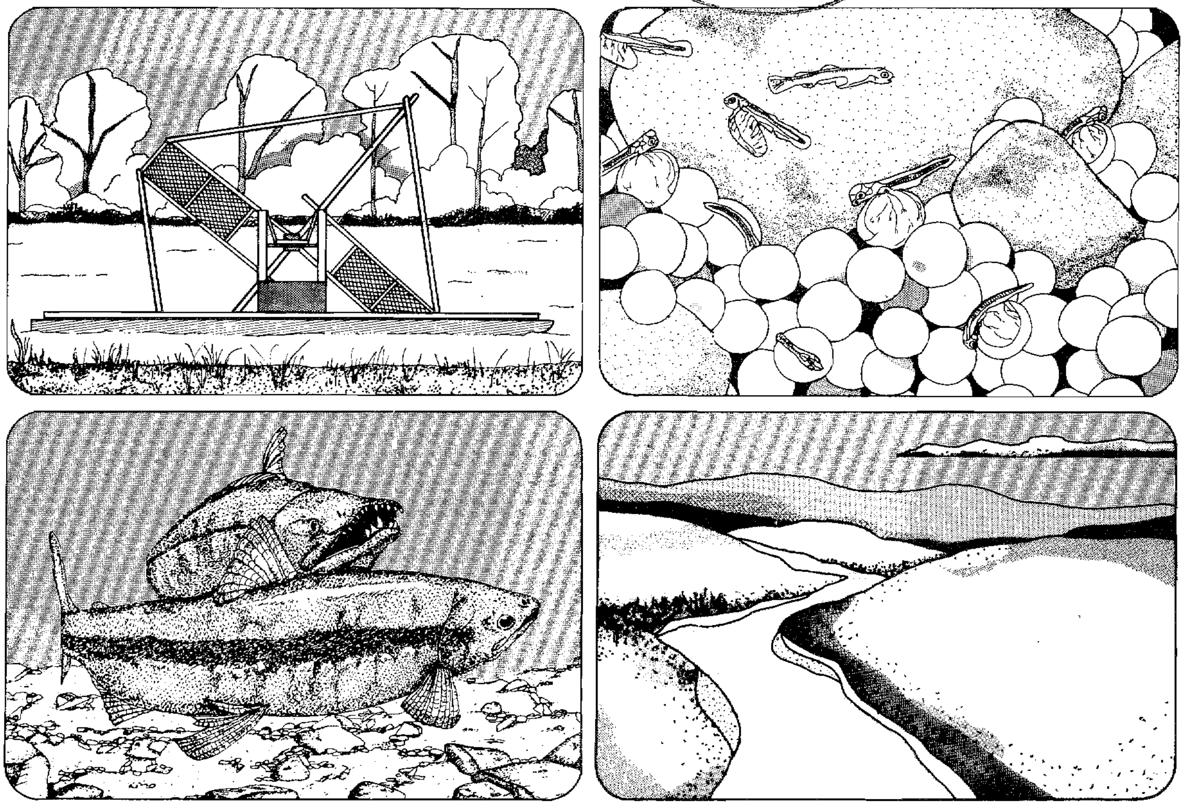

REPORT NO. 4

ACCESS AND TRANSMISSION CORRIDOR AQUATIC INVESTIGATIONS (JULY - OCTOBER 1983)

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

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SUSITNA HYDRO AQUATIC STUDIES

REPORT NO. 4

ACCESS AND TRANSMISSION CORRIDOR AQUATIC INVESTIGATIONS (JULY - OCTOBER 1983)

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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 Hydro Aquatic Studies program was initiated in November 1980. Beginning with the reports for the 1983 open water season, all reports will be sequentially numbered as part of the Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Report Series.

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	1984
4	Access and Transmission Corridor Aquatic Investigations: May - October 1983	September, 1984

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CONTENTS OF REPORT NO. 4

INTRODUCTION TO REPORT NO. 4

This report includes two parts. Part 1 provides information collected during the 1983 open water field season on the aquatic habitat and fish resources within the proposed access and transmission corridors for the Susitna Hydroelectric Project. Part 2 analyzes the potential effects of an expanded sport fishery on Arctic grayling in tributaries of the upper Susitna basin.

PART 1

Access and Transmission Corridor Studies

ACCESS AND TRANSMISSION CORRIDOR STUDIES

1984 Report No. 4, Part 1

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ABSTRACT

Construction of the proposed access and transmission corridors (ATC) associated with the development of the Susitna Hydroelectric Project may affect the aquatic habitat and fish resources along these routes. Studies were conducted by The Alaska Department of Fish and Game during a portion of the 1983 open water field season to provide information on the aquatic habitat and fish resources within the proposed corridors to enable project participants to assess potential impacts on these resources from construction activities. Forty-two proposed stream crossing sites and ten lake habitats were sampled within the ATC study area. Three study reaches of Deadman Creek, which closely parallels the ATC, were also sampled. A total of 13 fish species were found to inhabit the streams and lakes within the ATC study area. Arctic grayling, Dolly Varden and lake trout were the major sport fish species identified within these habitats. General water quality (dissolved oxygen, pH, conductivity and water temperature), discharge, and substrate data were collected at stream crossing study sites. Selected physical and chemical data were collected in Deadman Lake. Population estimates were generated for Arctic grayling within the three study reaches of Deadman Creek. Among the impacts which could result from development of the ATC, the increase in sport fishing pressure, due to the increased access to the area, may have the greatest effect on various sport fish species within the study area. The increase in sport fishing pressure may result in reduced numbers and sizes of fish species such as Arctic grayling, Dolly Varden and lake trout. Other impacts which may occur at proposed stream crossing sites include alterations of stream hydraulics, deterioration of water quality, and removal or shifting of substrates.

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1.0 INTRODUCTION

This report presents an evaluation of the aquatic habitat and fish resources within the proposed Susitna Hydroelectric Project access corridor (Plan 18, also referred to as Denali-North) and that portion of the proposed transmission corridor from the Watana dam site to its intersection with the Anchorage-Fairbanks Intertie (referred to as the Gold Creek - Watana transmission corridor) (Acres 1983a). These corridor routes (Figure 1) were selected by the Alaska Power Authority (APA) for submittal to the Federal Energy Regulatory Commission (FERC) as part of the license application process for the Susitna Hydroelectric Project.

These studies were conducted by the Alaska Department of Fish & Game (ADF&G) Susitna Hydroelectric Aquatic Studies Program during a portion of the 1983 open water field season. No previous field investigations of the fish resources specific to these routes have been conducted by the ADF&G or other subcontractors. Future route changes to these corridors or selection of alternate corridors will necessitate a reevaluation of the aquatic habitat and fish resources in the affected areas.

1.1 Objectives

The Access and Transmission Corridor (ATC) studies were initiated in July, 1983 by a joint Aquatic Habitat and Instream Flow (AH) and Resident and Juvenile Anadromous Fish (RJ) study team to meet the following objectives:

A. Determine the baseline fishery and aquatic habitat resources in streams crossed by the proposed corridors to provide information to enable project participants to assess the potential impacts on these resources from construction activities and increased access into the area;

B. Determine the baseline fishery resources in selected lakes which are near the proposed corridors to enable project participants to evaluate whether these resources will be affected by project related construction activities and increased access into these areas; and

C. Determine the population of sport fish species in selected reaches of Deadman Creek which are near the proposed access corridor to enable project participants to evaluate how improved access could affect these previously unexploited fish populations.

To meet the above objectives the following tasks were pursued by the joint ATC study team:

A. Inventory fish species which presently use habitats in stream reaches which are crossed by the proposed access corridors;

B. Collect baseline physical and chemical data (substrate, water quality, discharge) in stream reaches which are crossed by the proposed access corridors;

