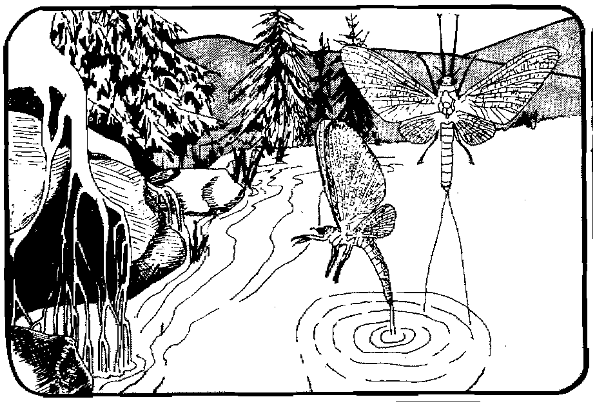
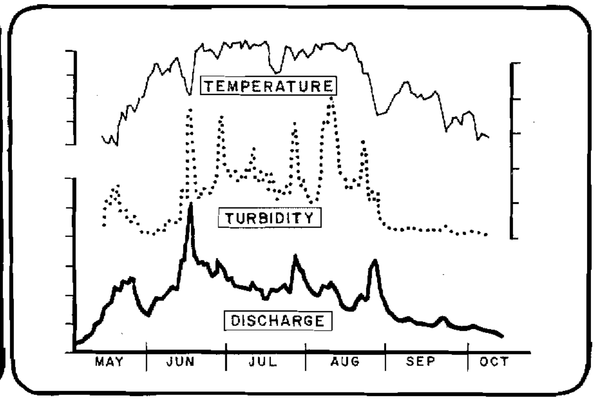
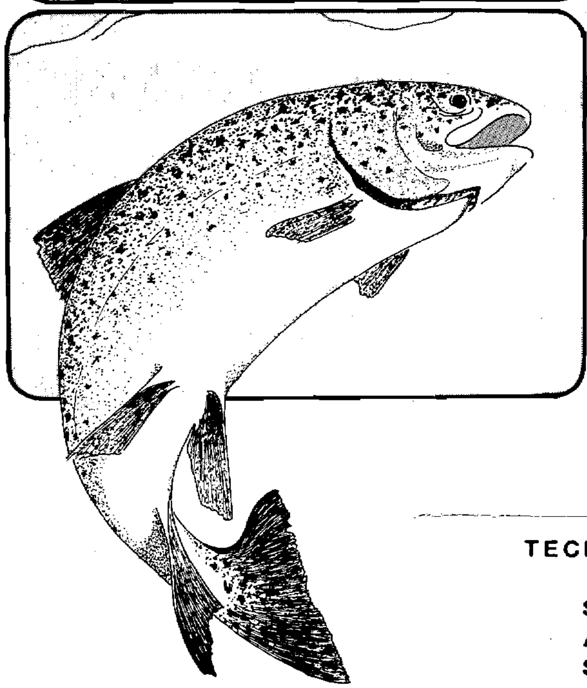
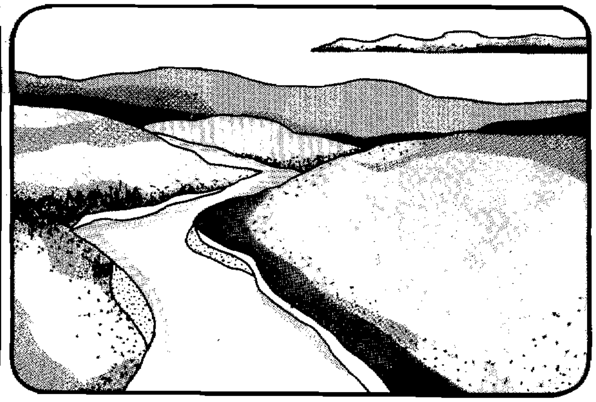








TECHNICAL DATA REPORT NO. 12

SUMMARY OF WATER TEMPERATURE AND SUBSTRATE DATA FROM SELECTED SALMON SPAWNING AND GROUNDWATER UPWELLING SITES IN THE MIDDLE SUSITNA RIVER

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

ALASKA DEPARTMENT OF FISH AND GAME
SUSITNA RIVER AQUATIC STUDIES PROGRAM

TECHNICAL DATA REPORT NO. 12

SUMMARY OF WATER TEMPERATURE AND SUBSTRATE DATA FROM SELECTED SALMON SPAWNING AND GROUNDWATER UPWELLING SITES IN THE MIDDLE SUSITNA RIVER

Authors: Donald R. Seagren
and
Robert G. Wilkey

Prepared for:

ALASKA POWER AUTHORITY
334 W. FIFTH AVENUE, SECOND FLOOR
ANCHORAGE, ALASKA 99501

December 1985

PREFACE

This report is one of a series of reports prepared for the Alaska Power Authority (APA) by the Alaska Department of Fish and Game (ADF&G) to provide information to be used in evaluating the feasibility of the proposed Susitna Hydroelectric Project. The ADF&G Susitna River Aquatic Studies Program was initiated in November 1980.

The studies described in this report were conducted in support of mitigation planning being done by ENTRIX, Inc., the primary mitigation contractor. This report includes studies conducted from July 1984 through May 1985 in the middle reach of the Susitna River from Talkeetna (RM 98.0) to the mouth of Devil Canyon (RM 150.0). The study examined general habitat characteristics at selected salmon spawning and groundwater upwelling sites during the open-water season and site specific surface and intragravel water temperatures and substrate conditions during the ice-covered season.

The combined data from these open-water and ice-covered studies will be used by ENTRIX, Inc. to assist in determining the suitability of side channel and mainstem sites as replacement salmon spawning habitats to mitigate for adverse impacts to present salmon spawning and incubation habitats as a result of the proposed hydroelectric development.

Questions concerning this report should be directed to:

Alaska Power Authority
334 West 5th Avenue
Anchorage, Alaska 99501
Telephone (907) 276-0001

TITLES IN THIS SERIES

Report Number	Title	Publication Date
1	Adult Anadromous Fish Investigations: May - October 1983	April 1984
2	Resident and Juvenile Anadromous Fish Investigations: May - October 1983	July 1984
3	Aquatic Habitat and Instream Flow Investigations: May - October 1983	September 1984
4	Access and Transmission Corridor Aquatic Investigations: May - October 1983	September 1984
5	Winter Aquatic Investigations: September 1983 to May 1984	March 1985
6	Adult Anadromous Fish Investigations: May - October 1984	June 1985
7	Resident and Juvenile Anadromous Fish Investigations: May - October 1984	July 1985
8	Availability of Invertebrate Food Sources for Rearing Juvenile Chinook Salmon in Turbid Susitna River Habitats	July 1985
9	Summary of Salmon Fishery Data for Selected Middle Susitna River Sites	August 1985
10	Preliminary Evaluations of Potential Fish Mitigation Sites in the Middle Susitna River	November 1985
11	Winter Studies of Resident and Juvenile Anadromous Fish: October 1984 - May 1985	December 1985
12	Summary of Water Temperature and Substrate Data from Selected Salmon Spawning and Groundwater Upwelling Sites in the Middle Susitna River	December 1985

SUMMARY OF WATER TEMPERATURE AND SUBSTRATE DATA FROM SELECTED SALMON SPAWNING AND GROUNDWATER UPWELLING SITES IN THE MIDDLE SUSITNA RIVER

Technical Data Report No. 12

by

Donald R. Seagren

and

Robert G. Wilkey

Alaska Department of Fish and Game

Susitna River Aquatic Studies Program

620 East 10th Avenue, Suite 302

Anchorage, Alaska 99501

December 1985

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued) Page

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF APPENDIX FIGURES

LIST OF APPENDIX FIGURES (Continued)

LIST OF APPENDIX FIGURES (Continued)

LIST OF APPENDIX TABLES

1.0 INTRODUCTION

The purpose of this study was to provide additional data to supplement previous fish mitigation plans (Moulton et al. 1984) and to collect reconnaissance level information to allow for the design of more in-depth studies of mitigation options to insure that there is no net loss of salmon spawning habitat as a result of the operation of the proposed Susitna Hydroelectric Project.

This technical data report presents a summary of surface and intragravel water temperature and substrate composition data collected at selected salmon spawning and groundwater upwelling sites in the middle reach of the Susitna River (Figure 1). Data presented in this report were collected during the open-water (July 1 to October 15, 1984) and ice-covered (November 1, 1984 to April 25, 1985) sampling periods.

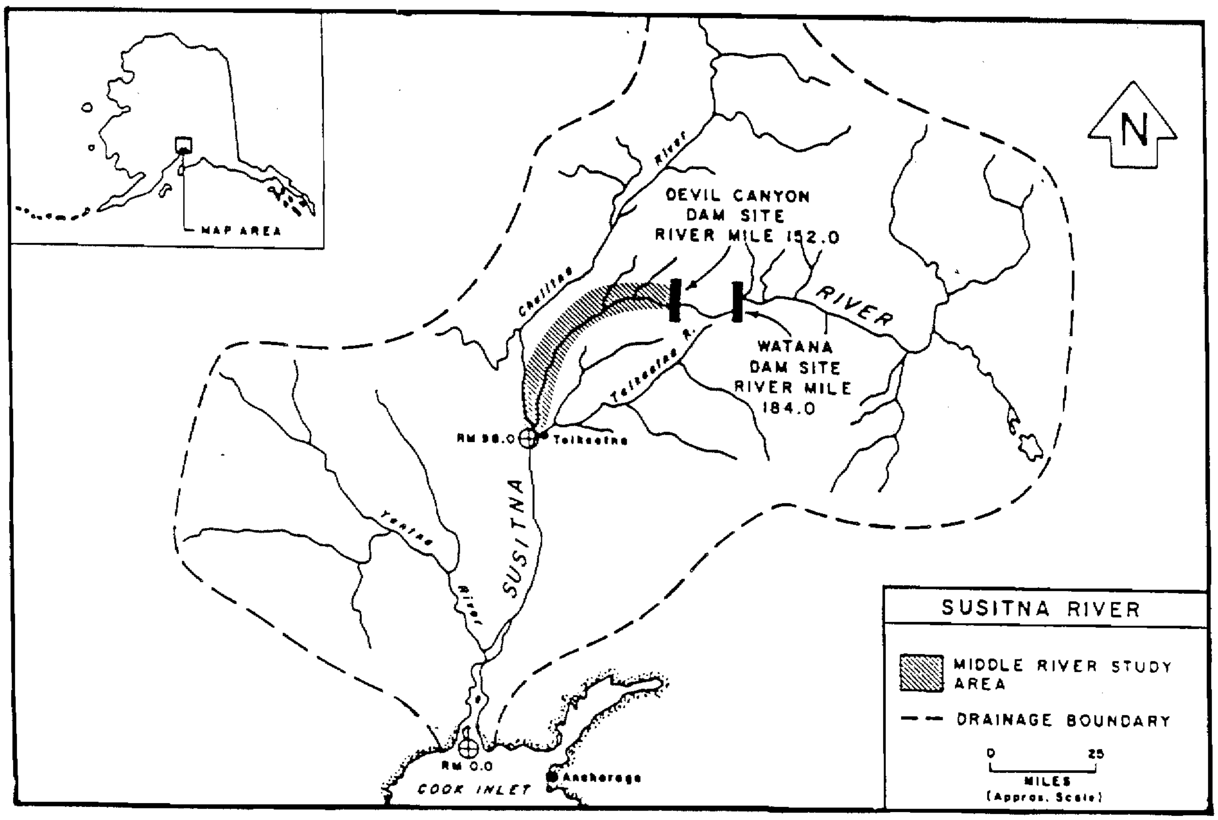


Figure 1. Map of the study area in the Susitna River basin, 1984-1985.

2.0 METHODS

This study was conducted in the middle reach of the Susitna River because that is where the most significant changes in the physical characteristics of aquatic habitats are expected to occur. The study focused on mainstem and side channel habitats because they are the primary areas where replacement spawning habitats may become available under with-project flow conditions. Tributary habitats were included in the ice-covered study for comparison of water temperature and substrate characteristics with salmon spawning areas in mainstem and side channel habitats. Open lead areas, as an indicator of spawning sites, have not been delineated in tributaries. Therefore, tributary habitats were not included in the open-water surveys. Tributary habitats are not expected to be affected by changes in mainstem discharge (Trihey 1983).

2.1 Open-Water Studies

2.1.1 Site Selection

Sixty-two side channel sites and 27 mainstem sites were selected for reconnaissance level surveys of general habitat characteristics during the 1984 open-water studies (Figures 2-8).

Fifty study sites were selected from aerial photos of mainstem and side channel habitats in the middle reach that contained open leads during the ice-covered period. Open leads in the mainstem Susitna River are considered to be indicators of either thermal influences resulting from the presence of groundwater upwelling, or high water velocities. Upwelling related open leads were used as indicators of possible salmon spawning areas based on the preference of chum salmon to select groundwater upwelling areas for spawning (Kogl 1965; Bakkala 1970; Vincent-lang et al. 1984; Vining et al. 1985). Open leads resulting from thermal influences were initially identified in the mainstem and side channels of the middle reach of the Susitna River by E. Woody Trihey and Associates (EWT&A) using aerial photographs from March 1983 (Trihey 1984).

An additional 39 study sites were selected based on an evaluation of 1984 salmon spawning utilization data at middle river mainstem and side channel sites. This evaluation enabled us to determine the extent of utilization of each of the initially selected sites by spawning salmon and to locate additional spawning sites not identified from open leads on aerial photos. The 1984 spawning survey data were useful in locating potential sites due to the high escapement and relatively clear water conditions.

The following classification of mainstem and side channel sites was developed:

1. Open leads that have been utilized for salmon spawning;

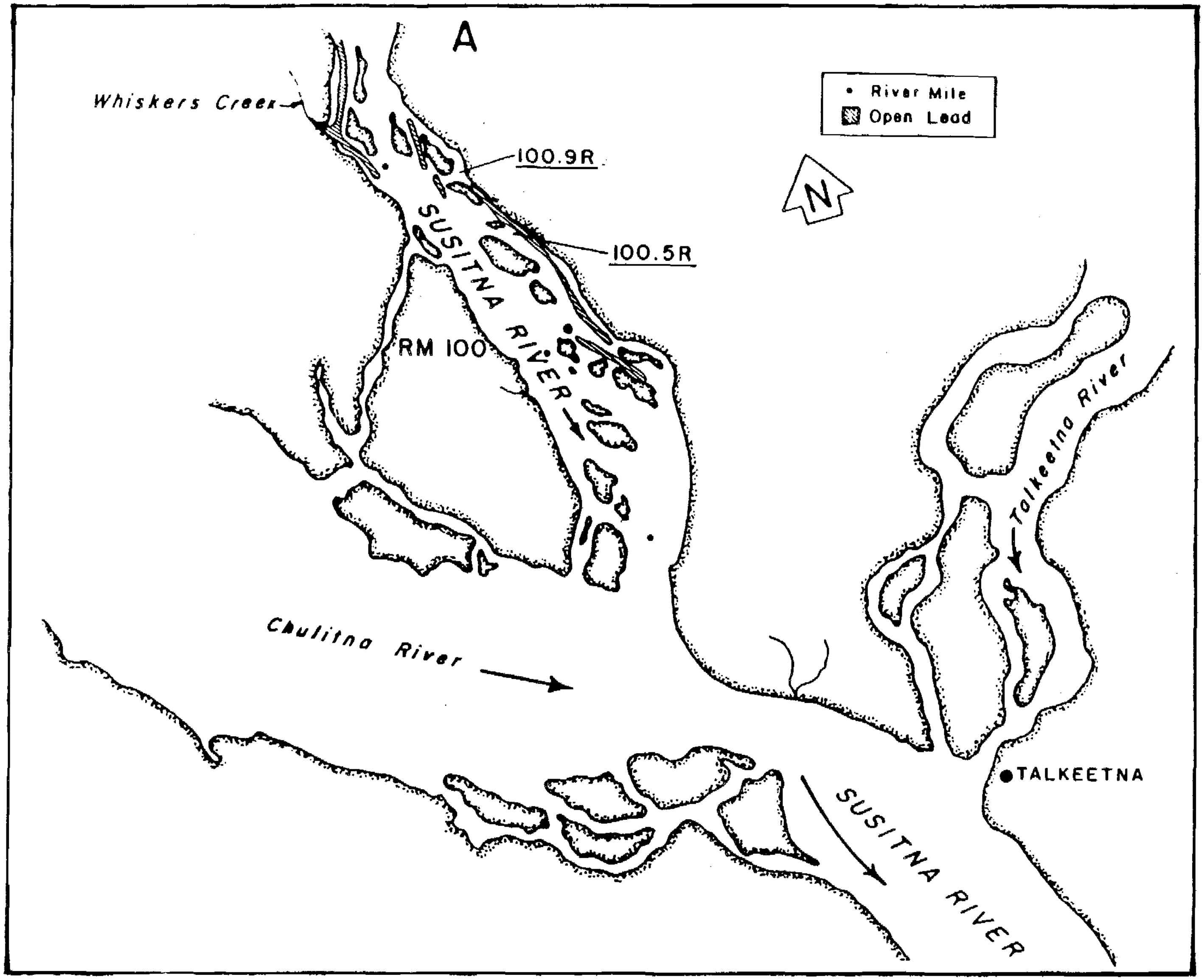


Figure 2. Map of the middle Susitna River from RM 98.0 to 101.5 showing study sites and open leads, 1984.

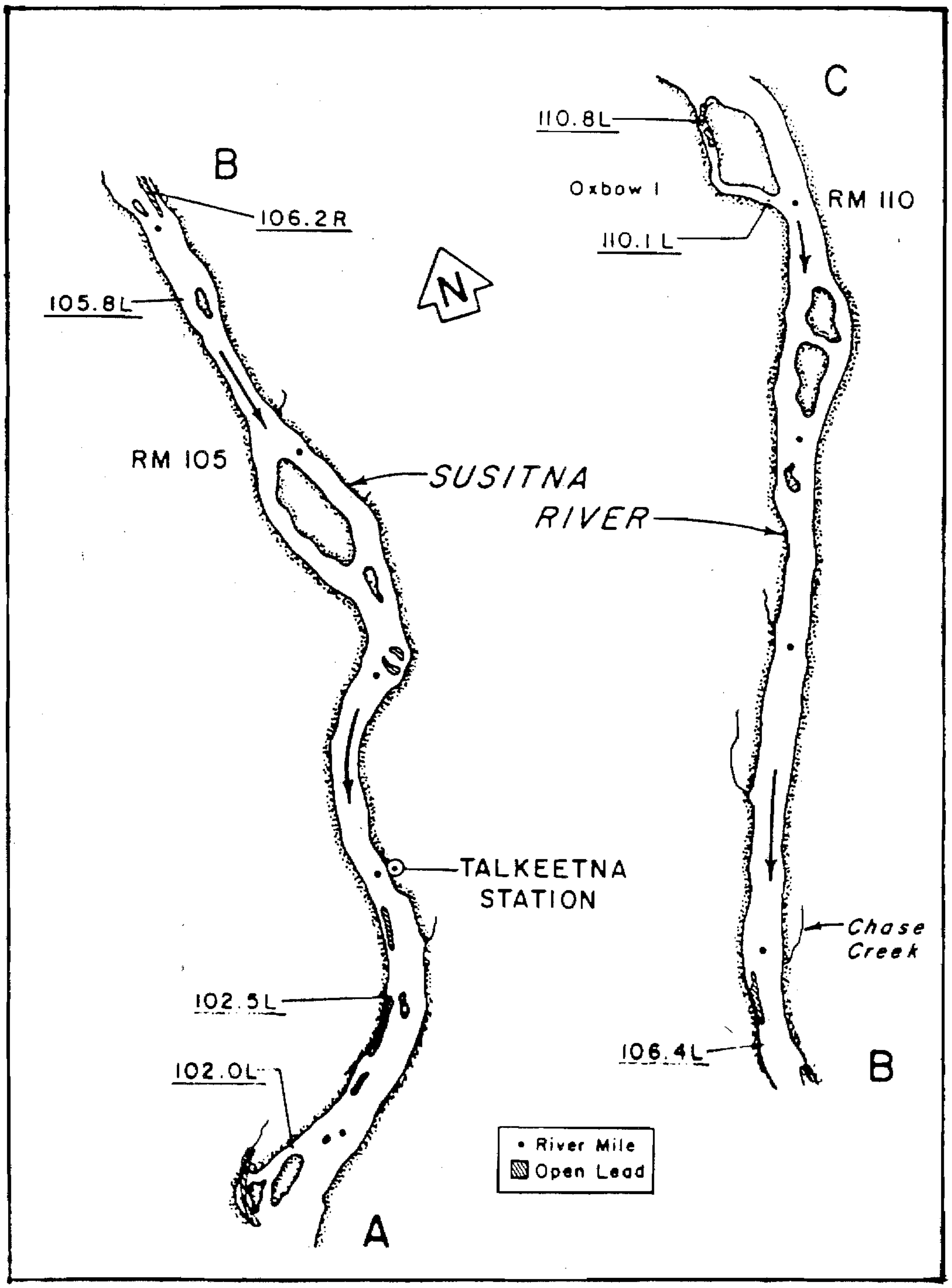


Figure 3. Map of the middle Susitna River from RM 101.5 to 110.5 showing study sites and open leads, 1984.

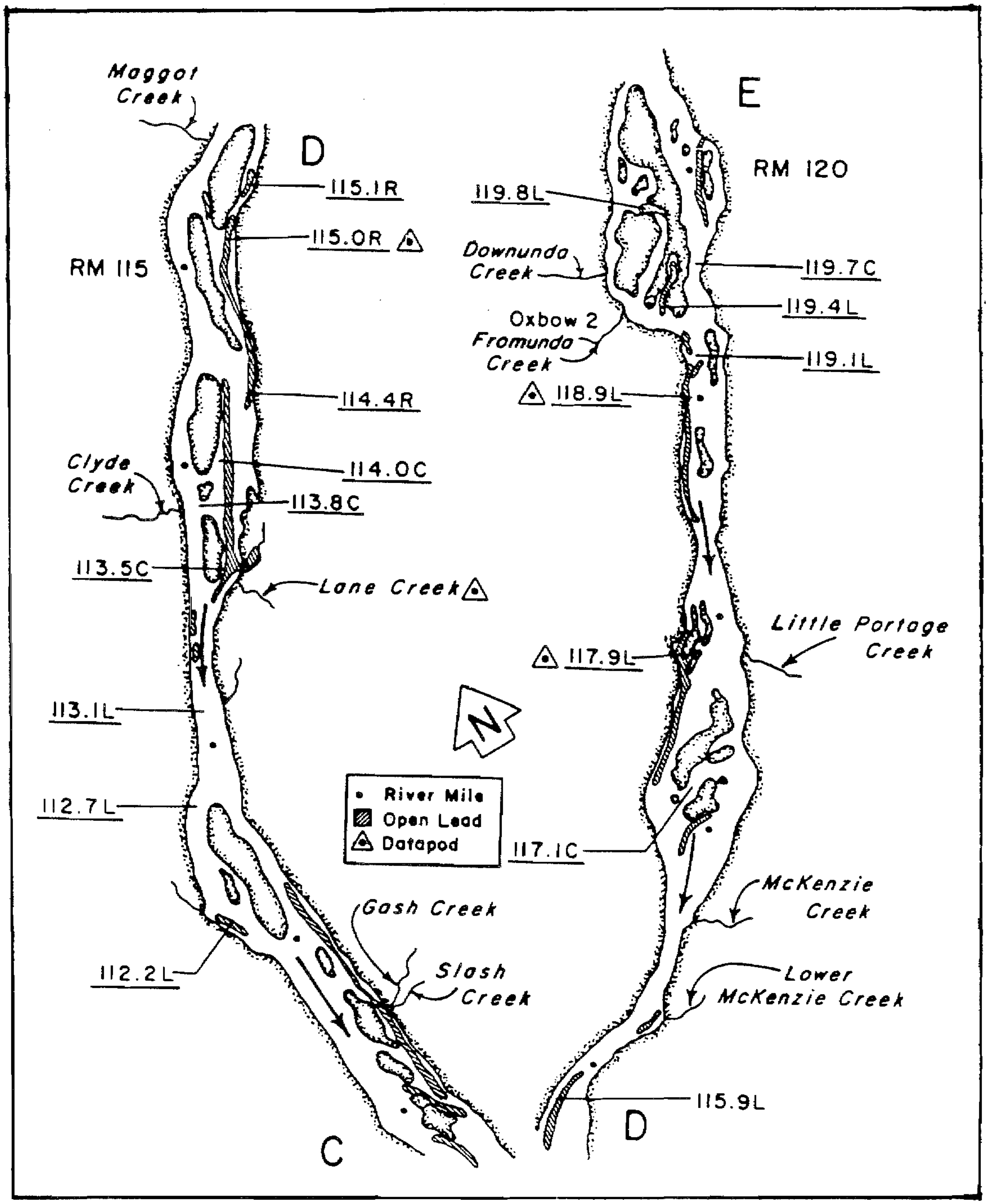


Figure 4. Map of the middle Susitna River from RM 110.5 to 120.5 showing study sites, open leads, and datapod locations, 1984.

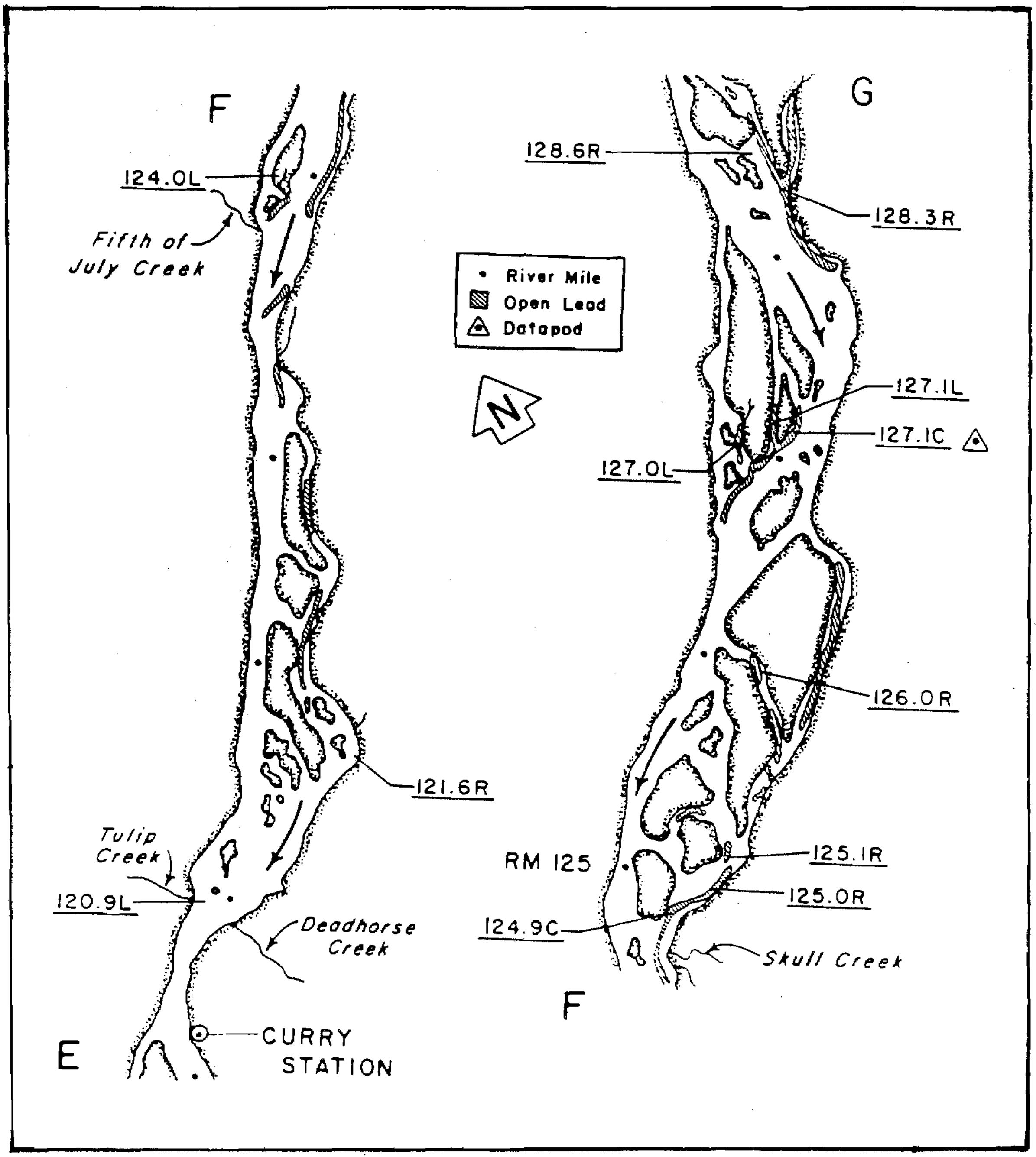


Figure 5. Map of the middle Susitna River from RM 120.0 to 128.5 showing study sites, open leads, and datapod locations, 1984.

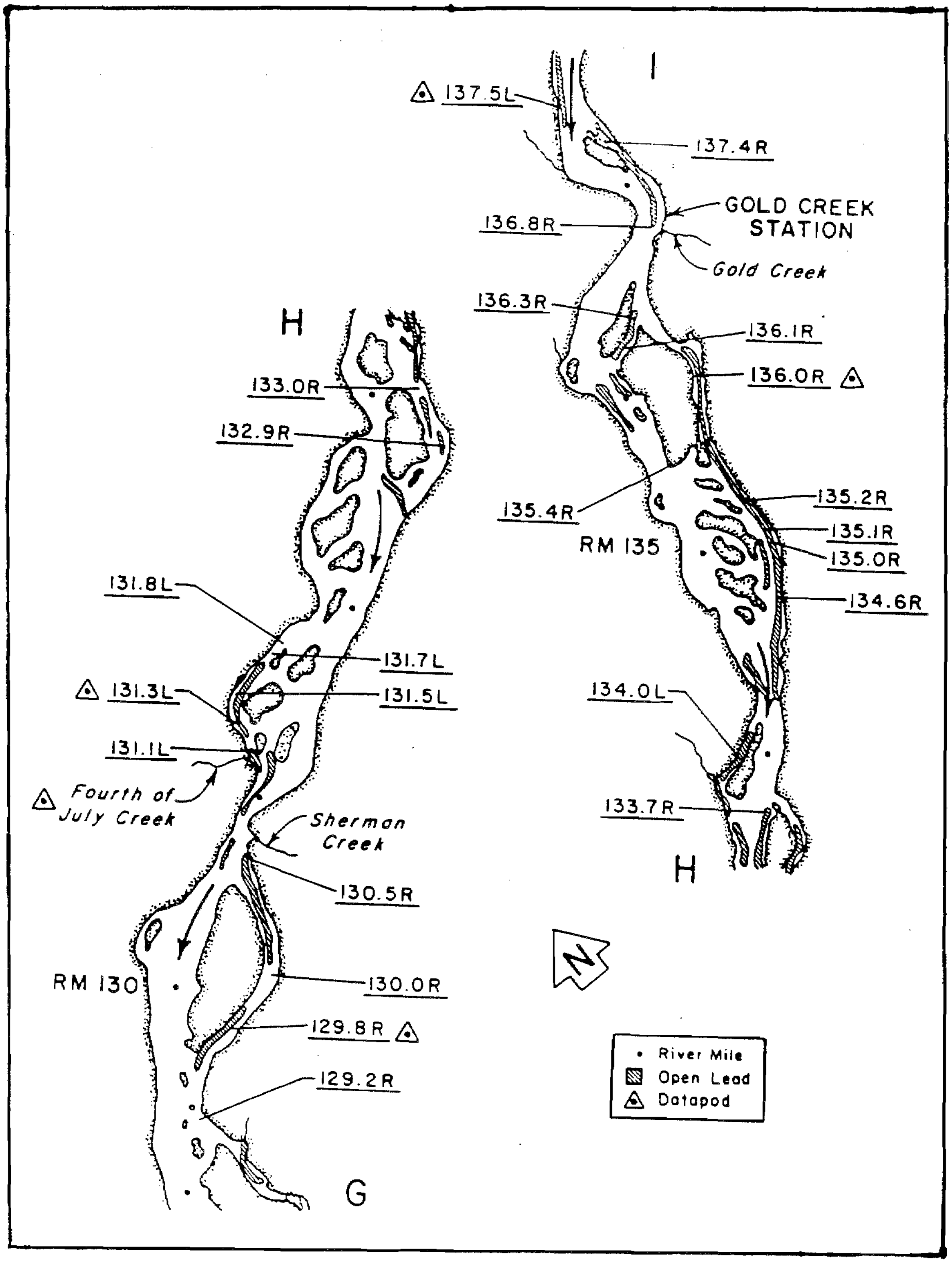


Figure 6. Map of the middle Susitna River from RM 128.5 to 137.5 showing study sites, open leads, and datapod locations, 1984.

