Fish were generally sampled from a minimum of seven cells within each grid at each site. The cells were selected to represent the complete range of habitat types available within the grid. Fish density was estimated by sampling the entire cell. Fish distribution and abundance data were also collected at RJ habitat model sites and IFG model sites.

2.1.3 Schedule of activities and frequency of sampling

The sampling schedule was dependent on the target species. Sites that predominantly had juvenile chum, pink, and sockeye salmon were sampled in May and June. In late June and early July, sampling efforts were redirected toward sites previously identified in 1981 and 1982 as rearing areas for chinook and coho salmon. The chinook and coho salmon sites were sampled until freezeup in early November. Because the primary objective of the JAHS study was microhabitat suitability and habitat modelling, there was not equal effort at all sites, which would be desirable, although not necessary, from the standpoint of a distribution and relative abundance study (the objective of this paper). This problem was partially solved by using catch per unit effort data.

2.2 Data Recording and Analysis

All field data were recorded on data forms and transmitted to the office, where they were entered into a mainframe computer data base. Data sorts and summary retrievals were extracted from this data base as needed.

2.2.1 Macrohabitat use

Percentage distribution of each salmon species among macrohabitat types was calculated by dividing the catch/cell for each type by the sum of the catch/cell for all types. The equations are:

$$\text{Percentage}_I = \frac{(\text{Total Fish})_I/(\text{Total Cells})_I}{\sum_{I=1}^{N=4} (\text{Total Fish})_I/(\text{Total Cells})_I}$$

where: I = each macrohabitat type

N = number of macrohabitat types = 4

2.2.2 Gear efficiency

Realizing that beach seining and electrofishing have different capture efficiencies and that these efficiencies vary with the turbidity level, amount of cover, and other factors, we conducted two small experiments in an attempt to be better able to interpret the catch data.

The first experiment was designed to determine if backpack electrofishing was equally efficient in cells with different amounts of cover. Previous experience had suggested that capture efficiencies were low in cells with a little cover because the fish would be disturbed and leave the area. Capture efficiencies might also be low in cells with a large amount of cover because all the fish could not be extracted from the substrate or dense vegetation.

We approached this problem by calculating the capture probabilities of fish in cells which ranged from low percent cover cells to high percent cover cells. Capture probability should have been relatively constant over this range if percent cover had no effect on capture efficiency. Capture probabilities were calculated by a computer program designed to estimate population size from multiple removal data (Platts et al. 1983). This program was implemented on a portable battery-powered microcomputer (Epson HX-20) so that the biologists would have on-site verification that they were using appropriate sampling techniques.

This experiment was conducted at Slough 11 on June 8th and at Slough 8 on August 2nd. Seven cells with a typical range of cover available to juvenile salmon were sampled at each site with a backpack electrofishing unit on three successive trials. At the completion of each trial, the fish were identified and counted and held until the end of the third trial. Successive trials were separated by about one hour. Turbidity was low at both sites and did not provide cover.

In the second experiment, five cells at Sidechannel 10A were first sampled with beach seines and then with backpack electrofishing gear. This was done on two different dates, once when the turbidity level was high and once when the turbidity level was low. The objective was to study the effect of turbidity on the sampling efficiency of the two gear types.

2.2.3 Analysis of variance

An analysis of variance (ANOVA) was conducted to examine the effect of several habitat variables on the distribution of each species. The two major variables considered were macrohabitat type and time of year. Site habitat characteristics (which contribute to differences among macrohabitat types) considered were: mean water depth, mean water velocity, mean percent cover, water temperature, and turbidity. All of these parameters can be influenced by discharge level. Temperature and turbidity are influenced by time of year; the other variables are indirectly influenced by time of year in that discharge levels have a seasonal pattern.

All sites were grouped into the four macrohabitat types - tributary, upland slough, side slough, or side channel. Periods were taken as the nine half-month periods from late May (May 16-May 30) to late September (Sept. 16-Sept. 30). Mean depth, mean velocity, and mean percent cover were the mean values of all 300 sq ft cells sampled in a particular interval of each parameter, such as 0.1 to 0.6 ft. There were usually at least seven cells per sampling site on each occasion. Because the cells were not randomly distributed at the site, the ANOVA is weakened for the three variables (depth, velocity, cover) which were taken as means of the cells. However, it was felt that the means of these three would generally characterize each site.

The intervals and frequencies for all the variables are given in Appendix Table 1. The break points for the intervals were selected to be physically or biologically meaningful while still maintaining an adequate sample size in each interval. For example, the first interval for turbidity is 0 to 10 NTU, which covers the non-flood tributary conditions.

Fish density data were taken as the total number of fish captured in a particular interval, divided by the number of 300 sq. ft. cells sampled in that interval. Mean catch per cell for each species was transformed by natural log (x+1).

The analysis of variance was run on BMDP Statistical Software, using the regression approach. One run was conducted for macrohabitat type and period, with fish catch/cell as the dependent variable and a second run was conducted for mean depth, mean velocity, mean percent cover, water temperature, and turbidity, with fish catch/cell as the dependent variable. Because of empty cells in the analysis of variance table, interactions among variables were not calculated.

3.0 RESULTS

3.1 Efficiency of Sampling Techniques

3.1.1 Effect of percent cover on electrofishing efficiency

Only chum and sockeye salmon at Slough 11 were captured in sufficient numbers to compare capture probabilities among cells with different percentages of cover. The low numbers of other species captured at this site and at Slough 8 led to high standard errors on the capture probability. All species/cells combinations where the standard error was greater than 2.0 were rejected from this analysis. The capture probability for chum salmon was high in cells where the percent cover was low and then steadily declined as the percent cover increased (Table 2). The capture probability for sockeye salmon also decreased as percent cover increased. These results should be regarded as preliminary because most percent cover categories are represented by only one cell.

Table 2. Capture probabilities for chum and sockeye salmon at Slough 11 as a function of percent cover.

Species	Percent cover	Capture Probability	Standard Error	Number of Cells
Chum	0-5	0.9	0.06	1
	6-25	0.8	0.12	1
	26-50	0.8	0.13	1
	51-75	0.7	0.10	1
Sockeye	6-25	0.9	0.03	1
	26-50	0.3	0.12	1
		0.9	0.09	1
		0.7	0.14	1

3.1.2 Comparison of beach seining with backpack electrofishing

On two occasions when turbidity levels were very different, five cells at Side Channel 10A were first sampled with beach seines and then with backpack electrofishing gear (Table 3). A comparison of the mean catches of chinook salmon fry suggests that beach seining was more effective in water of high turbidity (150 NTU), while electrofishing was more effective in clearer waters (24 NTU). The Wilcoxon Rank Sum test failed to reject the null hypothesis that the means are equal; however, the sample size was only five. Electrofishing at 150 NTU was very difficult even though the cells where the comparisons were made only ranged to 0.4 ft. in mean depth.

Table 3. Comparison of beach seining and backpack electrofishing juvenile chinook catches at five cells fished at two different turbidity levels.

Date	Turbidity (NTU)	Electrofishing Catch Chinook Salmon (Mean ± S.E.)	Beach Seining Catch Chinook Salmon (Mean ± S.E.)	Wilcoxon Rank Sum Test (One Tailed Significance Level)
9/07	24	1.6 ± 0.8	0.2 ± 0.2	0.14
7/22	150	1.2 ± 0.6	2.4 ± 0.4	0.11
		n=5	n=5	

3.2 Distribution of Juvenile Chinook Salmon

A total of 4,443 juvenile chinook salmon were captured at JAHS sites located between the Chulitna River (RM 98.6) confluence to Portage Creek (RM 148.8), in surveys conducted from May 1 to November 15, 1983.

Approximately 99% of these fish were Age 0+ and the rest were Age 1+. Chinook juveniles were captured at all of the study sites surveyed at least four times (Figure 3). Chinook juvenile salmon were widely distributed from early July through September. Portage Creek and Indian River produced the highest densities of chinook salmon through the ice free field season. Increases in densities were apparent as the season progressed at several sites.

Chinook juvenile salmon were unequally distributed among macrohabitats. Side channels contributed 22.6 percent of the catch per unit effort (CPUE), the highest percentage of the three macrohabitats influenced by mainstem flows (Figure 4). Twice the CPUE of chinook juveniles were captured from side channels as compared to side sloughs, and twelve times that of upland sloughs. (See also Appendix Table 1, which gives the means used in the analysis of variance). Four mainstem side channels (Slough 22, Side Channel 10A, Oxbow I and Slough 9) produced 80.8 percent of the juvenile chinook captured at 13 mainstem side channels sampled during the 1983 field season. Side channel 10A (RM 127.1) contributed 31.1 percent of the chinook juvenile captured at this macrohabitat type.

Chinook juvenile salmon CPUE's by macrohabitat type ranged from less than one fish per cell (fpc) in May at upland slough and side slough macrohabitats to 26.4 fpc at tributary macrohabitats in early July (Figure 5). Consistently higher densities of chinook salmon were recorded at tributary macrohabitats than for upland slough, side slough, or sidechannel macrohabitats from May through early August. Peak den-

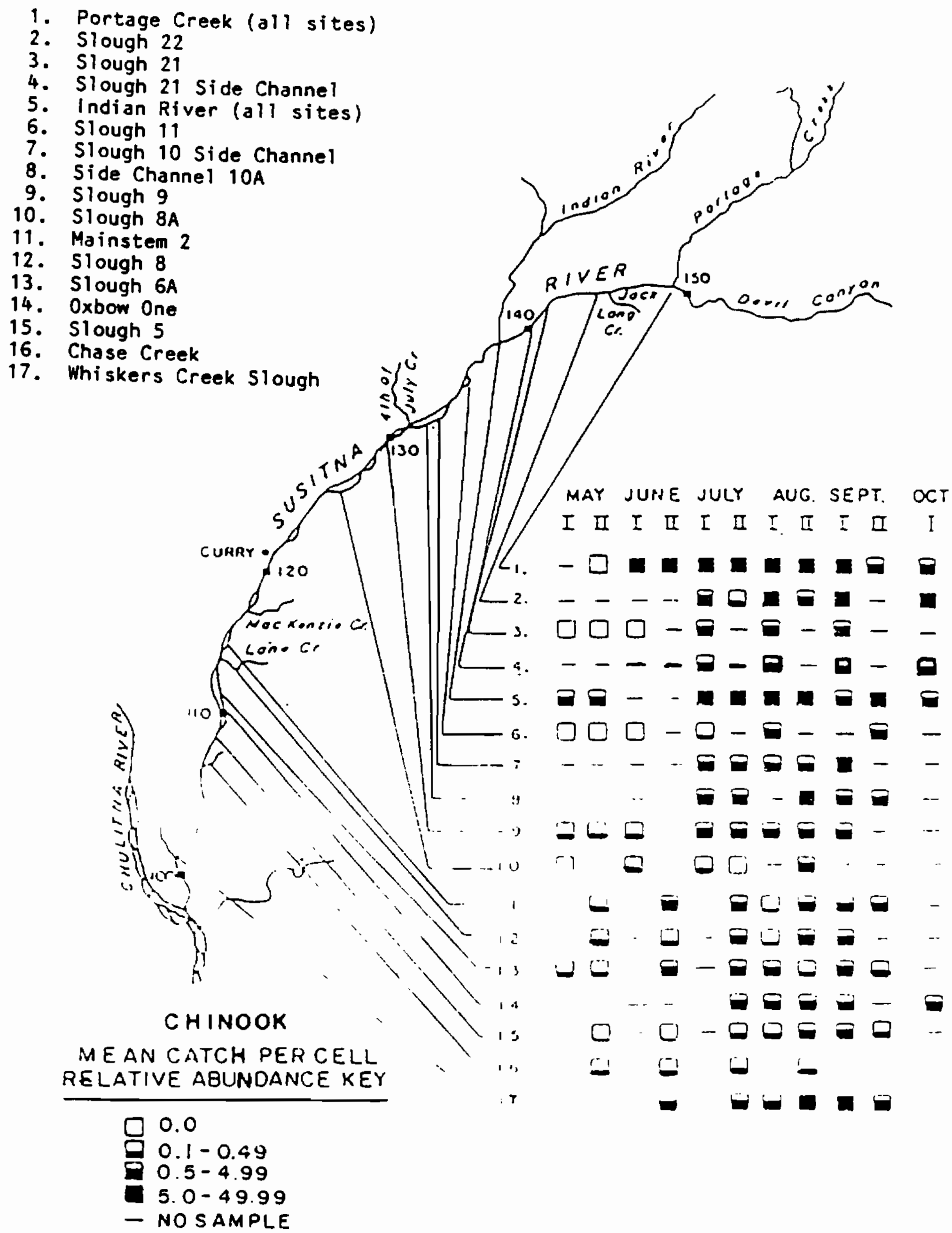


Figure 3. Seasonal distribution and relative abundance of juvenile chinook salmon on the Susitna River between the Chulitna River confluence and Devil Canyon, May through November 1983.

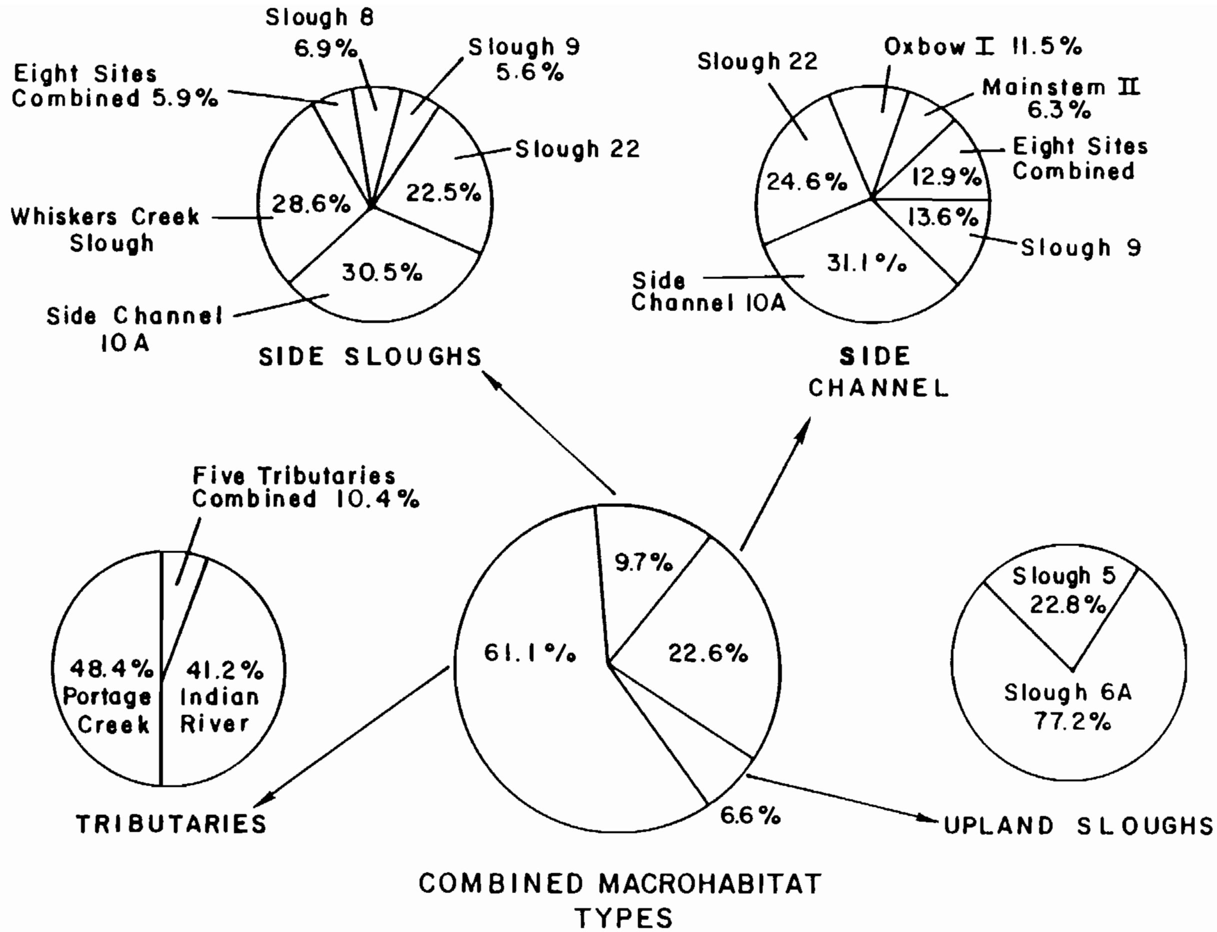


Figure 4. Density distribution of juvenile chinook salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devil Canyon, May through November 1983. Percentages are based on mean catch per cell.