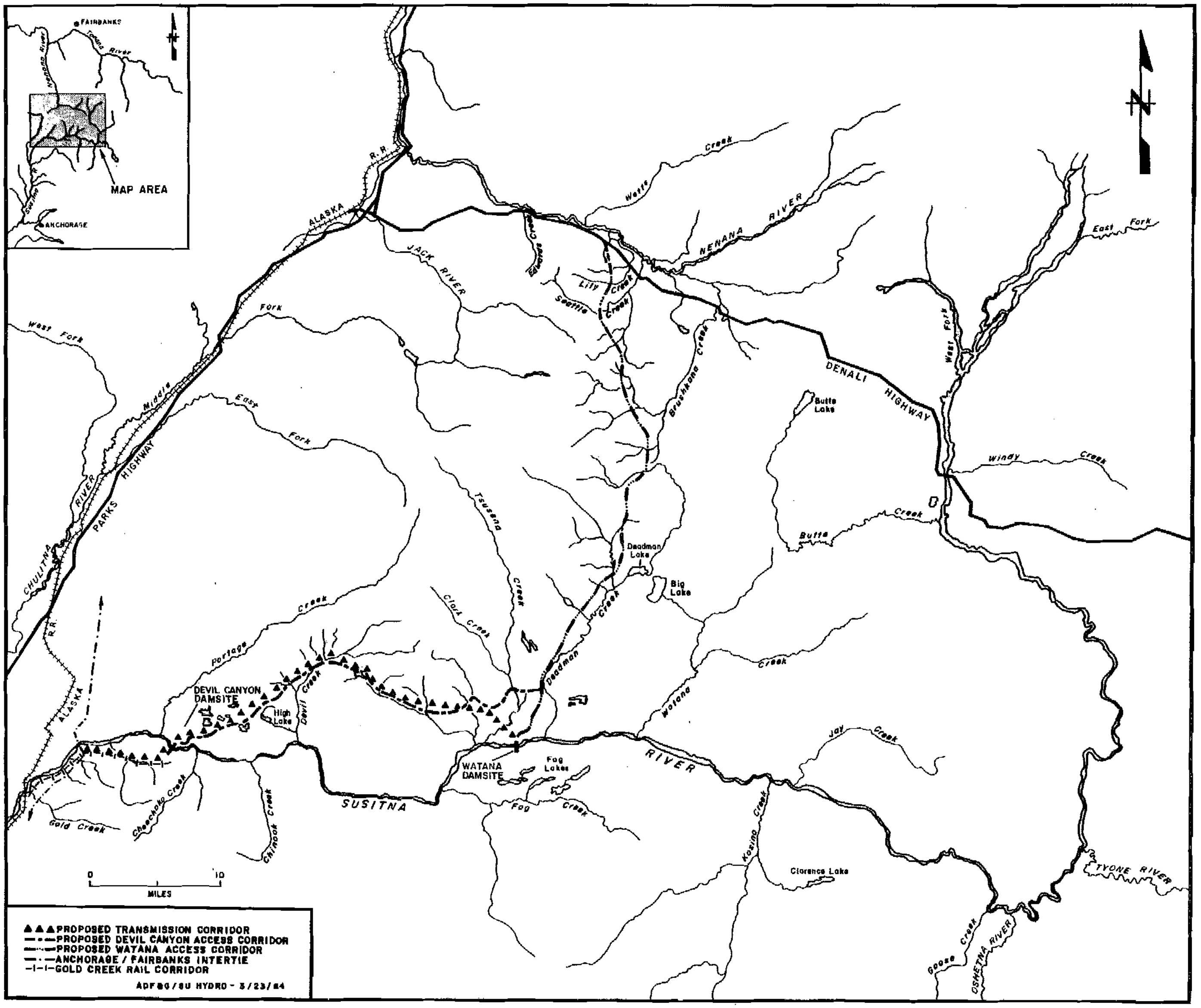

Figure 1. Access and transmission corridor study area, 1983.

C. Inventory fish species in selected lakes which are near the proposed access and transmission corridors and construction sites. This includes obtaining data for generating a population estimate for selected fish species in Deadman Lake;

D. Evaluate selected physical and chemical characteristics of Deadman Lake to support fish population analysis; and

E. Estimate the population of Arctic grayling (Thymallus arcticus) in representative reaches of Deadman Creek which are near the proposed access corridor.

1.2 Background

The proposed location for the Susitna Hydroelectric dams (approximately 120 air miles north of Anchorage) is set in a remote wilderness area of high aesthetic and recreational value (Figure 1). Because there are no permanent roads within the area, access is limited primarily to aircraft, however, portions are also accessible by boat from the Denali Highway. Due to these access limitations and the remote nature of the area, construction work on the Susitna dams would require the building of access roads and construction camps to serve the project area on a year-round basis. Transmission lines would also be required from the proposed dam sites to interconnect the project with the Anchorage-Fairbanks Transmission Line Intertie near Gold Creek.

Eighteen alternate plans have been proposed to provide road and rail access into the project area (Acres 1983a). These plans center on three general corridor areas for developing an overall access plan (Figure 2). Corridors one and two, which would serve both the Devil Canyon and Watana dam sites, are located on the north and south side of the Susitna River, respectively, and extend from the Parks Highway to the Watana dam site. Corridor three extends south from the Denali Highway to the Watana dam site.

The primary access corridor being considered by the APA is Plan 18, also referred to as the Denali-North plan (Acres 1983a). This plan incorporates the basic components of corridors one and three (Figure 2). A major modification of this plan is that the access road is connected to Gold Creek by a rail spur from the Devil Canyon dam site instead of connecting directly to the Parks Highway as in other plans. The Denali Highway would provide initial access into the area until the rail spur was completed allowing for access by both road and rail. A section of the Denali Highway extending 21 miles from Cantwell would be upgraded to accommodate the increased traffic. In addition, a two mile section of road would be built to connect the railroad to the main highway at Cantwell.

This study of the access corridor focuses only on the Denali-North plan with road access beginning at mile 21 at the Denali Highway. The access road from the Denali Highway extends south for approximately 44 miles to the Watana dam site. At approximately corridor mile (CM) 38 of the Watana access road, a spur road would extend along the north side of the

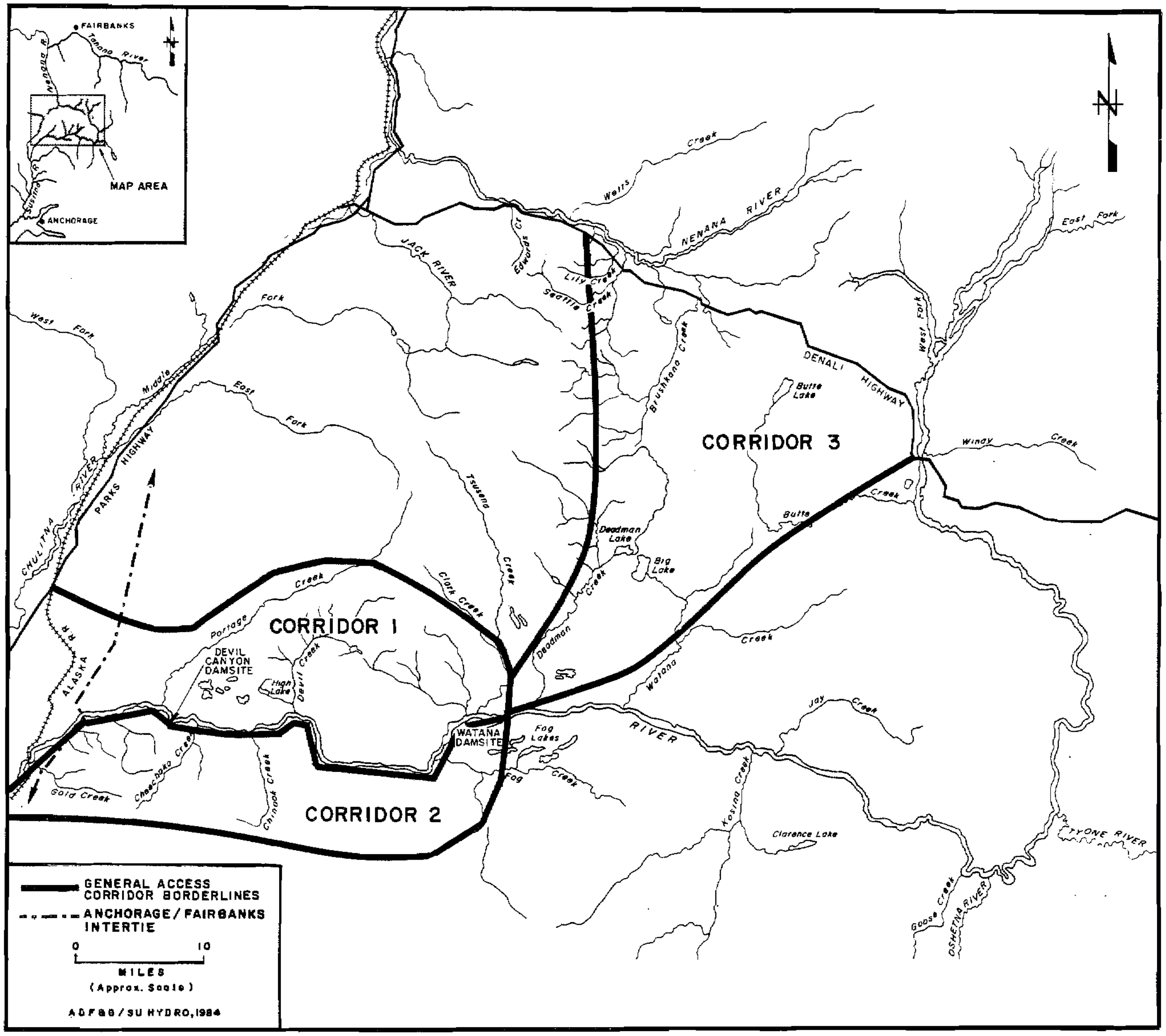

Figure 2. Three general access corridor areas used for developing an overall access plan to the Devil Canyon and Watana Dam sites for the Susitna Hydroelectric Project (adapted from Acres 1983c).

Susitna River for approximately 36 miles to the Devil Canyon dam site. At this point the road would cross over the Susitna River by way of a suspension bridge located approximately one mile downstream of the Devil Canyon dam and connect with the rail access corridor to Gold Creek extending an additional 12 miles.

The APA has identified three study areas for developing an overall transmission system for delivering power from the Susitna dams to the railbelt area (Acres 1983c). Two of these study areas refer to the northern and southern portion of the Anchorage-Fairbanks Intertie and were not the subject of this study. The third study area, referred to as the central area, provides transmission line alternatives for interconnecting the power generating facilities at the Susitna dams to the Anchorage-Fairbanks Intertie. The transmission line corridor portion of this report deals only with transmission alternatives within the central study area.