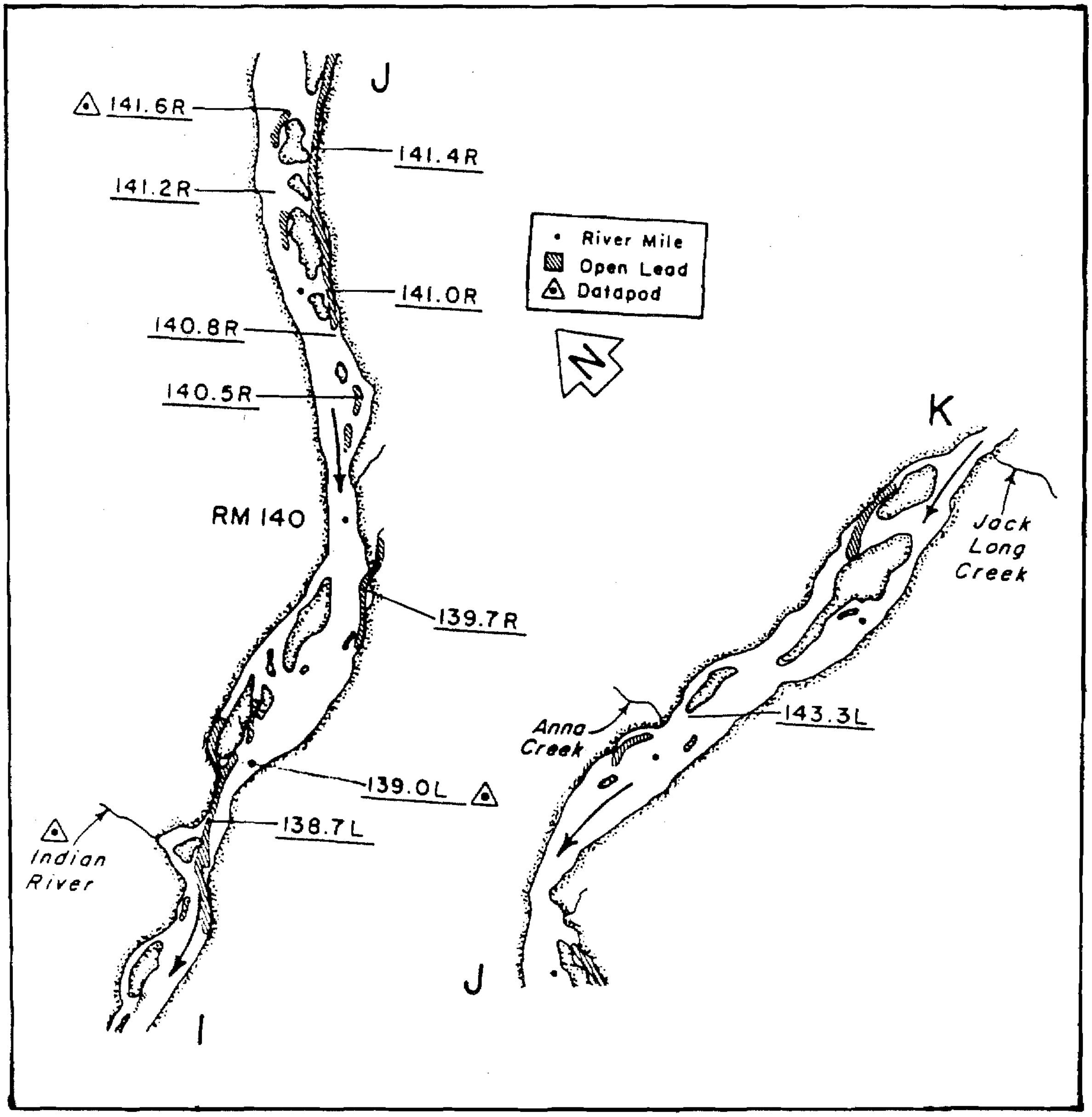


Figure 7. Map of the middle Susitna River from RM 137.5 to 144.5 showing study sites, open leads, and datapod locations, 1984.

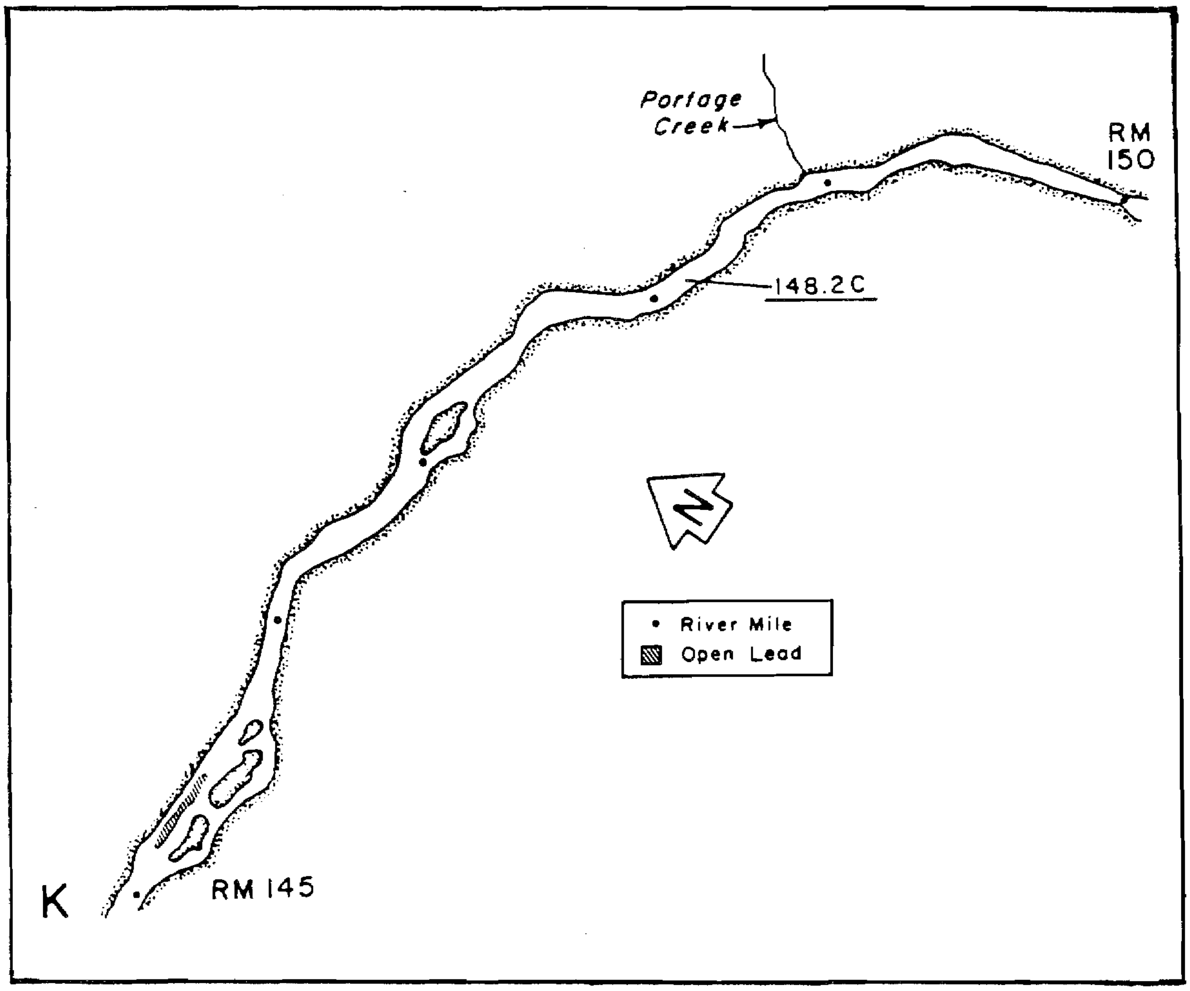


Figure 8. Map of the middle Susitna River from RM 144.5 to 150.0 showing study sites and open leads, 1984.

2. Open leads that have not been used for salmon spawning; and

3. No open leads but salmon spawning had occurred.

Sites in each classification were evaluated for the purposes of the initial reconnaissance surveys.

2.1.2 Instantaneous Surface and Intragravel Water Temperature

A single series of instantaneous surface and intragravel water temperature measurements were made at five arbitrarily selected locations in each study site for general comparison of water temperatures between sites. The measurements were made using a Digisense Model 8522-10, digital thermistor thermometer, and a Yellow Springs Instrument (YSI) Model 419 stainless steel probe. Intragravel water temperatures were taken at a depth of about 10 inches, the average egg deposition depth for chum salmon (Vining et al. 1985). These data were used as a measure of suitability of the incubation habitat in each site. In locations where it was difficult or impossible to push the probe in to a depth of 10 inches due to large substrate or cementation of substrate, the probe was inserted only as deep as possible. Surface water temperatures were taken as near as possible to the middle of the water column. These data were used for general comparisons between sites.

2.1.3 General Substrate Evaluations

General substrate evaluations were conducted by two observers who recorded their visual assessment of the substrate types present throughout each study site. Substrate evaluations were conducted when the mainstem discharge, as measured at Gold Creek, approximated the proposed summer project discharges of 9,000 to 12,000 cfs. This resulted in a better assessment of the wetted area of substrate under anticipated project conditions and also provided better visibility conditions due to clearer water at these discharges in 1984. The substrate evaluation was based on the size classification scheme presented in Table 1.

Table 1. Substrate classifications to evaluate general substrate composition at mainstem and side channel study sites.

Substrate Code	Substrate Description	Size
SI	silt	very fine
SA	sand	fines
SG	small gravel	1/4"-1"
LG	large gravel	1"-3"
RU	rubble	3"-5"
CO	cobble	5"-10"
BO	boulder	greater than 10"

Substrate data are presented to provide a general comparison of all the sites surveyed.

2.1.4 Groundwater Upwelling and Bank Seepage

Both groundwater upwelling and bank seepage contribute to a suitable spawning and incubating habitat for chum salmon(Kogl 1965; Bakkala 1970; Vincent-Lang et al. 1984; Vining et al. 1985). Groundwater upwelling and bank seepage are important because they prevent dewatering and freezing of redds, stabilize the incubation environment, and increase the rate of exchange of water to replenish dissolved oxygen and remove metabolic wastes (Vining et al. 1985). For these reasons, locating areas of groundwater upwelling and bank seepage are important for identifying potential mitigation sites.

The presence or absence of groundwater upwelling and bank seepage areas were recorded during foot surveys of each study site. Groundwater upwelling was usually observed as water percolating through the substrate of a site. It is most readily apparent in areas of silt or sand where the flow of water could be easily observed as a bubbling action. In areas of substrate with little silt or sand, groundwater upwelling was observed as a current circulating through the water column if the water was calm and/or the upwelling strong enough. Bank seepage appeared as a lateral movement of water from the banks of a site.

Observing groundwater upwelling in mainstem sites was difficult, therefore, several approaches were used to discern its presence at a study site. First, a visual assessment of the presence or absence of groundwater upwelling or bank seepage was made at the study site. If the visual assessment failed due to the presence of larger substrates, turbid water, and/or high water velocities, winter aerial photos were used to assess the presence of groundwater upwelling at these sites by the presence or absence of open leads. During winter, open leads in the ice cover due to thermal influences are known to be associated with the presence of upwelling (Vincent-Lang et al. 1984). Thus, study sites that exhibited open leads on March, 1983 aerial photographs and also have historically had salmon spawning activity (Appendix A), were assumed to be affected by thermal influences resulting from upwelling.

In some areas, open leads may be a result of high water velocity rather than upwelling. If water velocities appeared to be a controlling factor, and there was no apparent upwelling and no historical chum salmon spawning was reported, then the open lead was assumed to be a result of water velocity and was not considered further in this study.

2.2 Ice-Covered Studies

2.2.1 Site Selection

The ice-covered study used the 89 sites surveyed during the open-water period as a basis for site selection.

The site selection process for the ice covered studies involved two steps. The first step divided the middle reach of the Susitna River into the following three subreaches: Talkeetna (RM 97.0) to Curry (RM 120.5); Curry (RM 120.5) to Gold Creek (RM 136.6); and Gold Creek (RM 136.6) to the mouth of Devil Canyon (RM 150.0). These subreaches were established so that selected sites would be equally distributed throughout the middle reach of the Susitna River. The second step included dividing the initial sites into primary and secondary sites. Primary sites included side channel and mainstem habitats, that exhibited both upwelling and salmon spawning activity, and tributary spawning habitats. Secondary sites were limited to side channel and mainstem habitats and included: 1) sites that exhibited upwelling but had no salmon spawning activity; and 2) sites that had spawning activity but exhibited no upwelling. Within each subreach, a primary site, representing each habitat type (mainstem, side channel, and tributary), as well as a secondary site, representing each classification, was selected for monitoring of surface and intragravel water temperatures and substrate composition (Table 2).

The number of winter study sites was limited by the number of temperature recorders available for continuous monitoring of surface and intragravel water temperatures.

2.2.2 Continuous Surface and Intragravel Water Temperatures

Surface and intragravel water data were collected at each ice-covered study site. A continuous record of surface and intragravel water temperatures was obtained using Omnidata Model 2321 two channel temperature recorders (datapod). These temperature recorders were installed and operated continuously following the procedures outlined in ADF&G (1983b), Keklak and Quane (1985), and Keklak and Withrow (1985).

Continuous surface and intragravel water temperatures were measured at one location in each site with the exception of Indian River which had two sites. One Indian River site (datapod #3) was initially installed in a chinook salmon spawning site for another ADF&G study. Monitoring of temperatures was continued for this study to obtain temperatures on a spawning site used only by chinook salmon. The second Indian River site (datapod #4) was installed in a coho, chum, and pink salmon spawning area.

2.2.3 Freeze-Core Substrate Evaluations

The freeze-core substrate sampling technique (Walkotten 1976; Everest et al. 1980) was selected for this study for the following reasons:

1) it allows sub-sampling of the freeze-core at varying increments of depth;

2) it is versatile, functions under a wider variety of weather and water conditions;

Table 2. Location of ice-covered study sites in the middle Susitna River where continuous water temperatures were monitored and freeze-core substrate samples were collected, 1984-1985.

		Site Name	River Mile[a]	Geographic Code
Sub Reach I (Talkeetna to Curry)				
Primary:	Tributary spawning area	Lane Creek	113.6 R/TRM 0.1	S 28N 05W 12 DAA
	Side Channel spawning area with open leads	Mainstem 2	115.0 R	S 23N 04W 06 BAB
	Mainstem spawning area with open leads	Susitna River at 118.9L	118.9 L	S 29N 04W 16 CDD
Secondary:	Open lead Without Spawning	Side Channel at 117.9L	117.9 L	S 29N 04W 29 AAA
Sub Reach II (Curry to Gold Creek)				
Primary:	Tributary spawning area	4th of July Creek	131.1 L/TRM 0.2	S 30N 03W 03 DBA
	Side Channel spawning area with open lead	Side Channel at 4th of July Creek	131.3 L	S 30N 03W 03 ADD
	Mainstem spawning area with open lead	Susitna River at 132.9R	132.9 R	S 30N 03W 01 BAD
Secondary:	Open lead Without Spawning	Susitna River at 127.1C	127.1 C	S 30N 03W 09 ACB
	Spawning Without Open lead	Side Channel at 129.8R	129.8 R	S 30N 03W 20 ADC
Sub Reach III (Gold Creek to Devil's Canyon)				
Primary:	Tributary spawning area	Indian River[b]	138.6 L/TRM 0.2	S 31N 11W 09 CAB
	Side Channel spawning area with open lead	Side Channel 21	141.6 R	S 31N 02W 02 AAB
	Mainstem spawning area with open lead	Susitna River at 139.0L	139.0 L	S 31N 02W 09 DAC
Secondary:	Open lead Without Spawning	Susitna River at 137.5L	137.5 L	S 31N 02W 17 ACB

[a] L = Left Bank, looking upstream
R = Right Bank, looking upstream
C = Center Channel
TRM = Tributary River Mile

[b] Indian River had two study sites, one on each side of the river. The left bank site (Datapod #3) was a chinook spawning area. The right bank site (Datapod #4) was a spawning area utilized by chinook, coho, chum, and pink salmon.

3) the metal probe of the freeze-core technique provides easy penetration of the large and cemented substrates present at many sites; and

4) it allows for accurate sampling of sediments less than 0.062 mm (Walkotten 1976).

The only change made in the freeze core system described by Walkotten was the use of steel probes instead of copper. This modification was made because steel probes were more durable.

Substrate samples were collected above, below, and near the temperature recorder at arbitrarily selected locations in each winter study site. Freeze core samples were collected to a depth of 16 inches at each location using a single probe freeze-core apparatus as described in Walkotten (1976) (Figure 9). A depth of 16 inches was selected to encompass the average redd depth for all salmon species (Seagren and Wilkey 1985, Appendix Table D-2).

Substrate core samples were obtained by discharging an entire 20 lb. tank of CO_2 into the probes before extracting the sample. This procedure usually took about 10 minutes. Frozen substrate samples were then extracted from the streambed using a tripod and hand operated winch. Cores were thawed using portable propane heaters and split into two samples, the top 8 inches and the bottom 8 inches, to observe differences in composition with depth (Everest et al. 1980, 1981; Scrivener and Brownlee 1981).

Freeze core samples were taken to the Alaska Department of Transportation (ADOT) Central Materials Testing Laboratory for analysis. Sieve analysis of the samples were done using the standard method of sampling and testing procedures (T27-82 and T11-82) of the American Association of State Highway and Transportation Officials (1982). The analysis was performed using a series of seven sieves with the following mesh sizes: 127, 76.2, 25.4, 2.0, 0.84, 0.50, and 0.062 mm. The sieve size selection was based on the previous ADF&G studies (Vining et al. 1985) as well as recommendations from Wendling (1976), Shirazi and Seim (1980), Lotspeich and Everest (1981), Everest et al. (1981), and Platts et al. (1983). After sieving, the dry weight of each size class of substrate was measured to the nearest gram and expressed as a percentage of the total weight.

The quality of spawning gravels obtained from freeze core samples was then compared to one another using a fredle index. The fredle index, is the number which results when the geometric mean particle size of a sample is divided by the sorting coefficient (a measure of the distribution of grain sizes) in the sample. This index incorporates the influence of texture on two fundamental properties of spawning gravels - pore size and permeability - that influence survival. Pore size and permeability regulate intragravel water velocity and oxygen transport to incubating salmonid embryos and control intragravel movement of alevins. Pore size, rather than porosity, was chosen as a component of the quality index because pore size (and permeability) is directly proportional to mean grain size while porosity has been shown to be indepen-

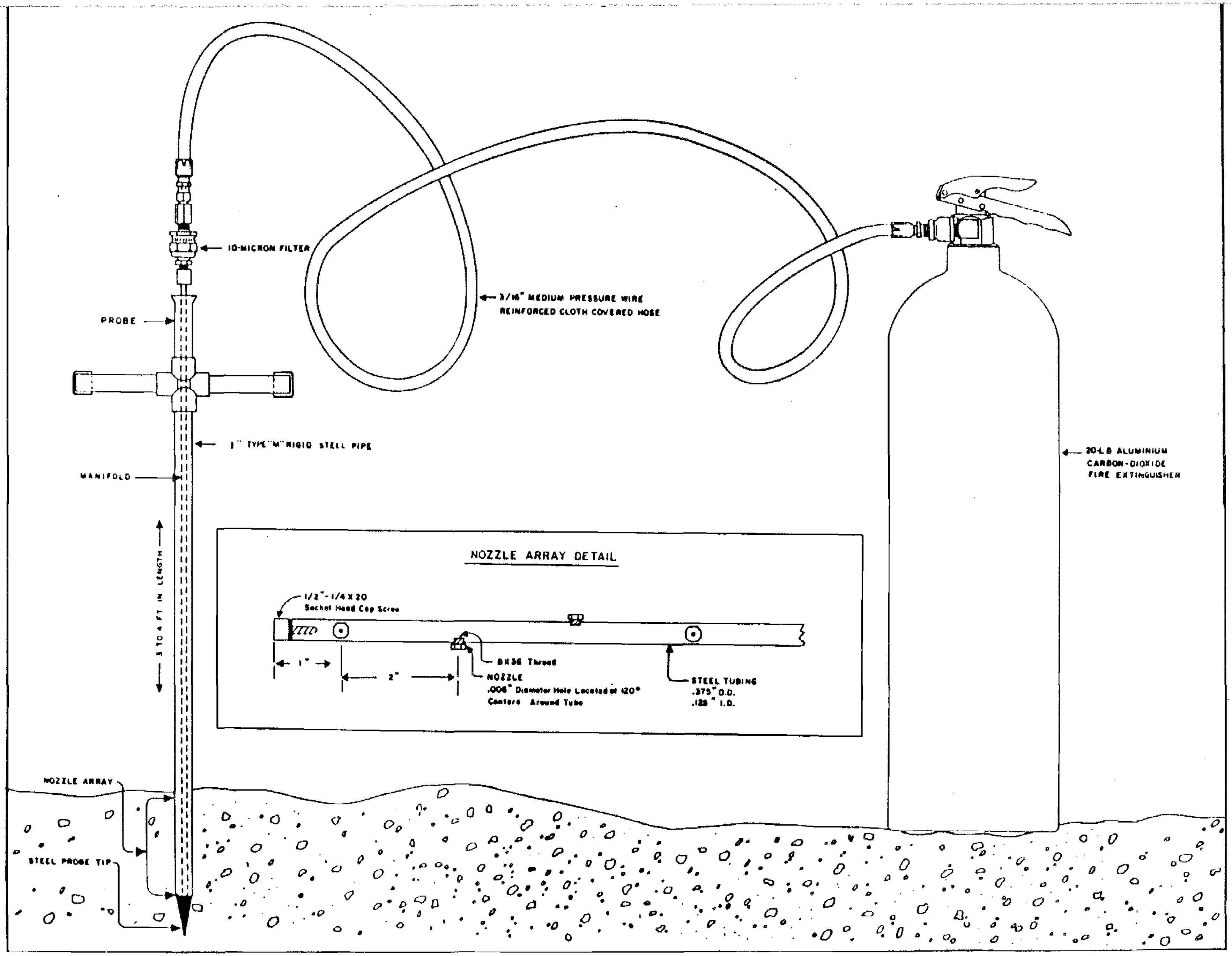


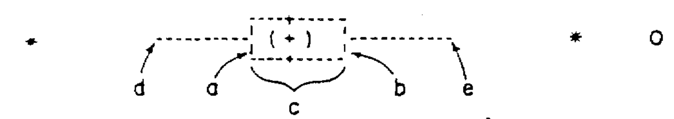
Figure 9. Single probe freeze core apparatus used to sample streambed substrates in the middle reach of the Susitna River, 1985 (adapted from Walkotten 1976).

dent of grain size. The fredle index has been used by Lotspeich and Everest (1981), Everest et al. (1981), and Platt et al. (1983) to evaluate the reproductive potential of spawning gravel.

A fredle index was derived for each freeze core sample by entering the raw data from the sieve analysis into a computer program developed by Porter and Rogers (1984). This program provides a concise summary of the indices which describe the textural composition of spawning gravels in each sample.

2.3 Interpretation of Figures

Boxplots are used in this report to summarize water temperature data. The format basically follows that used by Velleman and Hoaglin (1981). The boxplots, as presented here, were computer generated by a micro-computer program called MINITAB (Ryan et al. 1981). Water temperature data from each study site comprise a data batch, which is ordered from lowest value to highest. Specific symbols used in the boxplot figures are explained in Figure 10.



Symbol	Representative Term
a, b	lower and upper hinges (about 25 percent of the way in from each end of an ordered batch)
c	H-spread (the difference between the hinges; middle half of the data batch)
d	minimum adjacent value = minimum observed value greater than [lower hinge - (1.5 x H-spread)]
e	maximum adjacent value = maximum observed value less than [upper hinge + (1.5 x H-spread)]
+	median (middle value of the batch)
*	outside value (outside of the adjacent values)
0	far outside value-outside of the following range: lower hinge - (3 x H-spread) upper hinge + (3 x H-spread)
( )	notches (represent approximately a 95 percent confidence limit about the median): $\text{median} \pm 1.58 \times (\text{H-spread})/\sqrt{n}$

Figure 10. Definitions of symbols used in boxplots which summarize water temperature data.

3.0 DATA SUMMARY

3.1 Open-Water Studies

The following section contains a summary of data that was collected during the open-water studies at 89 potential mitigation sites in the middle reach of the Susitna River from July 1 to October 15, 1984. Of the 89 sites surveyed, 62 were side channel habitats and 27 were mainstem habitats. Spawning activity and groundwater upwelling was observed at 18 of the 62 side channel sites (Table 3), while nine of the 27 mainstem sites were similarly classified. Ten of the side channel and eight of the mainstem sites had neither observed spawning activity nor groundwater upwelling present. A total of nine side channel and two mainstem sites had groundwater upwelling present with no observed spawning.

3.1.1 Instantaneous Surface and Intragravel Water Temperature

The instantaneous surface and intragravel water temperature ranges recorded at each site (n=5) during the open-water sampling period are presented in Table 3. In both side channel and mainstem habitats, surface water temperatures were warmer than intragravel water temperatures early in the season and the difference between the two become less as the ice-covered period approached. During the open-water sampling period, surface water temperatures at side channel habitats ranged from 3.2 to 12.3°C and intragravel water temperatures ranged from 3.3 to 8.6°C (n=205). During the same time period, surface water temperatures at mainstem habitats ranged from 2.9 to 12.7°C and intragravel water temperatures ranged from 3.0 to 12.3°C (n=90). The highest recorded temperature for both surface and intragravel water in mainstem habitats was recorded at RM 143.3L, an area where spawning occurred but there were no open leads. Further studies indicated that, under present conditions, this site was a peripheral habitat unsuitable for incubation due to dewatering and freezing.

3.1.2 General Substrate Evaluations

Substrate types given in Table 3 are presented in order of their abundance at the site. Some study sites only had two substrate types present and others had as many as four.

Both side channel and mainstem habitats exhibit similar substrate patterns (Figures 11 and 12). Rubble-cobble-boulder substrate (3" to 10") predominate in both habitat types. Side channel habitats have an approximately equal number of sites containing rubble (3" to 5") and cobble (5" to 10") substrate while mainstem habitats contain a greater number of sites with cobble substrate. In comparing spawning with non-spawning areas in both habitats, the same trends appeared. Substrates at mainstem habitats appear to be more cemented with fine silts and sands than side channel habitats. Side channel and mainstem sites generally contain larger substrate (rubble-cobble-boulder, 3" to greater than 10") than tributary spawning habitats (small gravel - large gravel-rubble, ¼" to 5"). There are areas of suitable substrate in all

Table 3. All side channel and mainstem salmon spawning sites observed between 1981 and 1984 in the middle Susitna River and the habitat characteristics of all 1984 open-water study sites.

River[a] Mile	Habitat[b] Type	Sample Date	Groundwater Upwelling (Yes/No)	Bank Seepage[c] (Yes/No)	Open Lead (Yes/No)	Substrate[d]	Water Temperature Range Limits (°C)[e] Surface	Intragravel	Years[f] Spawning Observed
100.5 R	SC	10-8-84	N	Y	Y	CO-RU-BO	4.2 - 4.9	4.7 - 5.1	1981
100.9 R	SC	10-8-84	N	N	N	RU-CO-BO	3.5 - 5.0	4.0 - 6.4	1984
101.2 R	SC	10-8-84	N	N	N	RU-CO-BO	3.9 - 4.6	4.4 - 5.2	1984
102.0 L	SC	10-8-84	Y	Y	N	CO-BO-RU	3.9 - 4.3	3.3 - 3.9	----
102.5 L	SC	10-8-84	N	N	Y	CO-BO	-	-	----
105.8 L	MS	10-8-84	N	N	N	BO-CO	2.9 - 3.0	3.0 - 3.2	----
106.2 R	MS	10-8-84	N	N	Y	BO-CO	3.1 - 3.2	3.4 - 3.5	----
110.1 L	SC	10-8-84	N	N	N	SI-RU-CO	3.2 - 4.0	5.2 - 5.7	1984
110.8 L	SC	10-8-84	Y	N	Y	RU-CO-BO	3.9 - 4.5	5.0 - 5.4	----
112.2 L	MS	9-14-84	N	N	Y	RU-CO-BO-LG	6.8 - 6.9	6.9 - 7.0	----
112.7 L	MS	9-14-84	N	N	N	RU-CO-BO	7.2 - 7.4	6.2 - 6.9	----
113.1 L	MS	9-14-84	N	N	N	RU-CO-BO	-	-	----
113.5 C	SC	9-14-84	N	N	Y	LG-RU-CO	6.7 - 6.8	6.3 - 7.0	----
113.8 C	MS	9-14-84	N	N	N	RU-CO-BO	-	-	----
114.0 C	SC	9-14-84	Y	Y	Y	SG-LG-RU	7.1 - 7.3	4.1 - 7.1	1984
114.4 R	SC	g	-	-	Y	-	-	-	1984
114.5 R	SC	g	-	-	Y	-	-	-	1984
114.6 R	SC	9-14-84	N	N	Y	SA-RU-CO-BO	6.8 - 7.5	4.5 - 7.4	1982, 1983, 1984
115.0 R	SC	9-14-84	Y	N	Y	RU-CO-BO	-	-	1982, 1983, 1984
115.1 R	SC	9-14-84	Y	N	Y	BO-CO-RU	6.9 - 8.9	5.5 - 8.6	1983, 1984
115.4 R	SC	g	-	-	Y	-	-	-	1984

Table 3 (Continued).

River[a] Mile	Habitat[b] Type	Sample Date	Groundwater Upwelling (Yes/No)	Bank Seepage[c] (Yes/No)	Open Lead (Yes/No)	Substrate[d]	Water Temperature Range Limits (°C)[e] Surface	Intragravel	Years[f] Spawning Observed
115.9 L	MS	9-14-84	N	N	Y	CO-BO-RU	6.3 - 7.7	4.6 - 5.1	----
117.1 C	SC	9-14-84	N	N	N	SA-RU-CO	-	-	----
117.9 L	SC	9-14-84	Y	Y	Y	RU-CO-BO	7.2 - 7.8	5.7 - 7.3	----
117.9 R	MS	9-14-84	Y	N	N	CO-BO	-	-	1984
118.9 L	MS	9-14-84	Y	Y	Y	CO-BO-RU	7.1 - 7.2	5.2 - 7.1	1983, 1984
119.1 L	MS	9-18-84	N	N	Y	LG-RU-CO	7.8 - 8.0	7.6 - 7.9	1984
119.4 L	SC	9-18-84	Y	N	Y	SA-LG-RU-CO	7.0 - 8.2	5.3 - 7.6	1984
119.7 C	SC	9-18-84	N	Y	N	SA-LG-RU-CO	8.0 - 8.5	5.3 - 7.4	---
119.8 L	SC	9-18-84	N	N	Y	LG-RU-CO	8.0 - 8.2	6.9 - 8.2	1984
120.9 L	MS	9-18-84	N	N	N	-	-	-	1984
121.6 R	SC	g	-	-	N	-	-	-	1984
123.1 R	MS	9-13-84	N	N	Y	RU-CO-BO	7.5 - 7.6	7.5 - 7.6	----
124.0 L	SC	9-12-84	Y	N	N	SI-RU-CO	7.2 - 8.7	4.4 - 8.4	1984
124.9 C	SC	9-12-84	Y	N	Y	LG-RU-CO	7.5 - 10.9	4.5 - 5.5	1984
125.0 R	SC	9-18-84	Y	N	Y	RU-CO-BO	7.5	7.1 - 7.5	----
125.1 R	SC	9-18-84	N	N	Y	LG-RU-CO	7.4 - 7.6	7.6 - 8.4	----
127.0 L	SC	9-18-84	Y	N	Y	LG-RU-CO	5.7 - 7.4	5.9 - 7.4	----
127.1 L	SC	9-18-84	N	N	Y	LG-RU-CO	7.2 - 7.3	7.3 - 7.7	----
127.1 C	SC	9-18-84	Y	N	Y	LG-RU-CO	6.4 - 7.1	3.7 - 7.6	----
127.8 R	SC	g	-	-	Y	-	-	-	1984

Table 3 (Continued).

River[a] Mile	Habitat[b] Type	Sample Date	Groundwater Upwelling (Yes/No)	Bank Seepage[c] (Yes/No)	Open Lead (Yes/No)	Substrate[d]	Water Temperature Range Limits (°C)[e]		Years[f] Spawning Observed
							Surface	Intragravel	
128.3 R	MS	9-18-84	N	N	Y	-	-	-	1984
128.6 R	SC	9-17-84	Y	N	Y	RU-CO-BO	5.7 - 8.4	4.7 - 5.9	1982, 1984
128.7 R	SC	g	Y	N	Y	-	-	-	1984
129.2 R	SC	9-17-84	N	N	N	RU-CO-BO	7.6 - 7.7	7.7 - 7.8	1981
129.8 R	SC	9-17-84	N	N	Y	SA-RU-CO-LG	7.2 - 9.5	4.8 - 7.5	1981, 1982, 1984
130.0 R	SC	9-17-84	Y	N	Y	-	-	-	1981, 1984
130.5 R	SC	9-17-84	Y	N	Y	CO-BO-RU	7.8 - 8.5	5.6 - 7.8	1984
131.0 R	MS	g	N	N	N	-	-	-	1984
131.0 L	SC	9-17-84	Y	Y	Y	SA-RU-CO	6.7 - 7.1	4.3 - 6.0	1981, 1982, 1983, 1984
131.1 L	SC	9-17-84	Y	N	N	SA-LG-RU	6.4 - 7.3	4.3 - 5.3	1981, 1982, 1984
131.2 L	SC	g	-	-	Y	-	-	-	1984
131.3 L	SC	9-17-84	Y	Y	Y	RU-LG-CO	4.6 - 7.1	4.6 - 7.0	1982, 1983, 1984
131.5 L	SC	9-17-84	Y	N	Y	RU-LG-CO	-	-	1984
131.6 L	SC	g	-	-	Y	-	-	-	1981, 1982, 1983, 1984
131.7 L	SC	9-17-84	N	N	N	RU-CO	6.5 - 6.6	6.9 - 7.0	1984
131.8 L	SC	9-12-84	N	N	N	RU-CO	6.5 - 6.6	7.0	1984
132.9 R	MS	9-17-84	Y	N	Y	RU-CO-BO	-	-	1984
133.7 R	SC	9-17-84	N	N	Y	RU-CO-BO	7.1	6.5 - 7.2	----
134.0 L	SC	9-17-84	Y	Y	Y	LG-RU-CO	7.1 - 8.5	5.1 - 5.8	----
134.6 R	SC	9-17-84	N	N	Y	RU-CO-BO	6.7 - 6.9	6.5 - 7.0	----
134.7 R	SC	g	N	N	Y	-	-	-	1984

Table 3 (Continued).