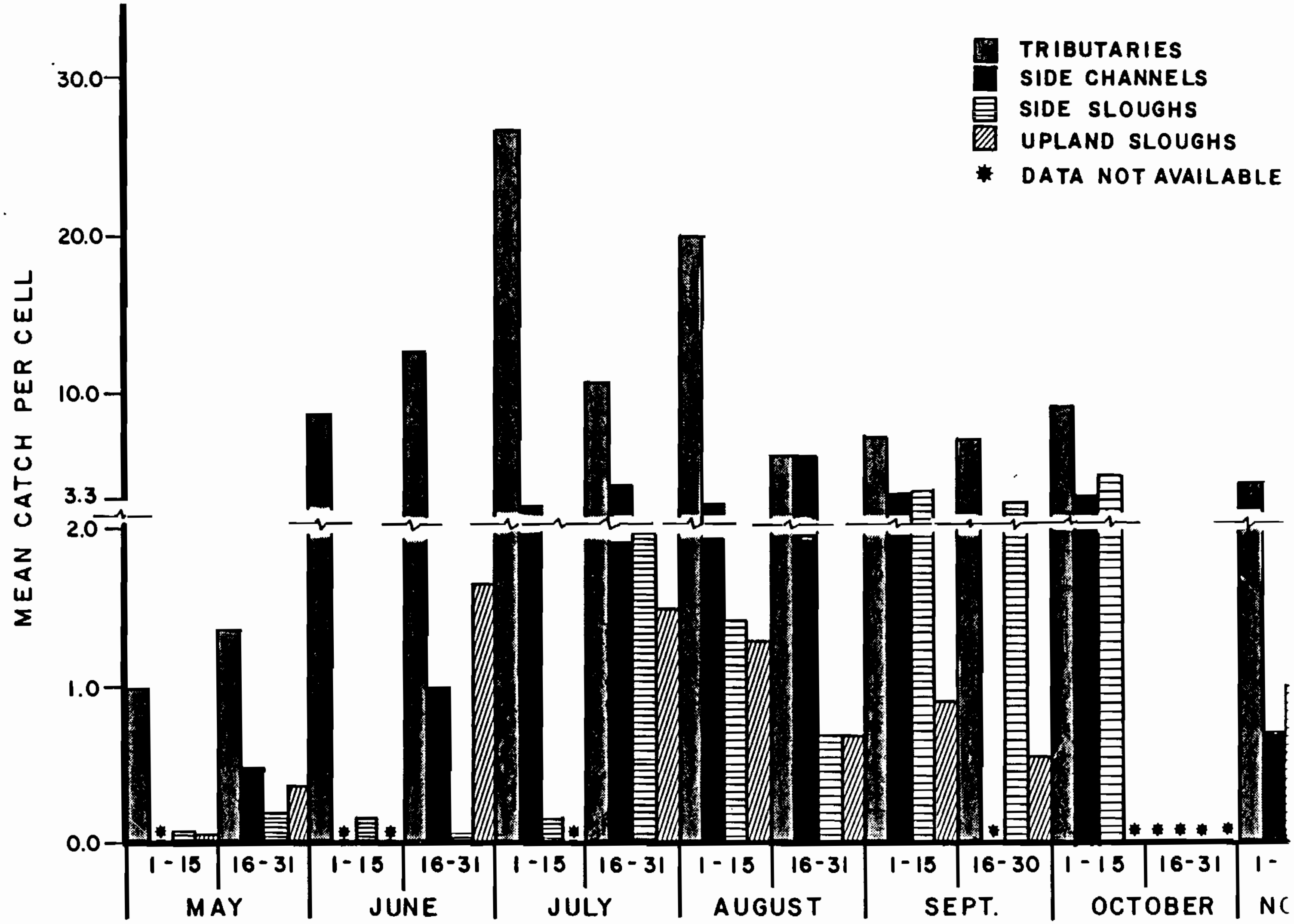


Figure 5. Juvenile chinook salmon mean catch per cell at four macrohabitats by sampling period, May through November 1983.

sities of 26.4 fpc and 19.5 fpc were recorded at tributary macrohabitats in early July and August, respectively. Chinook juvenile densities were much higher in tributaries in July and August than in side sloughs or side channels. Chinook juvenile densities increased at mainstem associated macrohabitats in late July. Chinook juveniles were redistributing into mainstem side channels, side sloughs and to a lesser extent upland sloughs during this time following outmigration from tributaries. Comparison of chinook juvenile salmon densities between side slough and mainstem side channel macrohabitats is illustrated in Figure 6. Chinook juvenile densities at side slough and mainstem side channels gradually increased until late August or early September. In general, side channel CPUE's were higher than those in side sloughs. Mainstem side channel densities of juvenile chinook salmon gradually decreased after August.

Densities were much higher in September and October at side sloughs than earlier in the season. Densities were five times greater at side sloughs in surveys conducted during September through November than before September.

3.3 Distribution of Juvenile Coho Salmon

A total of 2,023 juvenile coho salmon were captured at sites located between the Chulitna River (RM 98.6) and Portage Creek (RM 148.8). Three age classes of juvenile coho salmon from the 1980, 1981 and 1982 brood years (age 2+, 1+, and 0+ respectively) were captured. Ninety-seven percent of the coho juvenile salmon captured at JAHS sites

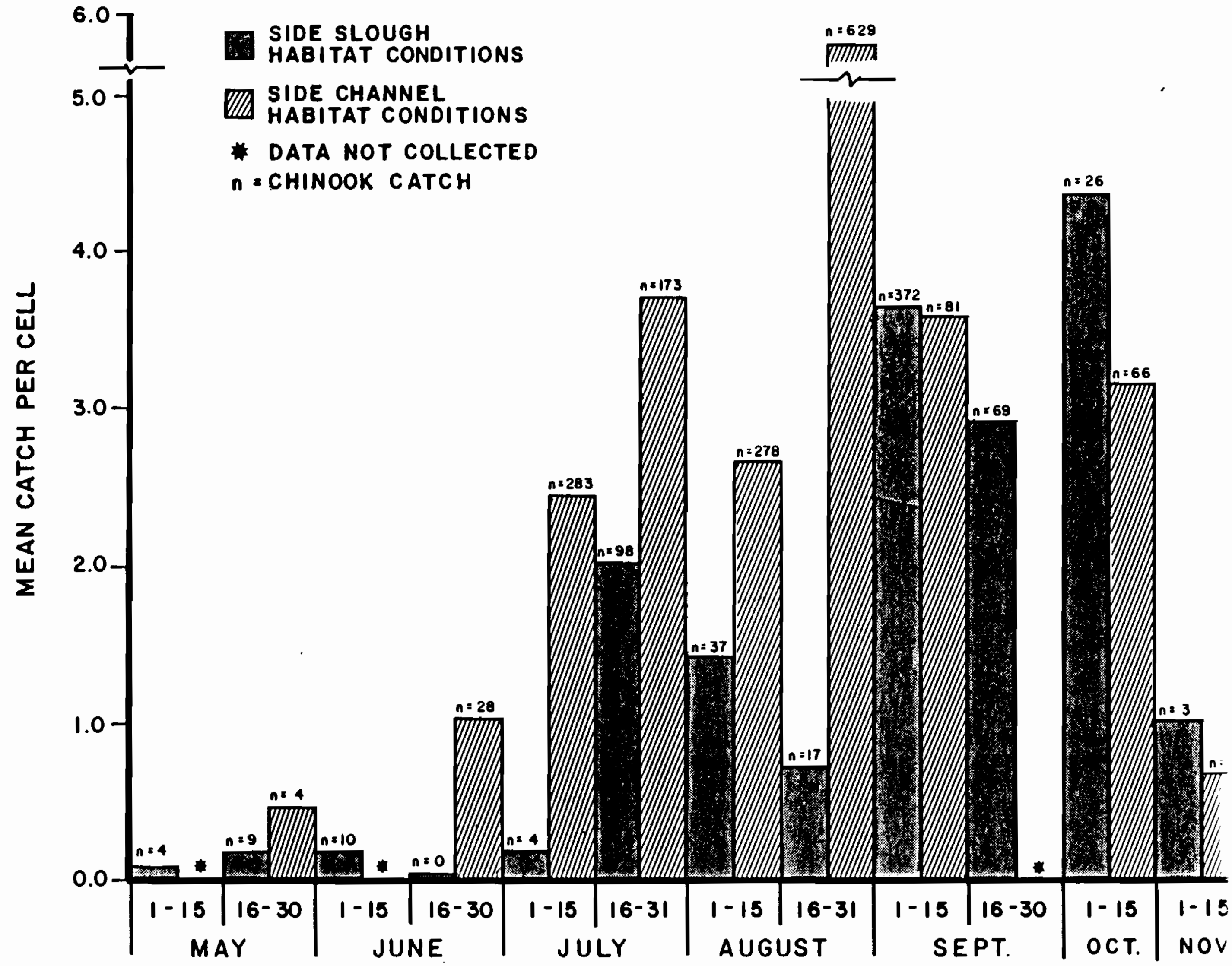


Figure 6. Juvenile chinook salmon mean catch per cell at side sloughs and side channels by sampling period, May through November 1983.

in 1983 were from the 1982 brood year (age 0+), three percent were age 1+, and less than one percent were age 2+ fish.

In general, coho juvenile salmon were widely distributed in low numbers at many sites in the Chulitna River to Devil Canyon reach of the Susitna River, prior to the occurrence of high tributary densities observed in early July and August (Figure 7). Juvenile coho CPUE's were frequently highest at sites located in the lower segment of the Chulitna River to Devil Canyon reach.

The comparative distribution of coho juvenile salmon by macrohabitat types is depicted in Figure 8. Coho juveniles were captured mainly in the tributaries and upland sloughs, with Whiskers Creek and Chase Creek being the primary tributary capture sites and Slough 5 and Slough 6A being the primary upland slough capture sites. Coho juvenile salmon were rarely encountered in side channels. Twelve mainstem side channel sites were sampled during 1983 and less than one percent of the juvenile coho salmon were captured at this macrohabitat type. Side channels appear to function as a pathway for redistribution of fish from tributaries macrohabitat into upland sloughs and side sloughs such as Whiskers Creek Slough and Slough 8. Side sloughs contributed 10% of the coho juvenile salmon total CPUE. Whiskers Creek Slough and Slough 8 contributed 99 percent of the juvenile coho captured at side sloughs.

Coho juvenile salmon catches ranged from 20 fish per cell (fpc) at tributaries, to less than one fish per cell at mainstem side channels and side sloughs (Figure 9). Densities were higher in upland and side

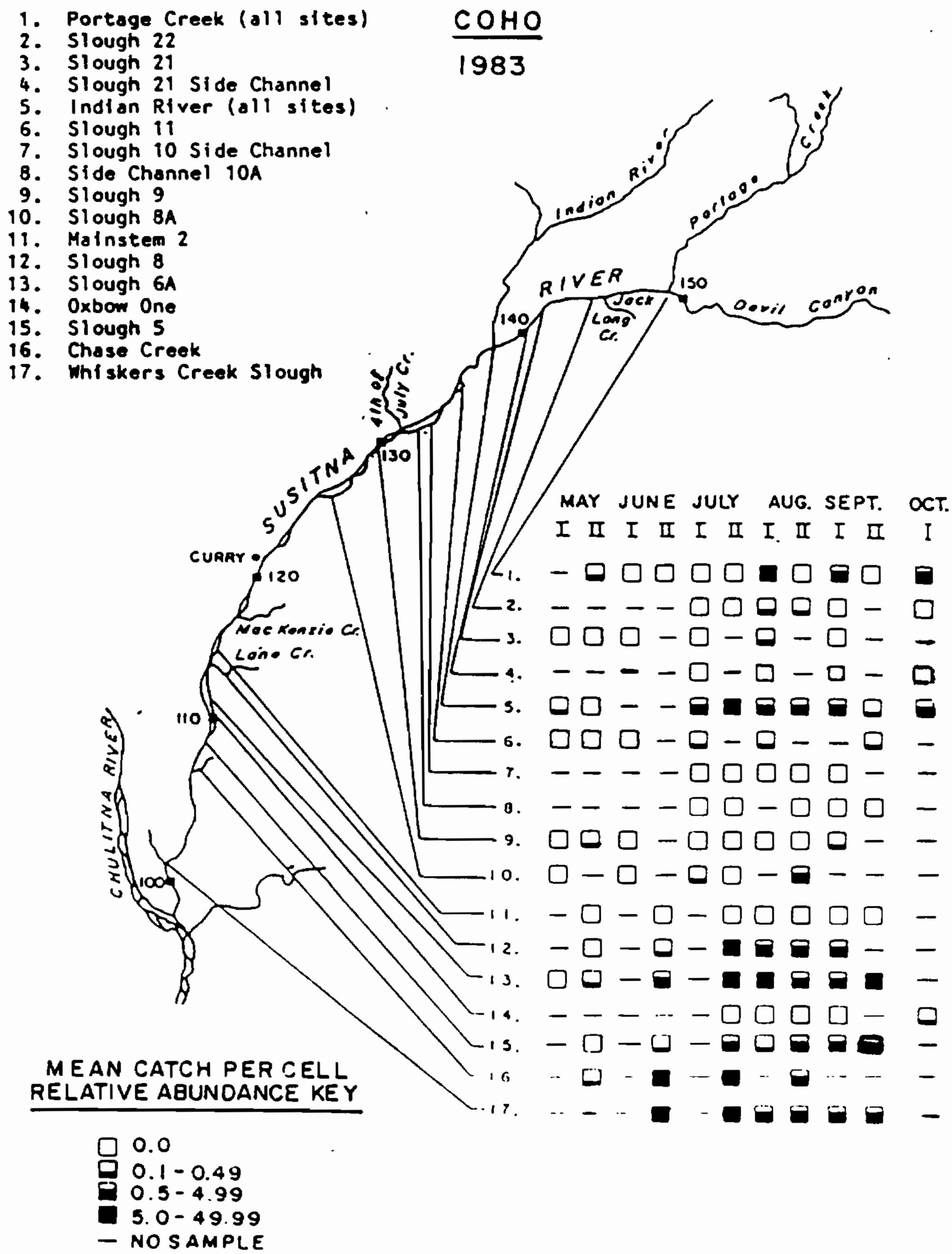


Figure 7. Seasonal distribution and relative abundance of juvenile coho salmon on the Susitna River between the Chulitna River confluence and Devil Canyon, May through November 1983.