Fifteen corridor segments have been identified for developing an overall transmission corridor within the central study area to carry power from the Susitna dam sites to the Intertie (Figure 3). These alternative corridors connect to the Intertie at four different locations. The APA has selected a corridor route composed of segments AJ, JC, and CD (Figure 3), which they refer to as the Gold Creek-Watana transmission corridor. This proposed transmission corridor, which closely parallels the access corridor, will eventually contain four separate transmission lines which will connect both the Devil Canyon and Watana dam sites to the Anchorage-Fairbanks Intertie near Gold Creek (Acres 1983a). The transmission line corridor from the Watana dam site extends 36.7 miles to the Intertie. The transmission line corridor from the Devil Canyon dam site extends for 8.3 miles to the Intertie.

Previous investigations conducted by the ADF&G (1981c, 1981d, 1983c) in the upper Susitna River basin (above Devil Canyon) have been confined to the areas that would be inundated by the proposed impoundments. Although these areas would be the primary fish habitats impacted, the development of the access and transmission line corridors, along with associated construction activities, could also impact many lake and stream fish habitats near the proposed corridors both during and after the construction period.

Dolly Varden (Salvelinus malma), Arctic grayling, and lake trout (Salvelinus namaycush) are the major sport fish species presently identified in the study area. Populations of Dolly Varden and lake trout are found in several lakes and portions of streams near the proposed corridor routes. Much of the Deadman Creek system below Deadman Lake, which parallels the proposed access corridor for approximately 15 miles, contains a high quality Arctic grayling fishery (ADF&G 1983c).

Examination of the physical and chemical characteristics of these aquatic habitats and the fish populations which utilize them is required by project participants in order to identify and evaluate potential impacts on these resources and evaluate appropriate mitigative options.

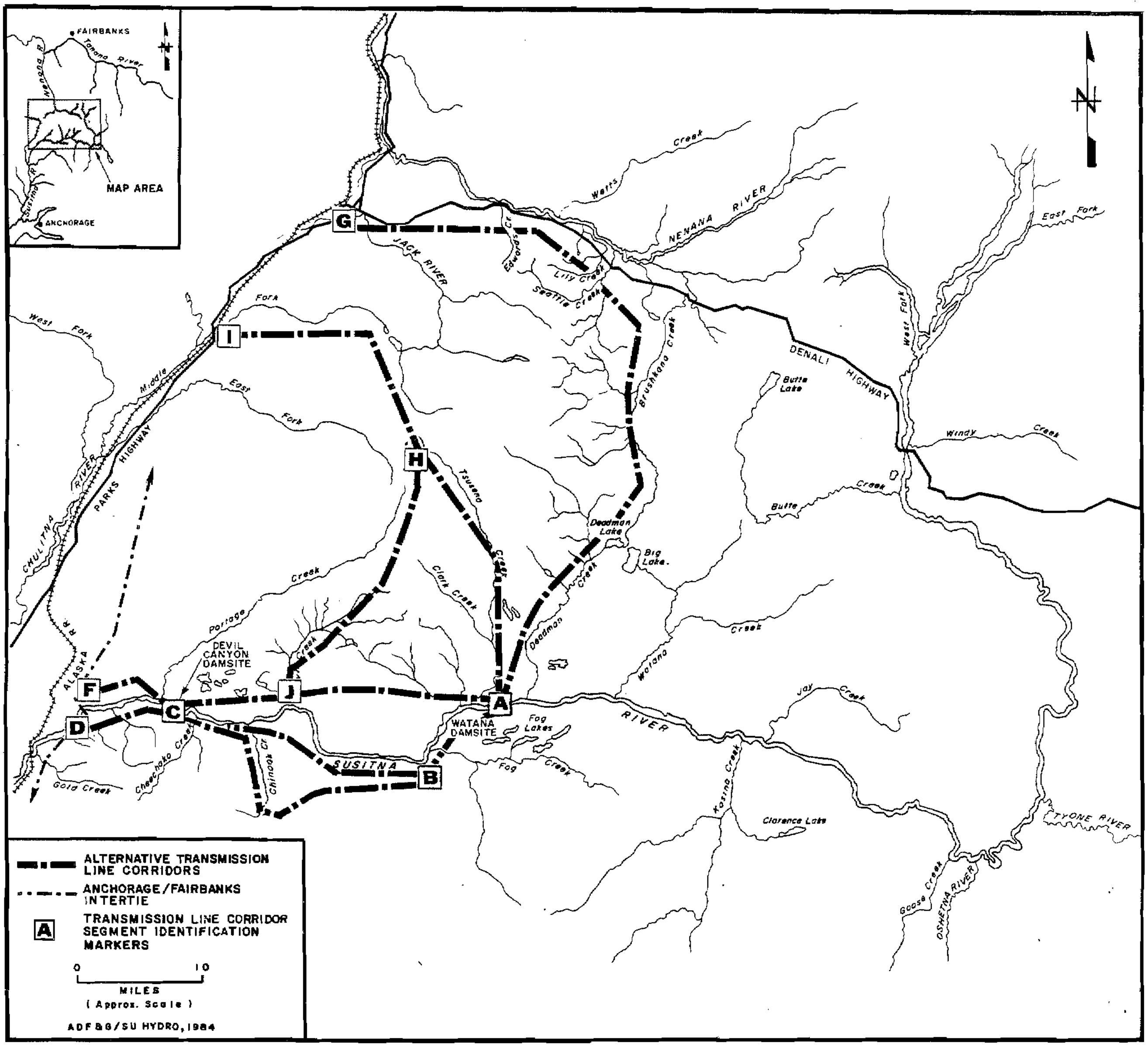

Figure 3. Alternative transmission line corridor segments from which an overall transmission corridor (adapted from Acres 1983c) was defined by the Alaska Power Authority for connecting the Watana and Devel Canyon generating systems to the Anchorge-Fairbanks Intertie.

2.0 METHODS

The ATC study was conducted from June through mid-October, 1983. Monthly field trips of approximately 15 days each were conducted from July through September. Arctic grayling population estimates and investigations of stream crossing study sites were completed during the July and August sampling periods, respectively. Fish inventory and population estimates on Deadman Lake were conducted primarily during the September field trip. Additional field trips of approximately five days were conducted in late September and early October to complete work on resident fish species of Deadman Lake.

2.1 Selection and Description of Study Sites

The ATC study area included the aquatic habitats lying within 500 feet of either side of the proposed corridors from the Denali Highway to Gold Creek (Figure 1). The study area also included selected nearby lakes and reaches of Deadman Creek that may be impacted by increased access to the area. Of these lakes, Deadman Lake received more intensive study because of its larger size and populations of lake trout and Arctic grayling. The Susitna River crossing site was excluded from the ATC study because this area has been the subject of study by other components of the ADF&G Su Hydro study team during previous years (ADF&G 1981a, 1983a, 1983b; Schmidt et al. 1984; Barrett et al. 1984).

2.1.1 Streams

The proposed access and transmission corridors closely parallel each other along most of the route from the Watana dam site to the Anchorage-Fairbanks Intertie. Many of the streams in this area are crossed by both of the proposed corridors in relative close proximity of each other. Sampling of proposed stream crossing sites on both corridors would have resulted in repetitive sampling of many streams. Therefore, on site investigations were limited to the proposed access corridor where more permanent alterations of habitats may occur.

The access corridor stream crossing study area consisted of three individual corridors:

(A) The proposed Watana access corridor beginning at mile 114 of the Denali Highway extending south approximately 44 miles to the Watana dam site (Figures 4 and 5*);

(B) The proposed Devil Canyon access corridor which closely parallels the transmission line corridor beginning at the Watana dam site and extending west and south approximately 36 miles to the Devil Canyon dam site (Figures 6 and 7); and

* To illustrate these routes the access and transmission corridor study area has been subdivided into four sections in Figures 4-7.