River[a] Mile	Habitat[b] Type	Sample Date	Groundwater Upwelling (Yes/No)	Bank Seepage[c] (Yes/No)	Open Lead (Yes/No)	Substrate[d]	Water Temperature Range Limits (°C)[e]		Years[f] Spawning Observed
							Surface	Intragravel	
135.0 R	SC	9-17-84	N	N	Y	LG-RU-CO	6.8 - 6.9	5.2 - 7.1	1984
135.1 R	SC	9-17-84	N	N	Y	LG-RU-CO	-	-	----
135.2 R	SC	9-17-84	N	N	Y	RU-CO	-	-	----
135.4 R	SC	9-17-84	N	N	N	SI-LG-RU	6.6 - 6.8	6.3 - 7.1	----
136.1 R	SC	9-17-84	Y	N	Y	SA-LG-RU-CO	4.9 - 5.4	4.0 - 6.1	1981, 1982, 1983, 1984
136.3 R	SC	9-17-84	N	N	Y	-	-	-	1981, 1982, 1983, 1984
136.5 R	SC	g	N	N	Y	-	-	-	1981, 1982, 1983, 1984
136.8 R	MS	9-15-84	N	N	Y	RU-CO-BO	8.7 - 10.1	6.3 - 7.3	1983, 1984
137.4 R	SC	9-15-84	N	Y	Y	SA-RU-CO-BO	10.4 - 12.3	4.7 - 8.1	----
137.5 L	MS	9-15-84	Y	N	Y	SA-BO-CO	10.4 - 11.6	4.7 - 8.1	----
138.0 L	MS	9-15-84	Y	N	Y	LG-RU-CO	-	-	1982
138.3 L	MS	9-15-84	N	Y	Y	LG-RU-CO	9.6 - 9.8	7.8 - 8.2	1982, 1984
138.7 L	MS	9-15-84	N	Y	Y	CO-BO-RU	8.8 - 9.0	7.9 - 8.1	1982, 1983, 1984
138.8 L	MS	g	-	-	Y	-	-	-	1984
139.0 L	MS	9-11-84	N	Y	Y	RU-LG-CO	7.7 - 8.6	5.3 - 6.6	1982, 1983, 1984
139.4 L	SC	9-11-84	N	N	Y	RU-LG-CO	8.5	7.6 - 8.1	1984
139.7 R	SC	9-15-84	Y	N	Y	SA-RU-CO-BO	7.7 - 8.0	6.9 - 7.7	----
140.5 R	SC	9-15-84	N	N	Y	CO-BO-RU	-	-	1984
140.8 R	SC	9-15-84	N	N	N	CO-BO-RU	-	-	1981, 1982, 1983, 1984
141.0 R	SC	9-15-84	Y	Y	Y	BO-CO-RU-LG	7.4 - 7.5	7.4 - 7.5	1981, 1982, 1983, 1984

Table 3 (Continued).

River[a] Mile	Habitat[b] Type	Sample Date	Groundwater Upwelling (Yes/No)	Bank Seepage[c] (Yes/No)	Open Lead (Yes/No)	Substrate[d]	Water Temperature Range Limits (°C)[e]		Years[f] Spawning Observed
							Surface	Intragravel	
141.2 R	MS	9-15-84	Y	Y	Y	CO-BO-RU	7.4 - 7.5	7.4 - 7.5	----
141.4 R	SC	9-15-84	Y	N	Y	SI-CO-BO	5.3 - 5.7	4.5 - 5.4	1981, 1982, 1983, 1984
141.6 R	MS	9-15-84	N	N	Y	RU-CO-BO	7.2 - 7.3	7.2 - 7.8	1984
141.6 R	SC	9-15-84	Y	N	Y	SA-RU-CO-BO	-	-	1981, 1982, 1983, 1984
143.0 L	MS	9-11-84	Y	N	N	RU-CO	9.3	7.4	1984
143.3 L	MS	9-11-84	Y	N	N	CO-BO	8.5 - 12.7	7.4 - 12.3	1982, 1984
148.2 C	MS	9-11-84	N	N	N	CO-BO	6.8 - 7.1	6.9 - 7.4	1982

[a] L = Left Bank, looking upstream
R = Right Bank, looking upstream
C = Center Channel

[b] MS = Mainstem
SC = Side Channel

[c] Identified from aerial photos made in March 1983.

[d] Substrate size classification as described in Table 1, in the methods section.

[e] Sample size equals 5. A single reading indicates all recorded temperature values were identical.

[f] Source - ADF&G (1981), ADF&G (1983a), Barrett et al. (1984), and Barrett et al. (1985).

[g] Not sampled, spawning survey data only.

---- No spawning observed.

\- No data available.

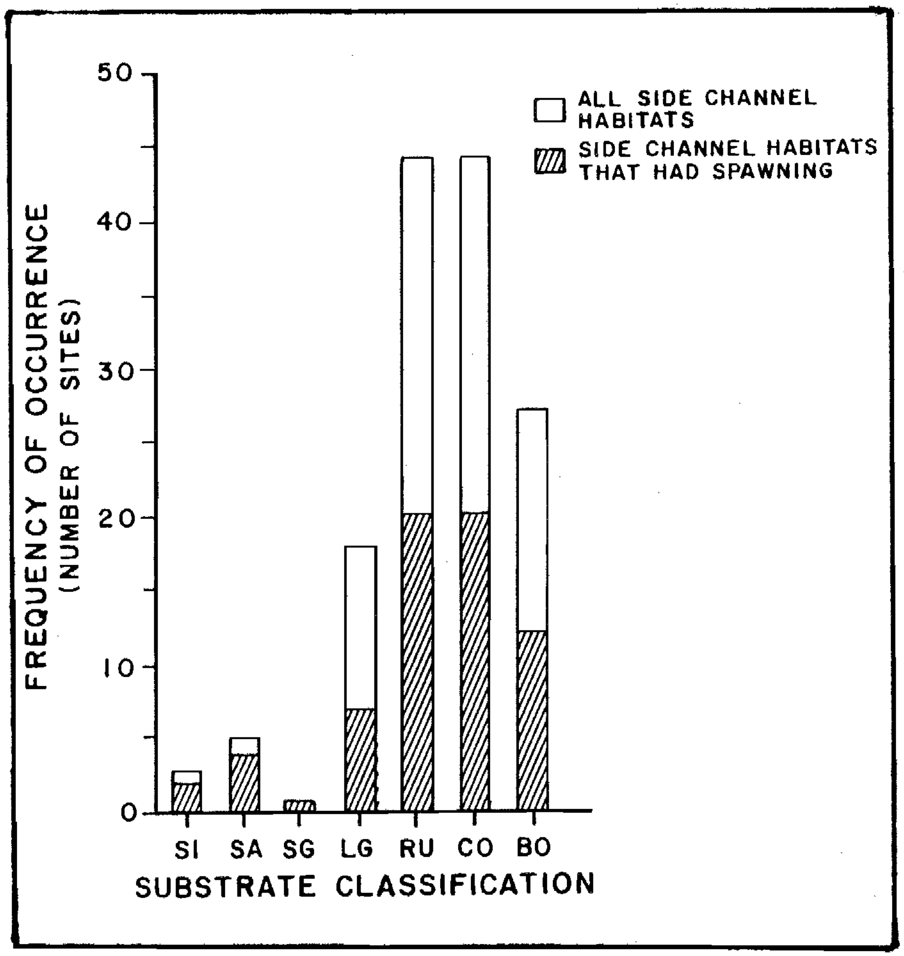


Figure 11. Frequency of occurrence of surface substrates in side channel habitats. Individual substrate types within each study site were weighted equally in this figure regardless of their abundance.

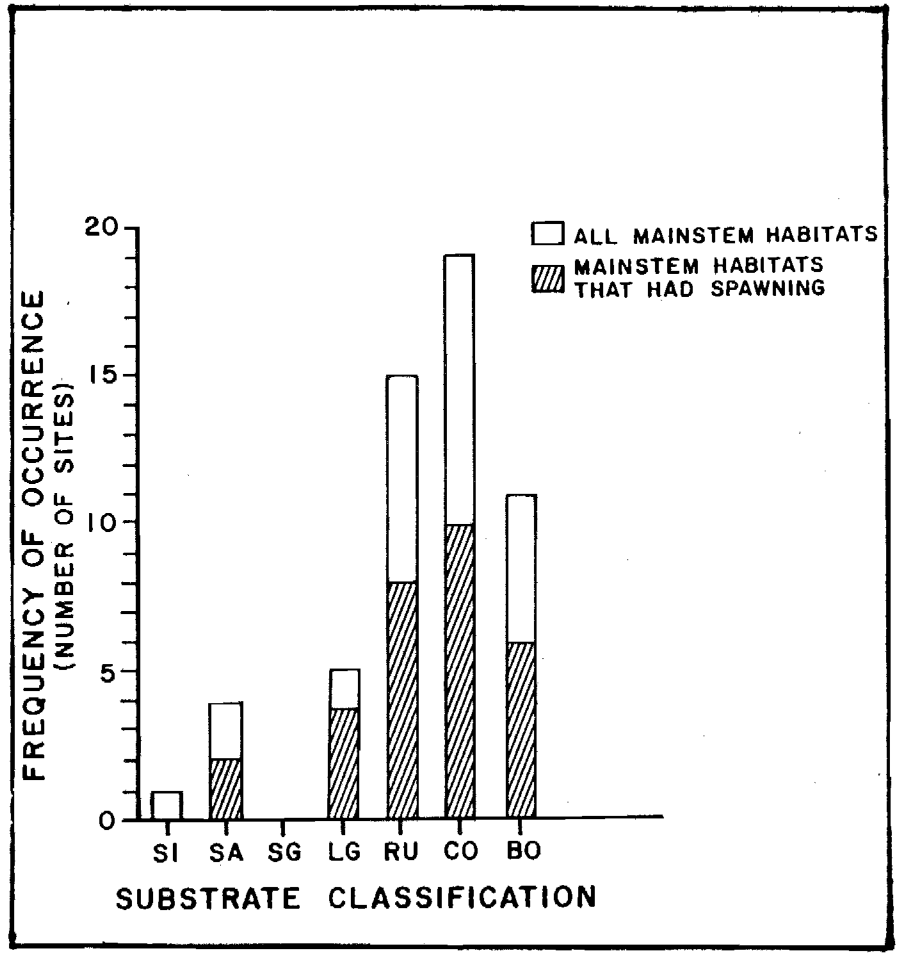


Figure 12. Frequency of occurrence of surface substrates in mainstem habitats. Individual substrates within each study site were weighted equally in this figure regardless of their abundance.

sites that coincide with the recommended size range for salmon spawning (1/2" to 4")(Reiser and Bjornn 1979; Lotspeich and Everest 1981; and Platts et al. 1983).

3.1.3 Groundwater Upwelling and Bank Seepage

The results of foot surveys that were conducted during the open-water season to confirm the presence or absence of groundwater upwelling or bank seepage at mainstem and side channel habitats are presented in Table 3. Of the 52 side channel sites that were surveyed during the open-water season, groundwater upwelling or bank seepage was observed at 29 (54%) side channels. Thirty-nine (75%) side channels had open leads during the winter. Four sites (14% of the sites with groundwater upwelling) had groundwater upwelling and no open leads on winter aerial photos of the sites. There were 15 sites (38% of the sites with open leads) that exhibited open leads in the winter but had no visible upwelling. Upwelling may be present in these sites but was not observed, possibly due to the difficult survey conditions. It appears that seven side channel sites have open leads that are all or partially controlled by water velocity.

Of the 25 mainstem sites that were surveyed during the open-water season, 11 (44%) had groundwater upwelling or bank seepage. Open leads were evident on aerial photos of 16 (64%) of the mainstem sites during the ice-covered period (Table 3). At 3 mainstem sites, groundwater upwelling was observed during the open-water season and no open leads were apparent on winter aerial photos. Eight sites (50% of those with open leads) had open leads during the ice-covered period and no evidence of groundwater upwelling observed during open-water sampling. This indicates that either upwelling is present but not observed possibly due to the difficult observation conditions present at mainstem sites, or that water velocity is the controlling factor. It appears that open leads in nine mainstem sites may be controlled, all or in part, by water velocity.

3.2 Ice-Covered Studies

3.2.1 Continuous Surface and Intragravel Water Temperature

Mean daily intragravel and surface water temperatures recorded by datapods at each sampling site in the middle reach of the Susitna River during the 1984-85 ice-covered sampling season indicate that similar trends occur for intragravel and surface water temperatures over time (Figures 13 through 28). In general, surface and intragravel water temperatures dropped in all sites from September through late October or early November. Then the temperatures rose slightly and stabilized. Intragravel water temperatures were generally warmer than surface water temperatures at this time. Intragravel water temperatures of 0°C or below were record in tributary, side channel, and mainstem spawning areas (Figures 13, 14, 15, 16, 17, 19, 22 and 23). No intragravel water temperatures less than or equal to 0°C were recorded at open lead areas in mainstem and side channel habitats where no spawning had occurred (Figures 25, 26 and 27).

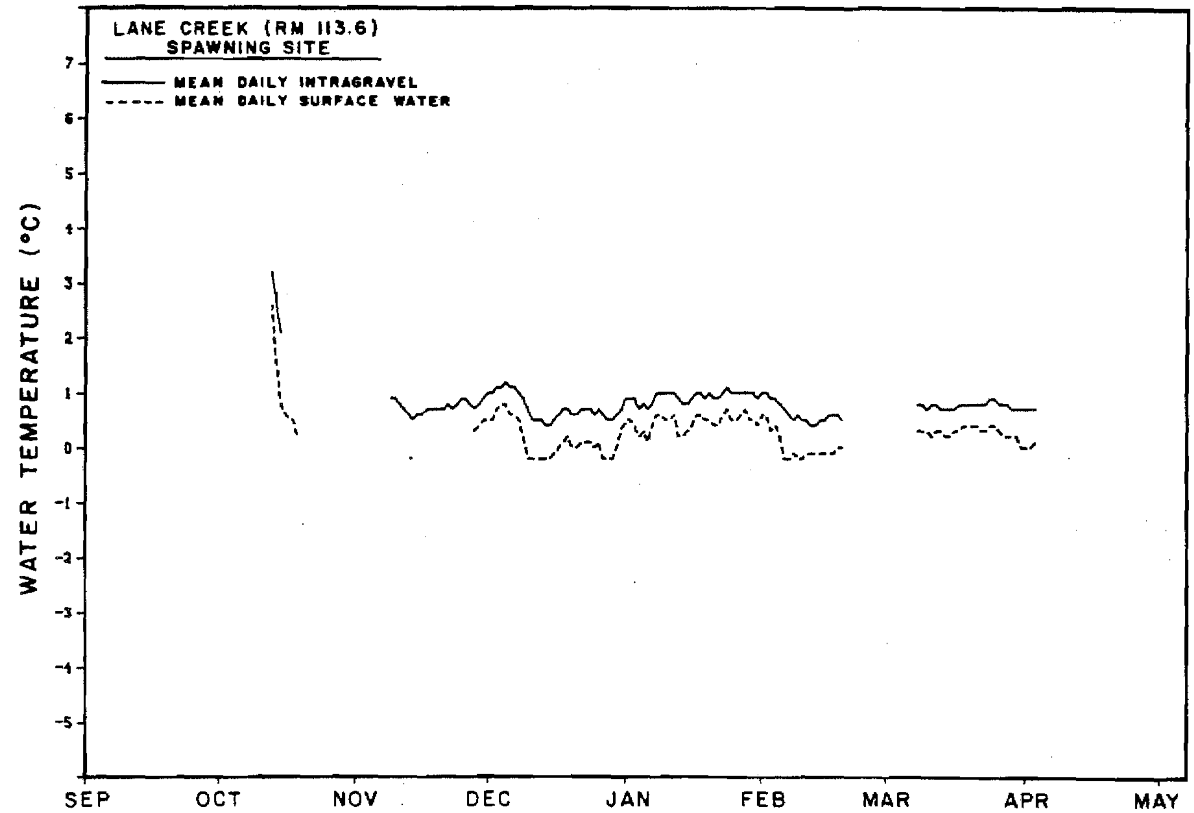


Figure 13. Mean daily intragravel and surface water temperatures (°C) recorded at Lane Creek, RM 113.6, TRM 0.1, during the ice-covered season, 1984-85.

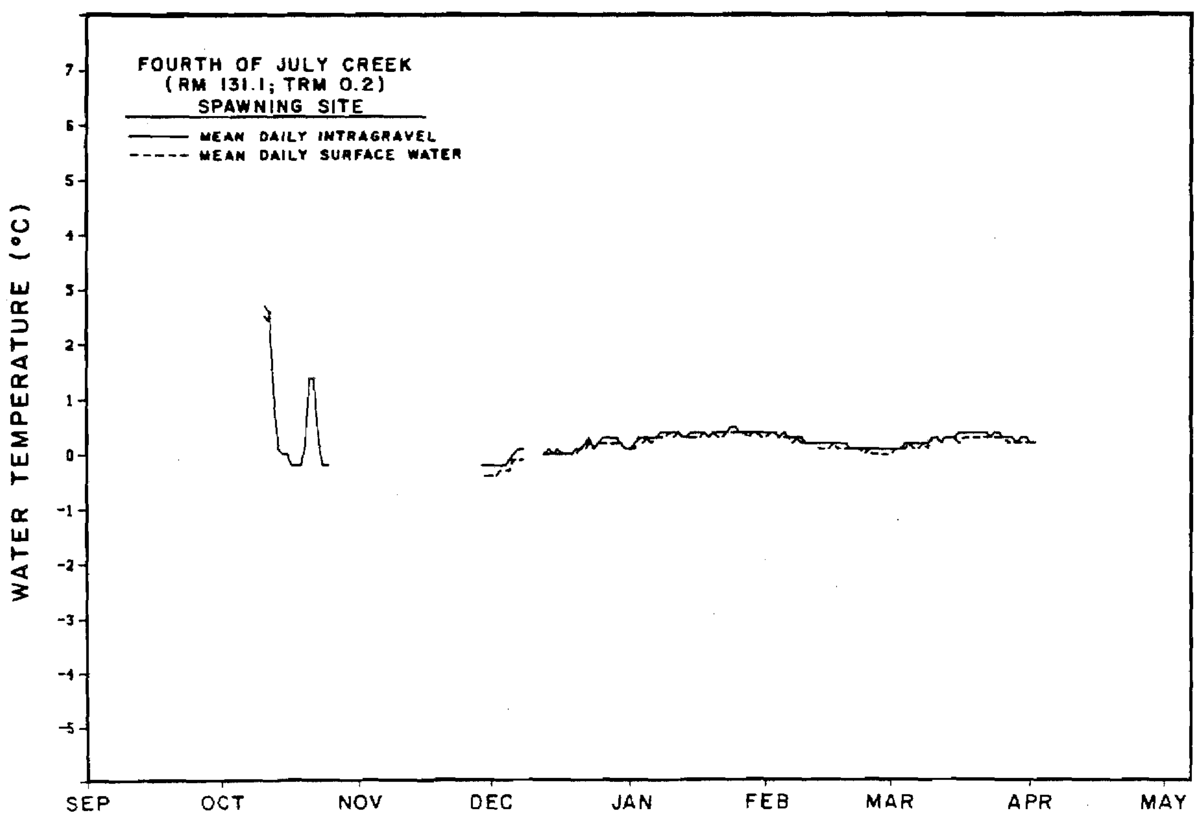


Figure 14. Mean daily intragravel and surface water temperatures (°C) recorded at Fourth of July Creek-Site 3, RM 131.1, TRM 0.2, during the ice-covered season, 1984-85.

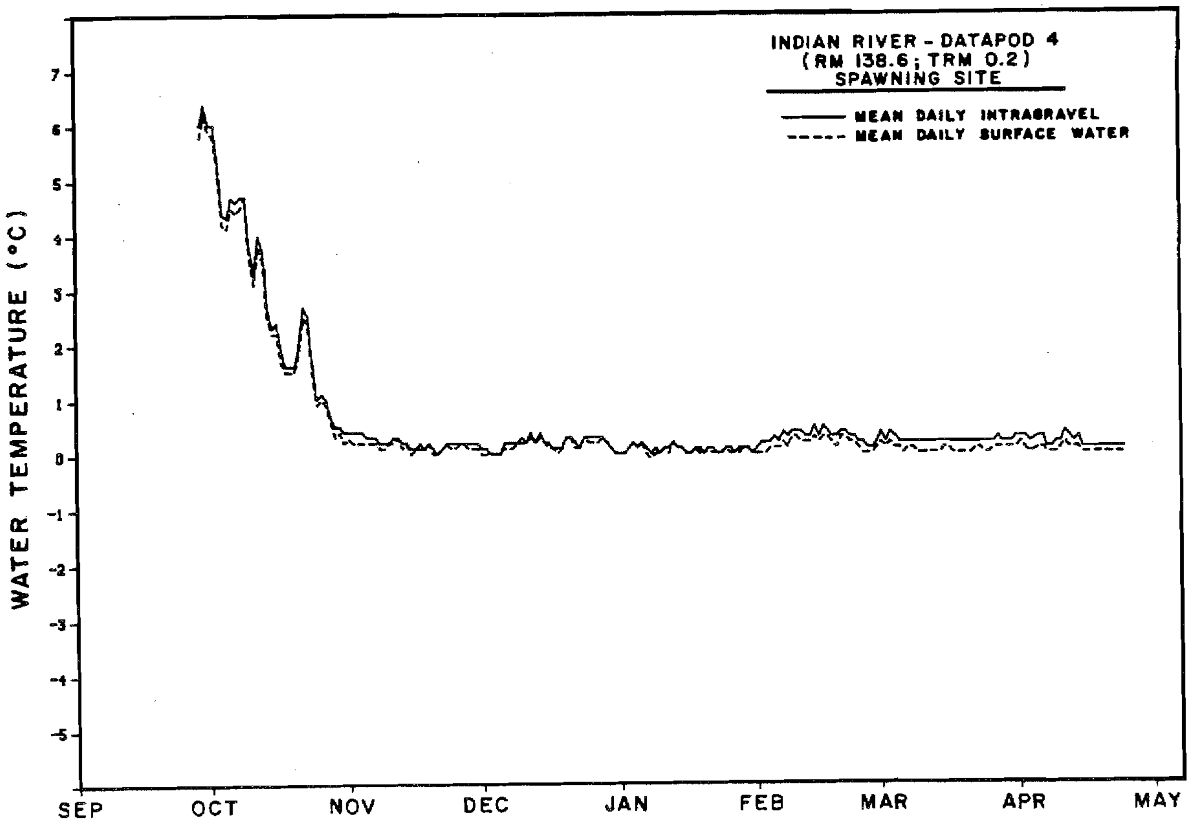


Figure 15. Mean daily intragravel and surface water temperatures (°C) recorded at Indian River-Site 4, RM 138.6, TRM 0.2, during the ice-covered season, 1984-85.

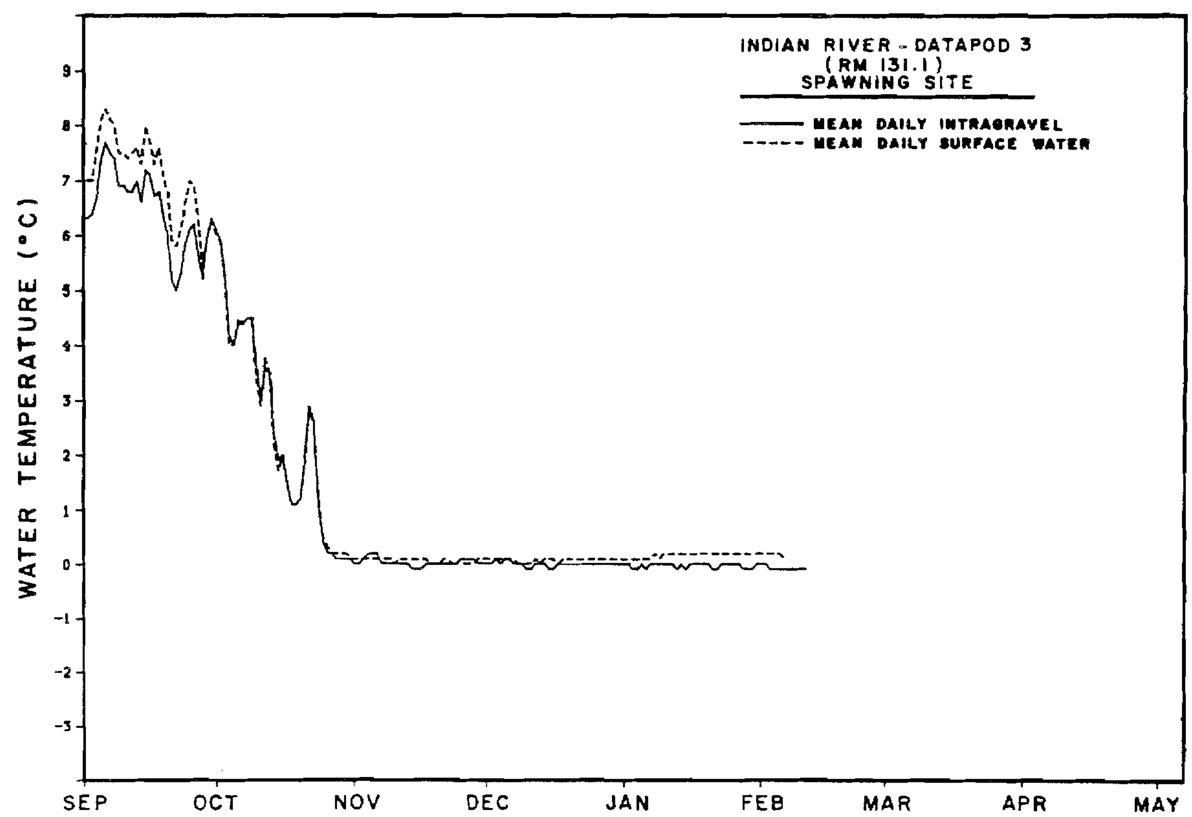


Figure 16. Mean daily intragravel and surface water temperatures (°C) recorded at Indian River-Site 4, RM 138.6, TRM 0.2, during the ice-covered season, 1984-85.

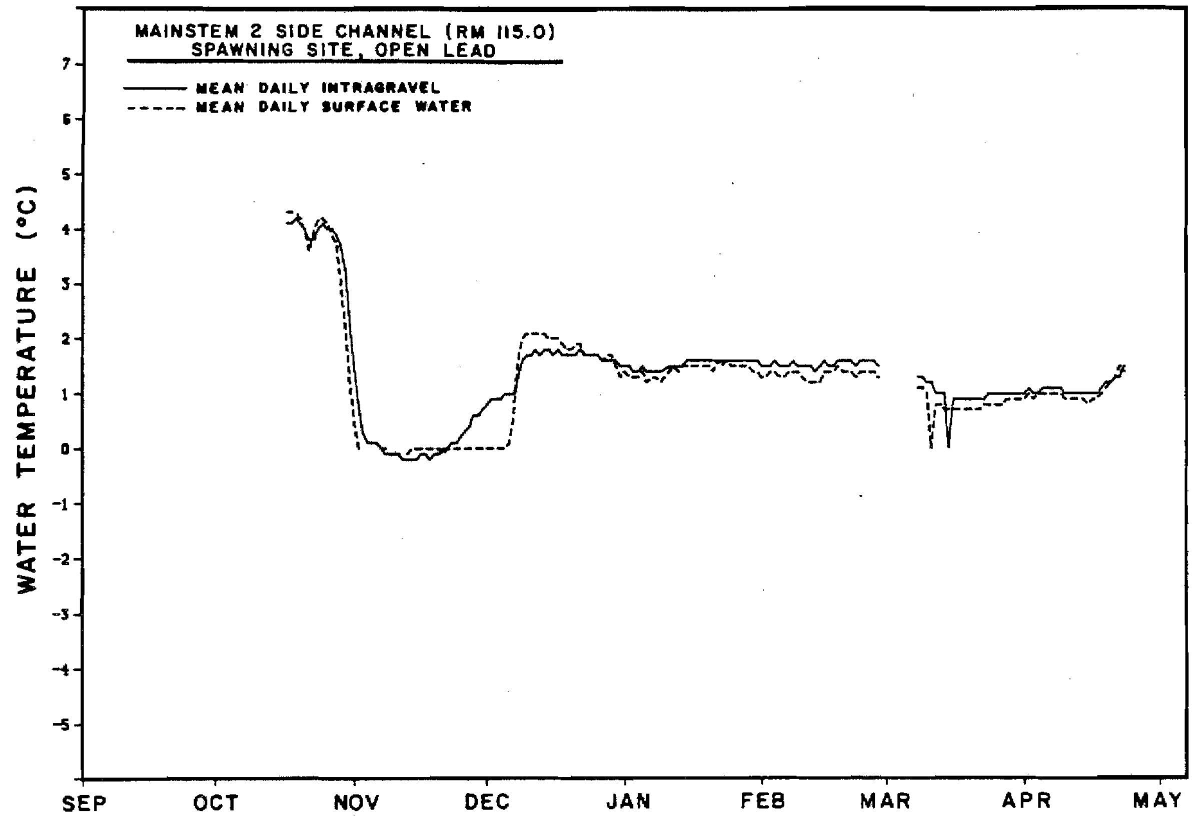


Figure 17. Mean daily intragravel and surface water temperatures (°C) recorded at Mainstem 2 Side Channel, RM 115.0, during the ice-covered season, 1984-85.

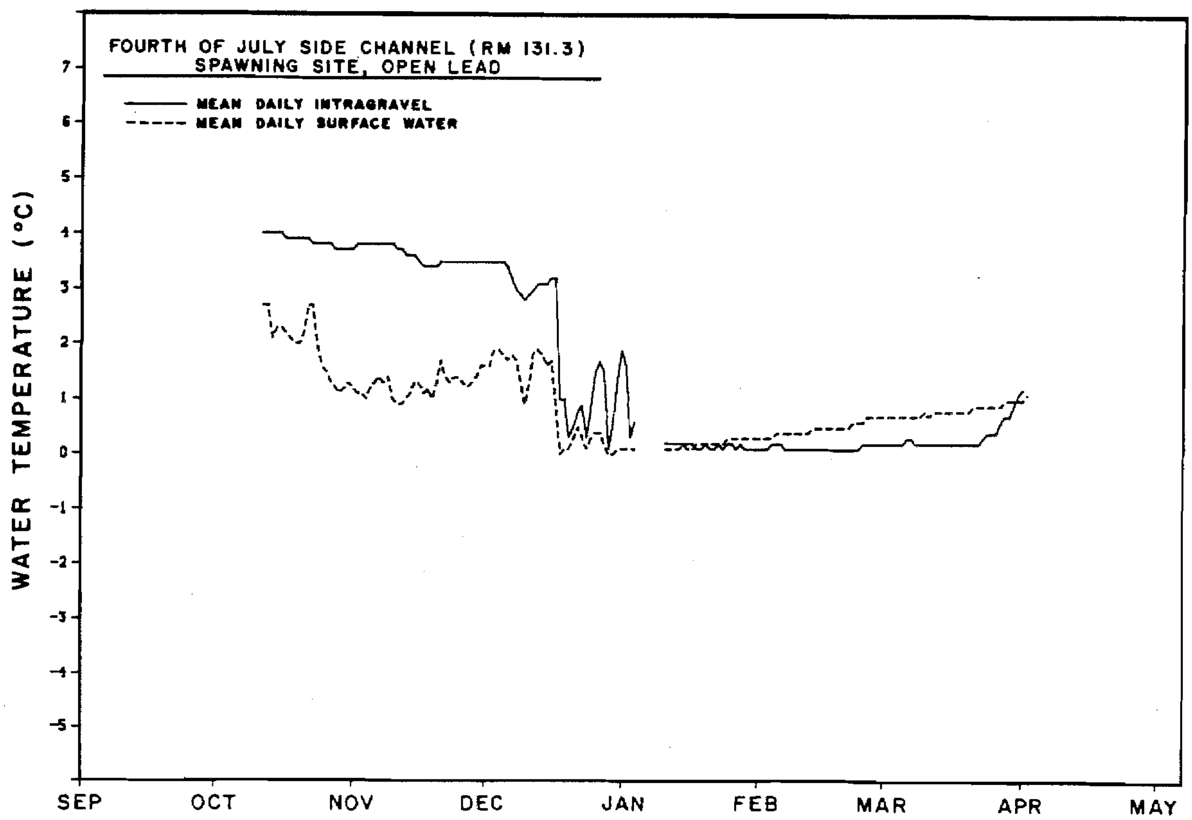


Figure 18. Mean daily intragravel and surface water temperatures (°C) recorded at the side channel RM 131.3, during the ice-covered season, 1984-85.