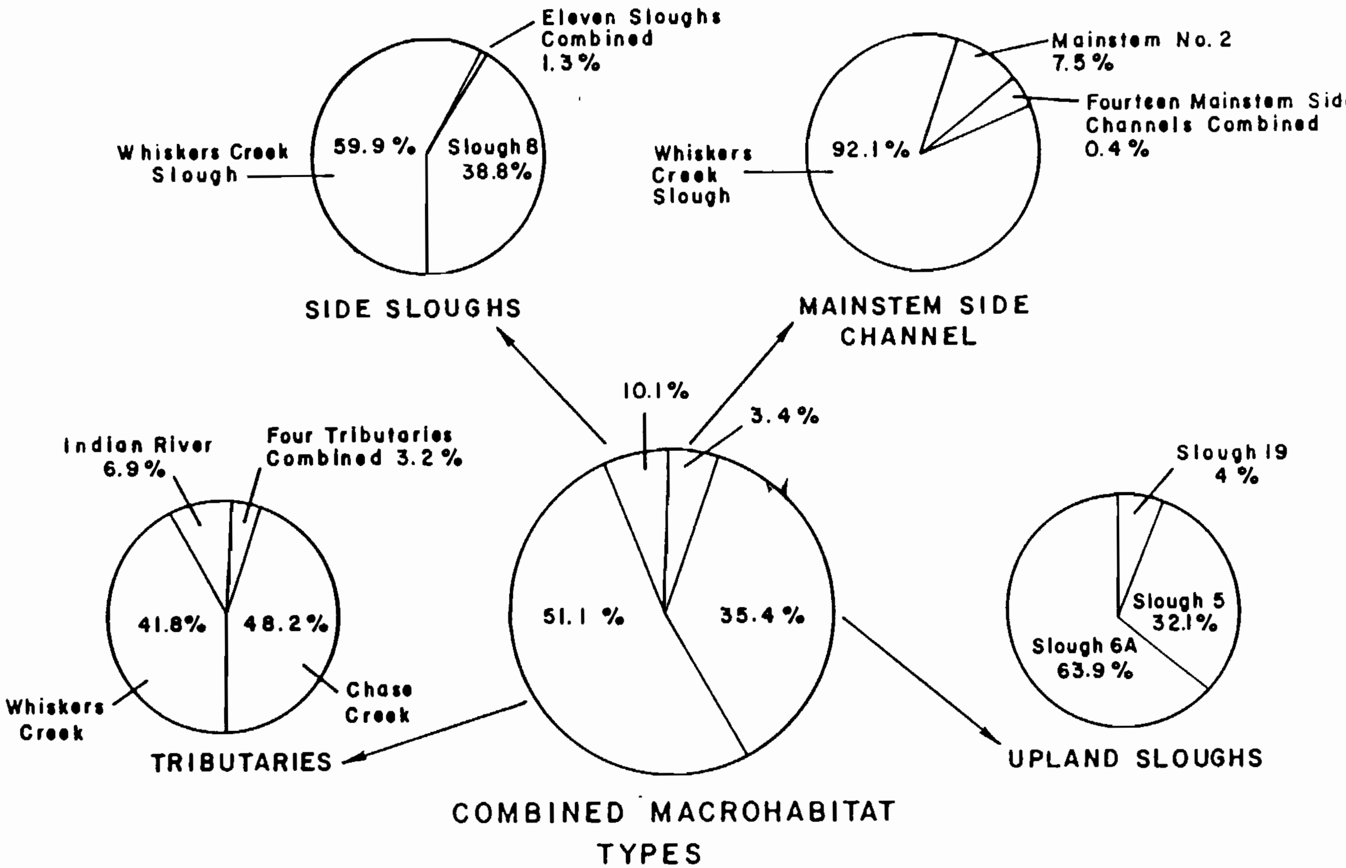


Figure 8. Density distribution of juvenile coho salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devil Canyon, May through November 1983. Percentages are based on mean catch per cell.

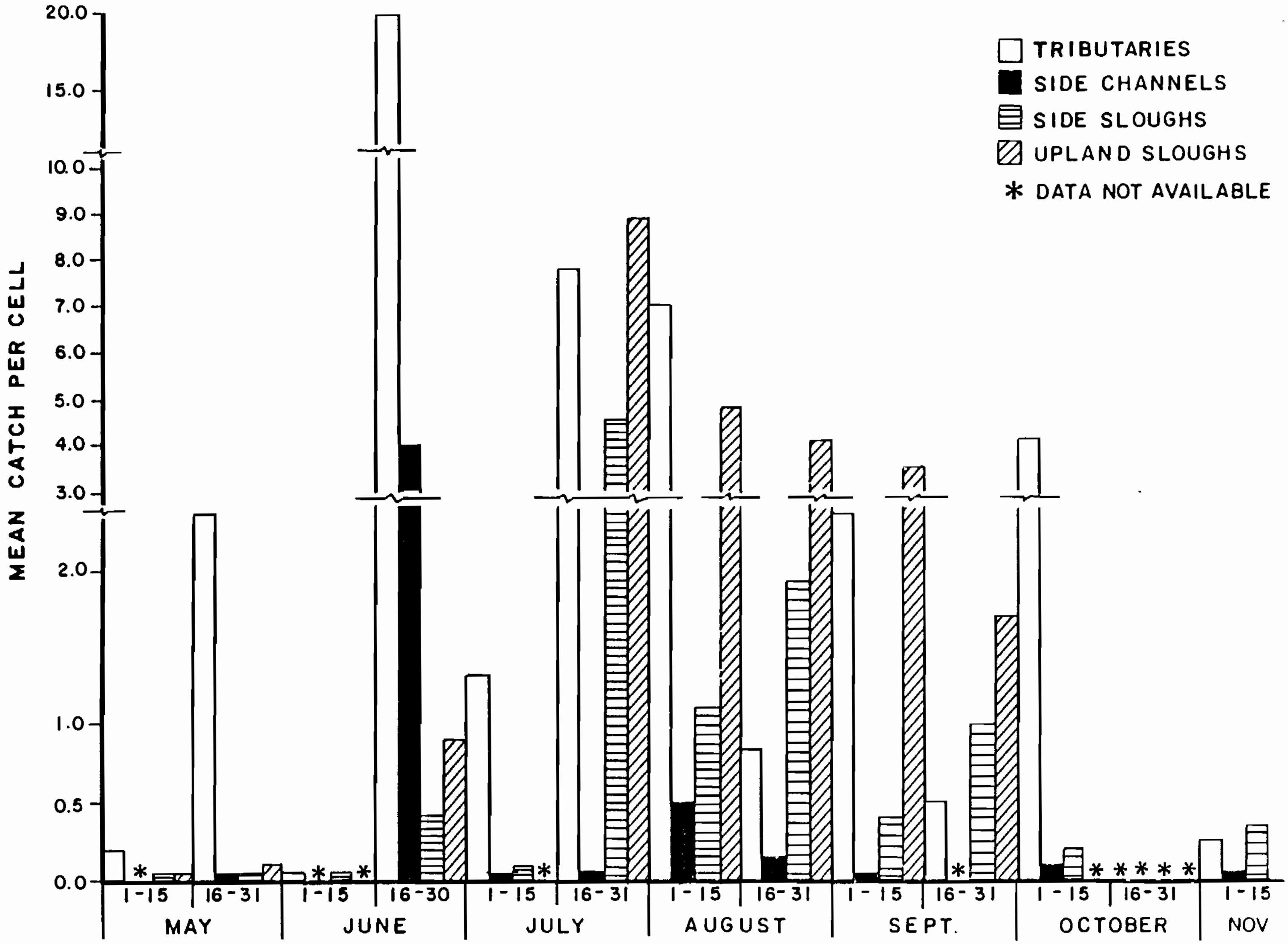


Figure 9. Juvenile coho salmon mean catch per cell at four macrohabitats by sampling period, May through November 1983.

sloughs during late July through late September than in May through early July or in October and November.

The highest densities of coho juvenile salmon were captured at tributaries in late June. Upland slough catch rates were higher from late July through late September than the catch rates for the other macrohabitat types. The highest densities of coho juvenile salmon at upland sloughs occurred in late July and then catch rates gradually declined through late September.

Juvenile coho salmon seasonal changes in densities between side slough and side channel macrohabitats were compared and no correlations in changes in magnitudes of densities were indicated from the data (Figure 10). Side slough densities of coho juvenile salmon were consistently higher than side channels except during late June.

3.4 Distribution of Juvenile Chum Salmon

A total of 1,174 juvenile chum salmon were captured by electrofishing and beach seining at the JAHS sites from early May through July. During this same time period, the downstream migrant trap captured 8,555 juvenile chum salmon. The outmigration of chum salmon from this reach of river by early August is apparent from Figure 11.

The percent of total juvenile chum catch by two week period is presented in Figure 12. Catches at JAHS sites peaked in late May, by which time over 60% of the total catch had occurred. The downstream migrant trap recorded two peaks, one in early June and one in early July.

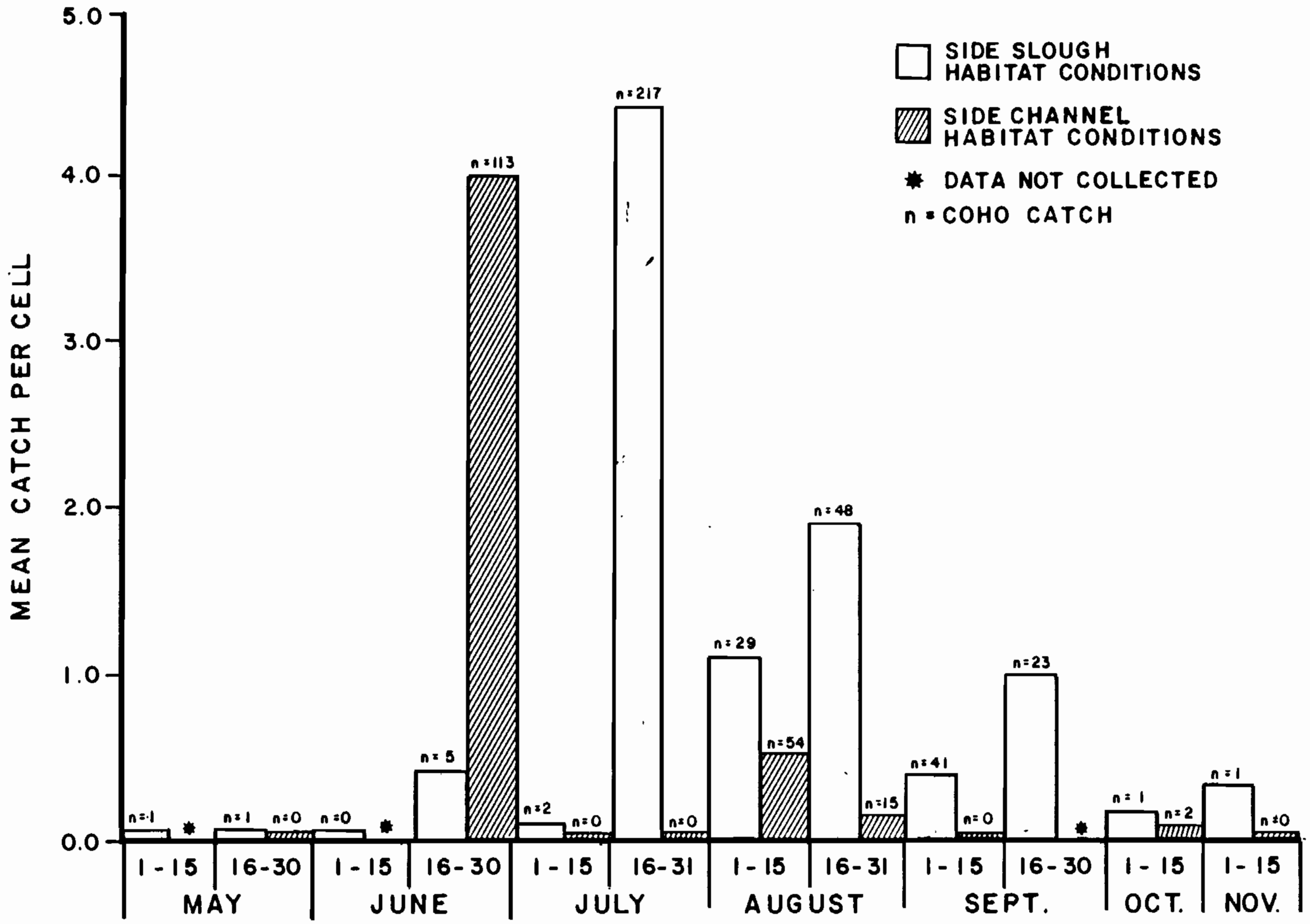


Figure 10. Juvenile coho salmon mean catch per cell at side sloughs and side channels by sampling period, May through November 1983.