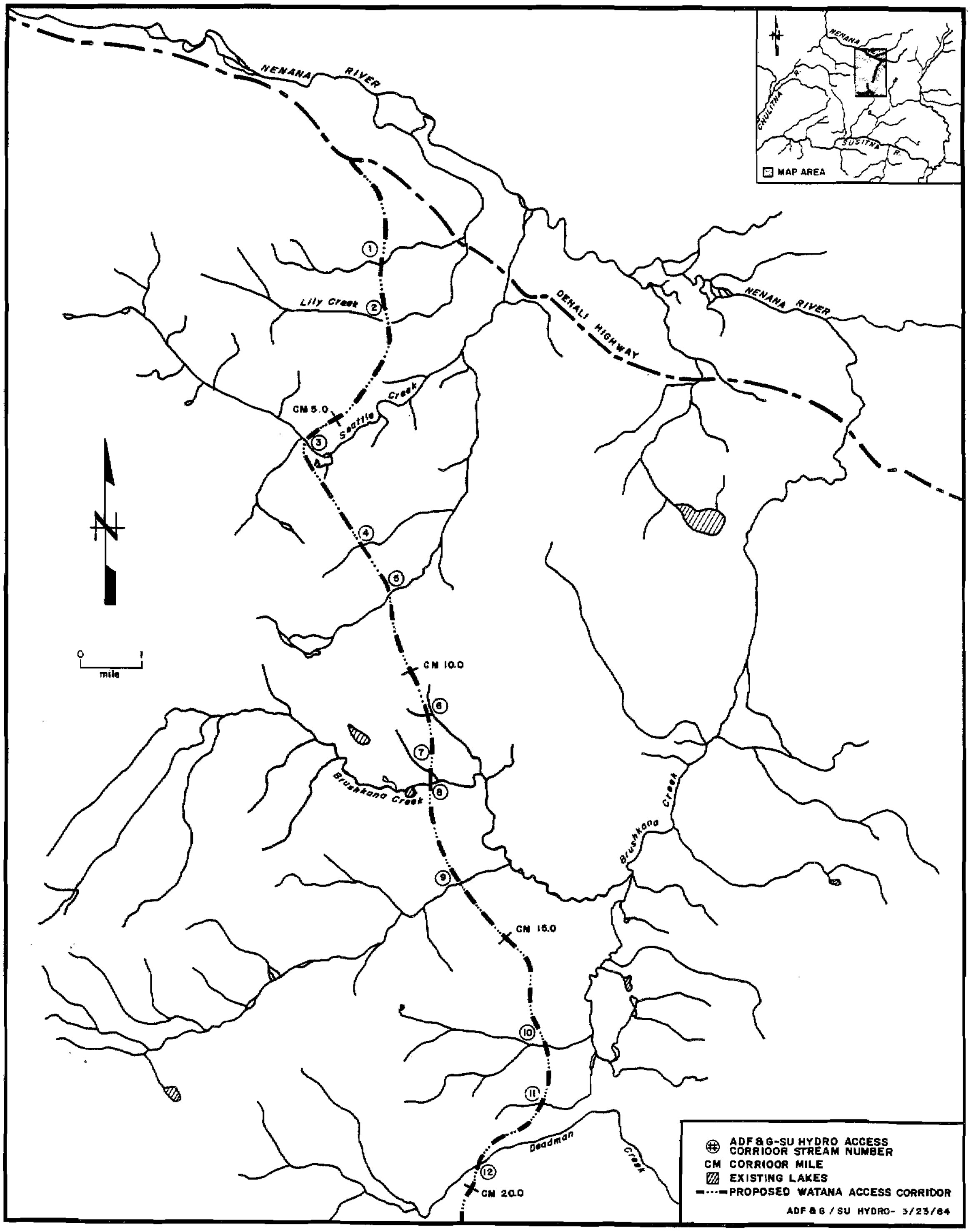

Figure 4. Stream crossing sites along the northern portion of the proposed Watana Access corridor, 1983.

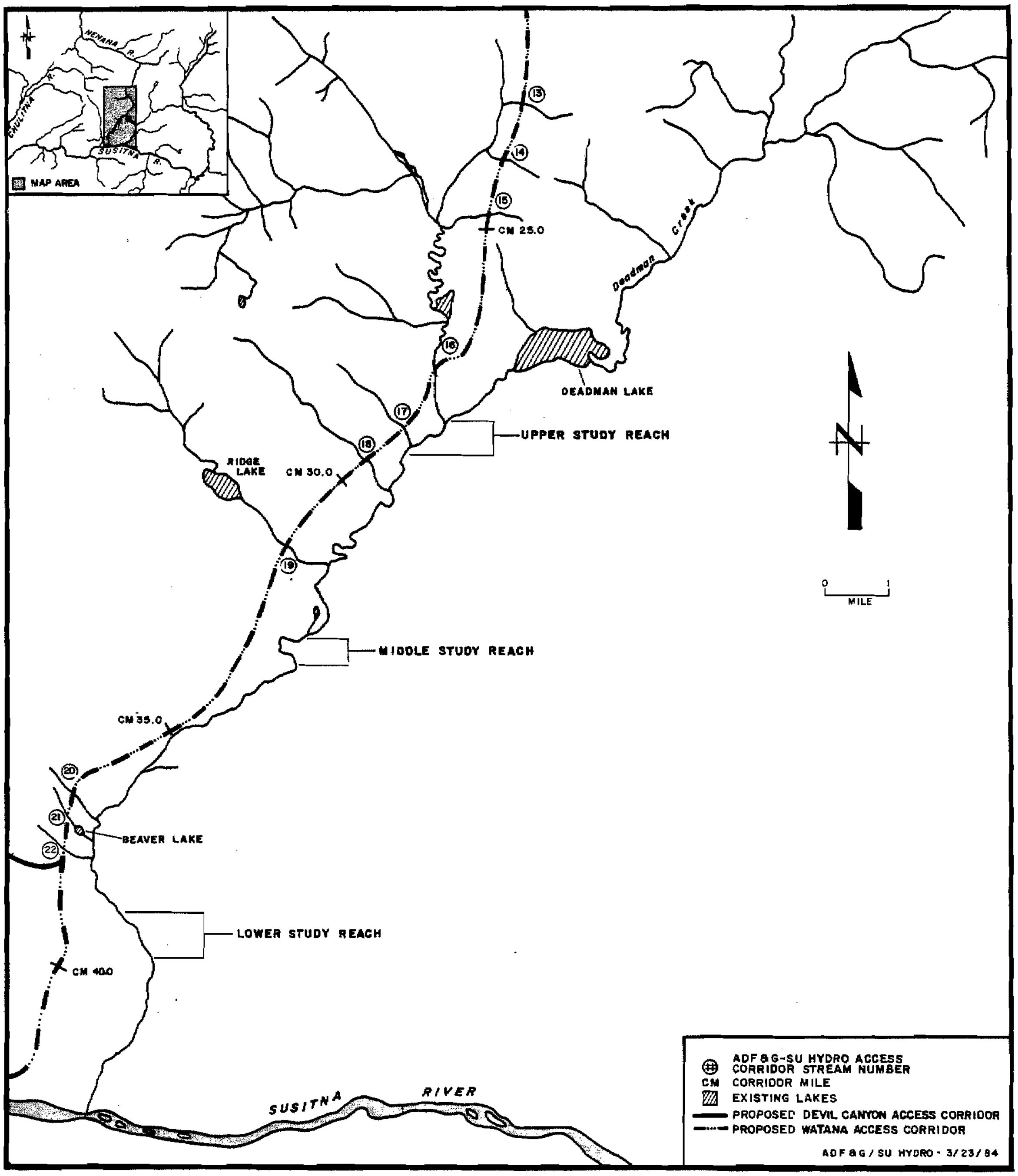

Figure 5. Stream proposed Watana access corridor, including three study reaches of Deadman Creek, 1983.