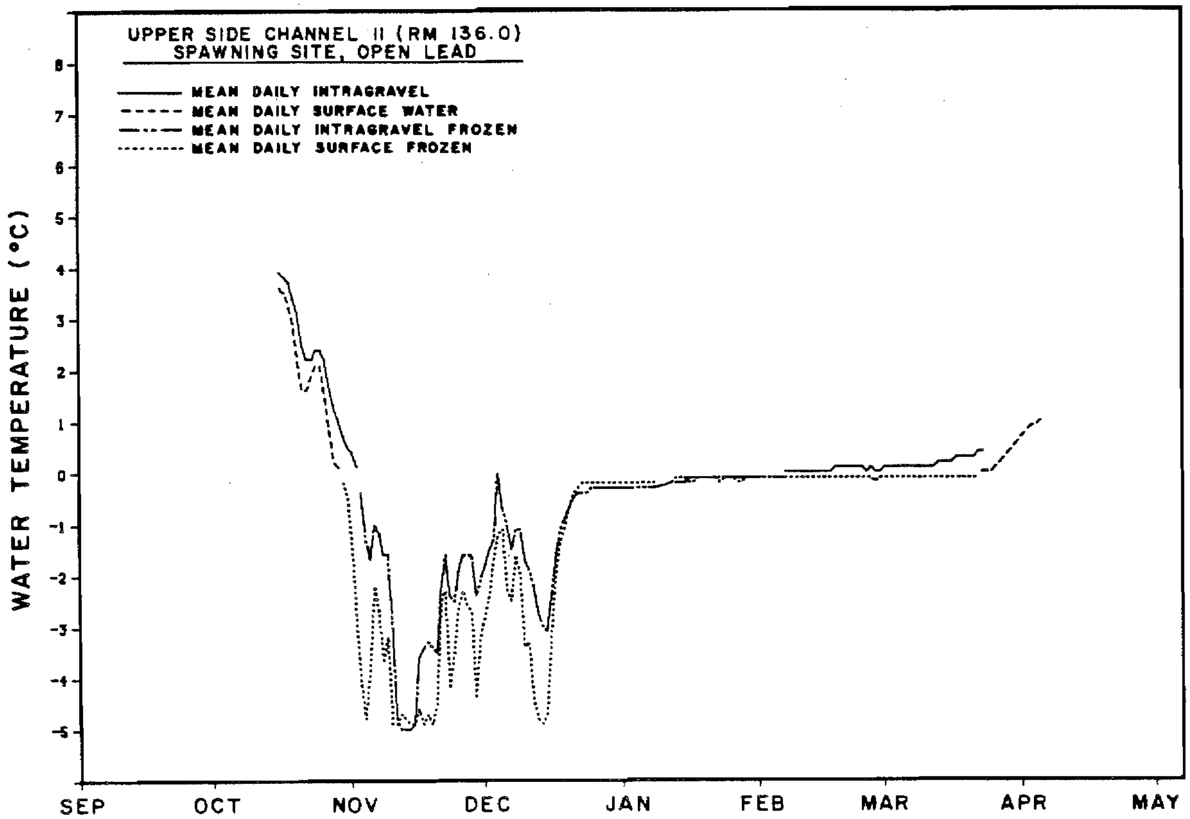


Figure 19. Mean daily intragravel and surface water temperatures (°C) recorded at Upper Side Channel 11 - Site 5, RM 131.3, during the ice-covered season, 1984-85.

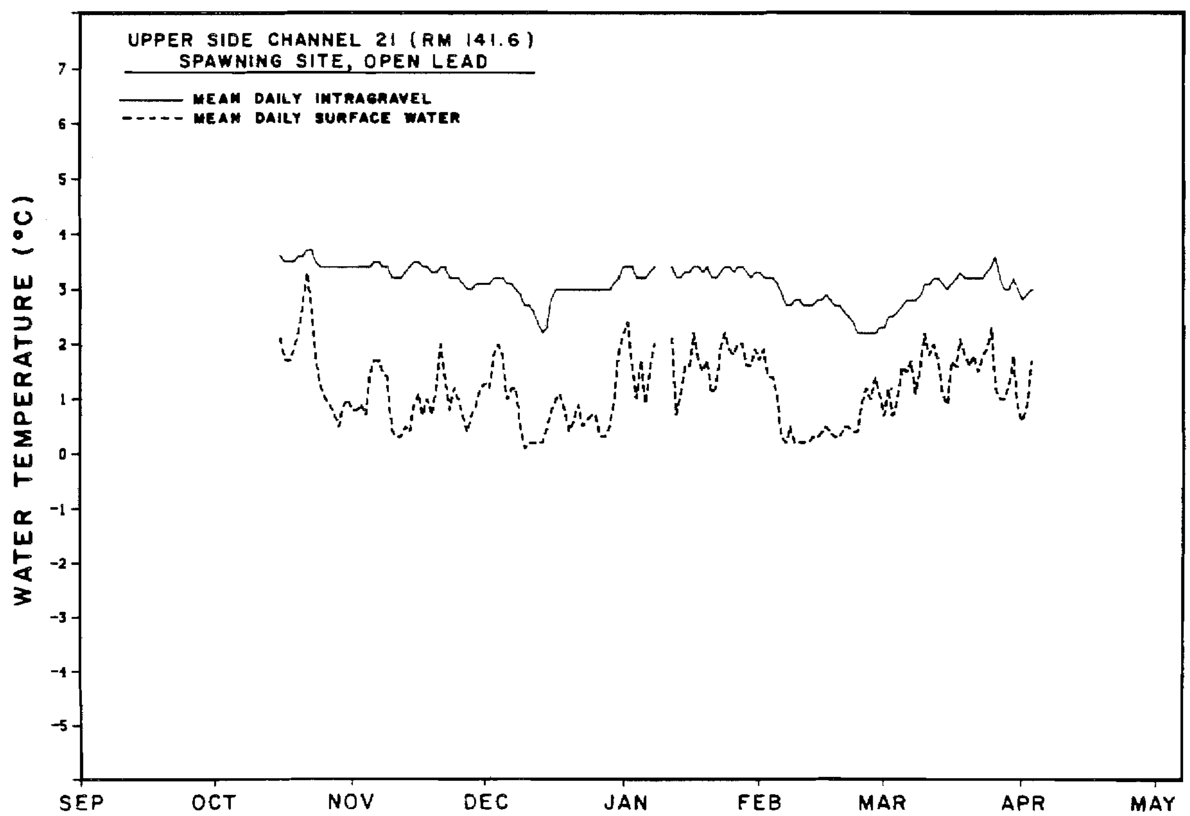


Figure 20. Mean daily intragravel and surface water temperatures (°C) recorded at Upper Side Channel 21, RM 141.6, during the ice-covered season, 1984-85.

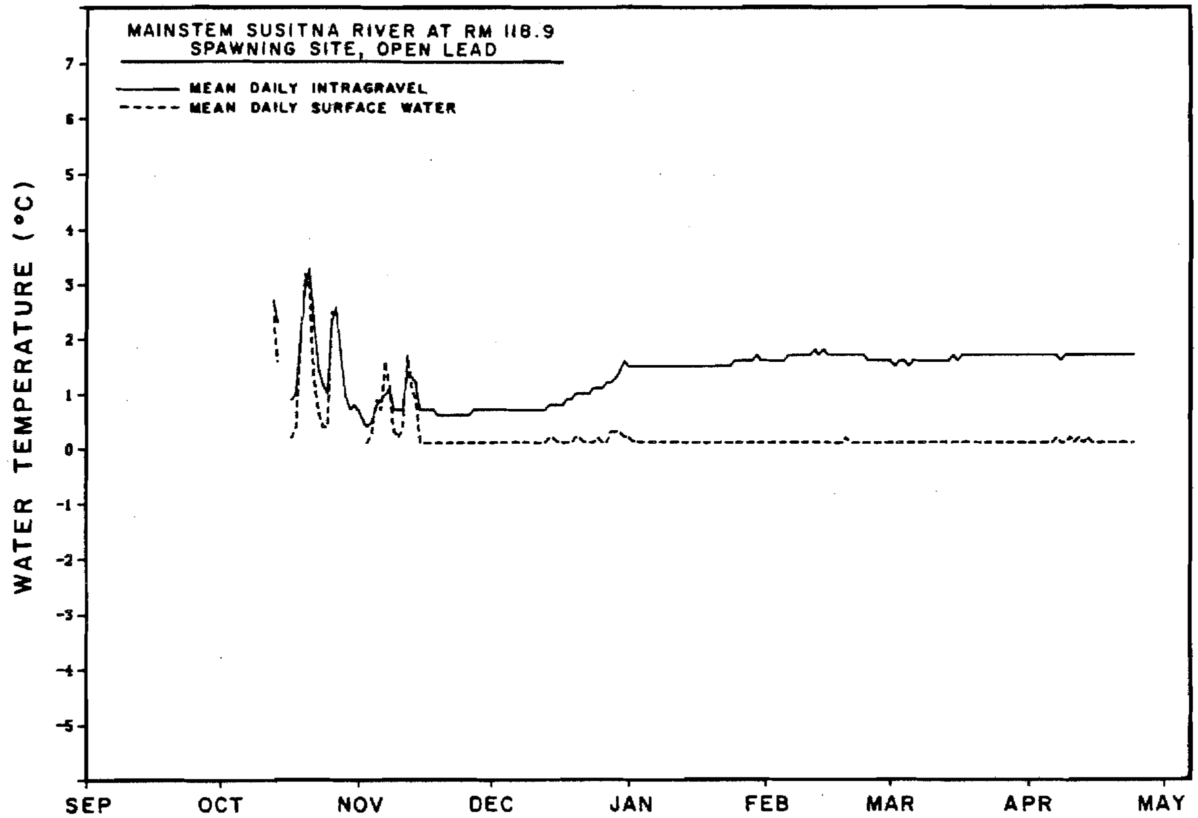


Figure 21. Mean daily intragravel and surface water temperatures (°C) recorded at Mainstem Susitna River, RM 118.9 during the ice-covered season, 1984-85.

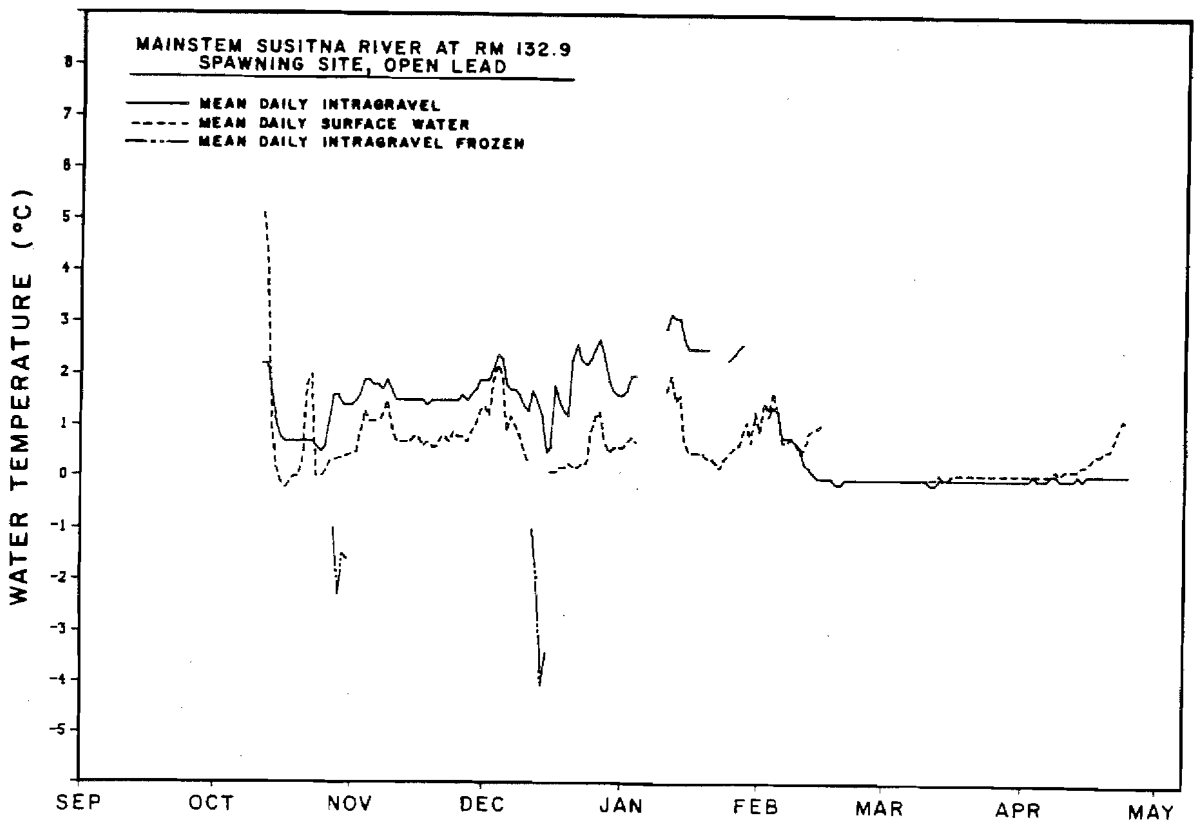


Figure 22. Mean daily intragravel and surface water temperatures (°C) recorded at Mainstem Susitna River below Slough 9A, RM 132.9, during the ice-covered season, 1984-85.

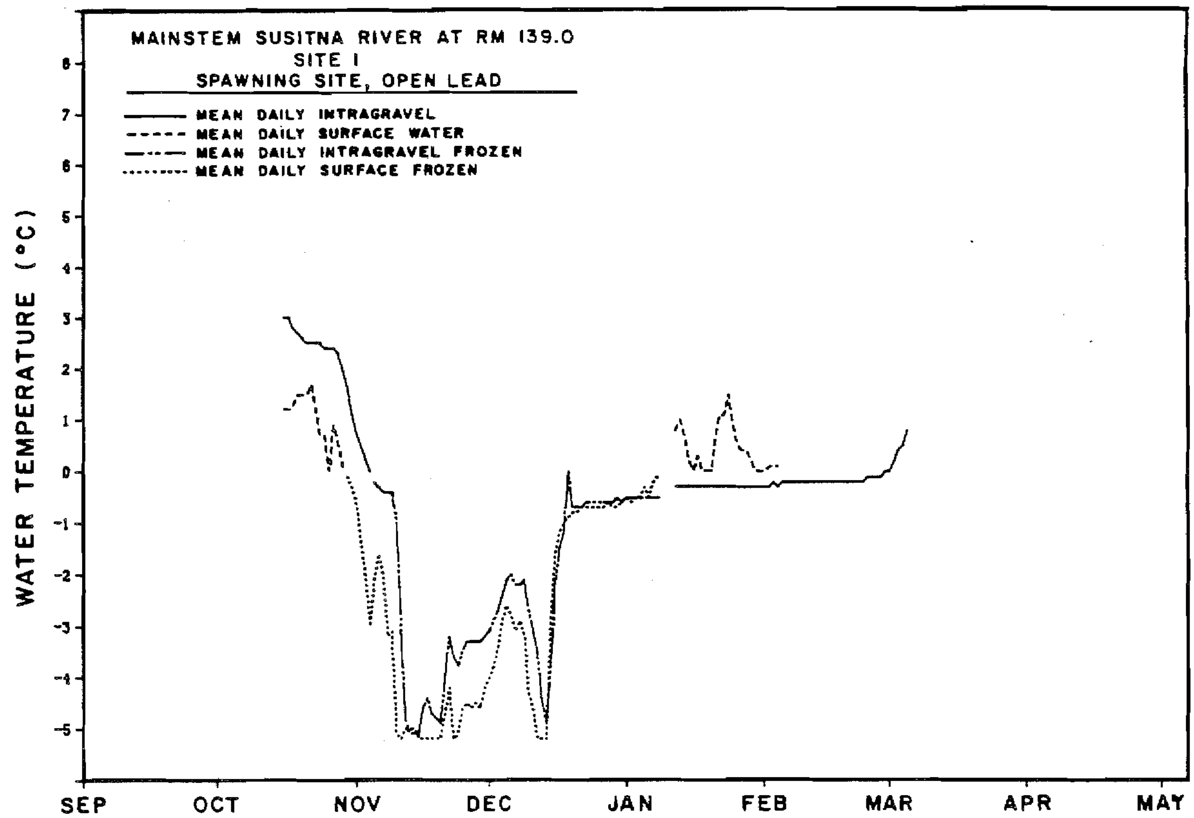


Figure 23. Mean daily intragravel and surface water temperatures (°C) recorded at Mainstem Susitna river, RM 139.0, Site 1, during the ice-covered season, 1984-85.

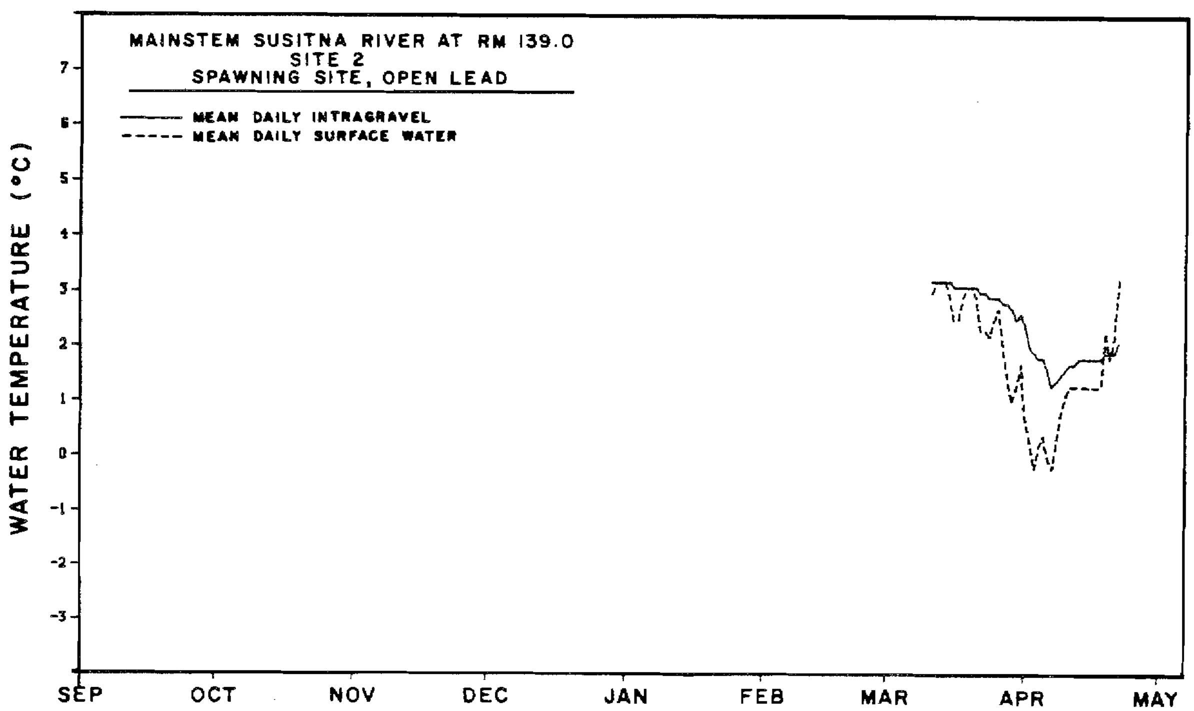


Figure 24. Mean daily intragravel and surface water temperatures (°C) recorded at Mainstem Susitna River, RM 139.0, Site 2, during the ice-covered season, 1984-85. Site 2 temperature probes were installed after Site 1 probes were damaged by ice movement.

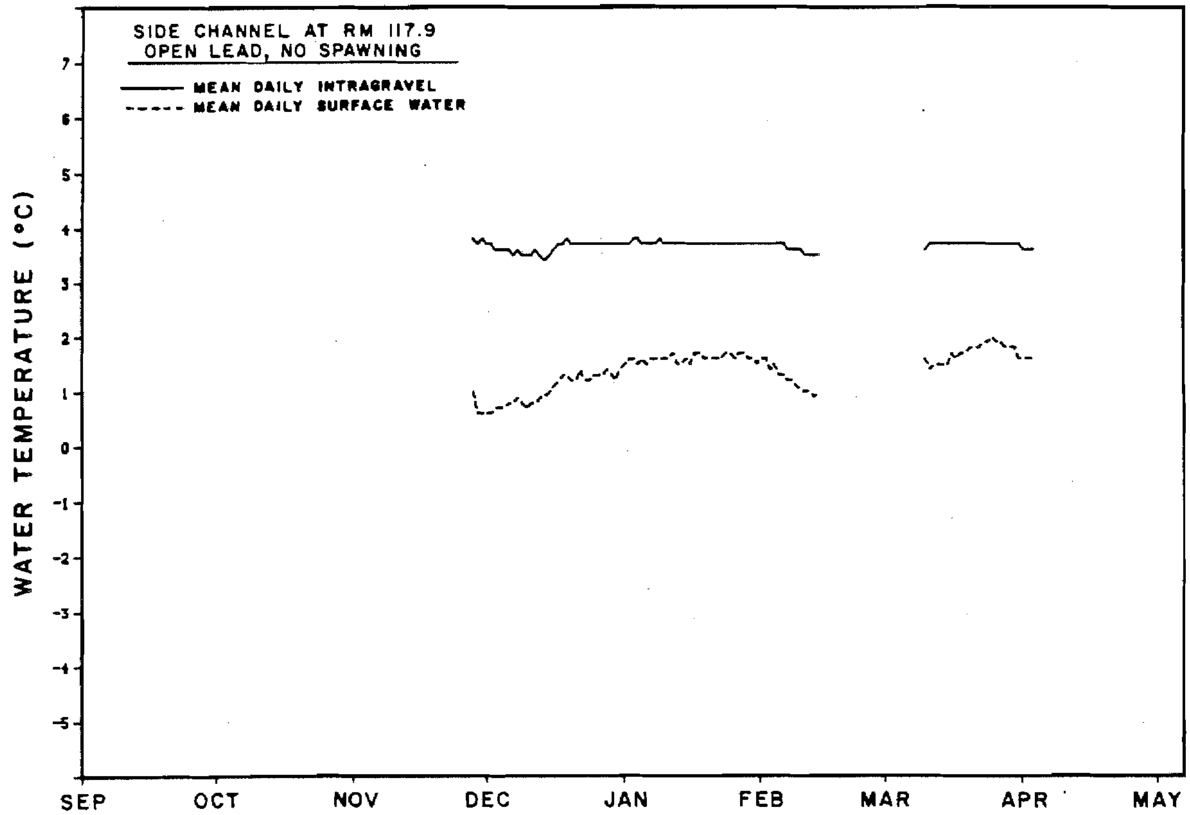


Figure 25. Mean daily intragravel and surface water temperatures (°C) recorded at the side channel at RM 117.9, during the ice-covered season, 1984-85.

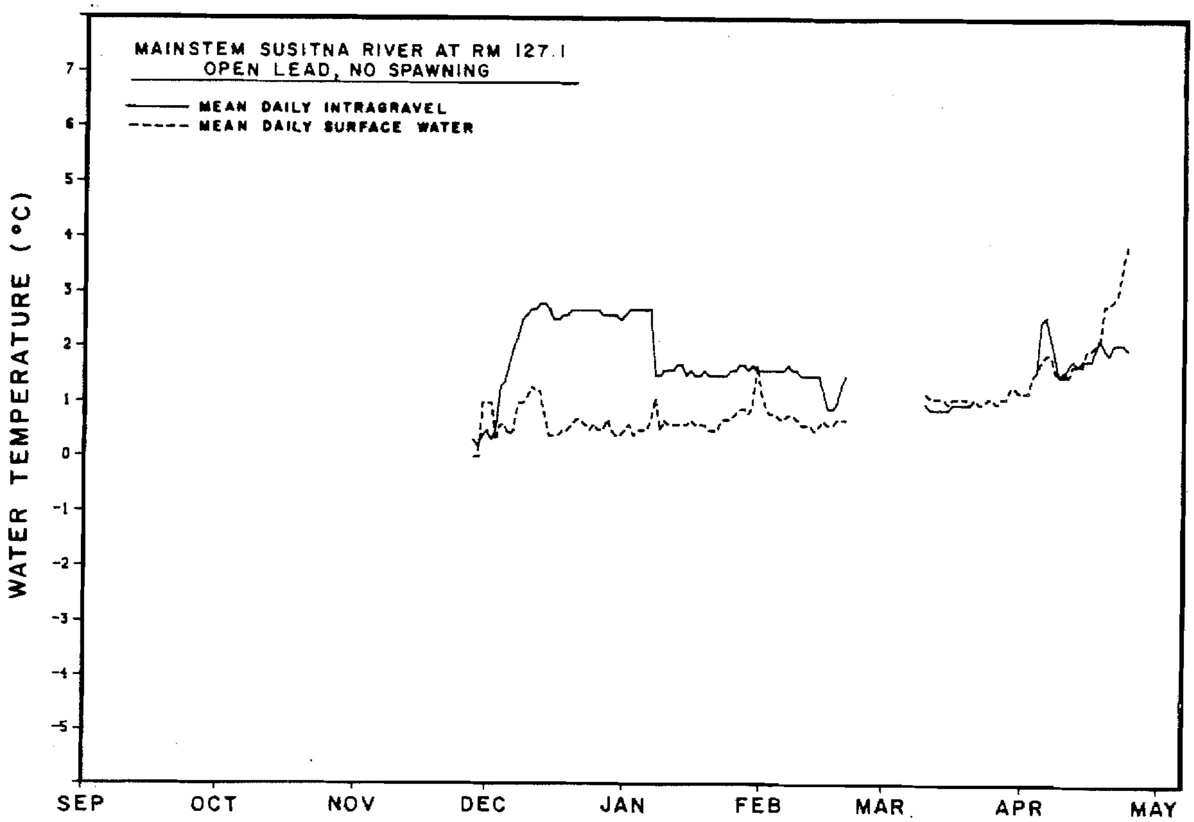


Figure 26. Mean daily intragravel and surface water temperatures (°C) recorded at Mainstem Susitna River, RM 127.1, during the ice-covered season, 1984-85.

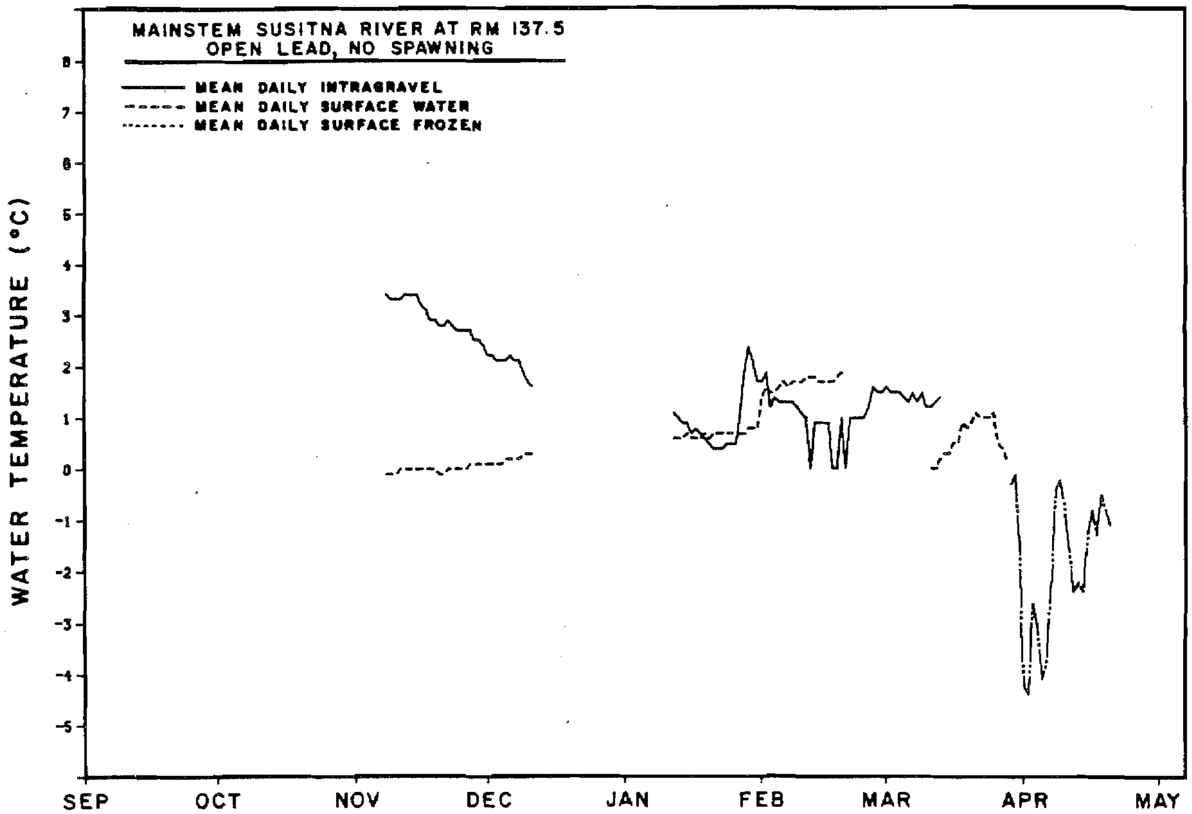


Figure 27. Mean daily intragravel and surface water temperatures (°C) recorded at Mainstem Susitna River, RM 137.5, during the ice-covered season, 1984-85.

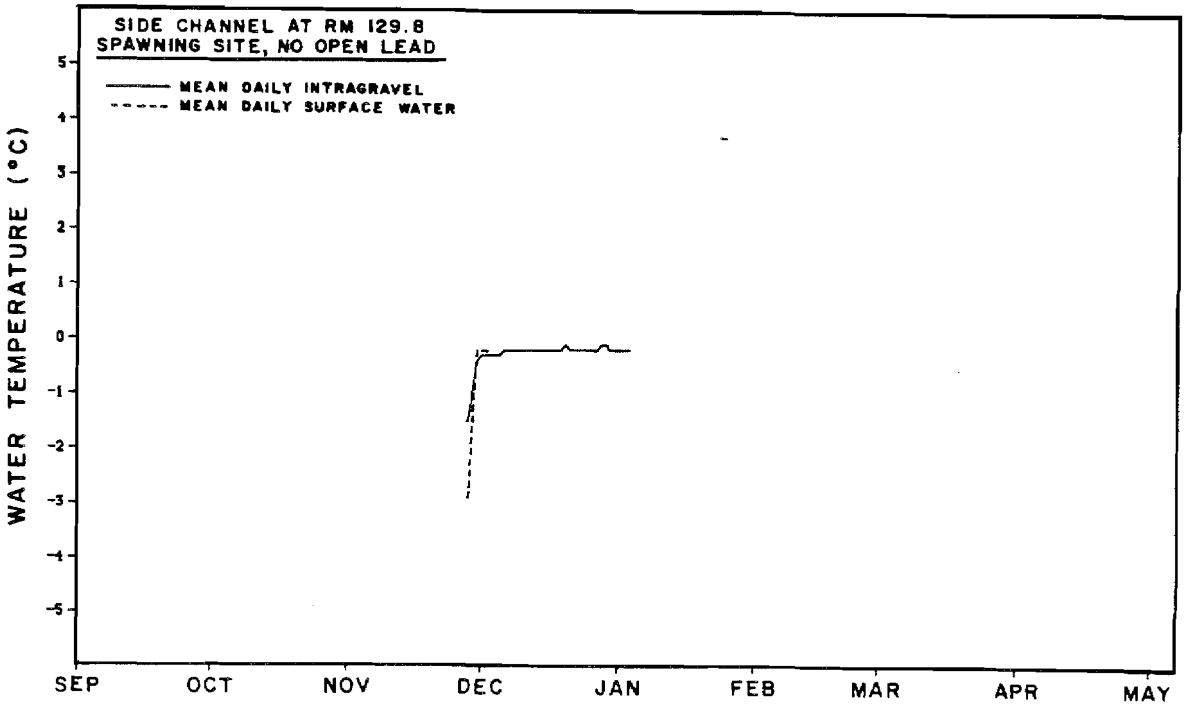


Figure 28. Mean daily intragravel and surface water temperatures (°C) recorded at the side channel at RM 129.8, during the ice-covered season, 1984-85. Data collected was limited due to dewatering and freezing.

Mean daily intragravel and surface water temperatures are summarized in boxplots (Figures 29 and 30). A complete presentation of these data are included in Keklak and Withrow (1985). The three sample periods correspond to the following general time frame: 1) Period I - the cooling period in the fall to freeze up; 2) Period II - the man ice-covered season; and 3) Period III - the warming period in the spring prior to break-up. In general, intragravel water temperatures were warmer than surface water temperatures in all site classifications, in each period. Areas of open leads with no spawning had the warmest intragravel and surface water temperatures during periods II and III. This indicates that water temperature does not appear to be a limiting factor for salmon spawning at these sites. Intragravel water temperatures are important to the incubation and development of salmon embryos and alevins at spawning areas during the winter (Vining et al. 1985). Water temperature and dissolved oxygen affect the rate of development, survival rate, and timing of emergence of incubating salmon embryos. Surface water temperature is important only to the extent that surface water influences intragravel water temperatures and as an indicator of upwelling.