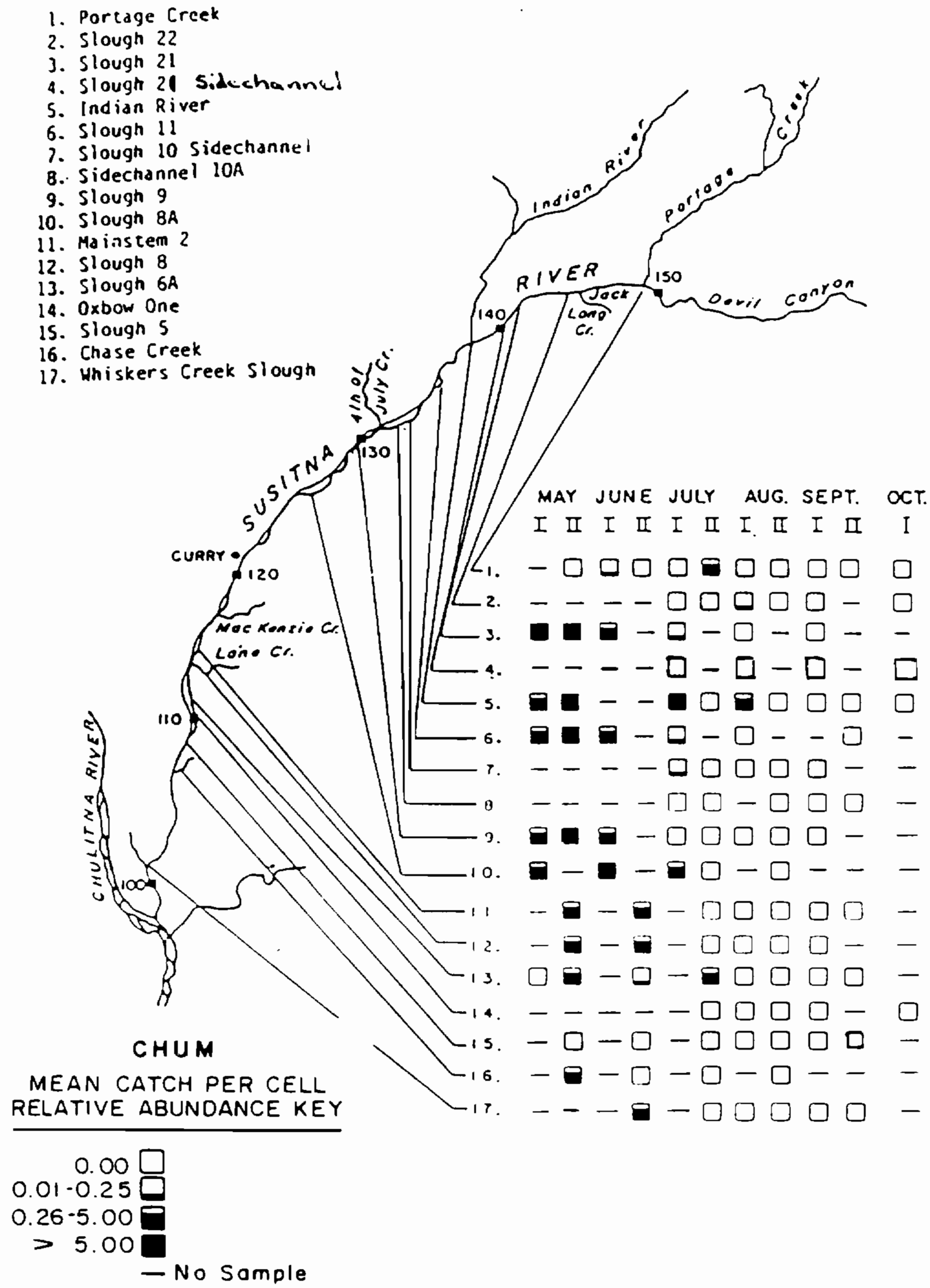


Figure 11. Seasonal distribution and relative abundance of juvenile chum salmon on the Susitna River between the Chulitna River confluence and Devil Canyon, May through November 1983.

Juvenile chum salmon were abundant during May and June at sites having previous year spawning and were absent from the study sites by the end of July. Catch rates were highest in side slough and tributary macrohabitats and extremely low in upland slough and side channel macrohabitats (Figure 13). Only 5% of the total catch was captured in these latter macrohabitats.

The comparative distribution of juvenile chum salmon densities is presented in Figure 14. Juvenile chum salmon were most dense at tributaries and side sloughs. As catches at side sloughs decreased; catches at upland sloughs used for rearing increased.

3.5 Distribution of Juvenile Sockeye Salmon

A total of 1,010 juvenile sockeye salmon were captured by electrofishing and beach seining at the JAHS sites from early May through September. All juvenile sockeye salmon captured at JAHS sites were age 0+. Age 1+ fish were observed at Slough 11 and in the downstream migrant trap, but total numbers were small.

The downstream migrant trap, located at the downstream end of this reach, captured 12,395 juvenile sockeye between May 18 and September 25. Juvenile sockeye salmon were captured at 13 (76%) of the 17 JAHS sites sampled at least four times (Figure 15). They were absent from the study site catches above Slough 8A by early August, while catches were still being made until the end of September at sites below this. The percent of total juvenile sockeye catch by two-week period is presented

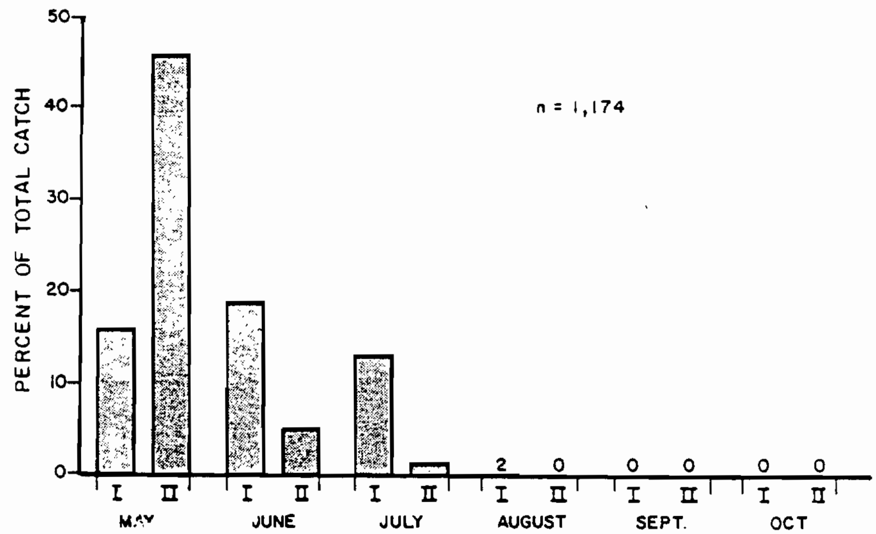


Figure 12. Percentages of the total juvenile chum salmon catch by sampling period, May through October 1983.

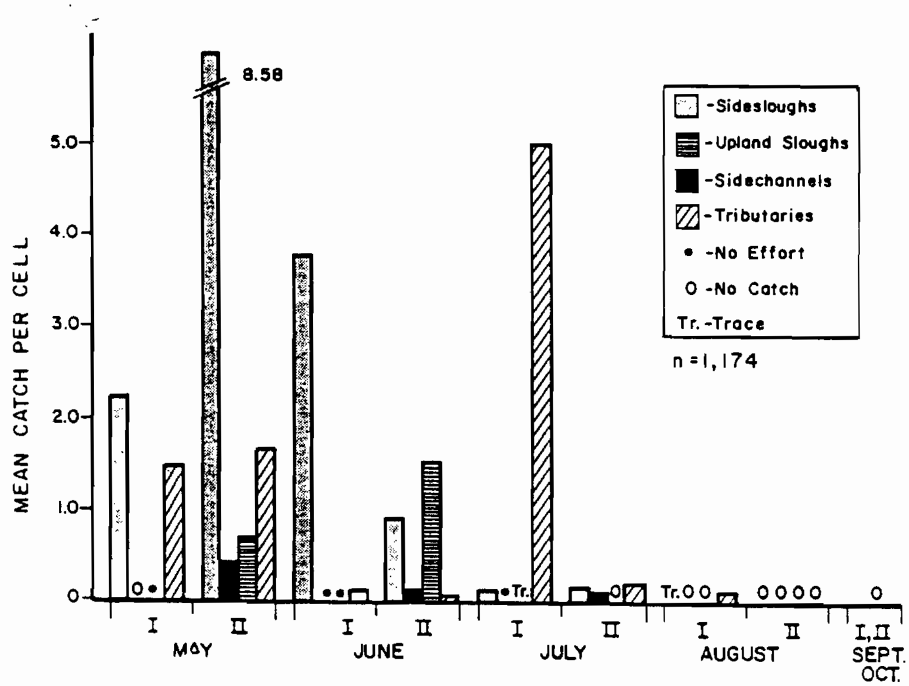


Figure 13. Juvenile chum salmon mean catch per cell at the four macrohabitats by sampling period, May through October 1983.

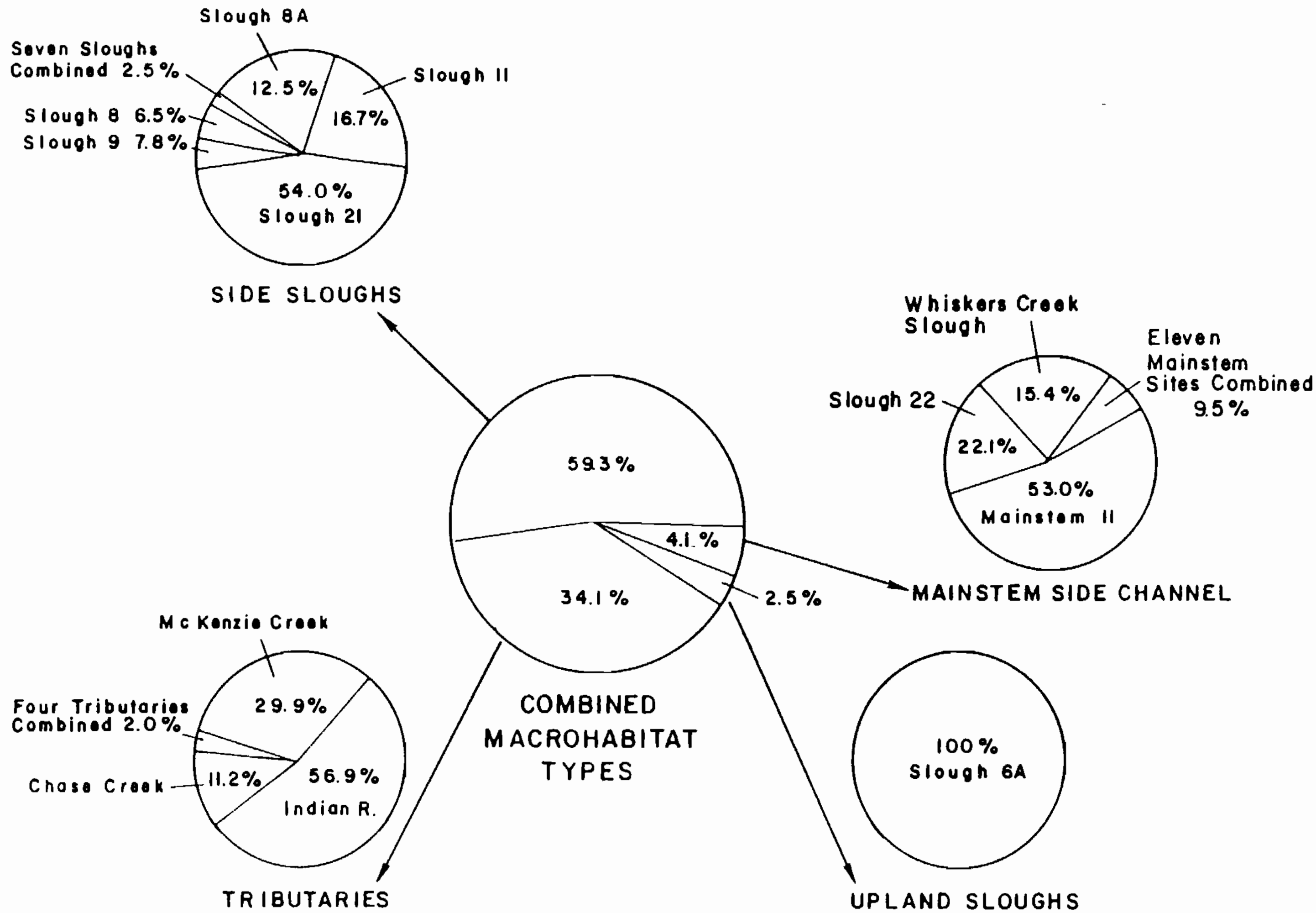


Figure 14. Density distribution of juvenile chum salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devil Canyon, May through October 1983. Percentages are based on mean catch per cell.

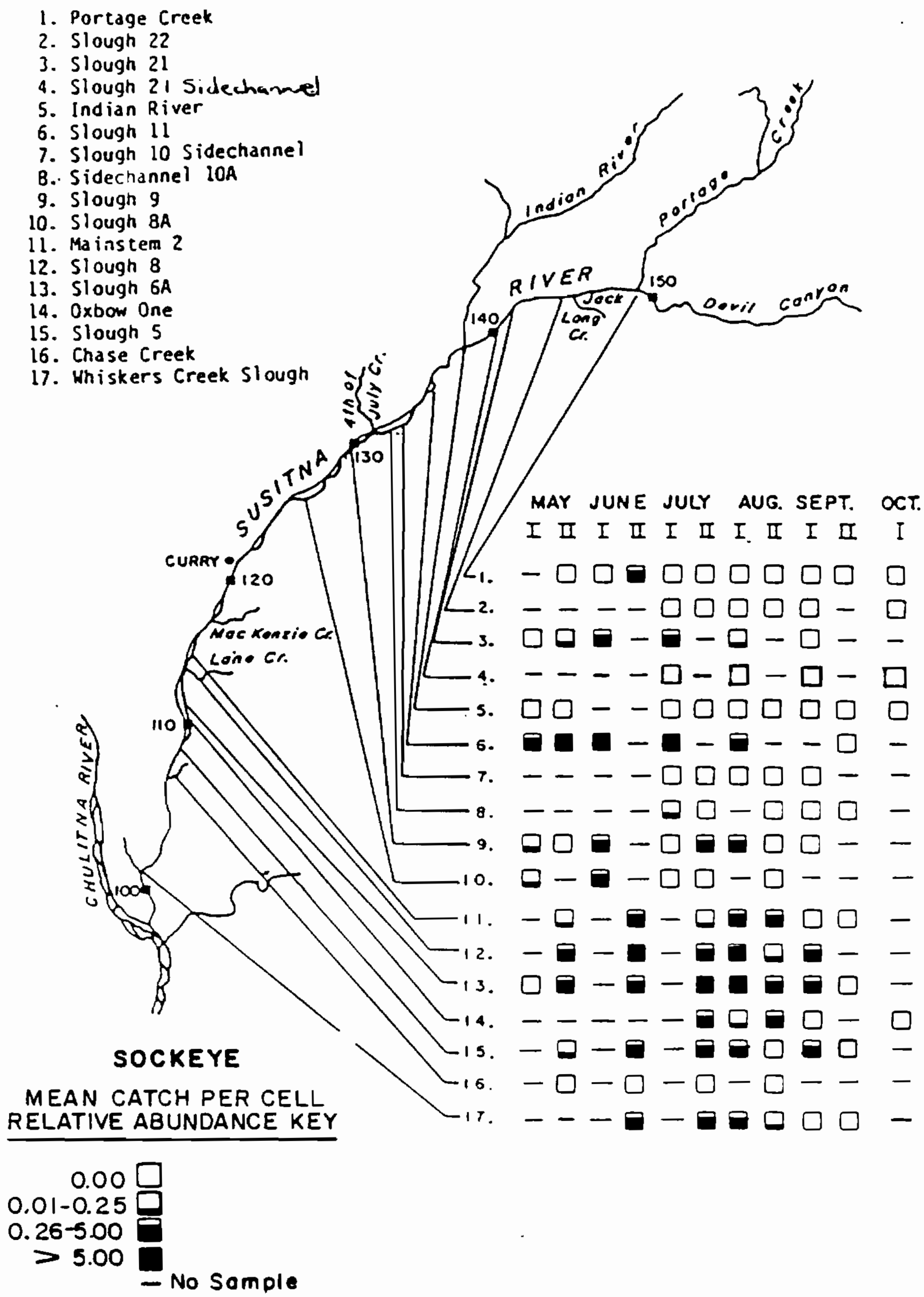


Figure 15. Seasonal distribution and relative abundance of juvenile sockeye salmon on the Susitna River between the Chulitna River confluence and Devil Canyon, May through November 1983.

in Figure 16. Two peaks occurred in the catches, one in late May-early June and one in early August. The major peak at the downstream migrant trap occurred in mid-July.