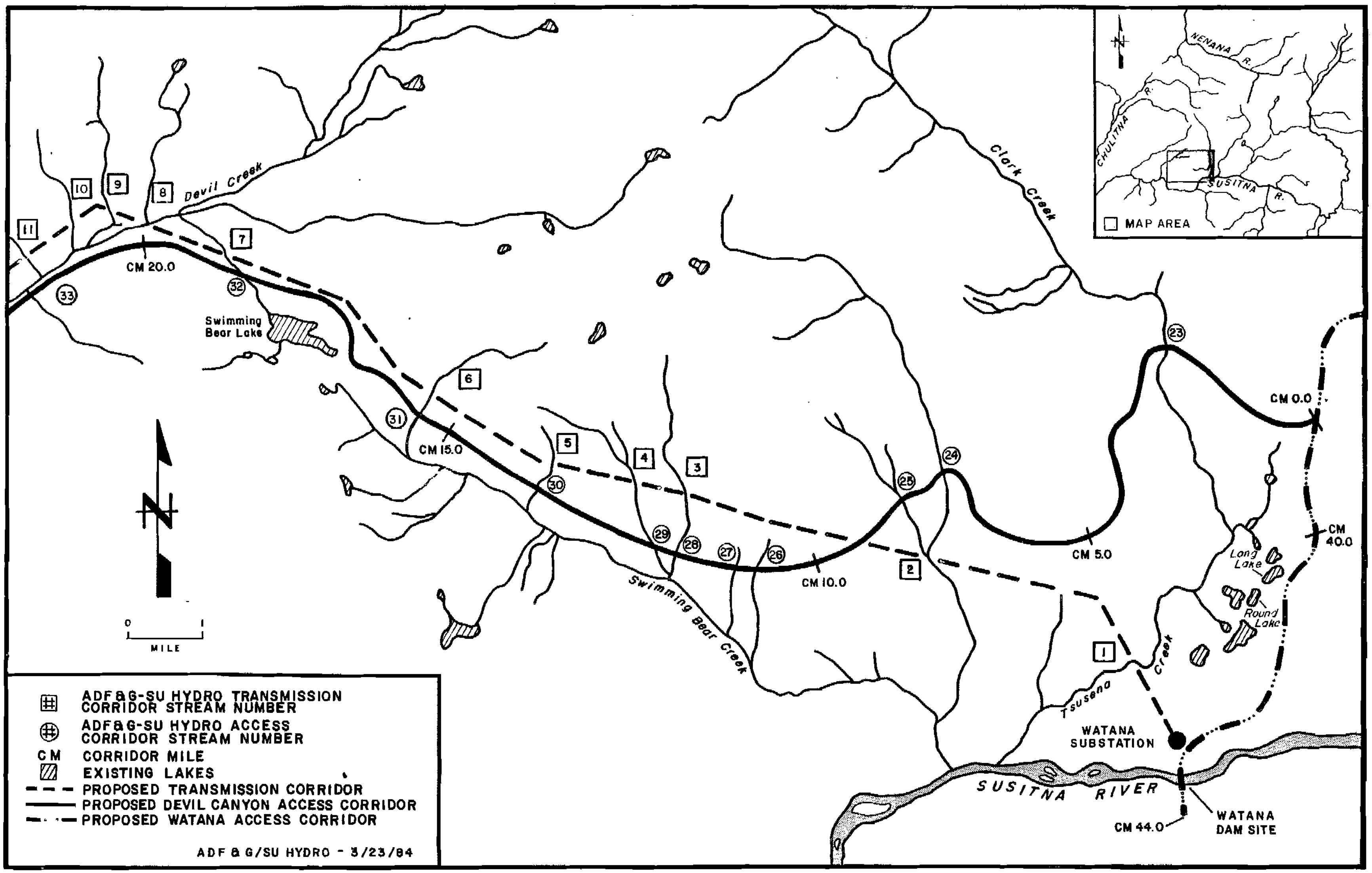

Figure 6. Stream crossing sites along the eastern portion of the proposed Devil Canyon access and transmission corridors, 1983.

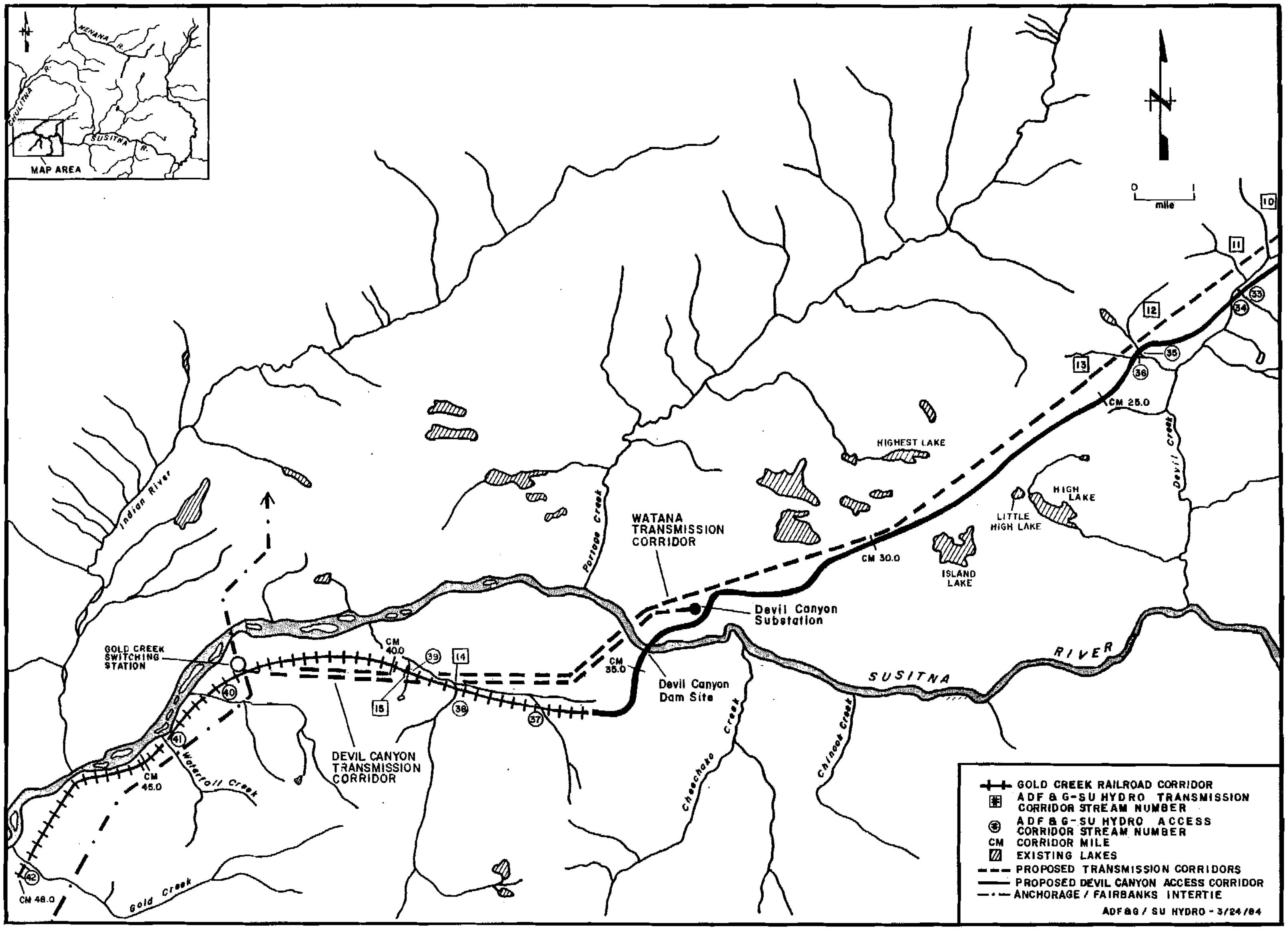

Figure 7. Stream crossing sites along the western portion of the proposed Devil Canyon access and transmission corridors, and the proposed Gold Creek rail access corridor, 1983.

(C) The proposed Gold Creek rail access corridor, approximately 12 miles in length, from the Devil Canyon dam site to Gold Creek (Figure 7).

Study sites were established at 42 proposed stream crossings within the above three corridors. Twenty-two sites were established along the Watana access corridor and included sites within the Lily, Seattle, Brushkana and Deadman Creek drainages. The Devil Canyon access corridor contained 14 sites including sites within the Tsusena, Swimming Bear and Devil Creek drainages. Six sites were established along the Gold Creek rail portion of the access corridor, including sites within the Jack Long and Gold Creek drainages.

Study site locations were determined by helicopter surveys using maps developed by R&M Consultants, Inc. (Proposed Access Plan 18, map #252210, 9/17/82) on which the proposed route was overlaid on USGS topographic maps (scale 1:63360, 1951 series). Corridor miles were established for all study sites within each of the three corridor study sections using the above mentioned maps and a Numonics 2400 electronic graphics calculator (digitizer). The Watana access corridor is 44 miles in length beginning at the Denali Highway (CM 0) and ending at the Watana dam site (CM 44). The Devil Canyon and Gold Creek rail corridor were combined to form a 48 mile long corridor. Corridor miles were assigned beginning at the junction of the Watana and Devil Canyon access corridors (CM 0) and ending at the termination of the Gold Creek rail corridor (CM 48). Streams were then assigned numbers from 1 to 42 and associated corridor miles, along the route beginning at the Denali Highway and ending at Gold Creek. Where applicable, common names are used for streams in addition to the assigned number.

Because the specific route has not been physically marked on the ground, the exact location of the proposed stream crossing sites could not be determined. Therefore, each proposed stream crossing site was located as accurately as possible within a specific stream reach using the above maps. The sampling reach generally included an area approximately 500 feet on either side of the proposed crossing site. However, some streams were sampled outside this area if access to the study reach was limited or if habitats of particular interest (fish passage barriers, spawning habitats, etc.) were located outside the immediate study area.

All proposed stream crossings were examined at least once during the field season either by aerial or on site evaluations.

Field investigations of the transmission corridor were limited to aerial surveys of proposed crossing sites to obtain a general assessment of the habitat to be affected. Since the Devil Canyon and Watana transmission lines closely parallel each other from the Watana dam site to the Anchorage-Fairbanks Intertie, the entire transmission corridor was considered a single study corridor. Corridor miles were established for the proposed transmission corridor beginning at the Watana dam site (CM 0) and ending at the intertie near Gold Creek (CM 36.7). Fifteen proposed stream crossing sites are located within the proposed transmission corridor.

Three one-mile reaches in Deadman Creek below Deadman Lake were selected for an Arctic grayling population estimate study (Figure 5). These reaches were selected as representative habitat based on differences in flow, substrate, and pool/riffle ratios.

2.1 2 Lake Studies

Most of the lakes within the vicinity of the proposed ATC study area could not be sampled because of time and personnel constraints. Therefore, nine lakes considered to be representative of the lakes in the study area were selected for sampling. The nine lakes are referred to in this report as: Ridge Lake, Beaver Lake, Long Lake, Round Lake, Swimming Bear Lake, High Lake, Little High Lake, Island Lake, and Highest Lake. With the exception of High Lake, none of the names listed here are official but have been adopted for identification purposes by ADF&G personnel. In addition to these nine lakes, Deadman Lake was also selected for study during the 1983 field season. Deadman Lake is considerably larger than other lakes in the study area and contains populations of lake trout and Arctic grayling which may be affected by increased access to the area. Therefore, this lake was studied more intensively than the others.

Specific sites for various sampling gear in each lake were selected according to gear effectiveness and aerial fish observations.