3.2.2 Freeze Core Substrate Evaluations

The composition of substrate samples collected at all sites are presented in Table 4. Based on our limited sampling effort, the substrate composition of salmon spawning areas in tributary, side channel, and mainstem sites in this study were similar. The predominant substrates collected were greater than 2.0 mm in size and only a small percent of the substrates were less than 2.0 mm. The substrate composition of one sample collected at Lane Creek was different from the general trend observed. At this site, 53% of the substrate was less than 0.62 mm.

Mainstem and side channel sites that had open leads during the ice-covered season and no reported salmon spawning during open-water sampling, had slightly smaller substrates. The majority of substrates in these sites were between 2.0 mm and 127 mm. Only a small percentage of the substrates were either smaller than 2.0 mm or greater than 127 mm. It appears that there is a slight increase with depth in the percent of fines found in the samples. No freeze core substrate samples were collected at sites that had spawning but no open leads (i.e. Side Channel 129.8R) due to dewatering and freezing of the substrates.

The results of the substrate quality analysis (fredle index) are presented in Table 5. This analysis is based on the entire 16 inch freeze core sample at each site. No clear trends were obvious in substrate quality with depth, in any of the habitats. A general comparison of the four indices (geometric mean particle size, sorting coefficient, percent finer than 1.0 mm, and fredle index) of substrate composition between site classifications that were sampled yields the following results.

1. The average geometric mean particle size was largest in tributary habitats and smallest in areas of open leads and no spawning. Mainstem spawning habitats had an average geometric mean similar to that of areas with open leads and no spawning.

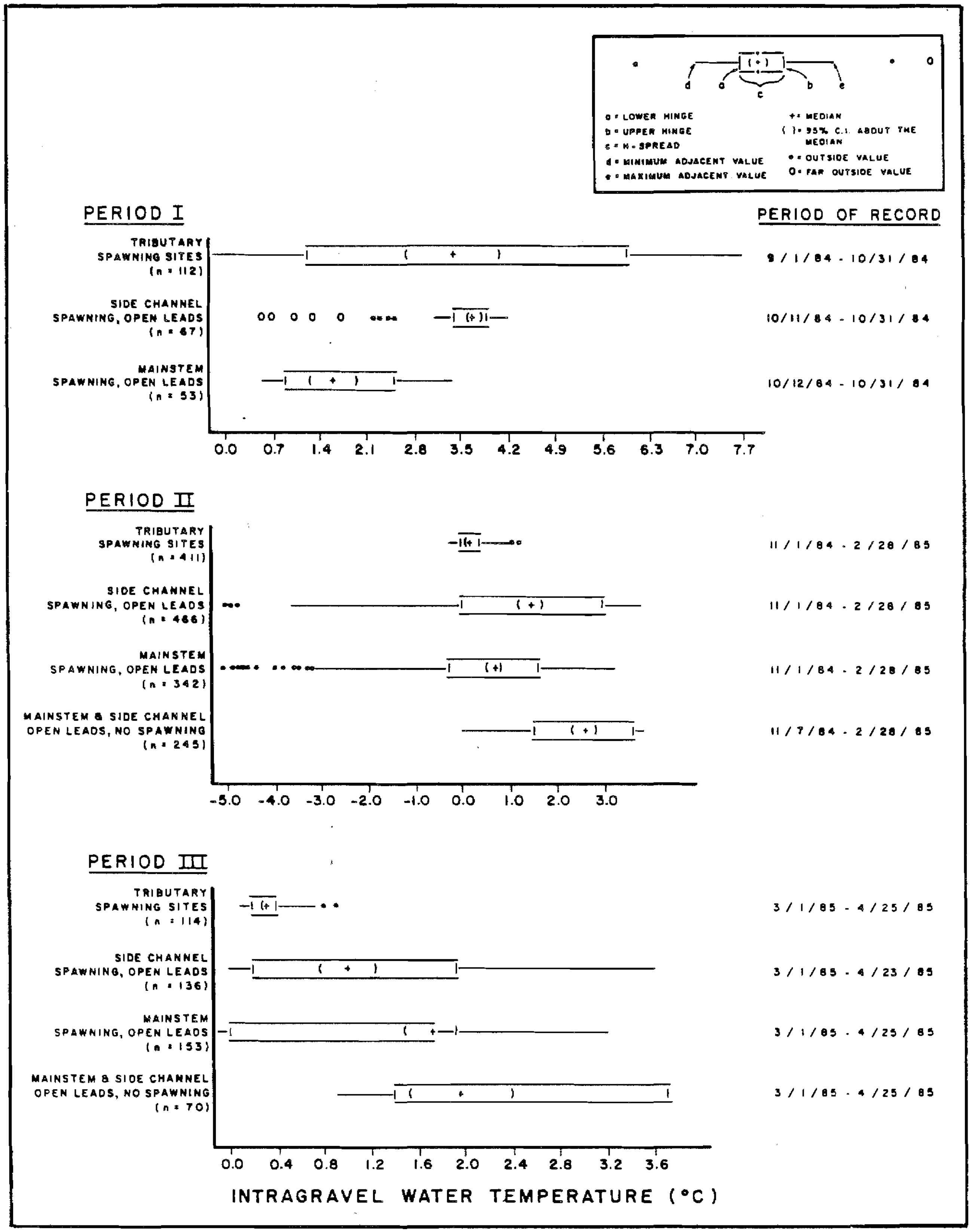


Figure 29. Boxplots of mean daily intragravel temperature data from the middle Susitna River summarized by sampling period and site classification, 1984-85 ice-covered season. Data from the site with spawning but no open lead was insufficient for analysis.

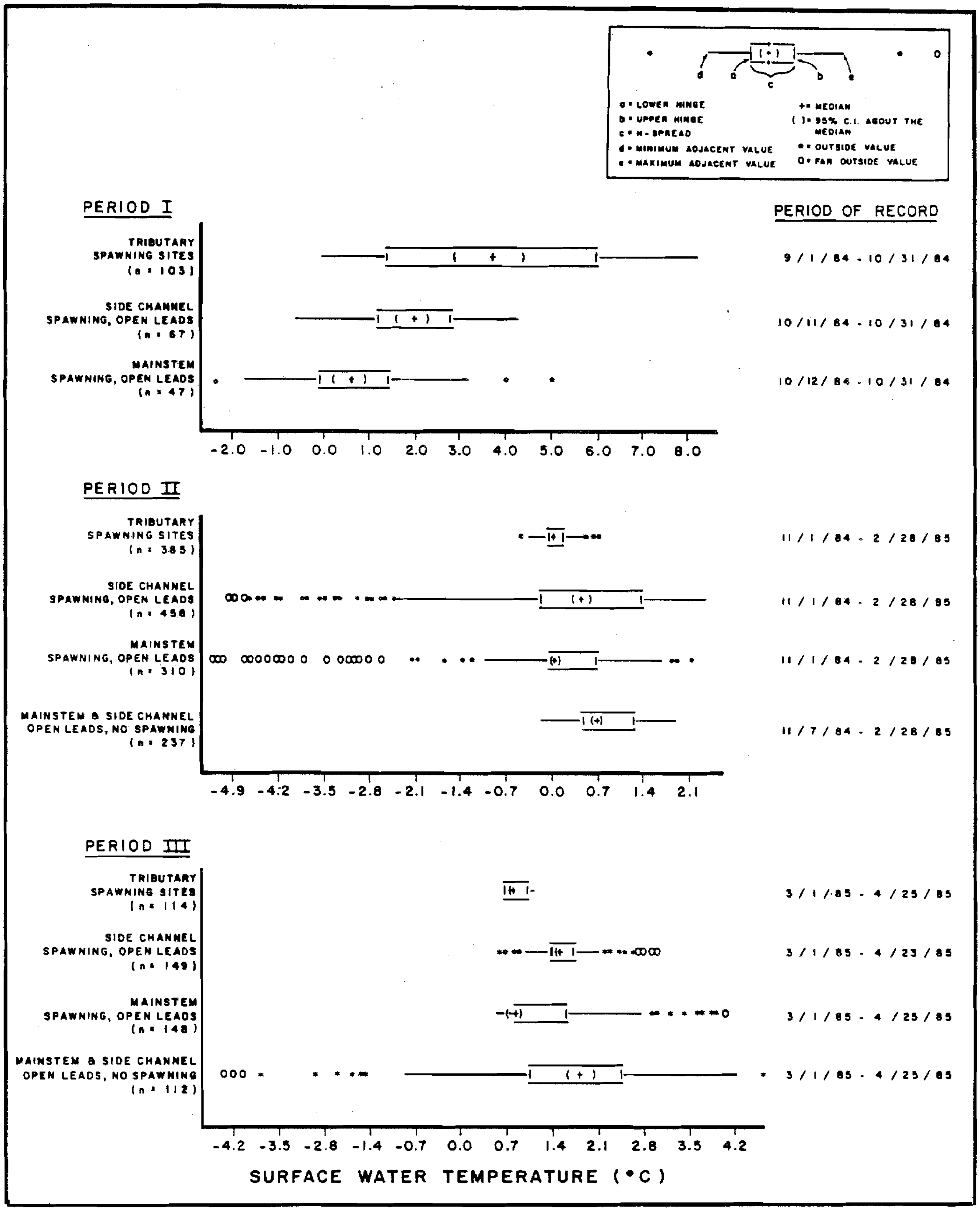


Figure 30. Boxplots of mean daily surface water temperature data from the middle Susitna River summarized by sampling period and site classification, 1984-85 ice-covered season. Data from the site with spawning but no open lead was insufficient for analysis.

Table 4. Substrate composition of freeze core samples collected at datapod sites in the middle Susitna River, April and May 1985.

Site (River mile)	Area[a]	Sampling Date (y/m/d)	Total Dry wt. (g)	>127 Dry wt. (g)	>127 % Tot.	127-76.2 Dry wt. (g)	127-76.2 % Tot.	76.2-25.4 Dry wt. (g)	76.2-25.4 % Tot.	25.4-2.0 Dry wt. (g)	25.4-2.0 % Tot.	2.0-0.84 Dry wt. (g)	2.0-0.84 % Tot.	0.84-0.5 Dry wt. (g)	0.84-0.5 % Tot.	0.5-0.062 Dry wt. (g)	0.5-0.062 % Tot.	<0.062 Dry wt. (g)	<0.062 % Tot.
Lane Creek (113.6R) TRM 0.1	1A	850411	22325	19374	87	0	0	1289	6	809	4	233	1	112	1	141	1	367	2
	2A	850411	5446	0	0	2397	44	1594	29	1117	21	149	3	54	1	108	2	27	0
	3A	850411	9979	0	0	1976	20	956	10	1301	13	257	3	61	1	93	1	5335	53
	1B	850411	2907	0	0	0	0	1887	65	596	21	145	5	95	3	142	5	42	1
	2B	850411	22777	17281	76	3383	15	879	4	872	4	179	1	70	0	84	0	29	0
	3B	850411	3037	0	0	0	0	1390	46	1079	36	187	6	105	3	164	5	112	4
Fourth of July[b] Creek (131.1L) TRM 0.2	2A	850424	9366	3969	42	0	0	4177	45	903	10	153	2	60	1	85	1	19	0
	2B	850424	6090	0	0	4023	66	902	15	709	12	189	3	78	1	139	2	50	1
Indian River Site 4 (138.6L) TRM 0.2	1A	850417	3817	0	0	0	0	2240	59	1242	33	157	4	75	2	93	2	10	0
	2A	850417	6540	2987	46	0	0	1335	20	1393	21	354	5	267	4	193	3	11	0
	3A	850417	6250	0	0	0	0	2899	46	2320	37	424	7	212	3	253	4	142	2
	1B	850417	4227	0	0	1612	38	1548	37	773	18	135	3	67	2	79	2	13	0
	2B	850417	12823	0	0	9443	74	1326	10	1496	12	236	2	112	1	197	2	13	0
	3B	850417	14700	9436	64	0	0	2633	18	2012	14	170	1	168	1	260	2	21	0
Indian River Site 3 (138.6L) TRM 0.2	1A	850417	12845	8694	68	774	6	1767	14	1024	8	158	1	55	0	49	0	324	3
	2A	850417	15311	11188	73	0	0	2461	16	1290	8	199	1	83	1	79	1	11	0
	3A	850417	14348	10868	76	1079	8	1864	13	505	4	10	0	5	0	10	0	7	0
	1B	850417	30563	24435	80	0	0	3440	11	1962	6	390	1	160	1	141	0	35	0
	2B	850417	17148	12077	70	1281	7	1510	9	1690	10	342	2	116	1	110	1	22	0
	3B	850417	6276	0	0	1301	21	3746	60	944	15	129	2	73	1	71	1	12	0
Mainstem 2 Side Channel (115.0R)	1A	850403	7861	0	0	3090	39	2928	37	1033	13	100	1	30	0	544	7	136	2
	2A	850403	8884	0	0	1477	17	3252	37	2352	26	307	3	124	1	947	11	425	5
	3A	850403	1603	0	0	0	0	1010	63	406	25	25	2	8	0	114	7	40	2
	1B	850403	2795	0	0	0	0	1269	45	1210	43	95	3	27	1	165	6	29	1
	2B	850403	7132	0	0	0	0	3299	46	2353	33	182	3	205	3	960	13	133	2
	3B	850403	8724	0	0	5677	65	1527	18	999	11	123	1	40	0	302	3	56	1

Substrate size classes (mm)

Table 4 (Continued).

Site (River mile)	Area	Sampling Date (y/m/d)	Total: Dry wt. (g)	>127: Dry wt. (g)	>127: % Tot.	127-76.2: Dry wt. (g)	127-76.2: % Tot.	76.2-25.4: Dry wt. (g)	76.2-25.4: % Tot.	25.4-2.0: Dry wt. (g)	25.4-2.0: % Tot.	2.0-0.84: Dry wt. (g)	2.0-0.84: % Tot.	0.84-0.5: Dry wt. (g)	0.84-0.5: % Tot.	0.5-0.062: Dry wt. (g)	0.5-0.062: % Tot.	<0.062: Dry wt. (g)	<0.062: % Tot.
Side Channel at Fourth of July Creek (131.3L)	1A	840429	7517	0	0	0	0	5015	67	2154	29	96	1	38	1	160	2	54	1
	2A	840429	5233	0	0	1993	38	887	17	1357	26	470	9	200	4	272	5	54	1
	3A	840429	18058	12157	67	685	4	3350	19	1005	6	84	0	35	0	543	3	199	1
	1B	840429	20428	14817	73	2207	11	2133	10	821	4	129	1	52	0	193	1	76	0
	2B	840429	6333	0	0	1500	24	2861	45	1391	22	266	4	121	2	167	3	27	0
	3B	840429	6741	0	0	2720	40	1912	28	1269	19	259	4	109	2	375	6	97	1
Side Channel 21 (141.6R)	1A	840424	13962	6151	44	919	7	4218	30	1668	12	286	2	215	2	477	3	28	0
	2A	840424	15822	9988	63	0	0	3532	22	1682	11	218	1	84	1	285	2	33	0
	3A	840424	25450	20250	80	1532	6	2123	8	1211	5	161	1	57	0	94	0	22	0
	1B	840424	10431	0	0	6200	59	1901	18	1324	13	243	2	118	1	552	5	93	1
	2B	840424	5293	1709	32	0	0	2273	43	840	16	112	2	60	1	243	5	56	1
	3B	840424	19797	11250	57	5928	30	999	5	1146	6	204	1	88	0	160	1	22	0
Susitna River at 118.9L (118.9L)	1A	850411	11053	4189	38	1082	10	3905	35	1161	11	107	1	51	0	396	4	162	1
	2A	850411	4241	0	0	0	0	2176	51	1489	35	99	2	40	1	389	9	48	1
	3A	850411	14203	0	0	11864	84	797	6	840	6	114	1	58	0	410	3	120	1
	1B	850411	2890	0	0	0	0	1218	42	1250	43	127	4	35	1	180	6	80	3
	2B	850411	4322	3110	72	0	0	142	3	708	16	102	2	28	1	185	4	47	1
	3B	850411	6747	2780	41	0	0	2149	32	1176	17	146	2	56	1	396	6	44	1
Susitna River at 132.9R (132.9R)	1A	850424	7398	0	0	0	0	4754	64	1643	22	256	3	137	2	496	7	112	2
	2A	850424	12689	3467	27	1668	13	3799	30	2235	18	338	3	269	2	781	6	132	1
	3A	850424	6519	0	0	2372	36	2215	34	1517	23	75	1	40	1	269	4	31	0
	1B	850424	15561	11018	71	0	0	2952	19	1095	7	0	0	148	1	291	2	57	0
	2B	850424	12034	5107	42	2118	18	1803	15	1955	16	277	2	185	2	430	4	159	1
	3B	850424	6726	0	0	2403	36	2508	37	1312	20	100	1	44	1	284	4	75	1
Susitna River at 139.0L (139.0L)	1A	850417	2233	0	0	0	0	1058	47	915	41	123	6	44	2	82	4	11	0
	2A	850417	11017	0	0	5603	51	3298	30	1333	12	163	1	66	1	478	4	76	1
	3A	850417	15997	9982	62	2212	14	2307	14	1223	8	102	1	49	0	101	1	21	0
	1B	850417	2987	0	0	0	0	1973	66	766	26	97	3	40	1	91	3	20	1
	2B	850417	9836	0	0	6508	66	1286	13	1132	12	222	2	152	2	529	5	7	0
	3B	850417	9207	0	0	5143	56	2177	24	1127	12	208	2	138	1	355	4	59	1

Substrate size classes (mm)

Table 4 (Continued).

Site (River mile)	Area	Sampling Date (y/m/d)	Total Dry wt. (g)	>127 Dry wt. (g)	>127 % Tot.	127-76.2 Dry wt. (g)	127-76.2 % Tot.	76.2-25.4 Dry wt. (g)	76.2-25.4 % Tot.	25.4-2.0 Dry wt. (g)	25.4-2.0 % Tot.	2.0-0.84 Dry wt. (g)	2.0-0.84 % Tot.	0.84-0.5 Dry wt. (g)	0.84-0.5 % Tot.	0.5-0.062 Dry wt. (g)	0.5-0.062 % Tot.	<0.062 Dry wt. (g)	<0.062 % Tot.
Side Channel	1A	850410	7281	0	0	1900	26	3774	52	953	13	91	1	52	1	416	6	95	1
at 117.9L	2A	850410	1309	0	0	0	0	588	45	405	31	53	4	26	2	218	17	19	1
(117.9L)	3A	850410	14793	12236	83	0	0	1391	9	719	5	37	0	14	0	318	2	78	1
	1B	850410	7375	0	0	2953	40	1837	25	1526	21	190	3	99	1	583	8	187	3
	2B	850410	1780	0	0	0	0	763	43	651	37	47	3	26	1	243	14	50	3
	3B	850410	1864	0	0	0	0	504	27	937	50	121	6	48	3	215	12	39	2
Susitna River[b]	1A	850425	4411	0	0	0	0	1869	42	1909	43	77	2	34	1	486	11	36	1
at 127.1C	2A	850425	3273	0	0	0	0	216	7	2143	65	246	8	105	3	443	14	120	4
(127.1C)	1B	850425	15813	12556	79	0	0	2511	16	158	1	70	0	61	0	413	3	44	0
	2B	850425	2151	0	0	0	0	157	7	1065	50	118	5	148	7	651	30	12	1
Upper Side[b]	1A	850501	16581	6427	39	6409	39	1453	9	1152	7	240	1	133	1	599	4	168	1
Channel 11	2A	850501	2624	0	0	0	0	821	31	887	34	472	18	179	7	240	9	25	1
at 136.0R	1B	850501	4942	0	0	0	0	2630	53	1537	31	316	6	94	2	257	5	108	2
(136.0R)	2B	850501	9645	0	0	5737	59	2464	26	939	10	206	2	79	1	174	2	46	0
Susitna River	1A	850501	30925	19344	63	2500	8	213	1	3423	11	792	3	654	2	1199	4	2800	9
at 137.5L	2A	850501	11641	0	0	5305	46	2664	23	2277	20	289	2	296	3	673	6	137	1
(137.5L)	3A	850501	6613	0	0	827	13	2060	31	2428	37	267	4	182	3	709	11	140	2
	1B	850501	15674	0	0	11893	76	1396	9	1549	10	272	2	169	1	277	2	118	1
	2B	850501	7780	0	0	4777	61	599	8	1340	17	201	3	132	2	622	8	109	1
	3B	850501	9736	0	0	5870	60	832	9	1837	19	321	3	279	3	483	5	114	1

Substrate size classes (mm) apply to all columns from >127 through <0.062.

[a] The numbers identify the three freeze core samples taken at each site and their relative location - (1) furthest downstream, (2) near data pod, and (3) furthest upstream. The letters identify the upper (A) and lower (B) 8 inch subsamples of the 16 inch freeze core samples that were taken at each site.

[b] Limited data due to difficult sampling conditions (i.e. frozen substrate or core stripping of the probes).

Table 5. Summary of substrate quality analysis of freeze core samples obtained at selected sites in the middle reach of the Susitna River, 1984-85.

Site Classification	Site	Sample Size	Mean Total Sample Weight (gm)	Geometric Mean Particle Size (mm)	Sorting Coefficient	Fredle Index	Percent Finer Than 1.0 mm
Tributary Spawning Areas	Lane Creek	3	2215.70	86.80	13.16	52.69	16.94
	4th of July Creek[a]	1	1546.00	64.60	1.83	35.35	3.09
	Indian River #3	3	3216.37	128.92	1.88	71.09	1.47
	Indian River #4	3	1611.90	47.32	2.40	20.86	4.88
Side Channel Spawning Areas with Open Leads	Mainstem 2	3	1233.30	27.89	2.35	14.00	10.83
	Side Channel at 4th of July Creek	3	2143.67	66.64	2.42	27.93	5.33
	Upper Side Channel 11 #1[a]	1	2152.00	55.84	2.21	25.25	6.67
	Upper Side Channel 11 #2[a]	1	1227.00	34.82	2.08	16.75	6.82
	Side Channel 21	3	3025.17	97.75	2.07	51.19	3.76
Mainstem Spawning Areas with Open Leads	Susitna River at 118.9L	3	1448.53	47.76	2.62	23.09	7.00
	Susitna River at 132.9R	3	2030.90	50.62	2.59	19.45	6.54
	Susitna River at 139.0L	3	1709.23	50.85	1.90	26.93	5.22
Side Channel and Mainstem Sites with Open Lead and No Spawning	Side Channel at 117.9L	3	1146.73	50.86	2.54	23.57	11.24
	Susitna River at 127.1C #1[a]	1	2022.00	90.86	2.51	36.15	5.41
	Susitna River at 127.1C #2[a]	1	542.00	4.40	5.20	0.85	28.19
	Susitna River at 137.5L	3	2745.63	34.21	2.63	13.34	11.39

[a] Sampling problems limited the number of freeze cores collected at these sites. Due to the small sample size, each freeze core was analyzed individually. The results are the mean of a sample size of one instead of three.

2. The sorting coefficient, used to quantify the distribution of grain sizes in gravels, is a useful indicator of a gravel's reproductive potential for salmonids (Lotspeich and Everest 1981). A sorting coefficient greater than one implies that pores between large grains are filled with smaller grains that restrict permeability. The sorting coefficient is inversely proportional to permeability. Side channel and mainstem spawning sites with open leads had the lowest and most closely related average sorting coefficients, indicating less fine particles filling the pore spaces between larger particles. Tributary spawning habitats had the largest average sorting coefficients.

3. Areas of open leads with no spawning had the largest average percentage of fines less than 1.0 mm. The other three site classifications, tributary, side channel, and mainstem spawning areas, generally had less than half the percentage of fines then non-spawning areas.

4. Tributary spawning habitats had the largest average fredle index of all habitat types. The other three site classifications had almost identical average fredle index numbers. The average fredle index number in the other sites was roughly half of that found in tributary habitats.

4.0 CONTRIBUTORS

Adult Anadromous Project Leader	Bruce M. Barrett
Data Processing Project Leader	Allen Bingham
Graphics	Carol Hepler Roxann Peterson
Typing Staff	Peggy Skeers Vicki McCall Bobbie Greene
Editor	Joe Sautner Drew Crawford
Data Collection	Sheri Methven Pat Morrow Don Seagren Barry Stratton Bob Wilkey Tommy Withrow
Data Analysis	Allen Bingham Don Seagren Bob Wilkey
Text	Don Seagren Bob Wilkey

5.0 ACKNOWLEDGEMENTS

Special appreciation is extended to the following people for their contribution to this study:

- Steve Crumley, Elizabeth Bradley, and Tim Jennings of Entrix, Inc. for their assistance in data collection and helpful insights into the use of the freeze core sampler.
- State of Alaska, Department of Transportation, for assistance in analyzing substrate samples at their laboratory facility.
- Carol Kerkvliet of Woodward Clyde Consultants for her assistance in winter field data collection.

6.0 LITERATURE CITED

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

______. 1983a. Adult anadromous fish studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 final report. Volume 2 (2 of 2: Appendices A-H). Alaska Department of Fish and Game, Anchorage, Alaska.

______. 1983b. Winter aquatic studies (October 1982-May 1983). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

American Association of State Highway and Transportation Officials. 1982. Standard Methods of Sampling and Testing. 13th edition. Washington, D.C.

Bakkala, R.G. 1970. Synopsis of biological data on the chum salmon, Oncorhynchus keta (Walbaum) 1972. U.S. Department of Interior. USF&WS. FAO Species Synopsis No.41, Circular 315. Washington, D.C. 89 pp.

Barrett, B.M., F.M. Thompson, and S.N. Wick. 1984. Adult anadromous fish investigations: May-October 1983. Susitna Hydro Aquatic Studies. Report No. 1. Alaska Department of Fish and Game, Anchorage, Alaska.

______. 1985. Adult salmon investigations: May-October 1984. Susitna Aquatic Studies Program. Report No. 6. Alaska Department of Fish and Game, Anchorage, Alaska.

Blakely, J.S., J.S. Sautner, L.A. Rundquist, and N.E. Bradley. 1985. Salmon passage validation studies (August-October 1984). Susitna Aquatic Studies Program. Addendum to Report No. 3, Chapter 6. Alaska Department of Fish and Game, Anchorage, Alaska.

Everest, F.H., C.E. McLemore, J.F. Ward. 1980. An improved tritube cryogenic gravel sampler. Res Note PNW-350. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, 8 pp.

Everest, F.H., F.B. Lotspeich, and W.R. Meehan. 1981. New Perspective on Sampling, Analysis, and Interpretation of Spawning Gravel Quality. Presented at the Symposium on Aquisition and Utilization of Aquatic Habitat Inventory Information. Portland, Oregon.

Hale, S.S. 1981. Freshwater habitat relationships of chum salmon (Onchorhynchus keta). Alaska Department of Fish and Game, Habitat Division, Resource Assessment Branch. Anchorage, Alaska.

Keklak, T., and T. Quane. 1985. Appendix F: Winter temperature data. Volume 2 in: C.C. Estes, J. Sautner, D.S. Vincent-Lang editors. Winter aquatic investigations (September 1983-May 1984). Susitna Aquatic Studies Program. Report No. 5. Alaska Department of Fish and Game, Anchorage, Alaska.

Keklak, T., and T. Withrow. 1985. Continuous water temperature investigations. Susitna Aquatic Studies Program. Task 29 and 37, Support Technical Report. Alaska Department of Fish and Game, Anchorage, Alaska.

Kogl, D.R. 1965. Springs and groundwater as factors affecting survival of chum salmon spawn in a sub-arctic stream. Master's thesis. University of Alaska, Fairbanks, Alaska.

Lotspeich, F.B., and F.H. Everest. 1981. A new method for reporting and interpreting textural composition of spawning gravel. Res. Note PNW-369. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, 11 pp.

McNeil, W.J., and W.H. Ahnell. 1960. Measurement of gravel composition of salmon streambeds. Fisheries Research Institute, College of Fisheries, University of Washington, Seattle, Washington. Circular No. 120. Prepared for U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries. Contract #14-17-008-96.

Moulton, L.L., L.A. Rundquist, S.C. Crumley, and N.E. Bradley. 1984. Susitna Hydroelectric Project Fish Mitigation Plan. Woodward-Clyde Consultants. Prepared for Harza-Ebasco Susitna Joint Venture. November, 1984. Document No. 2466, Susitna File No. 4.3.1.4. Anchorage, Alaska.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. Gen. Tech. Rep. INT-138. Ogden, Utah: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 70pp.

Porter, P.E., and J.R. Rogers. 1984. A computer program to characterize the textural composition of salmonid spawning gravel. Presented to American Fisheries Society, Alaska Chapter Annual Meeting 1984. Forestry Sciences Laboratory, Juneau, Alaska.

Reiser, D.W., and T.C. Bjornn. 1979. Influence of forest and rangeland management in anadromous fish habitat in western North America. Number 1. Habitat requirements of anadromous salmonids. United States Forest Service General Technical Report PNW-96. Portland, Oregon.

Ryan, T.A., Jr., B.L. Joiner, and B.F. Ryan. 1981. Minitab reference manual. Minitab Project, The Pennsylvania State University, University Park, Pennsylvania.

Sandone, G., D.S. Vincent-Lang, and A. Hoffmann. 1984. Evaluation of chum salmon spawning habitat in selected tributary mouth habitats on the middle Susitna River, Chapter 8 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Sautner, J., L.J. Vining, and L.A. Rundquist. 1984. An evaluation of passage conditions for adult salmon in sloughs and side channels in the middle Susitna River. Chapter 6 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Scrivener, J.C., and M.J. Brownlee. 1981. A preliminary analysis of Carnation Creek gravel quality data, 1973-1980. p. 195-226. In Salmon spawning gravel: A renewable resource in the Pacific Northwest? Proceedings of the conference. Washington State University, Pullman, Washington.

Seagren, D.R., and R.G. Wilkey. 1985. Preliminary evaluations of potential fish mitigation sites in the middle Susitna River. Susitna Aquatic Studies Program. Report No. 10. Alaska Department of Fish and Game, Anchorage, Alaska.

Shirazi, M.A., and W.K. Seim. 1980. A stream systems evaluation - an emphasis on spawning habitat for salmonids. Report No. EPA 60013-79-109. Environmental Research Laboratory - Corvallis, Office of Research and Development, Environmental Protection Agency, Corvallis, Oregon.

Trihey, E.W. 1983. Preliminary assessment of access by spawning salmon into Portage Creek and Indian River. Prepared for Alaska Power Authority. Anchorage, Alaska.

______. 1984. Memorandum to B. Barrett and L. Moulton. August 28, 1984. Anchorage, Alaska.

Velleman, P.F., and D.C. Hoaglin. 1981. Applications, basics, and computing of exploratory data analysis. Duxbury Press, Boston, Massachusetts, USA.

Vincent-Lang, D.S., A.G. Hoffman, A.E. Bingham, C.C. Estes, D. Hilliard, C. Steward, E.W. Trihey, and S.C. Crumley. 1984. An evaluation of chum and sockeye salmon spawning habitat in sloughs and side channels of the middle Susitna River. Chapter 7 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Vining, L.J., J.S. Blakely, and G.M. Freeman. 1985. An evaluation of the incubation life-phase of chum salmon in the middle Susitna River, Alaska. Volume 1 in: C.C. Estes, J. Sautner, and D.S. Vincent-Lang, editors. Winter aquatic investigations (September 1983-May 1984). Susitna Aquatic Studies Program. Report No. 5. Alaska Department of Fish and Game, Anchorage, Alaska.

Walkotten, W.J. 1976. An improved technique for freeze sampling streambed sediments. Res. Note PNW-281. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, 11 pp.

Wendling, F.L. 1976. Preliminary report on gravel porosity studies along the Trans-Alaska Pipeline. Draft Report. National Marine Fisheries Service. Anchorage, Alaska.

7.0 APPENDICES

APPENDIX A

Salmon Spawning Utilization Data
of Mainstem and Side Channel Habitats
in the Middle Susitna River, 1981-1984.

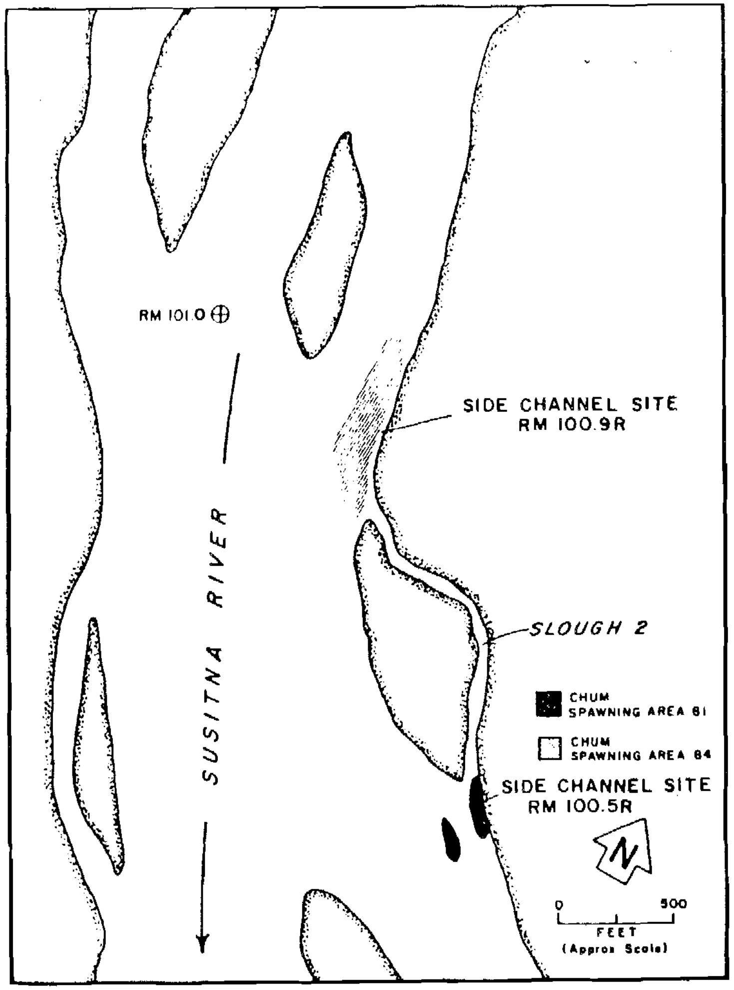
Information on salmon spawning utilization of mainstem and side channel sites in the middle reach of the Susitna River between 1981 and 1984 (Appendix Figure A-1 through A-22) was obtained via a literature review of Susitna Aquatic Studies reports on adult salmon (ADF&G 1981, ADF&G 1983a; Barrett et al. 1984, and Barrett et al. 1985).