Catch rates were highest in side sloughs and upland sloughs and lowest in side channels and tributaries (Figure 17). A single catch of four juvenile sockeye occurred in early June in Portage Creek, the sole tributary found to contain juvenile sockeye salmon.

The density distribution of juvenile sockeye salmon is given in Figure 18. Juvenile sockeye salmon were predominantly found at side sloughs and upland sloughs. Virtually all of the sockeye were caught at either upland sloughs or near their natal areas. Slough 11 was the dominant area of spawning which reflects the higher densities observed.

3.6 Analysis of Variance

The mean values of the transformed catch per cell which were compared among the intervals of each parameter are shown for each species in Appendix Table 1. If any one of the means within a parameter is significantly different from any of the other means, then the parameter is considered to significantly explain the varying levels of catch associated with the distribution of that species. The confidence level for this analysis was taken to be 90%.

Both macrohabitat type and sampling period were significantly linked to the distribution of all four species (Table 4). These results lend

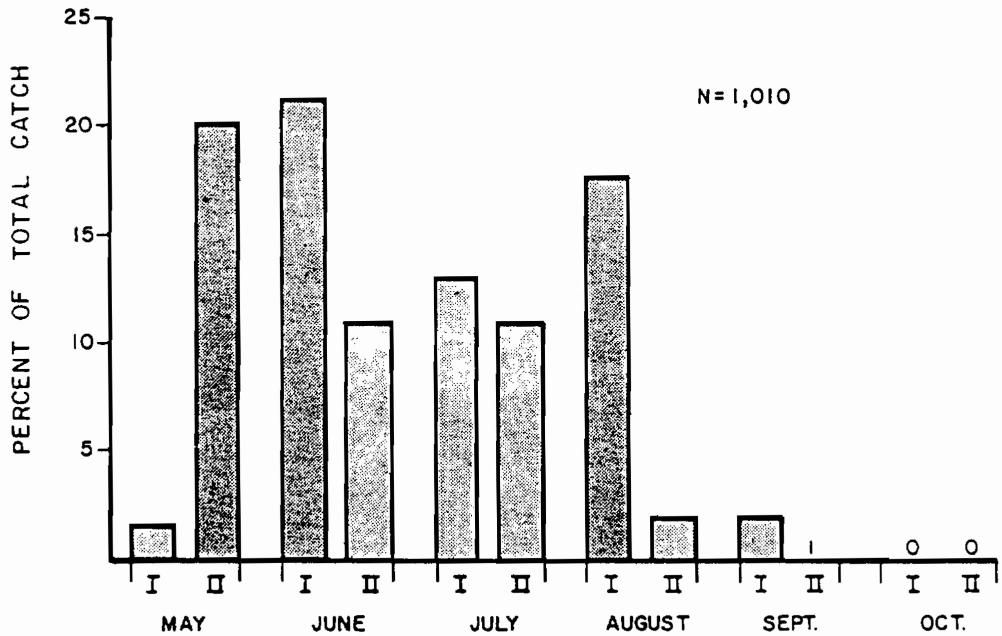


Figure 16. Percentages of the total juvenile sockeye salmon catch by sampling period, May through October 1983.

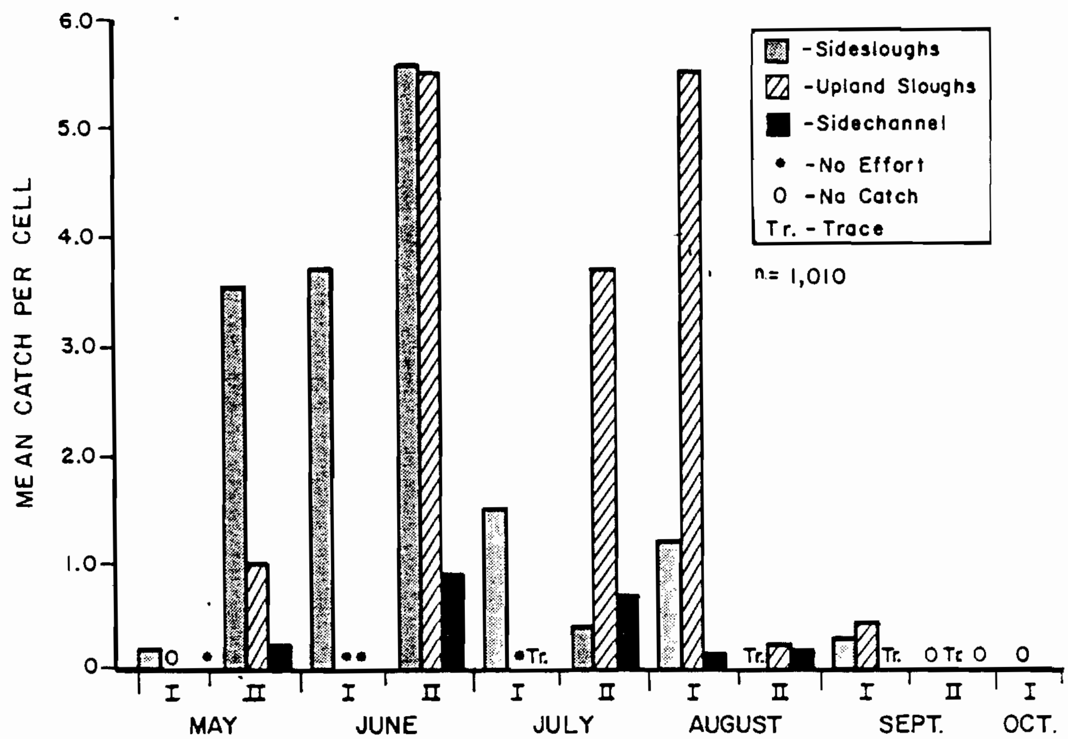


Figure 17. Juvenile sockeye salmon mean catch per cell at three macrohabitats by sampling period, May through October 1983.

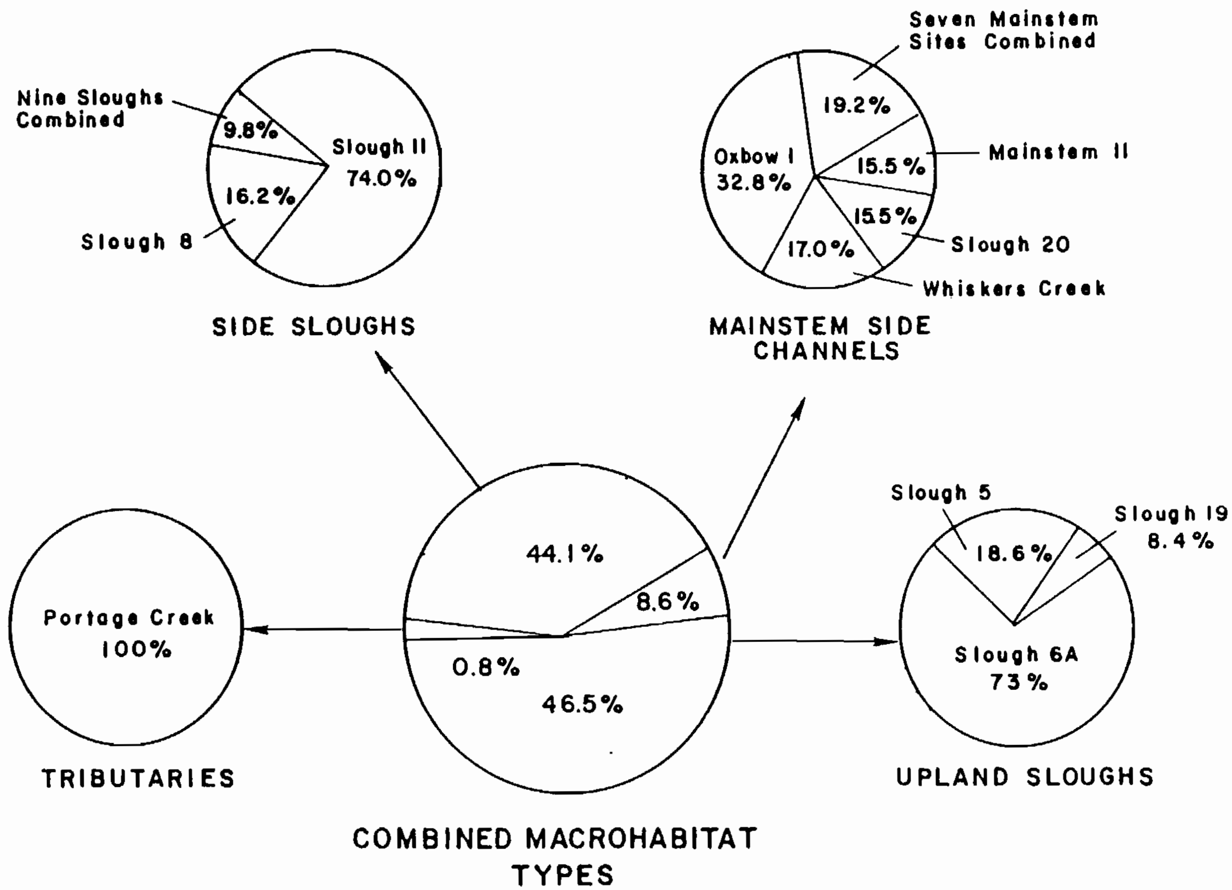


Figure 18. Density distribution of juvenile sockeye salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devil Canyon, May through October 1983. Percentages are based on mean catch per cell.

Table 4. Results of analysis of variance of juvenile salmon catch/cell by selected habitat variables. A parameter is considered to be significant if the probability is less than 0.10. The first two parameters were run together and then the next five parameters were run together. Catch/cell was the response variable in both runs.

	Probabilities for each Species			
Parameter	Chinook	Coho	Chum	Sockeye
Macrohabitat type	0.00	0.00	0.09	0.01
Sampling period	0.00	0.00	0.00	0.01
Mean depth	0.42	0.01	0.53	0.47
Mean velocity	0.01	0.87	0.87	0.05
Mean percent cover	0.24	0.40	0.43	0.51
Water temperature	0.35	0.21	0.37	0.32
Turbidity	0.03	0.02	0.60	0.98

credence to the figures and pie charts presented earlier in this section where the catch per cell for each species is compared among different macrohabitat types and sampling periods. All species show preferences for certain macrohabitat types over others. They also re-distribute themselves seasonally.

Mean catches/cell for chinooks and cohos were significantly different for different levels of turbidity. Mean velocity was significant for chinooks and sockeyes. Mean depth was significant only for coho distribution. No effect of temperature on the distribution of any species during the open water season was discernible from this analysis. Nor was any effect of mean percent cover noted. However, the effect of percent cover is "clouded" by the fact that fish use turbidity as cover. Also, the analysis was weakened for depth, velocity, and percent cover because of the non-randomness of the cells from which the means of these three variables were calculated. The ability to detect significant differences for chum catch/cell was reduced because 99% of the chums have left this study reach by mid-July (see Part 1 of this report).

4.0 DISCUSSION

4.1 Gear Limitations

Minnow traps, beach seines and electrofishing equipment have been used extensively as sampling methods for conducting fisheries surveys (Bennett 1970; Delaney et al. 1981; ADF&G 1981b, 1983c). However, we have determined that minnow traps were selective for juvenile chinook and coho salmon and that beach seining and electrofishing appear to be selective for smaller sized juvenile salmon (ADF&G 1983c). Burger et al. (1982) and Dauble and Gray (1980) have concluded that beach seining and electrofishing, when used in conjunction, provide a reliable index of species diversity, distribution, and relative abundance for juveniles of all salmon species except pinks. Minnow traps were not used in the Juvenile Anadromous Habitat Study (JAHS) in 1983. However, as with any sampling technique, the data collected were affected because of gear bias and limitations. Electrofishing and beach seining methods were sometimes difficult to use in sampling the entire range of the available habitat utilized by juvenile salmon.

Results from the preliminary experiment on the effect of percent cover on electrofishing efficiency indicate that capture efficiency decreases as percent cover increases. This is probably attributable to the difficulty of seeing fish when cover is abundant and also to the increased likelihood of stunned fish not rising to the surface in dense cover.

Although the standard error of the capture probabilities was high, capture probabilities also appeared to be lower in the 0-5% cover category for both sockeye at Slough 11 and coho at Slough 8. When cover is not abundant, the fish are perhaps more likely to flee the cell being sampled.

The lowest capture probabilities for all three species occurred in the 51-75% cover category (the highest percent cover category sampled in this experiment). However, cells with high percent cover were infrequently encountered during the 1983 juvenile salmon sampling. Only 13% of cells sampled at all sites throughout the season had greater than 50% cover. Therefore, the unequal sampling efficiency over cells with different amounts of cover was probably not much of a problem, although it is likely that fish density was probably underestimated in the cells with a high percentage of cover. This experiment should be repeated with a larger number of cells for all species of salmon.

The test conducted of beach seining and electrofishing efficiency at different levels of turbidity indicated that beach seining was more effective in water with a high turbidity and electrofishing was more effective in water with a low turbidity. Beach seining is not as effective in clear water because the fish are often hiding in deadfall, cobble, or other cover where the beach seine can not reach them. Electrofishing is not as effective in water with a high turbidity level because the samplers can not see the shocked fish.