2.2 Field Data Collection

Biological and aquatic habitat data referred to in this section were collected according to procedures presented in the Aquatic Studies Procedures Manual (ADF&G 1981b, 1982, 1984a) unless indicated otherwise.

2.2.1 Biological data

Streams

Access corridor stream crossing study sites were inventoried for fish species present by use of gas-powered backpack electroshockers. Sampling was generally conducted in the reach of stream 500 feet above and below the proposed crossing site. Streams were sampled one time only during the August field trip. Time of sampling varied depending on the size of the stream and sampling effectiveness. Streams with negligible or intermittent flows were not sampled.

From July 15 through 26, 1983, the three Deadman Creek study sites were each sampled four times with a minimum of 36 hours allowed between each sampling at any one site. Sampling was conducted by hook and line using various lures and flies. A standard tagging/recapture scheme was used to provide data to generate population estimates. All Arctic grayling over 150 mm and in good condition after capture were tagged using orange Floy anchor tags inserted adjacent and just posterior to the dorsal fin. To check for tag loss twelve grayling were tagged in this manner and held in a large live box for 55 days. No tag losses occurred during this time.

Scales and otoliths were taken from a representative sample of Arctic graying from each of the three study sites at Deadman Creek to determine the age/length structure of the population, compare the populations within the three reaches, and compare the Deadman Creek population to the Susitna River population. Scales and otoliths were also collected from Dolly Varden in selected streams along the proposed access corridor to compare the age/length structure of these fish between stream and lake study sites.

Scales were soaked overnight in a solution of laundry detergent and water. The scales were then placed on scale cards, 10 fish per card, and pressed in a Given (PHI) scale press. Scales were read on a Micron portable microfiche reader.

Otoliths were extracted with the tip of a knife blade after splitting the head of each fish longitudinally. The otoliths were then stored in dry scale envelopes. Otoliths were ground flat using a sheet of fine emory cloth. The otoliths were then placed in xylene and read under an American Optical Binocular Microscope. Similar techniques are outlined by Johnston (1938) and Tripp and McCart (1974).

Radio transmitters were surgically implanted subcutaneously in six Arctic grayling from Deadman Creek. Techniques were similar to those reported in the lower river resident fish studies method section (Report No. 3, Part 5, Section 2.2.2).

Lakes

Nine lakes along the proposed access corridor were sampled with gill nets, fry traps, and trotlines to determine the species of fish present in each. Since it was not feasible to transport boats or rafts to each site, all sets were made from shore using hip boots or chest waders. Sampling time and effort varied among lakes depending on the effectiveness of the sampling method, availability of logistical support, and the size of the lake. Sets were checked every 24 hours if logistical support and weather permitted. Sites were sampled for a maximum of three days or until a valid inventory of fish species could be obtained.

Scales and otoliths were collected from fish in selected lakes to compare the age/length structure of these fish between lake and stream study sites.

Deadman Lake was sampled periodically from June to October with hook and line, gill nets, and trotlines. Hook and line sampling was conducted from four to six man days per month. Fish were located using a depth finder (Lowrance, Model LRG-1510B) and then either trolled or jigged for from the boat or shore. Variable mesh gill nets were set in the shallower waters of Deadman Lake where aerial or boat surveys had located concentrations of fish. Gill nets used in this study were

30 feet long with four 7.5 foot panels of either 1, 1½, 2, and 3 inch (stretched) mesh or 2, 3, 4 and 5 inch (stretched) mesh monofilament. Trotlines were set in all depths of water to capture fish in Deadman Lake for identification.

A South Dakota trap net (Plate 1) was used in late September and early October at the outlet of Deadman Lake to monitor the movement of fish between Deadman Creek and Deadman Lake.

All lake trout captured in Deadman Lake by hook and line and in good condition after capture were tagged using orange Floy anchor tags. All fish captured by gill nets and trotlines were either dead or dying from injury due to capture so both scales and otoliths were collected from these fish. Fish captured in the trap net were in excellent condition and were fin clipped and released.

2.2.2 Habitat data

Streams

Aquatic habitat data collected at proposed stream crossing study sites included selected water quality (dissolved oxygen, pH, conductivity and water temperature), discharge, and substrate. These data were collected once at each site. Water quality and discharge data were collected at a representative location within the study site. Discharge data was not collected from smaller streams where negligible or intermittent flows made accurate discharge measurements difficult. Substrate composition was visually assessed for each stream in the vicinity of the proposed crossing site. The three major types of substrates were identified and categorized according to the size classification scheme outlined in the Aquatic Studies Procedures Manual (ADF&G 1984). Each study site was also photographed at least once during the season.

Selected water quality data (dissolved oxygen, pH, specific conductance, and surface water temperature) were collected once during July, August, and September at one representative site in each of the three selected study reaches of Deadman Creek.

Lakes

Selected water quality data (dissolved oxygen, pH, conductivity, and water temperature) were collected in Deadman Lake at various depths once during the month of July. These data were used to construct depth profiles for these water quality parameters. Water quality data were collected with a digital Hydrolab (Model 4041) and extension cables used according to manufacturer's instructions.

Depth contour profiles for Deadman Lake were recorded using a depth finder (Lowrance, Model LRG-1510B) mounted on an outboard powered boat traveling at constant speed on specified transects. Transects were established with the aid of an aerial photo (scale - 1" to 400') of the lake using landmarks for reference points. Profiles were recorded on a

Plate 1. South Dakota trap net set at the outlet of Deadman Lake, late September 1983.

printout and later used to determine placement of depth contours on the map.

The surface area of Deadman Lake was measured from the contour map by use of a Numonics 2400 electronic graphics calculator (digitizer). All other data associated with lake morphometry were derived according to procedures described in Wetzel (1975).

Surface areas of nine other study lakes were determined from USGS topographic maps (scale 1:63360, 1951 series) using the above mentioned digitizer. Lake elevations and distances from the corridor were also determined from these maps.

2.3 Data Recording and Analysis

Population estimates for the Deadman Creek study reaches were generated by standard multiple census estimators, including Schnabel and Schumacher-Eschemeyer methods (Ricker 1975), and by the computer program "CAPTURE" developed by the Utah Cooperative Wildlife Research Unit (Otis et al. 1978; White et al. 1982).

3.0 RESULTS

3.1 Access Corridor Stream Crossing Studies

Forty-two proposed stream crossing sites were surveyed along the access corridor from the Denali Highway to Gold Creek during the 1983 field season (Tables 1-3). The results of these surveys are discussed in order beginning with drainages near the Denali Highway and ending at Gold Creek. These drainages (and the number of stream crossing study sites within each drainage) include: Lily (2), Seattle (3), Brushkana (6), Deadman (11), Tsusena (1), Swimming Bear (8), Devil (5) and Jack Long (3). Three additional streams [40, 41 (Waterfall Creek) and 42 (Gold Creek)] are presented separately in Section 3.1.9. Descriptive narratives on individual streams within each drainage are presented in their respective section.

All streams within the proposed access corridor are clear water tributaries of either the Nenana or Susitna River watersheds. Lily, Seattle and Brushkana drainages are part of the Nenana River watershed. All other drainages are part of the Susitna River watershed.

Water quality, discharge and substrate data collected at stream crossing study sites are presented in Tables 4 through 6. Due to the limited number of water quality measurements taken, and the variations in sampling times, a comparison cannot be made of the ranges of these data among individual streams. Therefore, these data only provide a general overview of the physical and chemical characteristics of habitats at stream crossing study sites.

Instantaneous water temperature measurements ranged from 5.0°C in Stream 13 to 10.7°C in Stream 21. Percent dissolved oxygen saturation in surface water at all sampling sites ranged from 72% in Stream 21 to 99% in Deadman and Gold Creeks. Values of pH ranged from 6.0 in Stream 36 to 7.5 in Stream 18. Conductivity ranged from 21 umhos/cm in Stream 36 to 158 umhos/cm in Gold Creek.

Instantaneous discharge measurements taken at selected tributaries ranged from 3.0 cubic feet per second (cfs) in Stream 40 to 82.9 cfs in Brushkana Creek (Stream 8). These limited discharge measurements do not allow for a comprehensive evaluation of the ranges of discharges which may occur in individual streams during the year. Therefore, these data were only used to make relative comparisons of discharge among streams. All discharge data were collected within a 5-day period in which there was little precipitation to affect discharges.

Catch and length data on fish species observed at stream crossing sites along the proposed access corridor are presented in Tables 7-9. A total of four species were identified by ADF&G field crews during the 1983 field season. These species included: Arctic grayling, Dolly Varden, slimy sculpin (Cottus cognatus), and chinook salmon (Oncorhynchus tshawytscha). Chinook salmon were found only in streams below Devil Canyon on the Susitna River. Due to the limited sampling time available for each stream, the survey results cannot be considered conclusive and

Table 1. Stream crossing study sites along the proposed Watana access corridor, 1983.