Spawning surveys conducted in the middle reach of the Susitna River between 1981 and 1984 indicate that chum salmon are the predominant species that spawn in side channel and mainstem habitats. Sockeye salmon were observed spawning in eight side channel and three mainstem sites. Coho salmon have spawned in three side channel sites and pink salmon have spawned in two side channels. No coho or pink salmon spawning has been observed in mainstem sites. Chinook salmon have not been observed spawning in either side channel or mainstem sites. The general spawning habitat preference of the five species of salmon in the Susitna River are presented in Appendix Figure A-23.

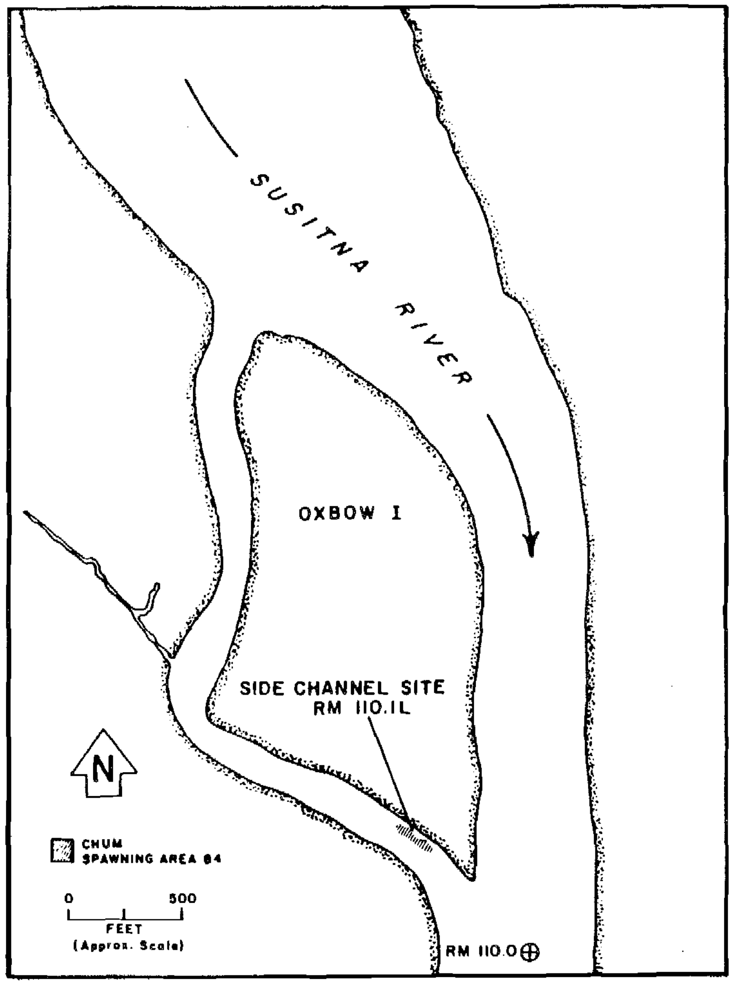
A comparison of observed spawning activity in side channel and mainstem sites from 1981-1984 is presented in Appendix Table A-1. While the number of sites varies between habitat type, the percentage in each category is similar between habitat types. The relatively high percentage of new spawning sites in each habitat type observed during 1984 can be attributed to a high escapement and excellent survey conditions.

Appendix Table A-1. A comparison of observed salmon spawning activity between side channel and mainstem sites in the middle reach of the Susitna River, 1981-1984.

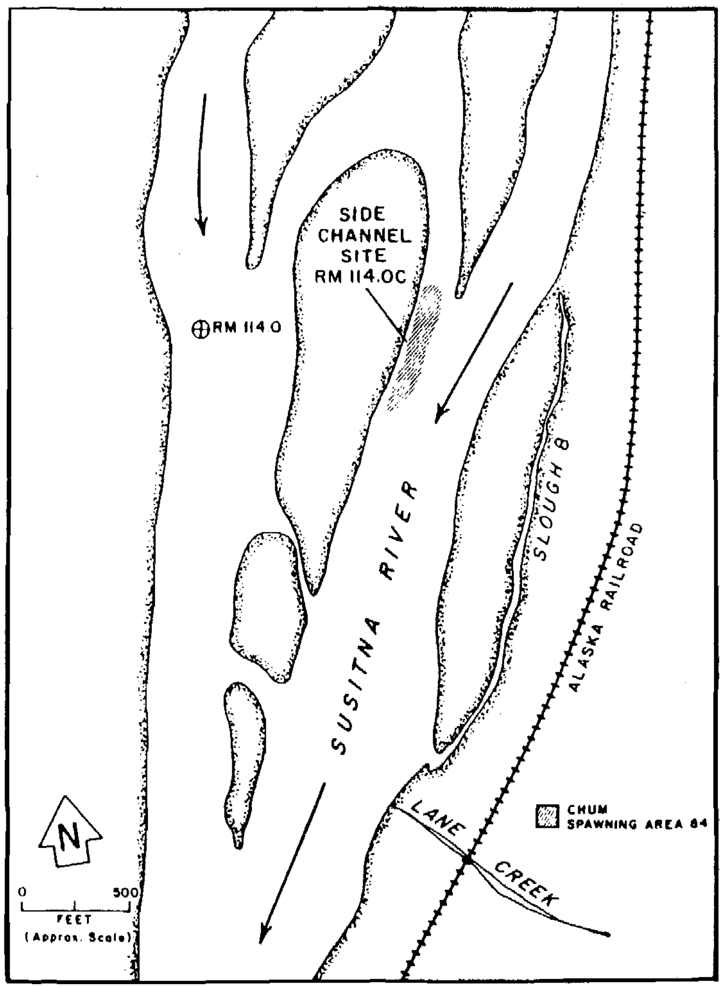
Spawning Utilization Category	Side Channel (62 Total Sites) (No. of Sites/ % of Total)	Mainstem (27 Total Sites) (No. of Sites/ % of Total)
Spawning during at least 1 year	42 (68%)	17 (63%)
Spawning during more than 1 year	17 (27%)	6 (22%)
No spawning	20 (32%)	10 (32%)
First spawning during 1984	23 (37%)	9 (33%)



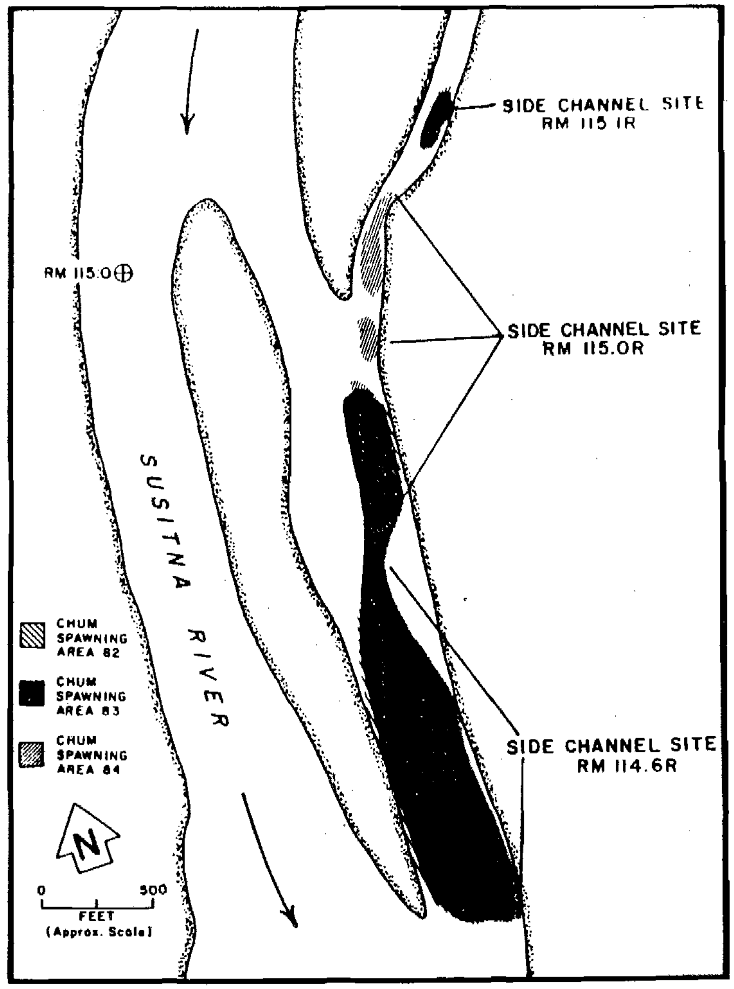
Appendix Figure A-1. Observed chum salmon side channel spawning sites between RM 100.0 and 101.0 in the middle Susitna River.



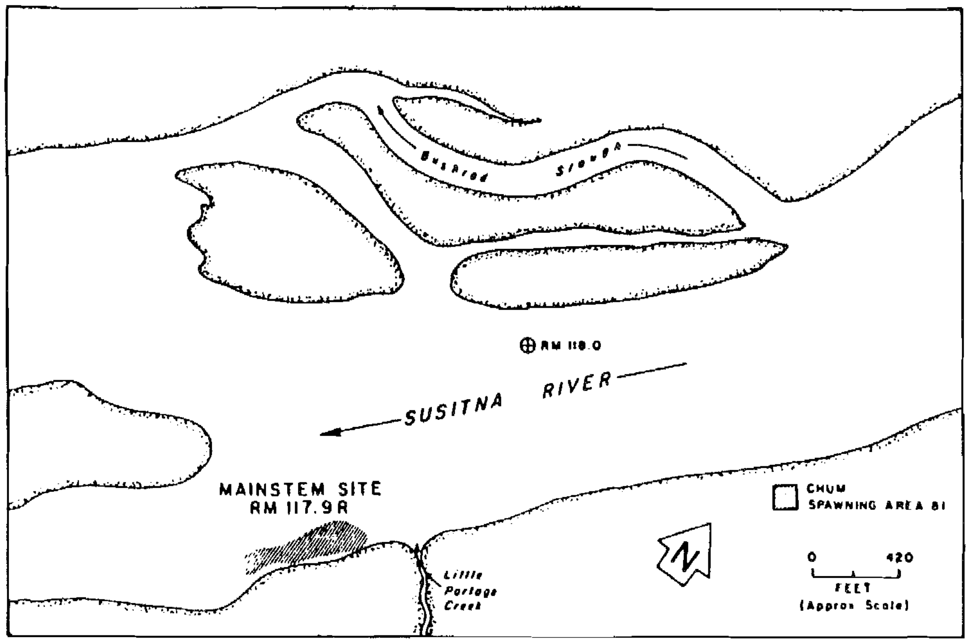
Appendix Figure A-2. Observed chum salmon side channel spawning site at RM 110.1 in the middle Susitna River.



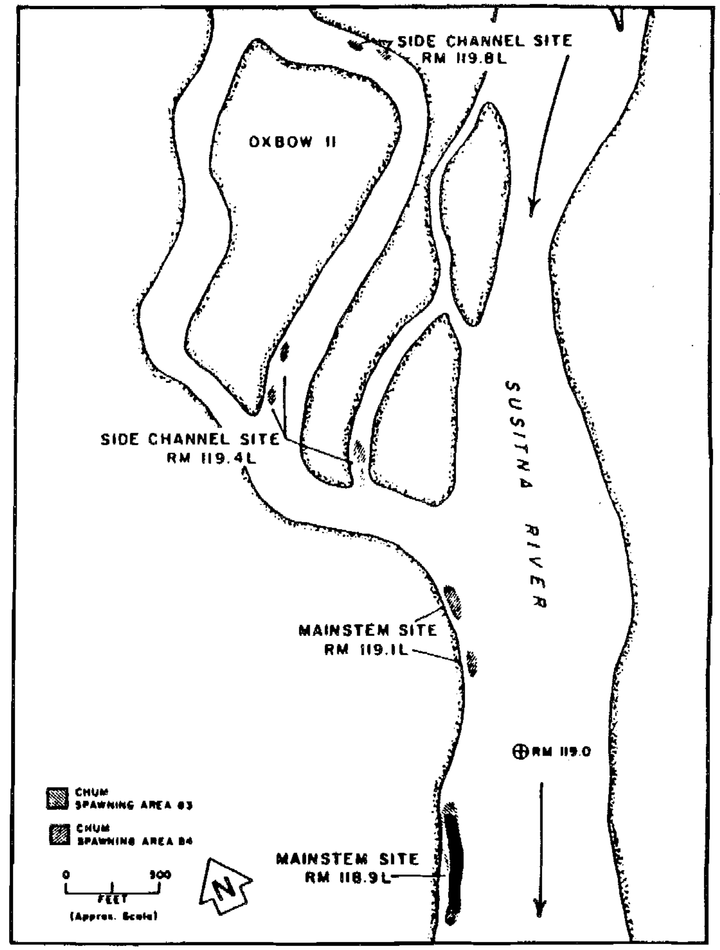
Appendix Figure A-3. Observed chum salmon side channel spawning site at RM 114.0 in the middle Susitna River.



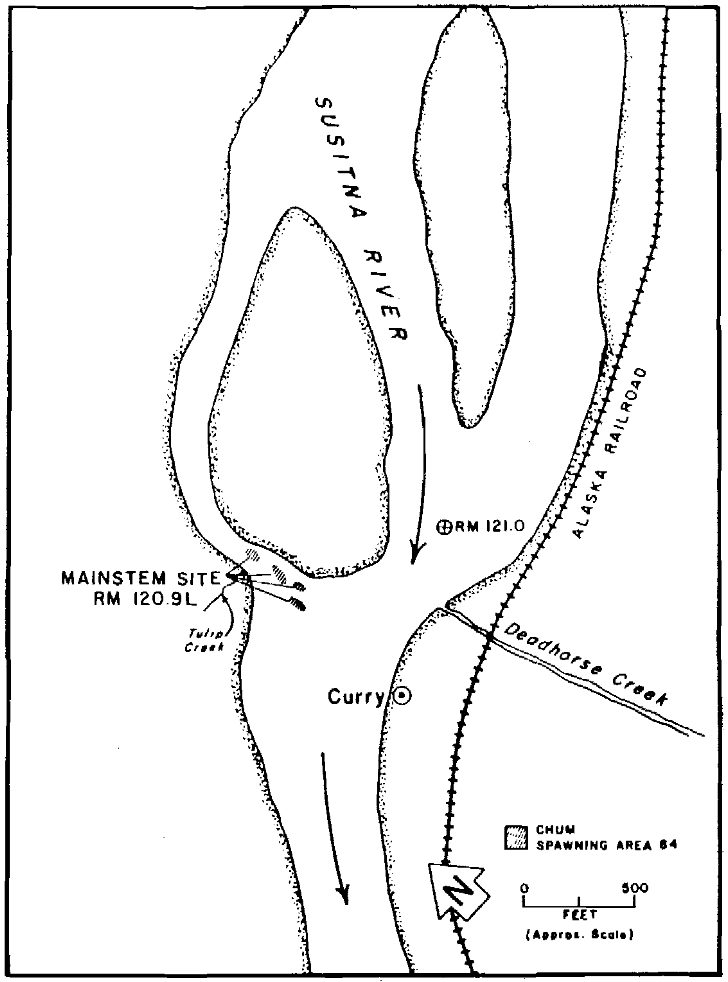
Appendix Figure A-4. Observed chum salmon side channel spawning sites between RM 114.5 and 115.5 in the middle Susitna River.



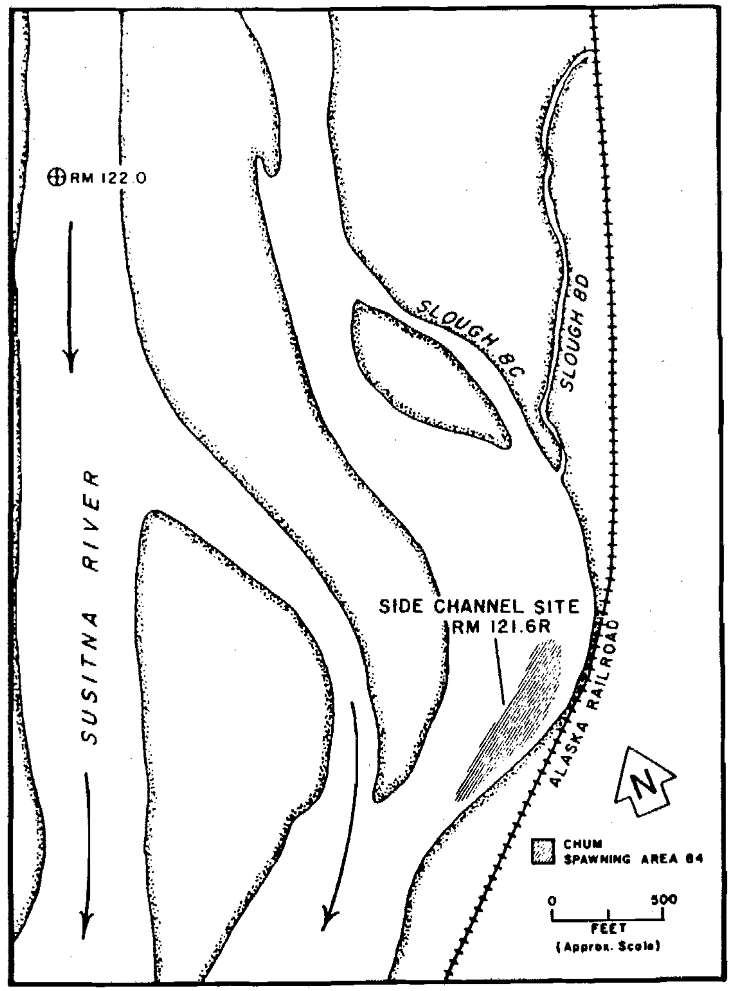
Appendix Figure A-5 Observed chum salmon mainstem spawning site at RM 117.9 in the middle Susitna River.



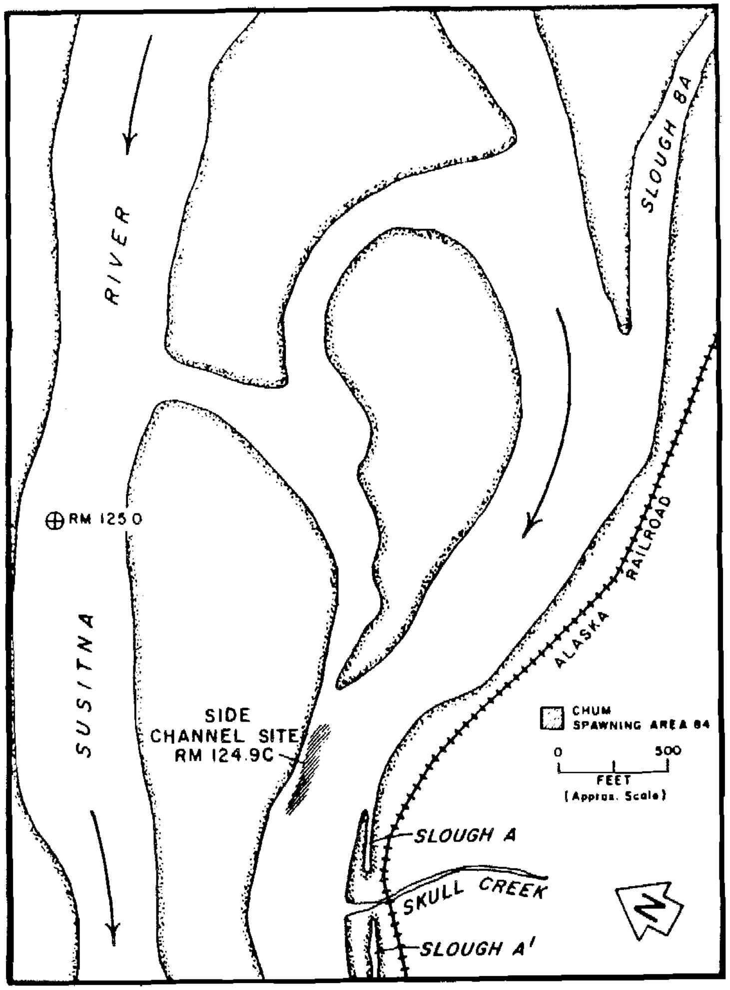
Appendix Figure A-6. Observed chum salmon side channel and mainstem spawning sites between RM 118.5 and 120.0 in the middle Susitna River.



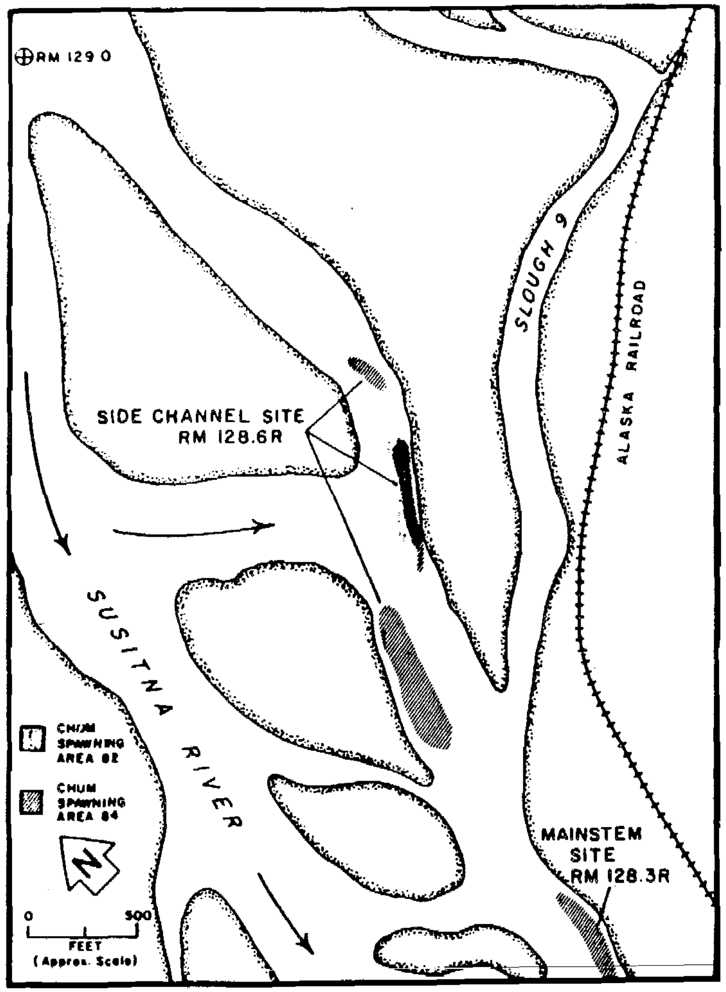
Appendix Figure A-7. Observed chum salmon mainstem spawning site at RM 120.9 in the middle Susitna River.



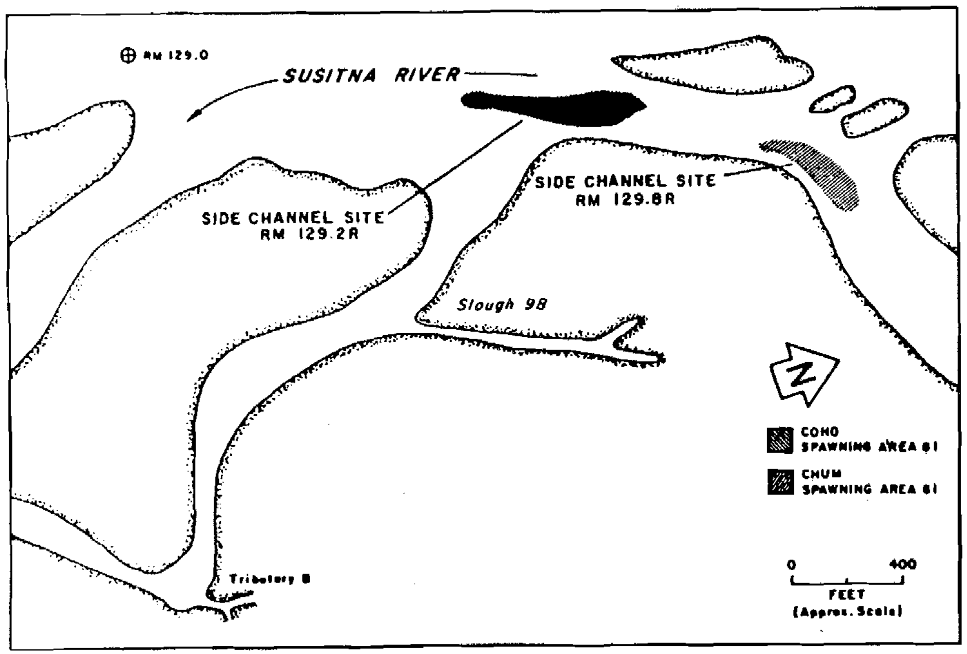
Appendix Figure A-8. Observed chum salmon side channel spawning site at RM 121.6 in the middle Susitna River.



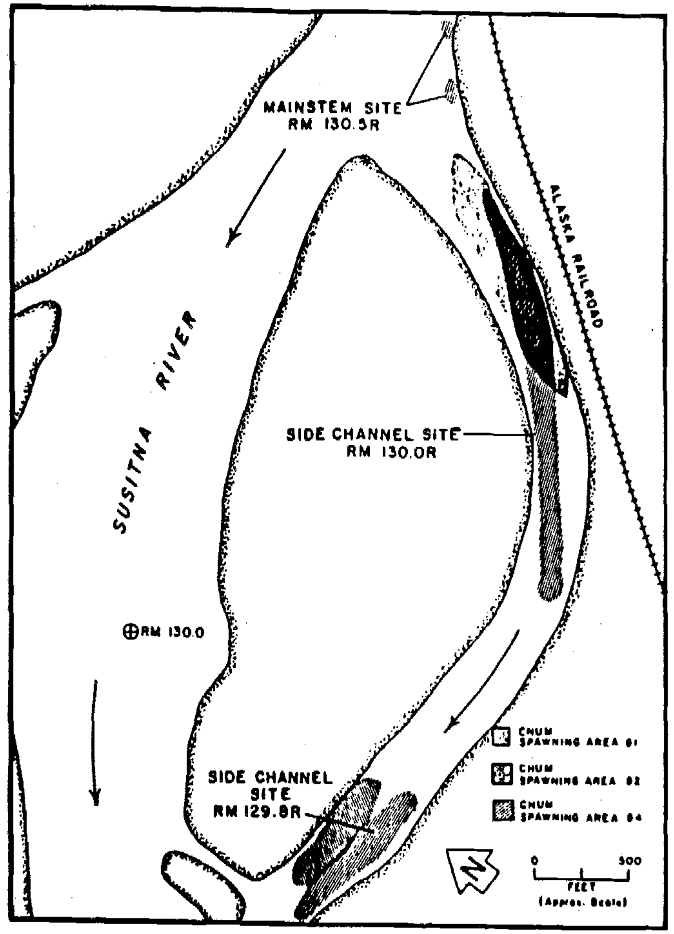
Appendix Figure A-9. Observed chum salmon side channel spawning site at RM 124.9 in the middle Susitna River.



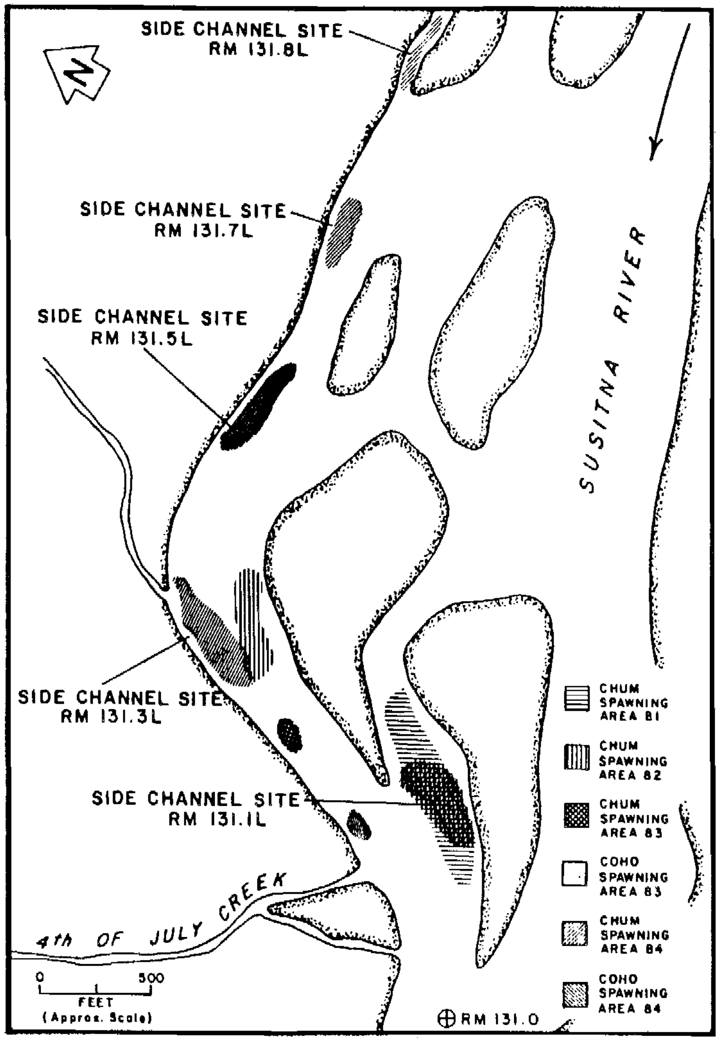
Appendix Figure A-10. Observed chum salmon side channel and mainstem spawning sites between RM 128.0 and 129.0 in the middle Susitna River.



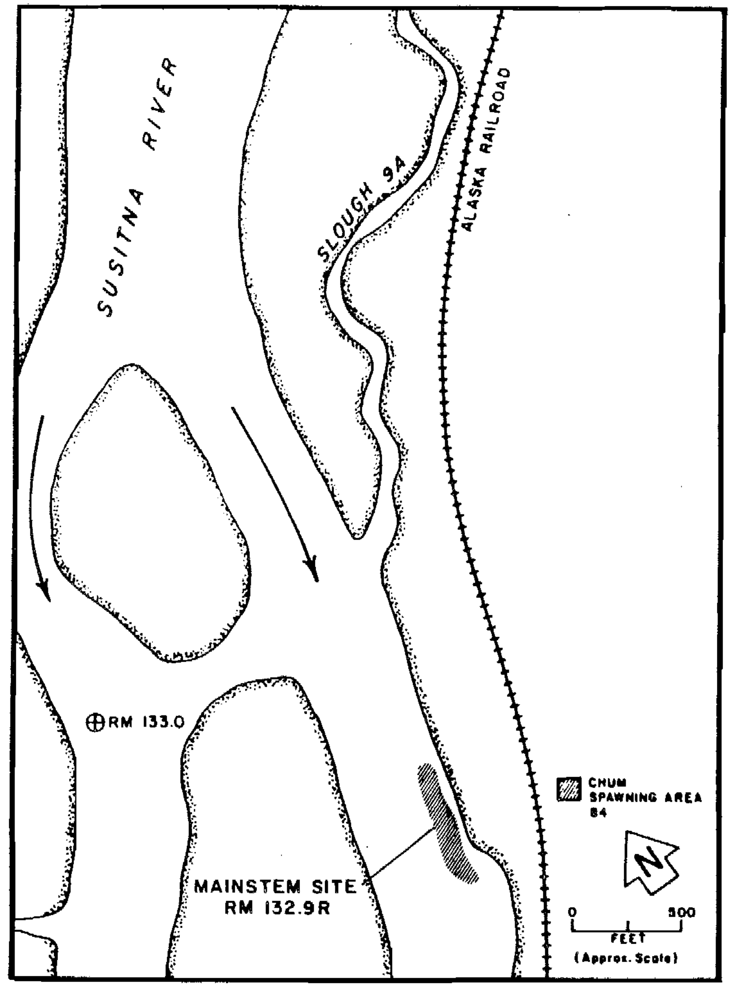
Appendix Figure A-11. Observed chum and coho salmon side channel spawning sites between RM 129.0 and 129.8 in the middle Susitna River.