In conclusion, it may be assumed that estimates of fish density, as determined by beach seining or electrofishing catches, are often biased toward an under-estimate. This bias is probably small, however, in comparison to seasonal and macrohabitat type variations in numbers. This contrasts with our minnow trap data of previous years in that minnow traps attract fish to an area.

4.2 Chinook Salmon

The low numbers of age 1+ chinook salmon captured can be attributed to sampling gear bias and to the outmigration of this age class from the study area before July 15. Outmigrant trap data collected during the same time period indicated that a higher number of age 1+ chinook were present in the study area above the Chulitna River and subsequently rearing in the four macrohabitat types than the data from the distribution study indicated. Seven percent of the seasonal catch at the outmigrant trap consisted of age 1+ chinook. Of course, since age 1+ chinook would be most likely to outmigrate, one would expect a higher proportion of age 1+ chinook at an outmigrant sampling location.

Early in the summer, densities (fish per cell) of the two age classes of chinook salmon were considerably higher at tributaries as compared to upland sloughs, side sloughs, and side channels. Tributaries provided the highest concentrations of chinook early in the summer with side channel concentrations increasing in July.

Heavier cover in tributaries and the turbidity in side channels probably reduced gear effectiveness somewhat. The data presented reflect minimal densities at those sites. The effects of gear efficiency were probably not as significant at side sloughs. In general, sites which represented this macrohabitat type such as Slough 22 and Whiskers Creek Slough, consisted of shallow, relatively clear water habitats with low to moderate cover which permitted effective use of electrofishing gear.

Densities of age 0+ chinook salmon were higher at side sloughs from July through November than before July. Lower densities at side sloughs before June were due to the tributary outmigrations which had not yet occurred.

Only one percent of the seasonal catch was collected in upland sloughs. Preference for habitat conditions that optimize rearing and proximity of study sites to natal tributaries were the two major factors which affected distribution. Previous studies conducted by Delaney and Wadman (1979), ADF&G (1983c), and Burger et al. (1983) concluded that the preferred habitat included moderate water velocities and water depths. Low densities of chinook salmon at upland sloughs may have resulted from the avoidance of this habitat type because of their preference for areas with moderate flow. The analysis of variance confirmed this preference. (See also Part 3 of this report which presents suitability criteria curves for each species).

Habitat conditions at side channels were more favorable for chinook salmon juveniles and, consequently, significantly more fish were found rearing in this habitat type. Fish collected from side channels were actively feeding at these sites although they were never directly observed in this activity. Examination of stomach contents conclusively indicated that some feeding was occurring at these sites in spite of the relatively high water turbidity. Turbidity was found by the analysis of variance to be a significant factor affecting distribution. We have observed that chinooks in side slough/side channels such as Slough 22 are widely distributed at the site when the head is overtopped and the water is therefore turbid. When the head is no longer overtopped and the water clears, the fish either move to the available cover such as cobble or leave the site.

Chinook salmon juveniles were distributed in large numbers at tributary sites, because these fish originated in these tributaries and were rearing to attain sufficient size prior to leaving and dispersing into favorable side channel or side slough macrohabitat.

The high densities of chinook juvenile salmon observed at side sloughs in September was a response to changes in side channel conditions. Decreasing side channel water temperatures may have stimulated chinook juveniles to immigrate into side sloughs where conditions were more favorable for over-wintering. Also, as mainstem discharges decreased, some side channels which harbored large numbers of juveniles became side sloughs and fish moved into any available cover or outmigrated. They may have stayed in higher densities than would normally occur when temperatures were higher and there was more competition for available food. Although water temperature was not found by the analysis of variance to be a significant factor in affecting chinook distribution during the open water season, our observations suggest that temperature is a factor during the fall re-distribution.

A comparison of outmigration from the tributaries or out of the lower river may provide some insight as to how catch rates are related to migration. Two peaks in catch rates for chinook juvenile salmon occurred at the four macrohabitat types and the Talkeetna outmigrant trap (Figure 19). The first peak in catch rates was recorded at tributary macrohabitats in early July. Large numbers of age 0+ fish left the natal tributaries to redistribute into the other major macrohabitats (upland sloughs, side sloughs, and side channel). Some of these fish outmigrated from the study area above the Chulitna River. A second peak in catch rates occurred at tributaries and the outmigrant trap in mid August. A substantial number of the juvenile chinook salmon in August apparently moved into mainstem associated areas as catches at these locations peaked in late August. Although overall catch rates declined in September for juvenile chinook in the study area, relatively high densities were recorded at side sloughs at this time. Apparently, fish were immigrating into side sloughs prior to freeze up to overwinter.

Chinook juvenile densities generally declined at all the macrohabitat types surveyed from summer to fall. Similar declines in catch rates were also reported by Riis and Friese (1978) at tributaries and side sloughs. Furthermore, Riis and Fries concluded that juvenile chinook overwinter in side channels as opposed to tributaries or side sloughs. However, the conclusions were based on a very small sample size.

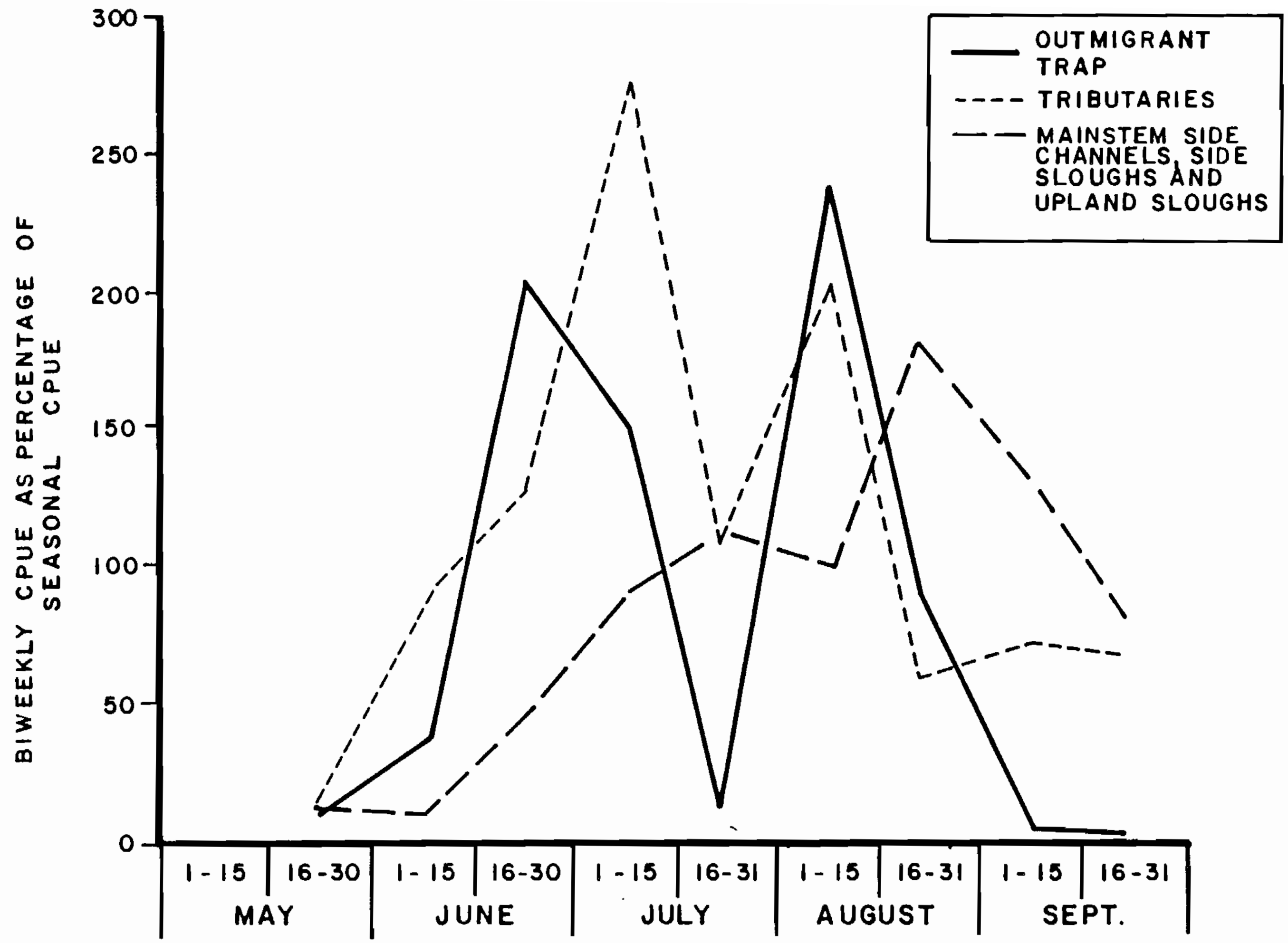


Figure 19 Seasonal deviation of catch per unit effort of juvenile chinook salmon on the Susitna River between the Chulitna River confluence and Devil Canyon, May through September 1983.

Surveys conducted in October and November 1983 of study sites located above the Chulitna River encountered significant numbers of chinook juvenile salmon utilizing tributaries, side sloughs and, to a lesser extent, side channels.

Although exact comparisons cannot be made the relative abundance of the three open water seasons sampled to date because of different gear and effort it is apparent that 1982 was a year of low abundance of chinook juveniles in this reach, relative to 1981 and 1983.

4.3 Coho salmon

Juvenile coho salmon were distributed primarily in tributaries, upland sloughs, and side sloughs associated with the Susitna River above the Chulitna River confluence. The highest densities of juvenile coho were found in natal tributaries such as Chase Creek and Indian River which were documented as spawning areas for adult coho salmon by ADF&G (1983b). Tributaries are only affected by changes in Susitna River mainstem flows at areas located near the mouths of the tributaries (ADF&G 1983c). Consequently, macrohabitat types which are critical rearing areas for juvenile coho salmon and were affected by mainstem flows consisted of upland sloughs and side sloughs. Changes in flows can affect access to and usability of these sloughs and consequently the distribution and abundance of juvenile coho.

Upland sloughs such as Slough 6A (RM 112.3) and Slough 5 (RM 107.6) and side sloughs were generally warmer than mainstem side channels or tributaries. Delaney and Wadman (1979) and Northcote (1969) concluded that warmer water attracted juvenile salmonids. Furthermore, Balchen (1976) argued that fish migration and redistribution was a behavioral response to seek optimal temperatures to maximize "comfort".

Upland sloughs probably enhance the survival of coho juvenile salmon by providing shelter from high discharges common for the Susitna River during the summer months. Skeesick (1970) and Cederholm and Scarlett (1981) concluded that juvenile coho immigration into lateral tributaries and riverine ponds was a behavioral response to high mainstem flows, to assure the viability of individuals under adverse flow conditions, and to escape high flow levels and turbid water.

Side sloughs and upland sloughs are generally clear water to slightly turbid water environments, in contrast to mainstem or side channel water. Their turbidity is not affected by turbid water conditions existing in the mainstream Susitna River, except at backwater zones near the mouths of these macrohabitat types. Juvenile coho apparently immigrate into these macrohabitat types for rearing, because mainstem turbidity levels within the 70-100 NTU range may impair feeding (Alabaster 1972; Bisson and Bilby 1982). The analysis of variance confirmed the preference of juvenile cohos for waters with a lower turbidity level. Furthermore, the high densities of juvenile coho captured at Slough 6A may be a result of high availability of food (invertebrates) present due to organic matter originating from beaver activity.

Surveys of the upper reaches of Portage Creek (RM 148.8) and Indian River (RM 138.6) in 1983 and studies conducted by Delaney and Wadman (1979) found high densities of post emergent fry were synonymous with spawning areas of adult coho salmon. These authors concluded, that age 0+ coho salmon were found to be most numerous in tributaries in close proximity to salmon redds from April through June. Furthermore, the study indicated that juvenile coho move from areas of high emergent fry densities and undertake a general pattern of dispersal.

Significant increases at upland sloughs and, to a lesser degree, at side channels were detected during the same sampling periods when the high densities were recorded for tributary macrohabitats. Notable increases in the number of coho juveniles occurred in late July at Slough 8, Slough 6A and Whiskers Creek Slough. Although Delaney and Wadman (1979) concluded that 60mm was the average length for coho juveniles before indications of outmigration from tributaries and redistribution into suitable habitat, data collected in 1983 indicated that mobility size was considerably less (37mm - 45mm). The smaller size age 0+ coho salmon captured at upland sloughs and side sloughs were fish probably displaced from natal tributaries because of high flow events, intraspecific competition with other juvenile coho and or interspecific competition with juvenile chinook salmon. Small coho juveniles were also captured at the Talkeetna outmigrant trap from late June through July.