Stream Number and/or Name	Geographic Code	Corridor Mile	Approximate Elevation at Crossing Site
1	F 18S 04W 28 AAC	2.0	3000
2 - Lily Creek	F 18S 04W 33 AAC	3.0	2950
3 - Seattle Creek	F 19S 04W 08 ADA	5.8	3250
4	F 19S 04W 16 DDC	7.7	3400
5	F 19S 04W 22 CBD	8.7	3300
6	F 19S 04W 34 DCA	10.7	3400
7	F 20S 04W 03 DCB	11.7	3375
8 - Brushkana Creek	F 20S 04W 03 DCC	12.0	3375
9	F 20S 04W 14 CBC	13.7	3300
10	F 20S 04W 36 ACC	16.9	3375
11	F 21S 04W 01 ACD	18.0	3600
12 - Deadman Creek	F 21S 04W 12 BBC	19.7	3900
13	F 21S 04W 27 DDA	23.0	3900
14	F 21S 04W 34 ADC	23.7	3900
15	F 21S 04W 03 ACD	24.8	3400
16	F 22S 04W 16 DDD	27.5	3100
17	F 22S 04W 21 BCD	28.5	3000
18	F 22S 04W 29 ABA	29.5	3075
19	F 22S 04W 31 DBB	31.4	3100
20	S 32N 05E 02 BBA	36.9	2475
21	S 32N 05E 02 BCC	37.2	2475
22	S 32N 05E 02 CBC	37.8	2475

Table 2. Stream crossing study sites along the proposed Devil Canyon access corridor, 1983.

Stream Number and/or Name	Geographic Code	Corridor Mile	Approximate Elevation at Crossing Site
23 - Tsusena Creek	S 32N 05E 09 ACC	2.2	2250
24	S 32N 04E 12 CBC	8.0	2900
25	S 32N 04E 14 ABC	8.7	2925
26	S 32N 04E 21 ABB	11.1	2900
27	S 32N 04E 21 BAB	11.4	2900
28	S 32N 04E 17 DBC	12.0	2900
29	S 32N 04E 17 CAC	12.4	2900
30	S 32N 03E 12 DCD	13.9	3100
31	S 32N 03E 11 BBC	15.7	3250
32	S 33N 03E 32 DBB	18.9	3200
33	S 33N 02E 35 DCA	22.2	2575
34 - Devil Creek	S 33N 02E 35 CDD	22.4	2525
35	S 32N 02E 04 DAD	24.3	2650
36	S 32N 02E 04 DDC	24.5	2650

Table 3. Stream crossing study sites along the proposed Gold Creek rail access corridor, 1983.

Stream Number and/or Name	Geographic Code	Corridor Mile	Approximate Elevation at Crossing Site
37	S 31N 01W 02 DCC	37.3	1425
38	S 31N 01W 03 CBC	38.9	1350
39	S 31N 01W 04 BAB	39.9	1300
40	S 31N 02W 01 CBC	43.3	900
41 - Waterfall Creek	S 31N 02W 11 BCB	44.5	900
42 - Gold Creek	S 31N 02W 20 ACB	47.9	725

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Table 4. Aquatic habitat data collected at stream crossing study sites along the proposed Watana access corridor, 1983.

Stream Number and/or Name	Date	Time	DO (mg/l)	DO (% sat)	pH	Conductivity (umho/cm)	Temp. - °C Air	Temp. - °C Water	Discharge (cfs)	Substrate - 3 Major Types[a] 1	2	3
1	830817	1155	9.4	95	7.4	038	13.6	5.8	5.4	Bo	Co	Cr
2 - Lily Creek	830817	1240	10.5	97	7.0	028	13.8	6.1	14.9	Bo	Co	Ru
3 - Seattle Creek	830817	1330	10.3	95	7.0	043	17.0	6.6	31.1	Co	Ru	Cr
4	830817	1420	9.8	95	6.6	035	17.2	8.1	-	Bo	Co	Ru
5	830817	1440	9.2	89	7.2	040	17.2	8.1	4.5	Ru	Cr	Sa
6	830818	0950	9.6	89	6.5	033	13.7	6.6	-	Bo	Co	Ru
7	830818	-	-	-	-	-	-	-	-	-	-	-
8	830818	1015	9.8	92	7.2	057	10.4	7.3	82.9	Bo	Ru	Co
9	830818	1205	9.8	94	6.5	031	11.8	8.0	78.3	Bo	Co	Ru
10	830818	1300	9.6	92	6.6	036	11.8	7.8	11.0	Bo	Co	Ru
11	830818	1430	10.4	98	6.3	031	13.2	7.3	-	Bo	Co	Ru
12 - Deadman Creek	830818	1340	10.4	99	6.6	033	13.2	7.4	37.4	Bo	Co	Ru
13	830813	1230	10.4	95	7.1	023	6.7	5.0	-	Sa	Cr	Ru
[b]14	830813	-	-	-	-	-	-	-	-	-	-	-
[b]15	830813	-	-	-	-	-	-	-	-	-	-	-
[b]16	830813	-	-	-	-	-	-	-	-	-	-	-
[b]17	830813	-	-	-	-	-	-	-	-	-	-	-
18	830813	1345	9.8	89	7.5	027	6.8	5.7	12.7	Bo	Co	Ru
19	830813	1410	9.1	91	7.2	027	7.0	10.0	26.9	Bo	Co	-
20	830814	1125	9.6	88	7.0	029	11.2	7.2	6.5	Sa	Bo	Co
21	830814	1205	7.3	72	6.6	058	11.3	10.7	29.0	Bo	Cr	Co
22	830814	1255	8.1	77	7.0	038	11.2	8.8	-	Si	Mu	-

[a] Refer to Methods section of this report for substrate codes.

[b] Stream Reach not sampled.

- Data not collected.

Table 5. Aquatic habitat data collected at stream crossing study sites along the proposed Devil Canyon access corridor, 1983.

Stream Number and/or Name	Date	Time	DO (mg/l)	DO (% sat)	pH	Conductivity (umho/cm)	Temp. - °C Air	Temp. - °C Water	Discharge (cfs)	Substrate - 3 Major Types[a] 1	2	3
23 - Tsusena Creek	830818	1040	10.7	98	6.9	067	14.6	6.9	-	Bo	Co	Cr
24	830814	1315	10.5	96	7.1	037	10.4	6.7	52.1	Bo	Co	Ru
25	830814	1400	10.4	96	6.2	025	12.6	7.5	-	Bo	Co	Ru
26	830815	0955	10.4	95	6.6	028	9.0	6.3	-	Bo	Co	Sa
27	830815	1005	9.6	87	6.5	030	9.1	6.3	-	Bo	Co	Sa
28	830815	1055	9.7	88	7.0	028	9.8	6.2	7.2	Bo	Co	Ru
29	830815	1020	10.4	94	6.4	027	11.2	6.1	7.4	Bo	Co	Sa
30	830815	1215	10.0	92	6.5	025	7.2	6.2	-	Co	Ru	-
31	830815	1140	9.9	89	6.9	027	8.0	5.2	25.1	Bo	Co	Ru
32	830815	1230	9.2	94	7.2	027	8.0	10.5	18.0	Bo	Ru	Co
33	830815	1340	10.4	94	6.6	030	9.0	6.4	-	Co	Ru	Bo
34 - Devil Creek	830815	1320	9.1	82	6.8	039	9.0	7.1	-	Bo	Co	Ru
35	830815	1400	9.3	86	6.5	023	9.1	8.0	11.2	Bo	Co	Cr
36	830815	1420	10.2	94	6.0	021	9.1	7.3	10.8	Bo	Co	-

[a] Refer to Methods section of this report for substrate codes.
- Data not collected.

Table 6. Water quality data collected at stream crossing study sites along the proposed Gold Creek rail corridor, 1983.

Stream Number and/or Name	Date	Time	DO (mg/l)	DO (% sat)	pH	Conductivity (umho/cm)	Temp. - °C Air	Temp. - °C Water	Discharge (cfs)	Substrate - 3 Major Types[a] 1	2	3
37	830816	1110	10.9	93	6.3	029	17.6	6.0	-	Sa	Cr	-
[b]38	830816	-	-	-	-	-	-	-	-	-	-	-
[b]39	830816	-	-	-	-	-	-	-	-	-	-	-
40	830816	1155	10.9	94	7.3	059	16.0	7.5	3.0	Bo	Co	Ru
41 - Waterfall Creek	830816	1235	11.7	98	7.0	071	16.3	6.8	c	Bo	Co	Ru
42 - Gold Creek	830816	1300	11.3	99	7.4	158	18.6	8.4	c	Bo	Co	Ru

[a] Refer to Methods section of this report for substrate codes.
[b] Stream Reach not sampled.
[c] Data available in Phase II Final Draft Aquatic Habitat and Instream Flow Report (ADF&G 1983).
- Data not collected.

Table 7. Fish data collected at stream crossing study sites along the proposed Watana access corridor, 1983.