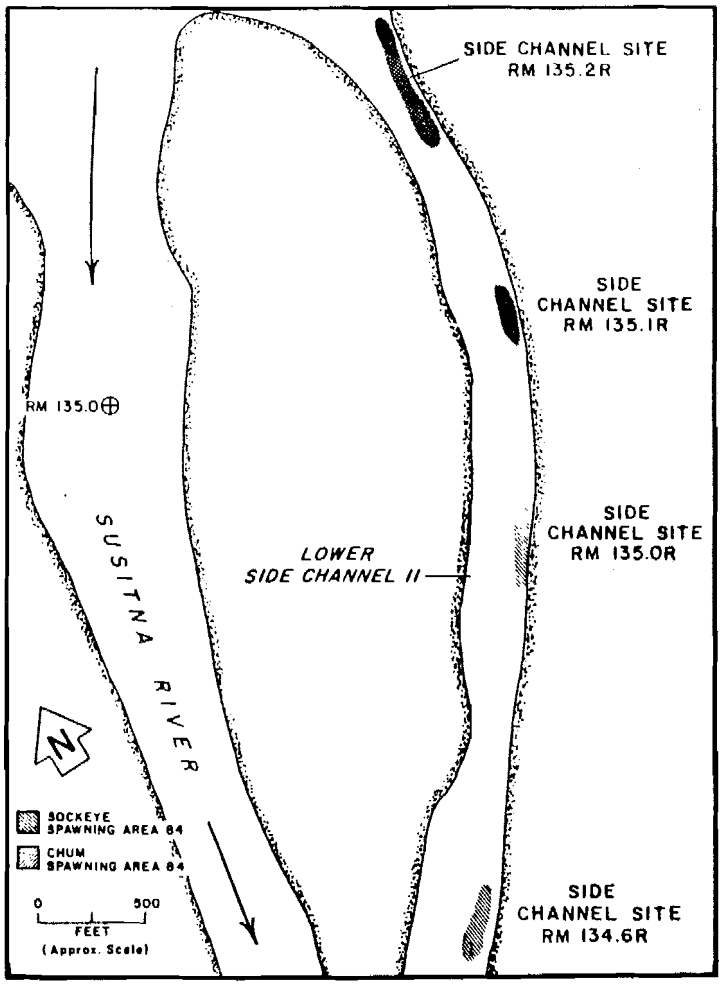
Appendix Figure A-12. Observed chum salmon side channel and mainstem spawning sites between RM 129.8 and 130.5 in the middle Susitna River.



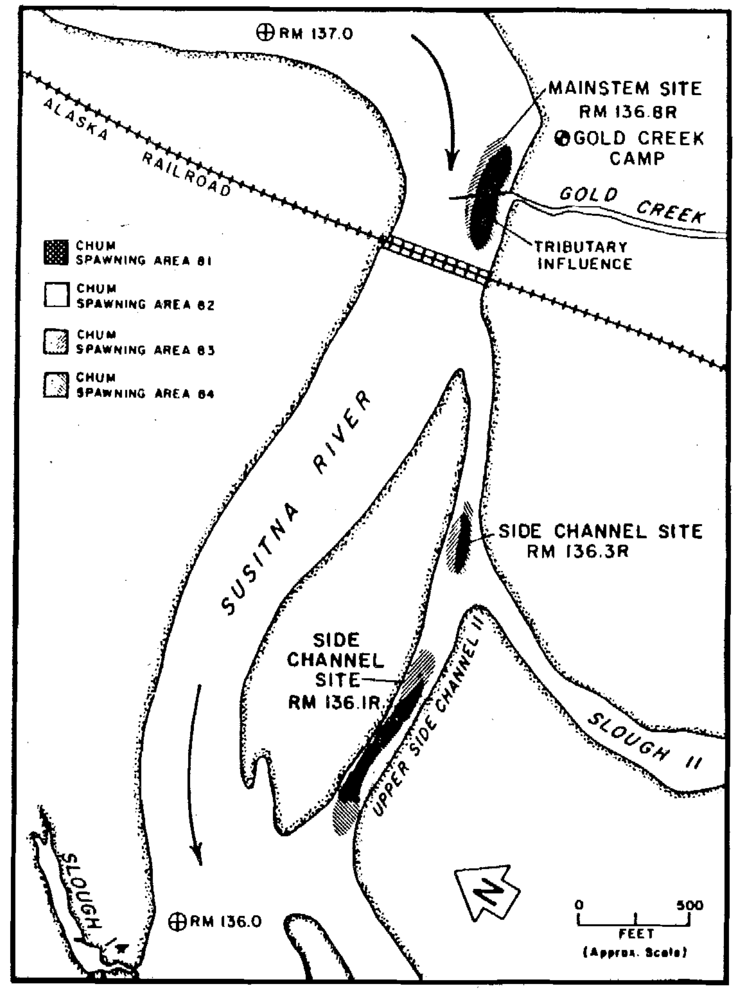
Appendix Figure A-13. Observed chum and coho salmon side channel spawning sites between RM 131.0 and 131.8 in the middle Susitna River.



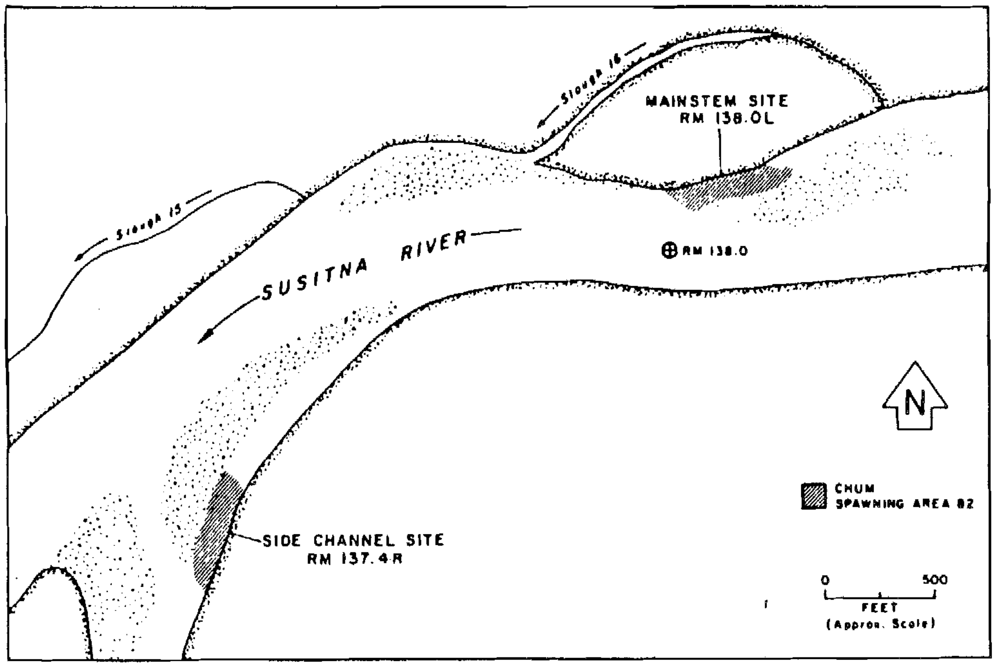
Appendix Figure A-14. Observed chum salmon mainstem spawning site at RM 132.9 in the middle Susitna River.



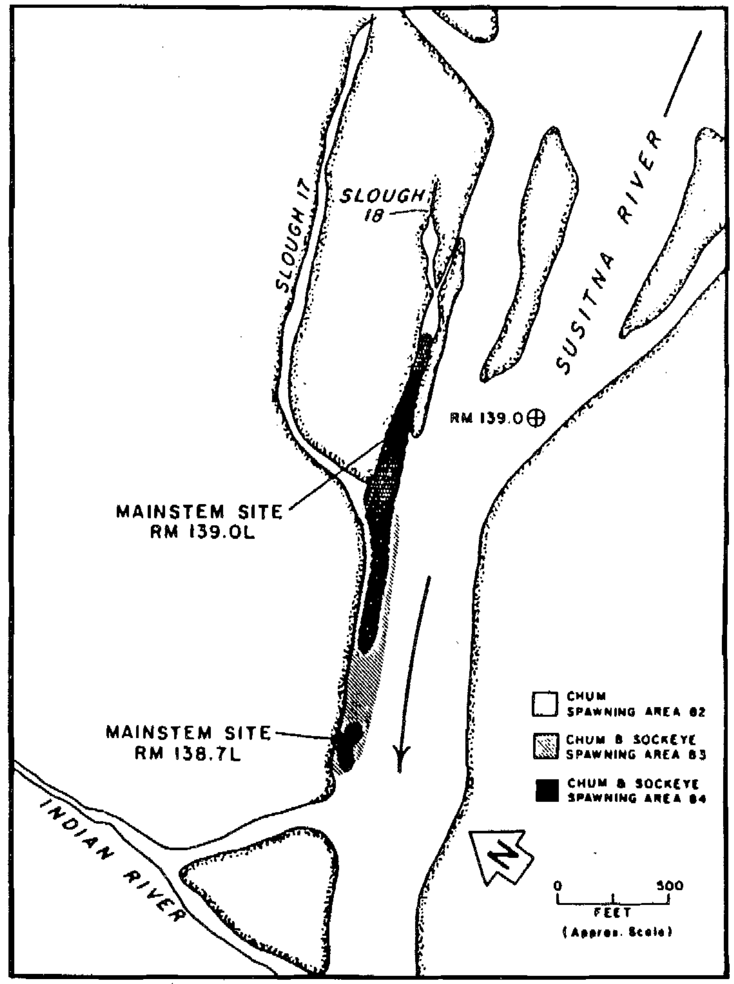
Appendix Figure A-15. Observed chum and sockeye salmon side channel spawning sites between RM 134.6 and 135.2 in the middle Susitna River.



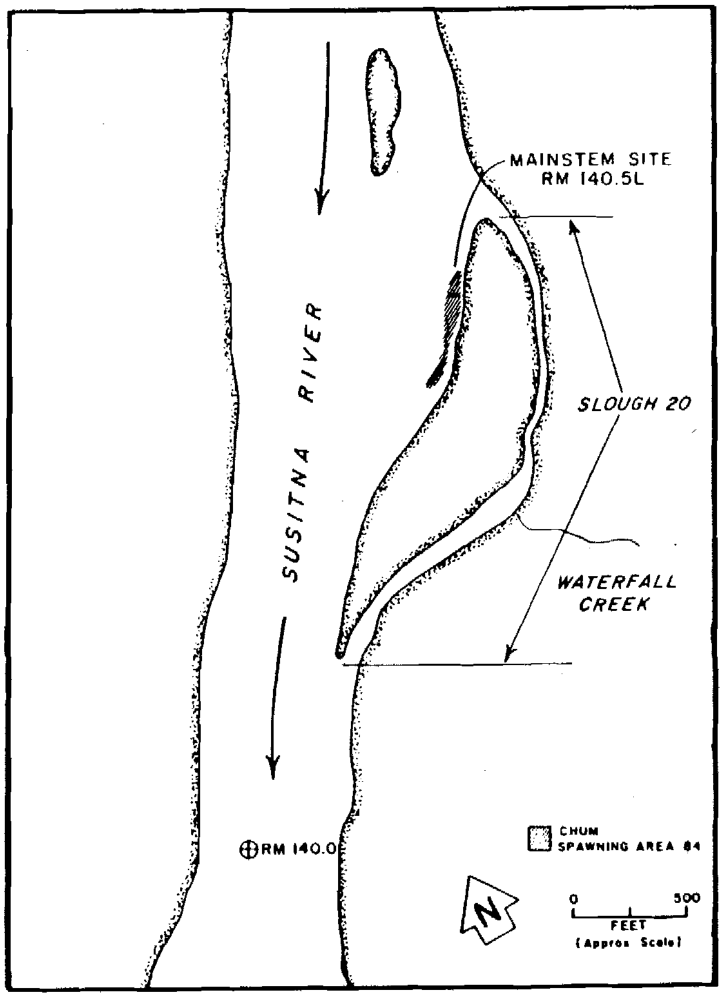
Appendix Figure A-16. Observed chum salmon side channel and mainstem spawning sites between RM 136.0 and 137.0 in the middle Susitna River.



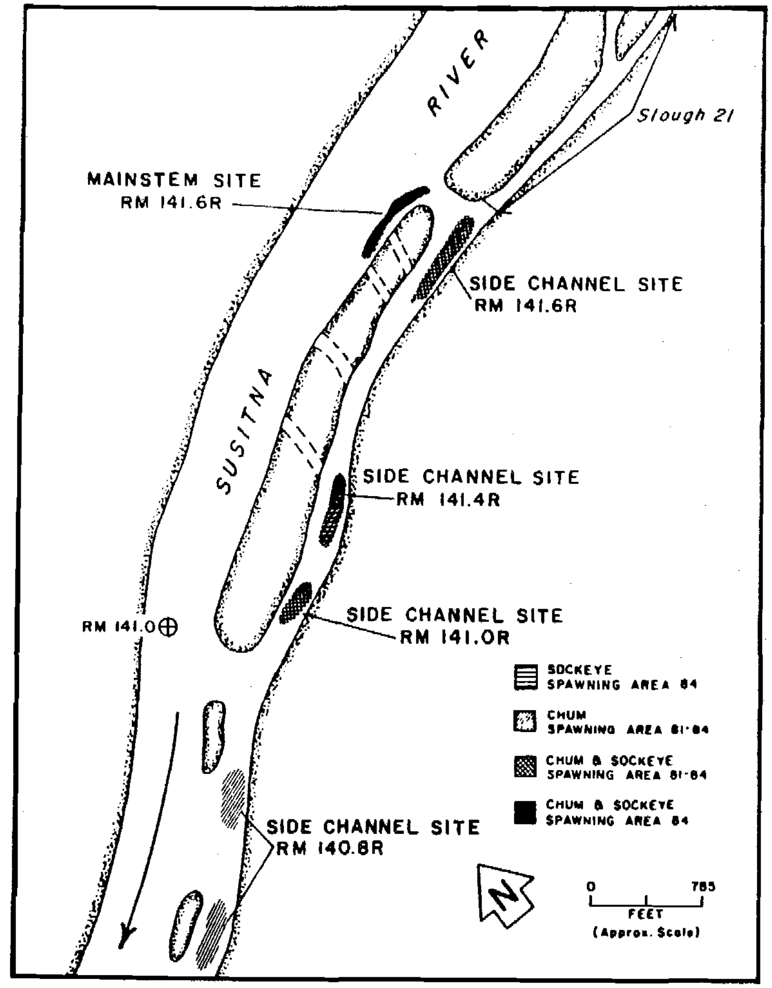
Appendix Figure A-17. Observed chum salmon side channel and mainstem spawning sites between RM 137.0 and 138.0 in the middle Susitna River.



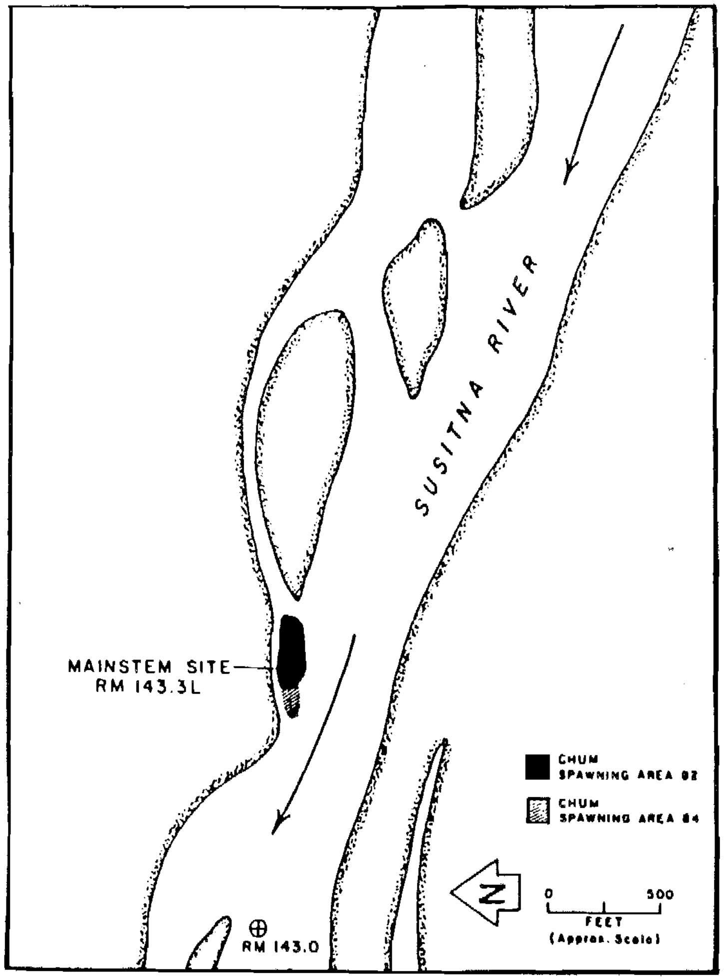
Appendix Figure A-18. Observed chum and sockeye salmon mainstem spawning sites between RM 138.5 and 139.5 in the middle Susitna River.



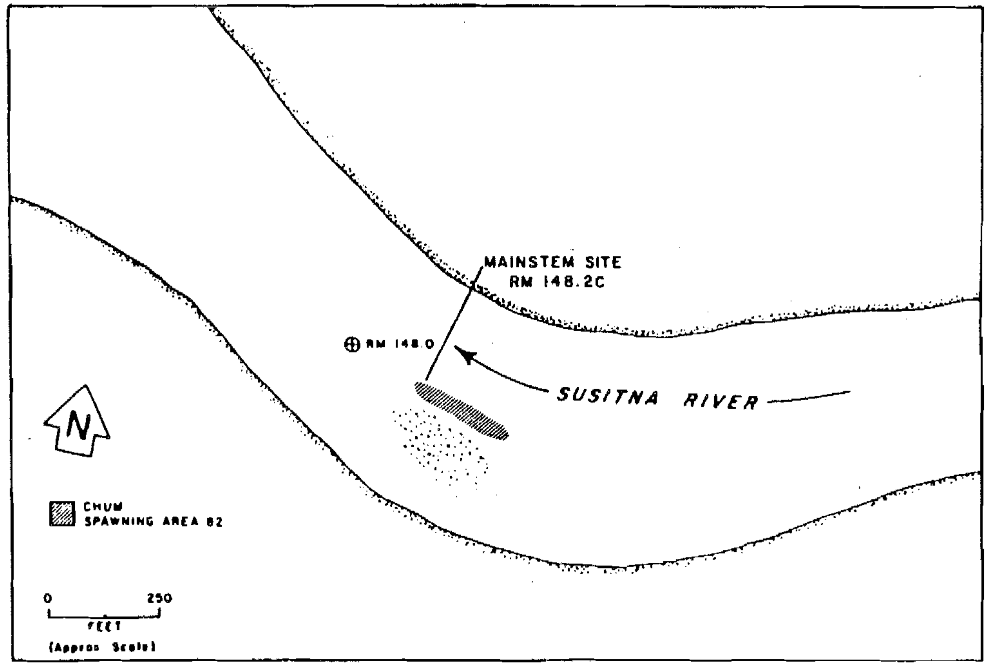
Appendix Figure A-19. Observed chum salmon side channel spawning site at RM 140.5 in the middle Susitna River.



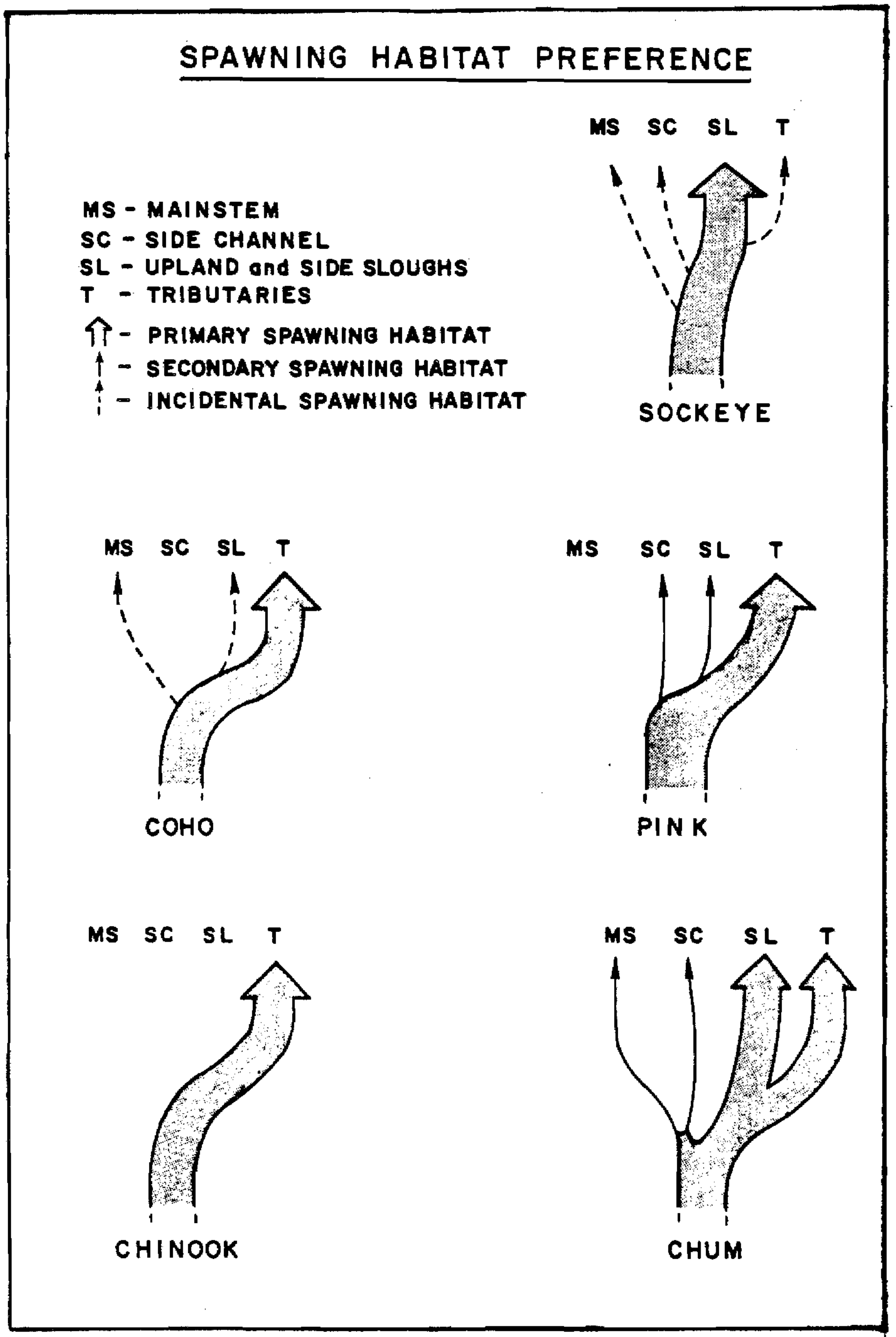
Appendix Figure A-20. Observed chum and sockeye salmon side channel and mainstem spawning sites between RM 140.8 and 141.6 in the middle Susitna River.



Appendix Figure A-21. Observed chum salmon mainstem spawning site at RM 143.3 in the middle Susitna River.



Appendix Figure A-22. Observed chum salmon mainstem spawning site at RM 148.2 in the middle Susitna River.



Appendix Figure A-23 General spawning habitat preference of the five species of salmon utilizing the Susitna River basin. (derived from data from Barrett et al. 1984).

APPENDIX B

Site Descriptions at Continuous Water Temperature Monitoring Locations, Ice-Covered Studies, 1984-1985.

Tributary Habitats

Lane Creek (RM 113.6R/TRM 0.1)

Lane Creek is a clear water stream originating in the sloping terrain bordering the east bank of the Susitna River, entering the mainstem Susitna River at river mile 113.6. It consists of a series of pools, riffles, and small falls flowing over boulder/cobble substrate. In the pools, there are areas of excellent large gravel/small gravel substrate suitable for salmon spawning. Overhanging vegetation grows along the banks, and algae flourishes on the rocks of the streambed.

Lane Creek is a traditional salmon spawning area for chinook, coho, chum, and pink salmon. There doesn't appear to be any barriers to salmon passage except at the mouth during periods of low mainstem discharge. Additional information on chum salmon spawning in the tributary mouth habitat can be found in Sandone et al. (1984).

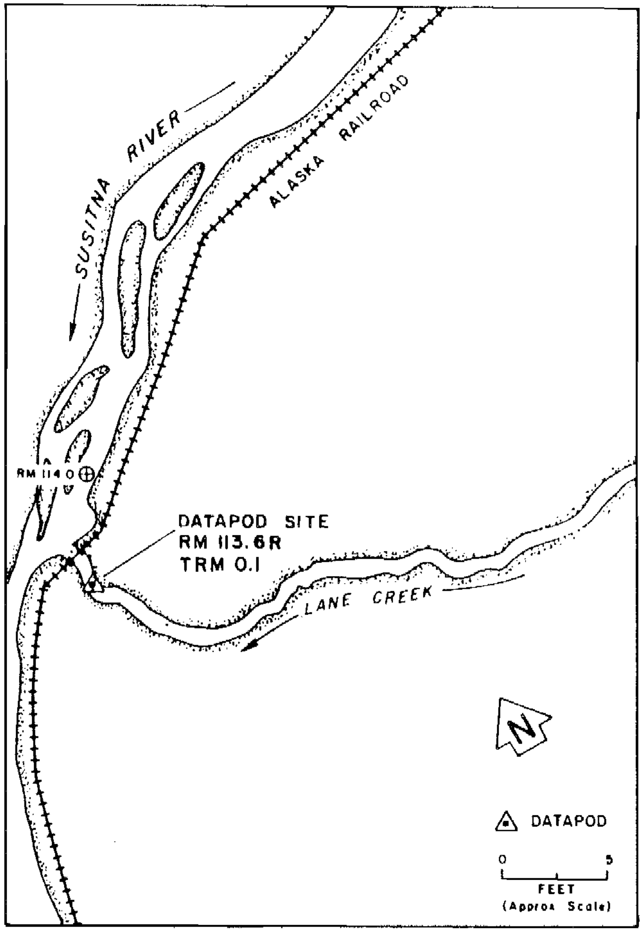
The datapod site is located in a 2-4 foot deep pool approximately 1,800 feet upstream from the mouth on the left bank (Appendix Figure B-1). Substrate in the pool consists of small gravel/large gravel. During winter, an open lead is present in this area except during the coldest periods. The lead may be due to velocity and current effects, as no groundwater upwelling or bank seepage was observed. This area was utilized by all species of salmon spawning in the creek.

4th of July Creek (RM 131.0/TRM 0.2)

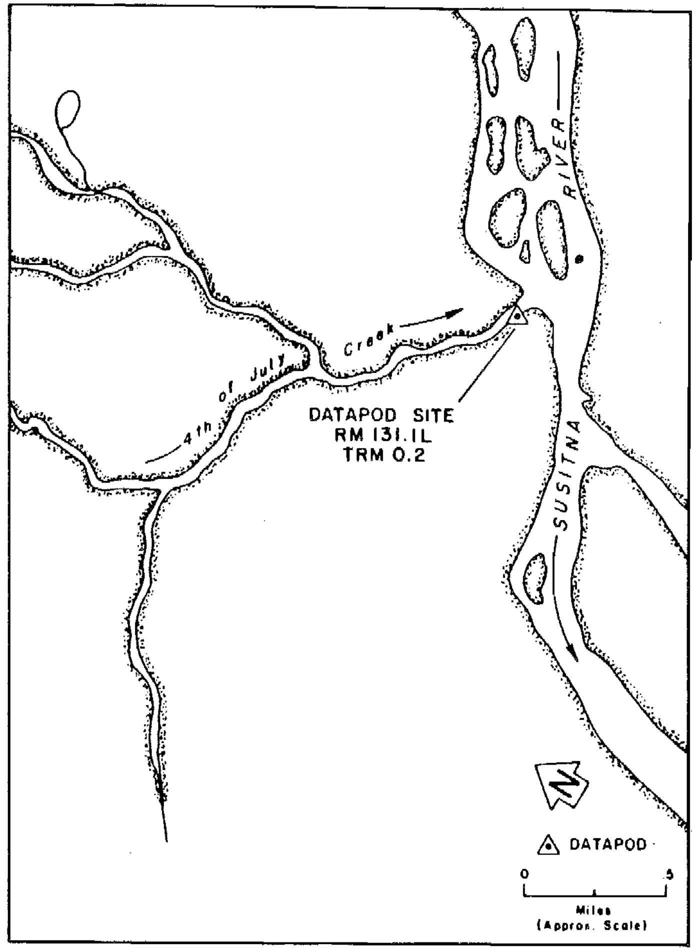
Fourth of July Creek enters the west side of the Susitna River at river mile 131.0. The habitat consists of a series of pools and riffles. Boulder/cobble substrate is present in the riffles, with pockets of large gravel and rubble in the slower velocity pool areas. Log jams are common in this reach. The mouth of 4th of July Creek is known for overflow events during mainstem staging and freeze up which can result in a build up of ice several feet thick.

Chinook, coho, chum, and pink salmon utilize 4th of July Creek for spawning. There is a large waterfall approximately 3.5 miles upstream from the mouth that is a fish passage barrier for fish migrating upstream. Suitable salmon spawning habitat exists above this waterfall that is inaccessable. Further information on chum salmon spawning in the tributary mouth habitat can be found in Sandone et al. (1984).

A datapod water temperature recorder was located near the first major log jam approximately 1,300 feet upstream of the mouth (Appendix Figure B-2). Immediately below this log jam is a deep pool with small gravel/large gravel substrate. The datapod probe was on the north side of this pool in about three-and-one-half feet of water. This area was utilized by all species of salmon spawning in the creek.



Appendix Figure B-1. Location of datapod in a tributary habitat, Lane Creek, RM 113.6R, TRM 0.1.



Appendix Figure B-2. Location of datapod in a tributary habitat, 4th of July Creek, RM 113.1L, TRM 0.2.

Indian River (RM 138.6L/TRM 0.2)

Indian River enters the Susitna River on the northwest side, at river mile 138.6. This is a clear-water tributary flowing over cobble/boulder substrate in a pool-riffle pattern. There are areas of large gravel/rubble substrates associated with pool areas. The first mile of stream channel in Indian River is braided due to a shallower gradient in this reach.

All five species of salmon spawn in Indian River. Chinook salmon use 13 miles of its reach. There appears to be little or no passage restrictions, as extensive areas are used for spawning.

There are two datapod water temperature recorders in Indian River (Appendix Figure B-3). One is on the right bank 3,000 feet upstream from the mouth. This spawning site was used by all species of salmon. The other datapod site is located on the left bank, 4,000 feet upstream from the mouth. This site was only utilized by chinook salmon.

Side Channel Habitats

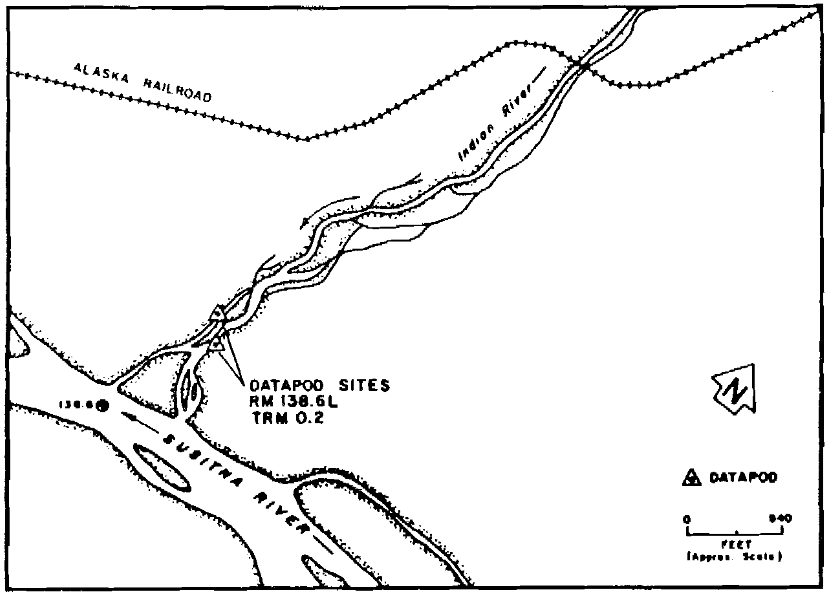
Mainstem Two Side Channel (RM 115.0R)

Mainstem Two is a Y-shaped side channel that is approximately one mile long. It is located one mile upstream of Lane Creek. The side channel is separated from the mainstem Susitna by a large vegetated island. The east and west forks are 4,400 and 2,800 feet long respectively. The confluence of the channels is approximately 1,600 feet upstream of the mouth. The east fork breaches at approximately 25,000 cubic feet/second (cfs) and the west fork breaches at 16,000 cfs.

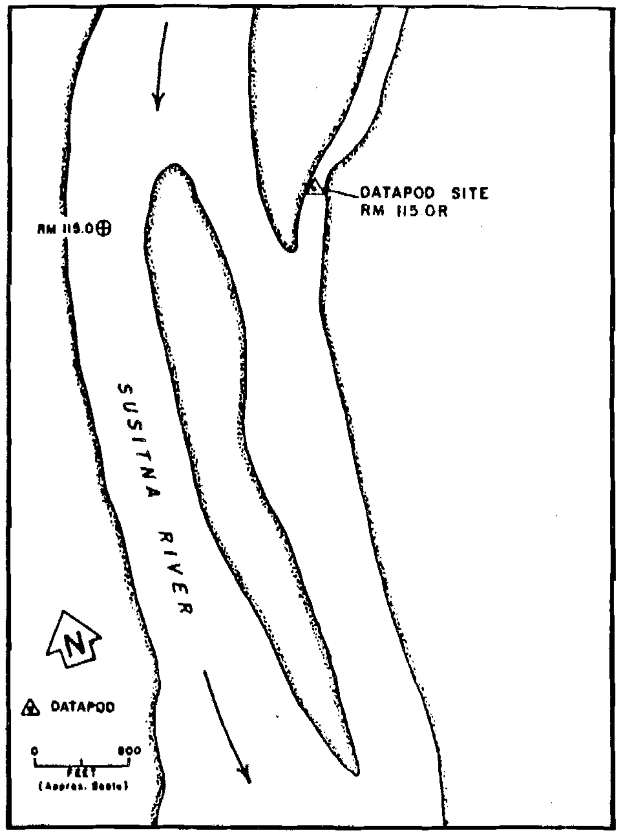
The first 1,600 feet of the side channel is primarily a backwater area. Above this reach the habitat consists of pool and riffle sequences throughout both forks. Substrate in the backwater area is composed of a deep layer of silt/sand over cobble/boulder except in the extreme upper portions where there are pockets of rubble/large gravel. The riffles have well cemented cobble/boulder substrate, while the pools contain rubble/large gravel substrate.