The deviations in catch rates of coho juvenile salmon were compared between tributaries, mainstem influenced macrohabitats, and the Talkeetna outmigrant trap (RM 103.0) in Figure 20. Although direct

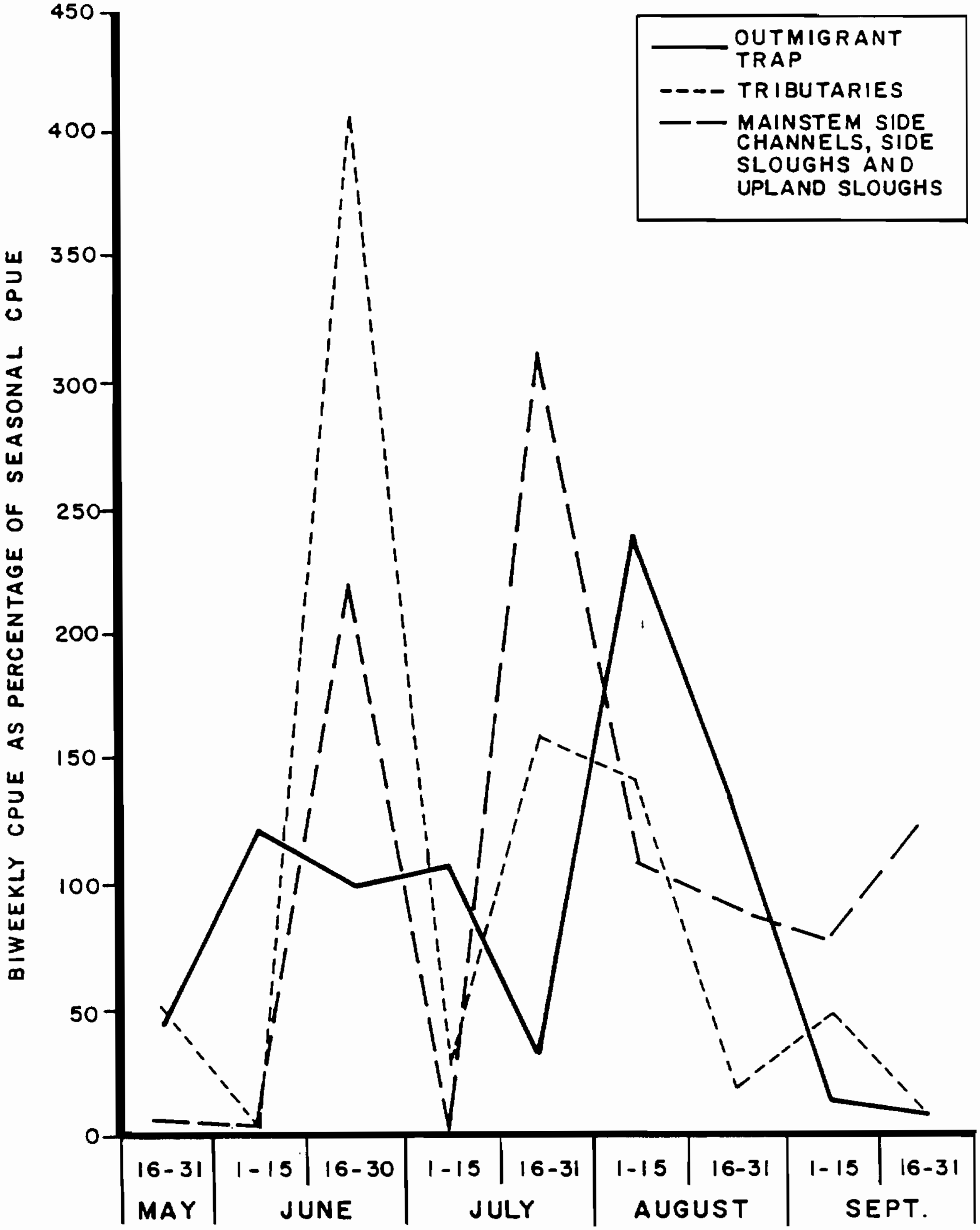


Figure 20. Seasonal deviation of catch per unit effort of juvenile coho salmon on the Susitna River between the Chulitna River confluence and Devil Canyon, May through September 1983.

comparisons of catch rates were impossible, because of the different units used to calculate catch per unit effort (catch/hour, trap; catch/cell, macrohabitat types), computing the deviations of catch rates allows comparisons of seasonal abundance.

The distribution patterns and outmigrant patterns do not provide very clear trends. Catch rates at the sites sampled in both tributaries and adjacent to the mainstem had similar catch rate variations but were not duplicated in the outmigrant catch.

Outmigrant trap catch rates declined sharply after mid August as compared to catch rates at side and upland sloughs during the same time period. This decline at the outmigrant trap may be attributed to redistribution of coho juvenile salmon into suitable rearing macrohabitat at sites above the location of the trap or a decline in the number of age 0+ coho outmigrating from the upper reaches of the Susitna River. The higher rates of catch recorded at habitats adjacent to the mainstem suggest use of these areas for wintering.

Catch rates of coho juveniles generally declined at all macrohabitats sampled from summer to winter in surveys conducted by ADF&G in 1981 and 1982. Similar decreases in catch rates were also reported by Riis and Friese (1978) at tributaries and side sloughs. Furthermore, Riis and Friese concluded that coho juveniles probably over winter in mainstem sidechannels, as opposed to tributaries or side sloughs because of reductions in rearing habitat resulting from lower flows. However, data collected during the 1981 through 1983 studies indicate that substantial winter rearing occurs in side sloughs and upland sloughs.

Studies conducted by Peterson (1980) indicate that upland slough immigrant coho juveniles incur a much lower winter mortality than the typical stream resident. In the winter, juvenile salmon are inactive, and hide in the gravel or deep pools, ensuring that they are not carried out of the system (Thorpe 1981).

4.4 Chum

An accurate record of the true distribution of juvenile chum and sockeye salmon may not be shown by 1983 data due to biases associated with the sampling schedule and techniques. During this and previous studies, beach seining and electrofishing have been the two most effective methods of collecting juvenile chum and sockeye salmon (ADF&G 1981b, 1983c). Beach seining and electrofishing efficiencies are directly correlated to mainstem discharge and turbidity levels at many macrohabitat locations. Burger et al. (1982) found that as the discharge and turbidity of the Kenai River increased, electrofishing efficiency decreased while beach seining efficiency increased. Comparisons of this years data with previous years studies on the Susitna River are also biased. During the 1981 Juvenile Anadromous studies, CPUE's were based mainly on minnow trapping, with only a minimal amount of beach seining effort. Minnow trapping is an extremely ineffective method of capturing juvenile chum and sockeye salmon.

A total of 1,174 juvenile chum salmon were captured in 1983 above the Chulitna River, while 1,104 were captured in the same reach in 1982. All of the sites where chum salmon were collected during 1982 studies which were sampled in 1983 again produced juvenile chums (ADF&G 1983c).

Tributaries and side sloughs accounted for 92% of the total juvenile chum catch in 1983, of which 92% were captured in natal sloughs and tributaries. In 1982, a large school of fish captured at upland slough 6A accounted for 81% of the total catch for all macrohabitat types. This uneven distribution creates biases in results when catch per unit effort data are used.

Upland sloughs were used primarily as rearing areas during 1983. Although this macrohabitat accounted for only 1% of the total catch, visual observations both within and outside the designated study areas confirmed that juvenile chum use upland sloughs for rearing and outmigration resting areas similar to sockeye juveniles.

Side channel and mainstem environments, where affected by high velocity, are not considered preferable rearing areas for juvenile chum salmon. Juvenile chums are captured in the mainstem, but usually only in low velocity, backwater zones near tributary and slough mouths.

Basically, juvenile chum salmon were found in high densities in natal side sloughs and tributaries early in the season (May-early June) and then in upland sloughs and side channels in late June and July. After July, catches and observations of juvenile chums at any of the macrohabitats were extremely rare. Chum salmon catches at the downstream migrant traps also plummeted after mid-July, indicating that the bulk of the outmigration had taken place (see Part 1 of this report).

Figure 13 illustrates the possibility of two distinct outmigrating juvenile chum populations; one from the natal sloughs in late May and one from the tributaries in early July. This corresponds with peak catches at the downstream migrant traps approximately one week after each. Although the tributary chums generally spawn earlier than the slough populations (ADF&G 1983b), the much colder intergravel temperatures found in the tributaries could account for a delayed emergence and outmigration.

Juvenile chums have been found to prefer the shallower, flowing waters of side sloughs and upland sloughs, as opposed to the no-flow, deeper pools preferred by juvenile sockeye. Juvenile chum salmon were more widely distributed than sockeye juveniles during 1983, the reason being that chum salmon spawn in more sloughs then sockeyes. This was also true in 1982 (ADF&G 1983b).

Although tributaries are not affected by mainstem flow, except at the confluence, higher mainstem flows usually occurred at times of higher tributary flows. Higher tributary flows acted as a flushing device, with fewer fish being present in natal areas and more fish being present at rearing and outmigrating areas after the high flows.

The first major peak of mainstem discharge in May coincided with the highest juvenile chum catch rates. By the time the peak mainstem discharge occurred in early June, the majority (62%) of the total juvenile chum catch had already occurred. Juvenile chum salmon from natal sloughs tend to take advantage of the first major rise in mainstem discharge and start outmigrating. This was also true in 1982 when the last juvenile chum was observed by mid July (ADF&G 1983c). The exact reason is not known, but is probably a combination of genetic behavior, increased cover (turbidity), increased water temperatures and the higher flows. Few juvenile chum were captured at tributary sites until early July, after the peak spring discharge in the mainstem. Similarly, few chum juvenile were captured (using the same methods) until late June in 1982, well before the peak mainstem discharge.

4.5 Sockeye Salmon

Gear bias also affected the catch data for sockeye salmon. Beach seining on the Kenai River, in areas where no sockeye juveniles were captured in minnow traps, proved that sockeyes were present (Burger et al. 1982). The 1983 catches by location can be loosely compared with 1982 data, as beach seining was the main method used in 1982. Juvenile sockeye salmon have been found to school in the clear waters of some of the side sloughs. Often schools were observed just prior to sampling, but unavoidable disturbances caused the fish to move out of the sampling grid and few, if any, would be captured. The data do not reflect this presence, but noncapture of fish. Sockeye juveniles were also observed to use the deeper pools and interstitial spaces in the larger substrate.

Due to their depth, many of the deeper pools were inaccessible to effective sampling. Fish using the substrate as cover might remain within the substrate during electrofishing and beach seining passes and, once again, the data would not reflect this presence.

A total of 1010 juvenile sockeye salmon were captured in 1983 above the Chulitna River, while 1324 were captured in the same reach in 1982. Distribution within this reach was similar both years, with 57% and 66% of the total catch occurring above RM 125.0 during 1983 and 1982, respectively. All of the sites where sockeyes were collected during 1982 sampling, which were sampled in 1983, again produced juvenile sockeye (ADF&G 1983c).

Side sloughs accounted for 71% of the total juvenile sockeye catch in 1983, of which 65% were captured in natal sloughs. Side sloughs only accounted for 31% of the total catch during 1982. The major reason for this lower number during 1982 is the large number of fish captured at Slough 6A, (62% of the total catch for all habitat types). These differences are probably a result of collection methodology rather than any major difference in distribution between years.

Upland sloughs were used primarily as rearing areas during 1983. They accounted for 20% of the total catch in 1983, with the majority occurring late in the summer (July-August). A distinct redistribution of sockeye juveniles from side slough natal areas to upland slough rearing areas at this time can be seen in Figure 18. Slough 6A, the major upland slough used by outmigrating and/or rearing sockeye juveniles, accounted for 86% of the total upland slough catch. Juveniles sockeyes are generally considered a lake rearing species, but slough populations are not uncommon (Foerster 1968, McCart et al. 1980). With the exception of the unique habitat at Slough 6A, including low velocity, clear water, depth and abundant cover and aquatic vegetation, all other major concentrations of juvenile sockeye salmon were found at natal side sloughs.

Slough 5, an upland slough with shallow depths and low gradient banks, did not have large numbers of sockeye. This slough was broadly covered with emergent vegetation. Thousands of threespine sticklebacks were observed and, as young sockeye use many of the same foods as threespine sticklebacks, competition may force the juvenile sockeyes out of this habitat (Morrow 1980).

Side channel and mainstem environments, where affected by high velocity, are not considered preferable rearing areas for juvenile sockeye. It is only when a backwater area is associated with this habitat type that they are used to any degree. Mainstem 2 and Oxbow I are both side-channels that were breached during much of the 1983 season and both had these backwater zones. Sockeye juveniles were captured at both of these two sites. The preference of sockeye juveniles for low velocity water was also clearly demonstrated by the analysis of variance.

Tributary spawning by sockeye salmon is extremely rare in the Chulitna confluence to Devil Canyon reach. During the past three years, a total of six adult sockeyes have been observed in the tributaries, four of them in Portage Creek during 1982 (ADF&G 1981a, 1983b; Barrett et al. 1984). Few juveniles have been captured in tributaries during the past three years due to this lack of tributary spawning (ADF&G 1983c). Basically, juvenile sockeye salmon were once again found to heavily use side and upland sloughs for rearing and migrating areas and only small portions of the mainstem Susitna River.

Two of the major natal areas of sockeye salmon were directly affected by mainstem discharges (head breaching) in 1983, Sloughs 9 and 21. Slough 11, the major sockeye spawning area in the upper Susitna River is only breached by very high flows, the last time in 1981 (ADF&G 1981c). Small changes occur at the mouths of side sloughs which are not breached, with increases in depth, turbidity, pool sizes and cover occurring at higher flows. Sockeyes have been found to prefer lower velocities and greater depths than the other juvenile salmon species. (See Part 3 of this report).

As mainstem discharges increase in May and June, catch rates also increased (Figure 16). The peak catch rate in the primary natal sloughs occurred in early June when the discharge was at its seasonal peak of 34,000 cfs. Sockeye juveniles may use the cover of the increased turbidity of the breached slough which is now a side channel to outmigrate. The increased depths, turbidity, and velocity may also act as a flushing mechanism to these small fish. Whatever the reason, lower catch rates in natal sloughs after head breaching does reflect a definite outmigration.

Intraspecific competition and genetic response to increased mainstem flows could initiate outmigration. The highest catch/hour of sockeye juveniles at the downstream migrant trap occurred in early July, corresponding to the highest catches at natal sloughs before July and at outmigrating and rearing sites during and after July.

Besides the hypothesis of genetically controlled outmigration, stressed in the 1982 report, the 1983 data suggest that other environmental factors may also stimulate outmigration. Mainstem flows, slough flows, turbidity, and temperature are four of the major factors that may influence outmigration timing.

Observations at sites during this study and downstream migrant catch data indicate that some overwintering in this reach by juvenile sockeye salmon does occur. Age 1+ sockeye were captured and observed in Slough 11 during 1981, 1982 and 1983. The downstream migrant trap juvenile sockeye catches included 1.1 and 0.7 percent catches of Age 1+ fish in 1982 and 1983, respectively. During the past three years of study, Age 1+ sockeyes have been observed at Slough 9, Slough 11 and Slough 6A (ADF&G 1981b, 1983c).

The capture at non-natal sites of juvenile sockeyes during August and September that were coded wire tagged in early June indicates that complete outmigration does not occur by this time and that overwintering in sloughs 6A and 11 and presumably other sites does occur.

Sockeye 0+ fry have been observed to remain in the shallower waters near shore both in rearing areas and while out migrating early in the summer. As they grow, they start using the deeper waters. Age 1+ fish, if they follow the same pattern, may be using the deepest waters of the macro-habitats for both rearing and outmigrating and therefore would not be susceptible to our sampling methods or to the downstream migrant trap.

5.0 CONTRIBUTORS

Field work for the project was conducted by Larry Dugan, Paul Suchanek, Bob Marshall, and Dave Sterritt.

Dana Schmidt and Steve Hale assisted with the study design and analysis.

The data base was keypunched by Donna Buchholz and managed by Allen Bingham, Gail Heineman, and Alice Freeman.

The analysis of variance section was prepared by Allen Bingham and Steve Hale. Steve Hale and Paul Suchanek wrote the section on analysis of gear efficiency.

Sally Donovan and Carol Kerkvliet drafted the figures and the typing was done by Skeers Word Processing.

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Appendix Table 1. Summary statistics for transformed catch/cell data of each species, by groups for each habitat parameter.

PAGE 13 BMDP1D STATISTICS OF GROUPED JAHS DATA (RJ8301) - BY HABITAT VARIABLES

VARIABLE NO. NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
15 LCHIN			133	1.112	.905	.0785	.81361	0.000	-1.23	3.965	3.15	3.965
	MACNUM	UPSLOUGH	24	.624	.584	.1192	.93668	0.000	-1.07	2.079	2.49	2.079
		SISLOUGH	42	.744	.703	.1084	.94480	0.000	-1.06	2.140	1.99	2.140
		SICHANNE	39	1.233	.634	.1016	.51431	0.000	-1.94	2.845	2.54	2.845
		TRIBUTAR	28	1.914	1.133	.2141	.59183	0.000	-1.69	3.965	1.81	3.965
	PERIOD	LMAY	15	.334	.496	.1280	1.48690	0.000	-.67	1.609	2.57	1.609
		EJUN	6	.516	.868	.3542	1.68174	0.000	-.59	2.230	1.96	2.230
		LJUN	10	.618	.610	.1929	.98733	0.000	-1.01	1.504	1.45	1.504
		EJUL	16	1.629	1.347	.3367	.82651	0.000	-1.21	3.965	1.73	3.965
		LJUL	19	1.246	.852	.1955	.68397	0.000	-1.46	2.868	1.90	2.868
		EAUG	18	1.128	.907	.2137	.80364	0.000	-1.24	3.186	2.27	3.186
		LAUG	20	1.274	.829	.1853	.65014	0.000	-1.54	2.845	1.90	2.845
		ESEP	20	1.343	.570	.1274	.42410	.531	-1.43	2.230	1.56	1.699
		LSEP	9	1.248	.707	.2356	.56622	.262	-1.39	2.542	1.83	2.279
	MEANDEP	0.1-0.6	52	1.214	1.018	.1412	.83878	0.000	-1.19	3.965	2.70	3.965
		0.7-0.9	46	1.188	.883	.1302	.74350	0.000	-1.34	3.640	2.78	3.640
		1.0-1.2	17	.779	.763	.1850	.97957	0.000	-1.02	2.845	2.71	2.845
		1.3-1.5	9	.887	.848	.2828	.95620	0.000	-1.05	2.701	2.14	2.701
		1.6+	9	.993	.472	.1572	.47489	0.000	-2.11	1.649	1.39	1.649
	MEANCOV	0-5%	71	1.100	.796	.0944	.72306	0.000	-1.38	3.186	2.62	3.186
		6-25%	53	1.255	1.042	.1431	.82986	0.000	-1.21	3.965	2.60	3.965
		26-100%	9	.364	.389	.1298	1.07142	0.000	-.93	1.099	1.89	1.099
	MEANVEL	0.0-0.5	103	.995	.860	.0848	.86494	0.000	-1.16	3.965	3.45	3.965
		0.6+	30	1.515	.952	.1738	.62821	0.000	-1.59	3.487	2.07	3.487
	SWATTEMP	0.0-5.0	13	1.283	.751	.2082	.58499	0.000	-1.71	2.542	1.68	2.542
		5.1-10.0	63	1.247	1.061	.1336	.85061	0.000	-1.18	3.965	2.56	3.965
		10.1+	56	.925	.714	.0954	.77173	0.000	-1.30	3.640	3.80	3.640
	TURB	0-10	85	.987	.938	.1017	.94969	0.000	-1.05	3.640	2.83	3.640
		>10-50	16	1.207	.744	.1859	.61589	0.000	-1.62	2.701	2.01	2.701
		>50-100	6	1.208	.537	.2190	.44430	.470	-1.37	1.841	1.18	1.371
		>100-200	11	1.664	.629	.1696	.37785	.993	-1.07	2.845	1.88	1.852
		200+	10	.857	.361	.1142	.42149	.262	-1.65	1.308	1.25	1.046

Appendix Table 1 (cont.). Summary statistics for transformed catch/cell data of each species, by groups for each habitat parameter.

PAGE 14 BMDP1D STATISTICS OF GROUPED JAHS DATA (RJ8301) - BY HABITAT VARIABLES

VARIABLE NO. NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
16 LSOCK			133	.300	.621	.0538	2.06598	0.000	-.48	3.246	4.75	3.246
	MACNUP	UPSLOUGH	24	.456	.694	.1417	1.52396	0.000	-.66	2.557	3.03	2.557
		SISLOUGH	42	.452	.819	.1263	1.81076	0.000	-.55	3.246	3.41	3.246
		SICHANNE	39	.245	.463	.0742	1.88967	0.000	-.53	2.197	4.21	2.197
		TRIBUTAR	28	.017	.089	.0168	5.29150	0.000	-.19	.470	5.10	.470
	PERIOD	LMAY	15	.297	.683	.1763	2.30000	0.000	-.43	2.632	3.42	2.632
		EJUN	6	.875	1.201	.4901	1.37235	0.000	-.73	3.246	1.98	3.246
		LJUN	10	.661	.773	.2444	1.16947	0.000	-.86	2.282	2.10	2.282
		EJUL	16	.234	.592	.1480	2.53521	0.000	-.39	2.361	3.59	2.361
		LJUL	19	.397	.653	.1497	1.64390	0.000	-.61	1.960	2.40	1.960
		EAUG	18	.476	.783	.1844	1.64385	0.000	-.61	2.557	2.66	2.557
		LAUG	20	.076	.139	.0312	1.82463	0.000	-.55	.336	1.87	.336
		ESEP	20	.109	.276	.0617	2.54142	0.000	-.39	1.163	3.82	1.163
		LSEP	9	.011	.032	.0106	3.00000	0.000	-.33	.095	2.67	.095
	MEANDEP	0.1-0.6	52	.279	.685	.0950	2.45872	0.000	-.41	3.246	4.33	3.246
		0.7-0.9	46	.175	.380	.0561	2.17911	0.000	-.46	2.197	5.32	2.197
		1.0-1.2	17	.356	.553	.1342	1.55408	0.000	-.64	1.629	2.30	1.629
		1.3-1.5	9	.639	.802	.2675	1.25624	0.000	-.80	2.282	2.05	2.282
		1.6+	9	.627	.973	.3244	1.55257	0.000	-.64	2.557	1.98	2.557
	MEANCOV	0-5%	71	.240	.524	.0622	2.18115	0.000	-.46	2.632	4.57	2.632
		6-25%	53	.373	.738	.1013	1.97905	0.000	-.51	3.246	3.90	3.246
		26-100%	9	.350	.591	.1970	1.68730	0.000	-.59	1.609	2.13	1.609
	MEANVEL	0.0-0.5	103	.376	.684	.0674	1.82012	0.000	-.55	3.246	4.20	3.246
		0.6+	30	.042	.136	.0247	3.25665	0.000	-.31	.588	4.03	.588
	SWATTEMP	0.0-5.0	13	.007	.026	.0073	3.60555	0.000	-.28	.095	3.33	.095
		5.1-10.0	63	.359	.748	.0943	2.08359	0.000	-.48	3.246	3.86	3.246
		10.1+	56	.308	.517	.0691	1.67991	0.000	-.60	2.197	3.65	2.197
	TURB	0-10	85	.303	.664	.0720	2.18942	0.000	-.46	3.246	4.43	3.246
		>10-50	16	.353	.678	.1695	1.92212	0.000	-.52	2.557	3.25	2.557
		>50-100	6	.419	.363	.1481	.86600	0.000	-1.15	1.099	1.87	1.099
		>100-200	11	.431	.709	.2138	1.64459	0.000	-.61	1.960	2.16	1.960
		200+	10	.086	.141	.0444	1.63690	0.000	-.61	.405	2.27	.405

Appendix Table 1 (cont.). Summary statistics for transformed catch/cell data of each species, by groups for each habitat parameter.

15 BMDP1D STATISTICS OF GROUPED JAHS DATA (RJ8301) - BY HABITAT VARIABLES

TABLE NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
LCOHO			133	.587	.899	.0780	1.53114	0.000	-.65	3.421	3.15	3.421
	MACNUM	UPSLOUGH	24	1.161	.944	.1926	.81247	0.000	-1.23	3.258	2.22	3.258
		SISLOUGH	42	.361	.715	.1103	1.98163	0.000	-.50	2.845	3.48	2.845
		SICHANNE	39	.199	.566	.0906	2.84859	0.000	-.35	2.380	3.85	2.380
		TRIBUTAR	28	.976	1.105	.2088	1.13132	0.000	-.88	3.421	2.21	3.421
	PERIOD	LMAY	15	.244	.591	.1526	2.41938	0.000	-.41	1.758	2.56	1.758
		EJUN	6	0.000	0.000	0.0000	0.00000	0.000	0.00	0.000	0.00	0.000
		LJUN	10	1.256	1.294	.4092	1.03025	0.000	-.97	3.421	1.67	3.421
		EJUL	16	.127	.368	.0921	2.90231	0.000	-.34	1.482	3.68	1.482
		LJUL	19	1.037	1.310	.3005	1.26296	0.000	-.79	3.258	1.70	3.258
		EAUG	18	.756	.965	.2276	1.27631	0.000	-.78	2.398	1.70	2.398
		LAUG	20	.564	.675	.1509	1.19666	0.000	-.84	1.988	2.11	1.988
		ESEP	20	.469	.707	.1581	1.50582	0.000	-.66	2.175	2.41	2.175
		LSEP	9	.652	.661	.2202	1.01305	0.000	-.99	1.792	1.72	1.792
	MEANDEP	0.1-0.6	52	.380	.712	.0988	1.87315	0.000	-.53	2.845	3.46	2.845
		0.7-0.9	46	.535	.924	.1363	1.72801	0.000	-.58	3.266	2.96	3.266
		1.0-1.2	17	.891	1.120	.2716	1.25738	0.000	-.80	3.421	2.26	3.421
		1.3-1.5	9	.633	.710	.2365	1.12067	0.000	-.89	1.758	1.58	1.758
		1.6+	9	1.433	.998	.3325	.69625	0.000	-1.44	2.667	1.24	2.667
	MEANCOV	0-5%	71	.406	.784	.0931	1.93026	0.000	-.52	3.256	3.64	3.258
		6-25%	53	.777	1.037	.1424	1.33379	0.000	-.75	3.421	2.55	3.421
		26-100%	9	.897	.581	.1938	.64827	.162	-1.23	1.988	1.88	1.806
	MEANVEL	0.0-0.5	103	.649	.961	.0947	1.48178	0.000	-.67	3.421	2.88	3.421
		0.6+	30	.376	.609	.1112	1.61840	0.000	-.62	1.792	2.32	1.792
	SWATTEMP	0.0-5.0	13	.558	.658	.1624	1.17850	0.000	-.85	1.792	1.88	1.792
		5.1-10.0	63	.534	.858	.1081	1.60542	0.000	-.62	3.258	3.18	3.258
		10.1+	56	.662	1.002	.1339	1.51200	0.000	-.66	3.421	2.75	3.421
	TURB	0-10	85	.764	.979	.1062	1.28176	0.000	-.78	3.421	2.71	3.421
		>10-50	16	.450	.809	.2024	1.79741	0.000	-.56	2.313	2.30	2.313
		>50-100	6	.244	.314	.1281	1.28808	0.000	-.78	.788	1.74	.788
		>100-200	11	.288	.798	.2407	2.77239	0.000	-.36	2.667	2.98	2.667
		200+	10	0.000	0.000	0.0000	0.00000	0.000	0.00	0.000	0.00	0.000

Appendix Table 1 (cont.). Summary statistics for transformed catch/cell data of each species, by groups for each habitat parameter.

PAGE 16 BMDP1D STATISTICS OF GROUPED JAHS DATA (RJ6301) - BY HABITAT VARIABLES

VARIABLE NO. NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
19 LCHUM			133	.246	.586	.0510	2.39483	0.000	-.42	2.856	4.44	2.856
	MACNUM	UPSLOUGH	24	.035	.101	.0207	2.86181	0.000	-.35	.405	3.65	.405
		SISLOUGH	42	.467	.806	.1244	1.72529	0.000	-.58	2.856	2.96	2.856
		SICHANNE	39	.102	.287	.0460	2.82787	0.000	-.35	1.435	4.64	1.435
		TRIBUTAR	28	.294	.658	.1243	2.23501	0.000	-.45	2.715	3.68	2.715
	PERIOD	LMAY	15	1.029	1.014	.2618	.98556	0.000	-1.01	2.856	1.80	2.856
		EJUN	6	1.130	.757	.3089	.66933	.095	-1.37	2.001	1.15	1.906
		LJUN	10	.448	.494	.1563	1.10252	0.000	-.91	1.435	2.00	1.435
		EJUL	16	.248	.673	.1682	2.70800	0.000	-.37	2.715	3.66	2.715
		LJUL	19	.087	.201	.0462	2.31837	0.000	-.43	.788	3.49	.788
		EAUG	18	.020	.065	.0152	3.24798	0.000	-.31	.262	3.76	.262
		LAUG	20	0.000	0.000	0.0000	0.00000	0.000	0.00	0.000	0.00	0.000
		ESEP	20	0.000	0.000	0.0000	0.00000	0.000	0.00	0.000	0.00	0.000
		LSEP	9	0.000	0.000	0.0000	0.00000	0.000	0.00	0.000	0.00	0.000
	MEANDEP	0.1-0.6	52	.399	.774	.1073	1.93835	0.000	-.52	2.856	3.17	2.856
		0.7-0.9	46	.125	.400	.0590	3.20910	0.000	-.31	2.001	4.69	2.001
		1.0-1.2	17	.194	.510	.1237	2.63547	0.000	-.38	2.001	3.54	2.001
		1.3-1.5	9	.272	.420	.1398	1.54322	0.000	-.65	1.030	1.81	1.030
		1.6+	9	.049	.100	.0334	2.02522	0.000	-.49	.262	2.13	.262
	MEANCOV	0-5%	71	.217	.520	.0617	2.40068	0.000	-.42	2.603	4.59	2.603
		6-25%	53	.327	.705	.0966	2.15894	0.000	-.46	2.856	3.59	2.856
		26-100%	9	0.000	0.000	0.0000	0.00000	0.000	0.00	0.000	0.00	0.000
	MEANVEL	0.0-0.5	103	.254	.588	.0579	2.31058	0.000	-.43	2.856	4.43	2.856
		0.6+	30	.216	.600	.1096	2.77718	0.000	-.36	2.715	4.16	2.715
	SWATTEMP	0.0-5.0	13	.154	.555	.1540	3.60555	0.000	-.28	2.001	3.33	2.001
		5.1-10.0	63	.373	.755	.0951	2.02046	0.000	-.49	2.856	3.29	2.856
		10.1+	56	.128	.294	.0392	2.29794	0.000	-.44	1.435	4.45	1.435
	TURB	0-10	85	.338	.696	.0755	2.06024	0.000	-.49	2.856	3.62	2.856
		>10-50	16	.143	.365	.0913	2.55629	0.000	-.39	1.435	3.54	1.435
		>50-100	6	.159	.390	.1593	2.44949	0.000	-.41	.956	2.04	.956
		>100-200	11	.049	.092	.0277	1.87422	0.000	-.53	.262	2.32	.262
		200+	10	.010	.030	.0095	3.16228	0.000	-.32	.095	2.85	.095