There is moderate to heavy bank seepage and groundwater upwelling from both banks in the backwater area and in the east fork. In an unbreached condition, intragravel flow through the head of both forks may exist. Winter aerial photos show an open lead extending from the lower one-quarter of the east fork down to the mouth (Figure 4). Due to low velocity and isolated pools during this time, this lead is likely the result of groundwater upwelling.

Chum salmon spawning in Mainstem Two has been documented for the past three years (1982-84) (Barrett et al. 1985). The preferred spawning areas appear to be the upper portions of the backwater and several pools of the east fork (Appendix Figure A-4). Spawning activity has not been recorded in the west fork. ADF&G personnel



Appendix Figure B-3. Location of datapod in a tributary habitat, Indian River, RM 138.6L, TRM 0.2.



Appendix Figure B-4. Location of datapod in a side channel habitat. Mainstem 2, RM 115.0R.

have identified nine passage areas in Mainstem Two that may be restrictive to salmon passage (Blakely et al. 1984; Sautner et al. 1984).

A datapod was located in a chum salmon spawning area in the east fork on the right side of a pool (Appendix Figure B-4). Characteristically substrates are well armored cobble/boulder with some rubble.

Side Channel at Fourth of July Creek (RM 131.3L)

This site is located in a side channel 1,200 feet upstream of the mouth of 4th of July Creek (Appendix Figure B-5). The left bank is a 12 foot cut bank. A small bog fed creek drains into the channel immediately upstream of the site. Substrate is a loose conglomeration of rubble/large gravel/cobble. Groundwater upwelling and bank seepage are present along the northwest bank especially in the area of the bog drainage. The groundwater upwelling is most likely responsible for the open lead present during the winter (Figure 6). Surface water temperatures ranged from 6.9° to 7.3°C and intragravel temperatures ranged from 4.4° to 5.3°C. Chum salmon and some coho salmon spawn in various areas of the side channel including the datapod site (Appendix Figure A-13).

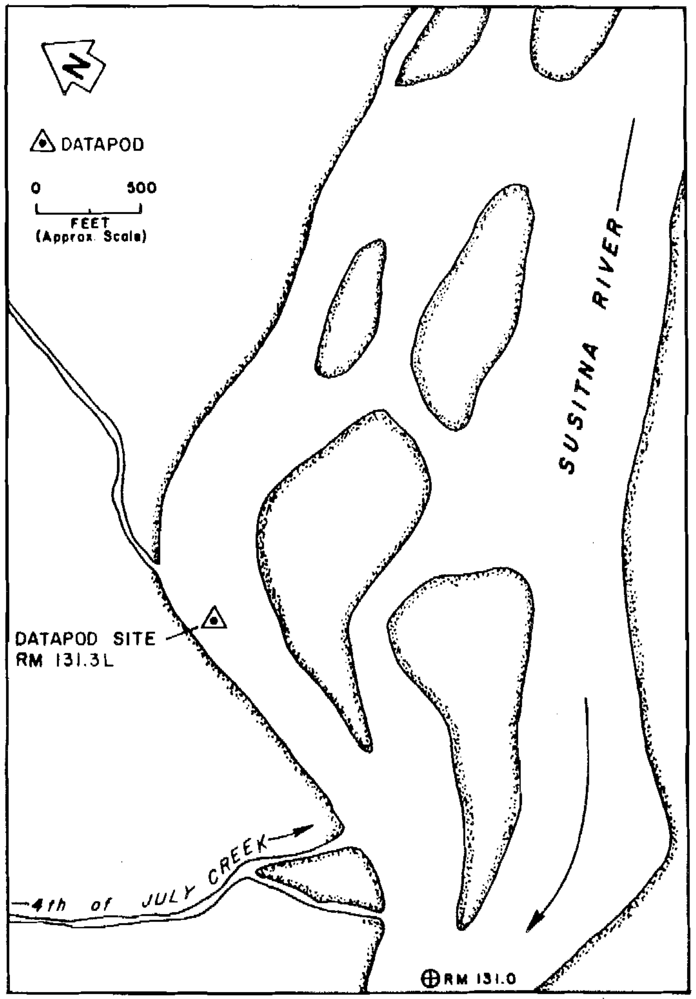
Upper Side Channel 11 (RM 136.0R)

Upper Side Channel 11 is a straight broad channel on the right side of the Susitna River at river mile 136.0. The head of Slough 11 bisects the side channel on the right bank. The first 500 feet of Upper Side Channel 11 consists of a wide backwater area with heavy silt accumulations over an unknown substrate. The remaining area consists of a series of pools and long riffles flowing over boulder/cobble substrate. There is extensive bank seepage and groundwater upwelling along both banks of the backwater area but none discernible in the upper reaches. An open lead is usually present during the winter (Figure 6), although none was present during 1984/1985.

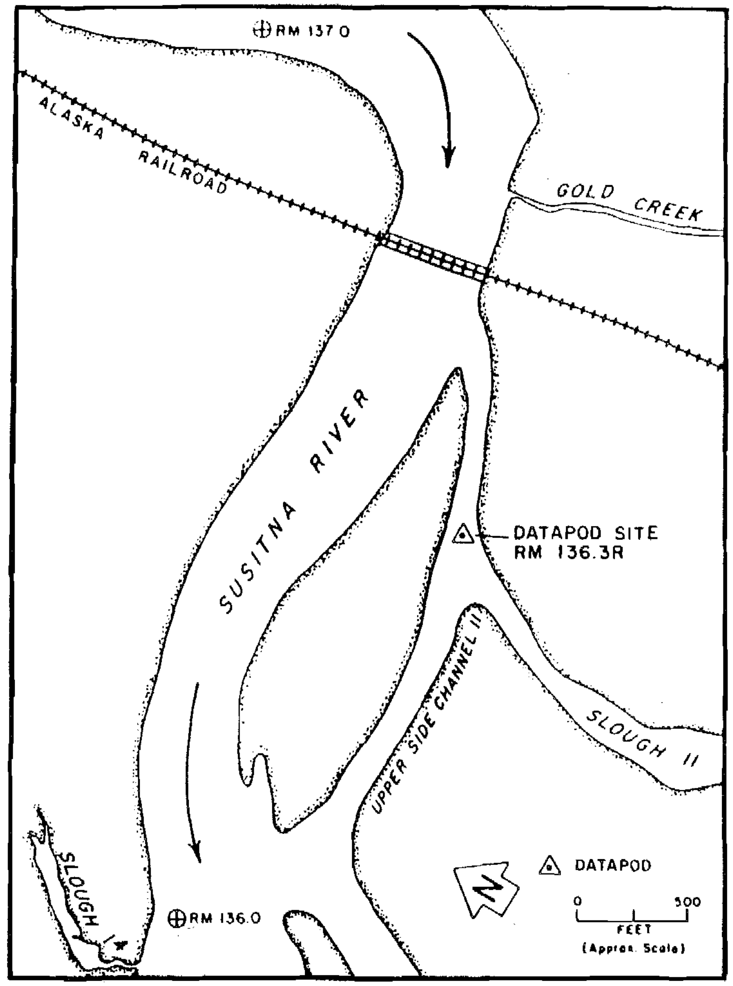
Chum spawning has been documented in two locations from 1981-84 (Appendix Figure A-16). The head of the backwater area and a pool adjacent to the head of Slough 11 are the primary spawning areas. The datapod probe was located in the uppermost chum salmon spawning site (Appendix Figure B-6).

Side Channel 21 (RM 141.6R)

This site is 200 feet below the mouth of Slough 21 in Side Channel 21. Side Channel 21 is an approximately one mile long channel flowing over cemented cobble/boulder substrate with sand deposits occurring in pools. Intermittent channels connect the side channel with the mainstem. There is groundwater upwelling and bank seepage along both banks, especially in the upper reaches which, when



Appendix Figure B-5. Location of datapod in a side channel habitat, RM 131.3L.



Appendix Figure B-6. Location of datapod in a side channel habitat, Upper Side Channel 11, RM 136.3R.

combined with Slough 21 outflow, results in an open lead originating in Slough 21 and extending beyond the mouth of the side channel (Figure 7). Surface water temperatures ranged from 5.3°C to 5.7°C, while intragravel temperatures ranged from 4.7°C to 5.4°C.

Chum and sockeye salmon have been observed spawning in the side channel from 1981-84 (Appendix Figure A-20). There are numerous reaches within this site that may be restrictive to upstream movements of salmon (Blakely et al. 1984 and Sautner et al. 1984).

A datapod probe was located in the middle of the channel approximately 250 feet downstream of the mouth of Slough 21 (Appendix Figure B-7). This area was heavily used by chum and sockeye salmon for spawning.

Mainstem Habitats

Susitna River at RM 118.9L

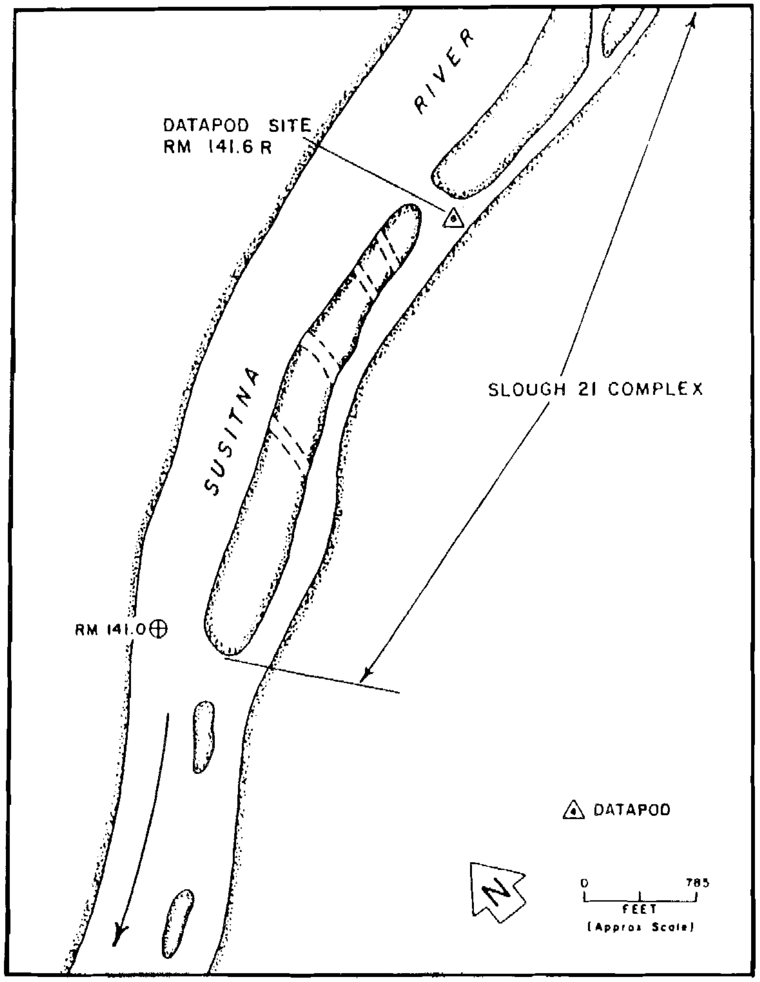
This site is located on along a straight, ten foot high cut bank section of the Susitna River approximately 3,000 feet below the mouth of Oxbow Two side channel (Appendix Figure B-8). A bog fed creek drains into the river 200 feet upstream of the site. Substrate is angular cobble/boulder through the lower 2/3 of the site with rubble/large gravel in the upper 1/3. The upper area has a good flow of bank seepage and groundwater upwelling, most likely related to the bog drainage. There is an open lead throughout this area which is apparently the combination of velocity and groundwater upwelling/bank seepage (Figure 4). Surface water temperatures ranged from 7.1 to 7.2 while intragravel temperatures were 5.2 to 7.1.

Chum salmon spawning activity has been documented on this site for the past two years (1983-84) (Appendix Figure A-6). The majority of spawning occurs in the upper 1/3 where the good substrates and groundwater upwelling are located.

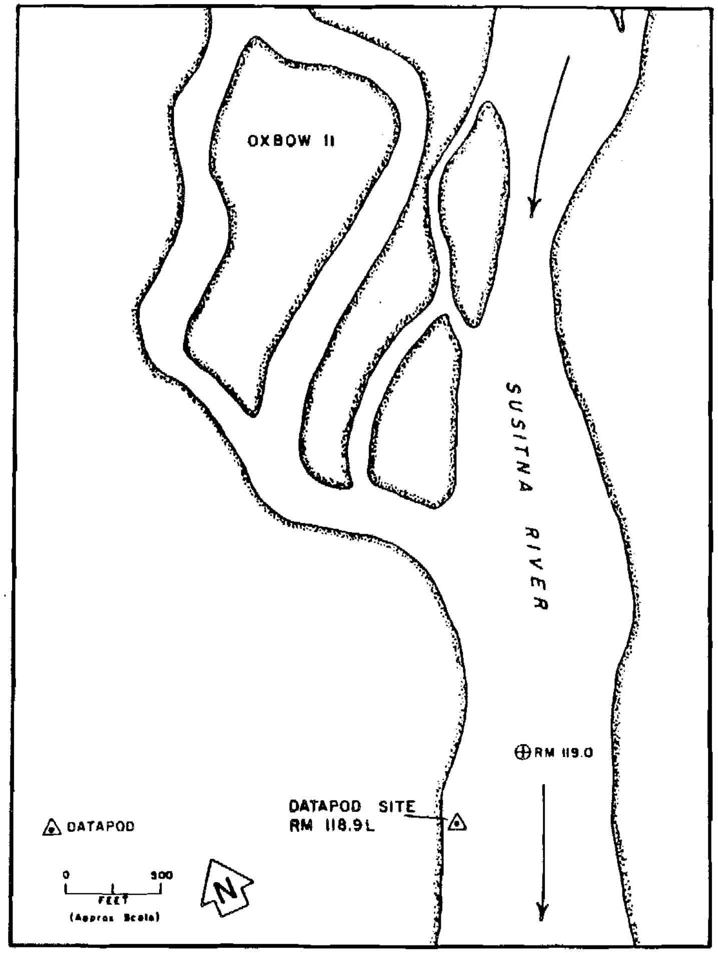
Susitna River at RM 132.9R

Mainstem site 132.9R is found 3,000 feet downstream of the mouth of Slough 9A on the east side of the river. The channel is broad and rectangular with gently sloping banks on both sides. Water velocity is fairly rapid and substrate consists of angular boulders and cobbles well cemented in. There was no groundwater upwelling visible and only limited bank seepage. There is a small lead on the east bank apparently associated with this seepage (Figure 6).

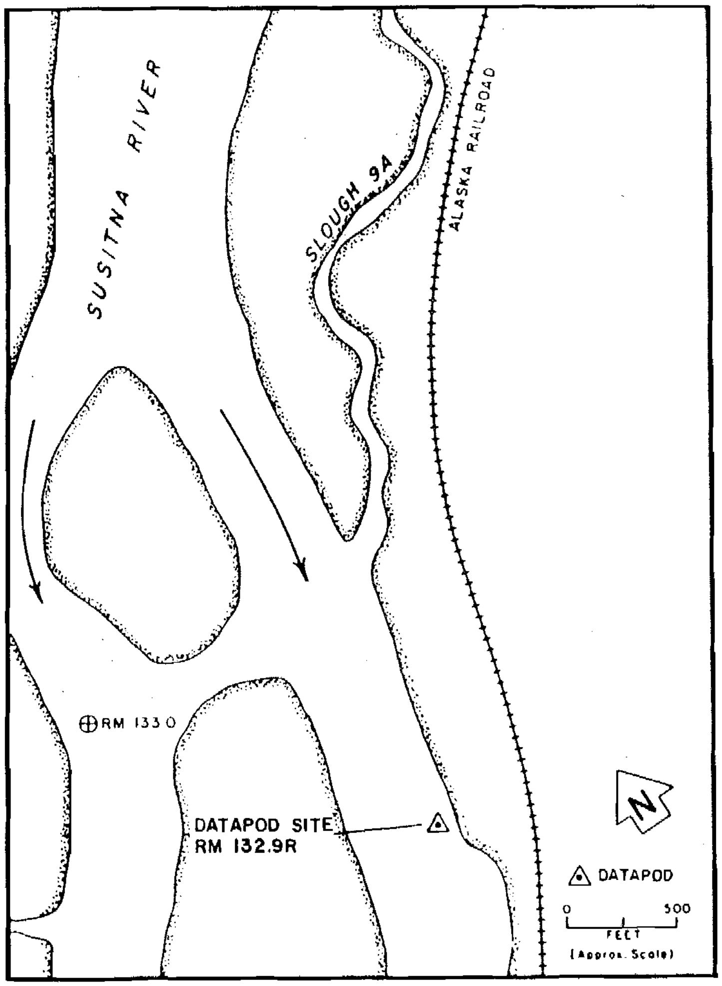
In 1984, chum salmon were reported spawning at this site (Appendix Figure A-14). The datapod probe was located in the spawning area (Appendix Figure B-9).



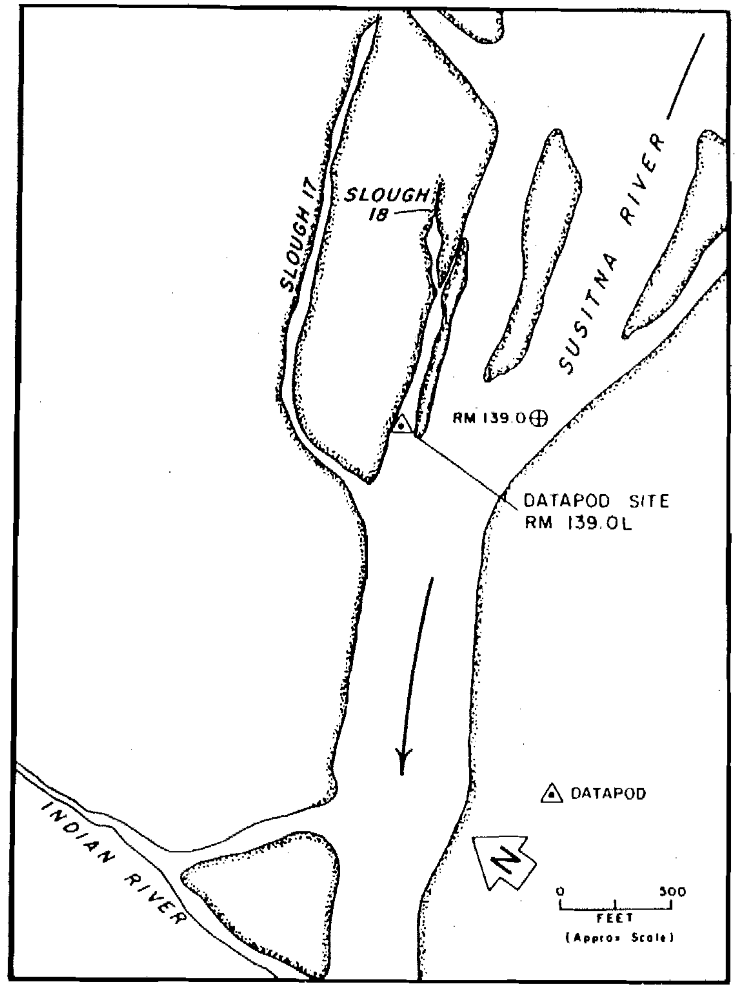
Appendix Figure B-7. Location of datapod in a side channel habitat, Side Channel 21, RM 141.6R.



Appendix Figure B-8. Location of datapod in a mainstem habitat, RM 118.9L.



Appendix Figure B-9. Location of datapod in a mainstem habitat, RM 132.9R.



Appendix Figure B-10. Location of datapod in a mainstem habitat, RM 139.0L.

Susitna River at RM 139.0L

This mainstem site is approximately a 600 feet reach near the mouth of Slough 17 on the west side of the river. It has moderate to high velocities under most discharge ranges. Substrates are rubble/cobble with some areas of large gravel. Groundwater upwelling and bank seepage are present along the west bank, probably originating in Slough 17. Groundwater upwelling is likely responsible for the open lead which occurs here (Figure 7). Surface water temperatures ranged from 7.7°C to 8.6°C while intragravel temperatures range from 5.3°C to 6.5°C.

Chum spawning has been documented at this site for 1982, 1983, and 1984 and sockeye spawning was documented in 1984 (Appendix Figure A-18). The datapod probe was installed in the chum salmon spawning area approximately 500 upstream of the mouth of Slough 17 (Appendix Figure B-10).

Open Lead No Spawning

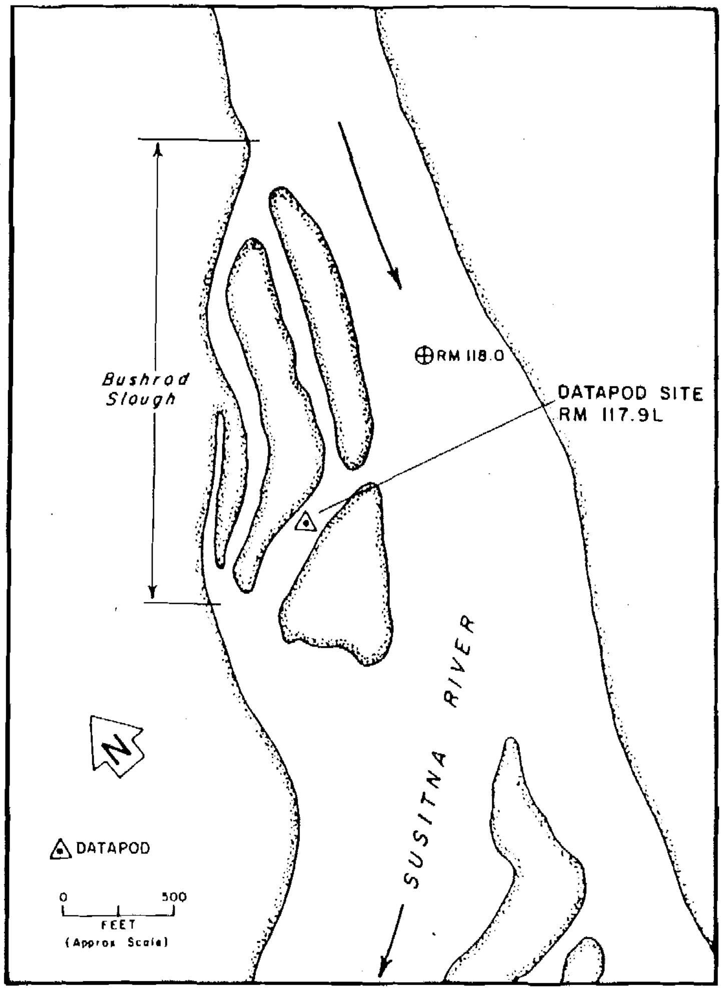
Side Channel at RM 117.9L

Datapod site 117.9L is a small 1,500 foot side channel adjacent to Bushrod Slough on the west side of the Susitna River. It has a wide sloping channel of cobble/rubble substrate with riffles at both the head and mouth. The left bank slopes up to a small cut bank island which separates the side channel from Bushrod Slough. Along this bank there is heavy bank seepage and groundwater upwelling, especially at the upper end of the side channel. Groundwater upwelling was not apparent along the right bank. Surface water temperatures ranged from 7.2 to 7.8°C, while intragravel temperatures were from 5.7 to 7.3°C. A dewatered channel extends upstream from the head of this side channel, connecting with the upper reach of Bushrod Slough. This channel is usually dry except during high water events at which time there is a backwater area at the lower end.

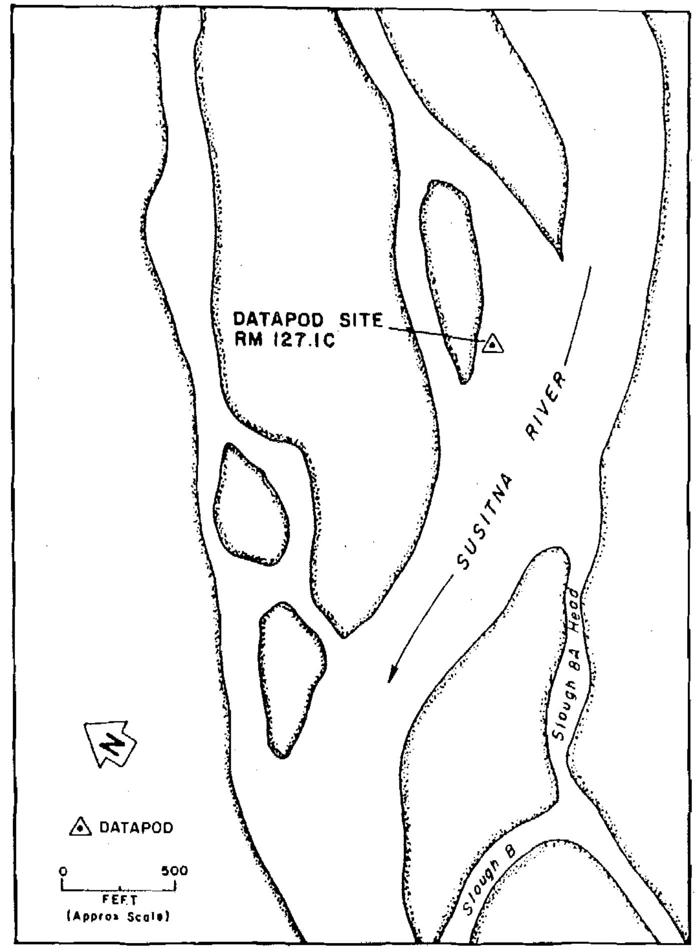
In winter, an open lead extends from just below the head down to and joining with the lead emerging from Bushrod Slough (Figure 4). This lead is likely the result of groundwater upwelling and bank seepage as there is little apparent flow during this time. Salmon spawning has not been reported in this side channel. The datapod probe was located in the open lead, approximately in the middle of the side channel along the northwest bank (Appendix Figure B-11).

Susitna River at RM 127.1C

This site is located in an island complex 1.2 miles downstream of the mouth of Slough 9. It is on the inside of a sweeping bend with moderate water velocities. Substrate is predominately large gravel/rubble with numerous sand deposits. Groundwater upwelling and bank seepage are strong along the left bank, accounting for the open lead that exists during the winter (Figure 5). Surface water



Appendix Figure B-11. Location of datapod in an area of an open lead with no spawning, RM 117.9L.



Appendix Figure B-12. Location of datapod in an area of an open lead with no spawning, RM 127.1C.

temperatures range from 6.4° to 7.1°C and intragravel temperatures ranging from 3.7° to 7.6°C. No salmon spawning has been recorded for this site, although it appears to contain excellent substrate. The datapod probe was located in the middle of the 200 foot reach about 15 feet from the left bank (Appendix Figure B-12).

Susitna River at RM 137.5L

This datapod site is located on the outside edge of a bend in the Susitna River, 100 feet downstream from the mouth of Slough 16 (Appendix Figure B-13). Water velocity in this reach is generally high. Accordingly, substrates tend to be well cemented boulder/cobble. The northwest bank slopes up to a 10 foot cut bank.

Open water surveys found surface water temperatures ranging from 10.4°C to 12.3°C, while intragravel temperatures range from 4.7°C to 8.1°C. There is no apparent groundwater upwelling or bank seepage. The open lead that exists here during the winter is most likely a velocity lead (Figure 6). Salmon spawning has not been documented on this site.

Spawning with No Open Lead

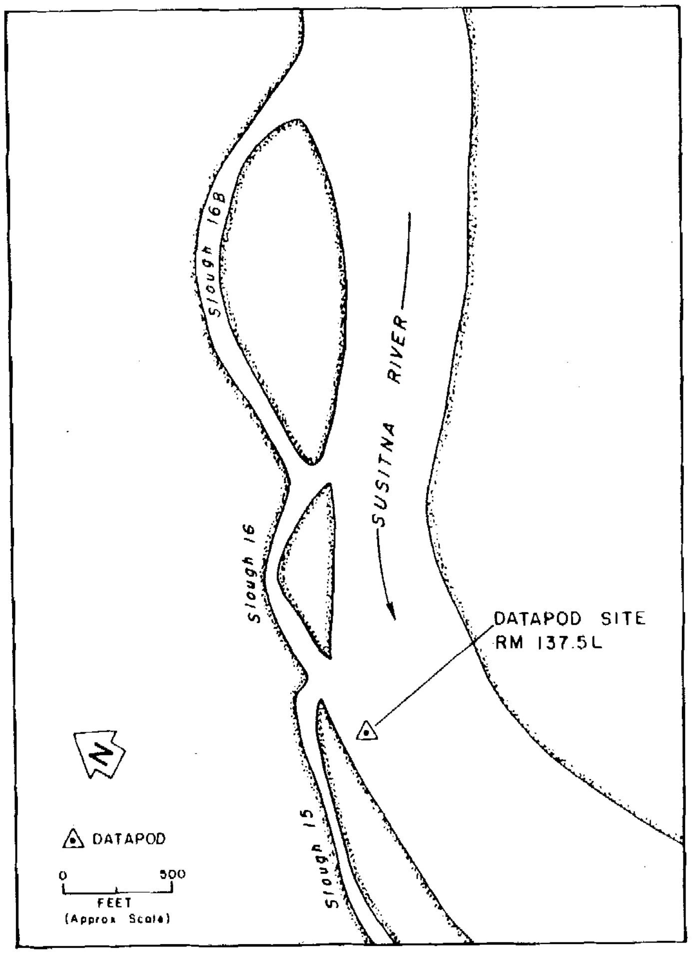
Side Channel at 129.8R

This is a broad side channel that extends from the head of Slough 9 to Sherman Creek along the south bank of the Susitna River. The site most often contains turbid mainstem water due to a low breaching discharge.

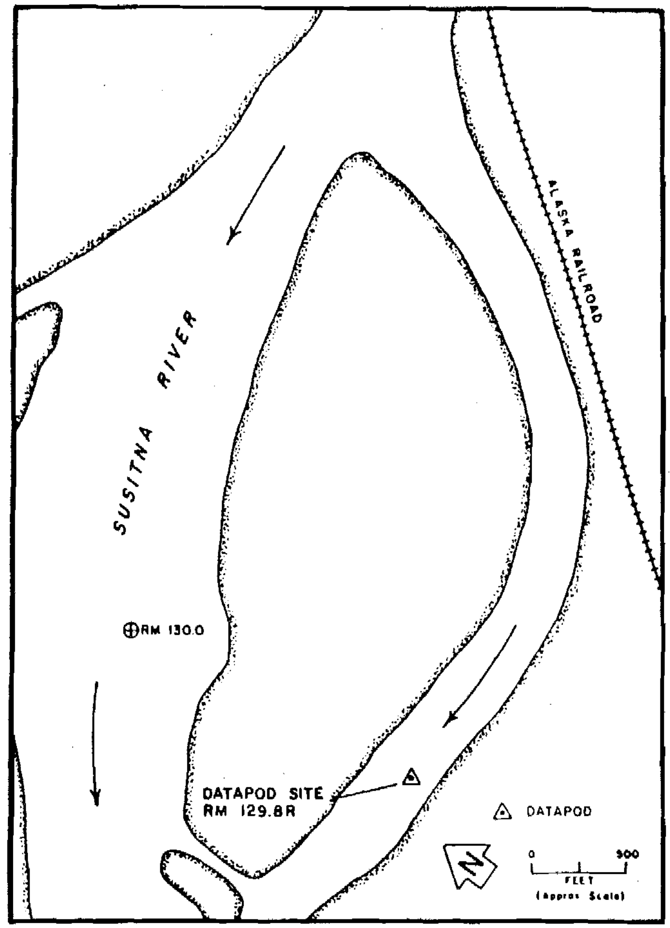
Open leads are generally present near the head of the side channel and along the left bank in the lower reach (Figure 6). Groundwater upwelling and bank seepage were observed near the head, probably due to the influence of Sherman Creek. While groundwater upwelling was not observed in the lower portion, chum salmon have previously spawned along the left bank (Appendix Figure A-12), indicating possible intermittent groundwater upwelling or bank seepage.

Substrates are generally well cemented rubble, cobble, boulder with limited areas of suitable substrate for spawning. Chum salmon have used this side channel for spawning during 1981, 1982, and 1984 (Appendix Figures A-11 and A-12).

The datapod was located in the lower portion of the site along the right bank (Appendix Figure B-14). This was an area of chum salmon spawning during 1984 but with no open lead usually present. This site dewatered and froze early in the winter, preventing an accurate assessment of temperatures and substrate.



Appendix Figure B-13. Location of datapod in an area of an open lead with no spawning, RM 137.5L.



Appendix Figure B-14. Location of datapod in an area of spawning with no open lead, RM 129.8R