Stream Number and/or Name	Date	Species Observed	Number Captured	Length Range (mm)
1	830817	Dolly Varden	9	85 - 150
		Sculpin	1	70
2 - Lily Creek	830817	Dolly Varden	10	105 - 190
		Sculpin	2	60 - 85
3 - Seattle Creek	830817	Dolly Varden	50	70 - 195
		Arctic grayling	9	100 - 310
		Sculpin	3	70 - 95
4	830817	Dolly Varden	3	80 - 125
5	830817	NONE	--	--
6	830818	NONE	--	--
7	830818	a	--	--
8 - Brushkana Creek	830818	Arctic grayling	3	350 - 385
		Sculpin	2	80 - 95
9	830818	Arctic grayling	9	60 - 380
		Sculpin	10	60 - 95
10	830818	Dolly Varden	30	90 - 205
		Arctic grayling	20	95 - 285
		Sculpin	10	80 - 95
11	830818	a	--	--
12 - Deadman Creek	830818	Arctic grayling	3	240 - 365
		Sculpin		50 - 95
13	830813	a	--	--
14	830813	a	--	--
15	830813	a	--	--
16	830813	a	--	--
17	830813	a	--	--
18	830813	Dolly Varden	3	105 - 170
		Sculpin	1	85
19	830813	Sculpin	2	80 - 95
20	830814	Dolly Varden	1	45
		Arctic grayling	1	105
		Sculpin	5	50 - 90
21	830814	a	--	--
22	830814	a	--	--

a - did not sample

Table 8. Fish data collected at stream crossing study sites along the proposed Devil Canyon access corridor, 1983.

Stream Number and/or Name	Date	Species Observed	Number Captured	Length Range (mm)
23 - Tsusena Creek	830818	Dolly Varden	1	50
		Sculpin	1	55
24	830814	Dolly Varden	11	105 - 180
		Sculpin	3	75 - 90
25	830814	a	--	--
26	830815	a	--	--
27	830815	a	--	--
28	830815	Dolly Varden	1	105
		Sculpin	1	65
29	830815	Dolly Varden	1	80 - 100
		Sculpin	1	65
30	830815	a	--	--
31	830815	Dolly Varden	20	90 - 190
		Sculpin	6	50 - 90
32	830815	Dolly Varden	15	150 - 375
		Sculpin	2	60 - 80
33	830815	Sculpin	1	65
34 - Devil Creek	830815	Sculpin	2	75 - 80
35	830815	Dolly Varden	1	155
		Sculpin	1	65
36	830815	Dolly Varden	1	140

a - did not sample

Table 9. Fish data collected at stream crossing study sites along the proposed Gold Creek rail access corridor, 1983.

Stream Number and/or Name	Date	Species Observed	Number Captured	Length Range (mm)
37	830813	Sculpin	1	60
38	830816	a	--	--
39	830816	a	--	--
40	830816	Chinook salmon	20	40 - 60
		Sculpin	3	50 - 95
41 - Waterfall Creek	830816	Arctic grayling	1	140
		Chinook salmon	30	40 - 60
		Sculpin	8	40 - 85
42 - Gold Creek	830816	a	--	--

a - did not sample

further field work would be required for a more comprehensive evaluation of fish species along the proposed corridors.

3.1.1 Lily Creek drainage

The Lily Creek drainage is the first watershed crossed by the proposed Watana access corridor starting from the Denali Highway. Two streams within this drainage, Stream 1 and Lily Creek (Stream 2), are crossed by the proposed route at corridor miles (CM) 2.0 and 3.0, respectively (Figure 4). Elevations of stream crossing sites within this drainage range from 2,950 to 3,000 feet. Fish species identified within this drainage include Dolly Varden and slimy sculpin.

Stream 1

Stream 1 is a small, high gradient tributary to Lily Creek. It originates in steeply sloping terrain and flows east for approximately four miles to its confluence with Lily Creek (Figure 4). The stream channel is situated in a small, narrow ravine for most of its length with progressively decreasing stream gradients in the lower reaches. Most of the stream is characterized by high velocity, cascading riffles with a few small, shallow pools. The fish habitat in the upper 1-2 miles becomes more limited due to the higher stream gradients.

The stream crossing study site is located on a relatively steep sloping ridge. The stream channel at this site is 4-8 feet in width and is frequently obscured by low lying vegetation (Plate 2). The substrate consists mostly of boulder and cobble in the dominant riffle areas with some gravel in the small, infrequent pools.

Fish species identified within the stream crossing study site included Dolly Varden and slimy sculpin. The Dolly Varden found here were relatively small and did not exceed 150 mm in length.

Stream 2 (Lily Creek)

Lily Creek is a relatively small, high gradient tributary to the Nenana River which originates in steep, mountainous terrain. The stream is approximately nine miles in length. It flows east for approximately four miles from its source and then north for another five miles before draining into the Nenana River (Figure 4).

The stream crossing study site is located on a steep ridge and the stream gradient decreases quickly below this site. Fish habitat above the crossing site becomes progressively limited due to rapidly increasing stream gradient which results in increased water velocities and a less accessible stream channel. The stream channel is between 10-15 feet wide and is situated in a small, narrow ravine at the crossing site (Plate 3). Substrate is composed mostly of large boulder and cobble. The stream habitat consists of high velocity riffles with few, small, shallow pools.

Dolly Varden, up to 190 mm in length, and slimy sculpin were the only fish species identified in the study area.

Plate 2. General vicinity of proposed stream crossing site on Stream 1.

Plate 3. General vicinity of proposed stream crossing site on Stream 2.

3.1.2 Seattle Creek drainage

The Seattle Creek drainage contains three streams which are crossed by the proposed Watana access corridor. These streams include Seattle Creek (Stream 3), and Streams 4 and 5 located at CM's 5.8, 7.7 and 8.7, respectively (Figure 4). Elevations at these proposed stream crossing sites range from 3,250 to 3,400 feet. Fish species identified within this drainage included Arctic grayling, Dolly Varden, and slimy sculpin.

Stream 3 (Seattle Creek)

Seattle Creek is a large clearwater stream originating in mountainous terrain approximately 12 miles above its confluence with the Nenana River (Figure 4). The stream flows east from its source to the proposed stream crossing site where it then flows northeast to the Nenana River. Most of the stream is situated in a broad, shallow valley with low stream gradients and relatively shallow, uniform depths (Plate 4). Approximately six miles of stream lie above the stream crossing study site.

Stream habitat near the proposed crossing site consists of long riffle areas with moderate flows and a few small, shallow pools. Stream widths are between 25 and 30 feet with split channels sometimes occurring. The substrate is composed of a relatively uniform mixture of cobble, rubble and gravel.

Fish species found in this area include Arctic grayling, Dolly Varden and slimy sculpin. The Arctic grayling found here were up to 310 mm in length which indicates that Seattle Creek may have potential for supporting a recreational fishery for this species.

Stream 4

Stream 4 is a small, low gradient stream which flows northwest for three miles from its source to its confluence with Stream 5 (Figure 4). It originates in a series of small ponds in gently sloping terrain 1.5 miles above the proposed corridor crossing site. The stream flows over open tundra for most of its length but is often concealed by low lying vegetation along its banks.

Stream habitat in the area of the crossing site consists mostly of long, shallow riffles with moderate flows. A few small pools are located behind large boulders in the stream. Substrate generally consists of boulder, cobble and rubble in equal proportions. Stream widths vary from 5-7 feet.

Most of this stream appears to contain marginal fish habitat suitable only for small fish. Dolly Varden less than 125 mm in length were the only species found within the study site.

Stream 5

Stream 5 is a small, shallow stream which originates near two small lakes (Figure 4). The stream flows north for approximately eight miles

Plate 4. General vicinity of proposed stream crossing site on Stream 3.

Plate 5. General vicinity of proposed stream crossing site on Stream 5.

from its source to its confluence with Seattle Creek. The stream lies in a broad, shallow valley for most of its length and is characterized by a meandering channel with a relatively low gradient (Plate 5).

The habitat at the stream crossing study site consists mostly of long riffles with moderate flows and frequent small, shallow pools. The substrate is mostly rubble, gravel and sand. Stream channel widths vary from 12-15 feet. Although no fish were found at this site, this reach contains good fish habitat, especially for juvenile fish. The approximate three miles of stream immediately above the crossing study site also appeared to contain good fish habitat. No apparent barriers to fish migration were observed in the lower reaches of the stream.

3.1.3 Brushkana Creek drainage

Six streams in the Brushkana drainage are crossed by the proposed Watana access corridor from CM 10.7 to CM 18.0 (Figure 4). These include streams 6 (CM 10.7), 7 (CM 11.7), 8 (Brushkana Creek, CM 12.0), 9 (CM 13.7), 10 (CM 16.9), and 11 (CM 18.0). Elevations at these proposed stream crossing sites range from 3,300 to 3,600 feet. Fish species found within this drainage include Arctic grayling, Dolly Varden and slimy sculpin.

Stream 6

Stream 6 is a small, moderate gradient stream which flows in a southeast for approximately two miles from its source to its confluence with Brushkana Creek (Figure 4). The creek flows through open tundra for most of its length but is frequently concealed by low lying vegetation along its banks (Plate 6). The lower reach of the stream flows through a series of small beaver ponds before draining into Brushkana Creek.

The habitat in the area of the stream crossing study site consists mostly of riffles with moderate streamflow velocities. The substrate consists of large boulders, cobble and rubble within a narrow stream channel of 2-3 feet which results in high flow velocities and marginal fish habitat. No fish were found in the study area. Fish habitat deteriorates in the 0.5 mile reach of stream which lies above the proposed crossing site due to low discharge and a corresponding reduction of habitat.

Stream 7

Stream 7 is a small, low gradient stream which flows southeast for approximately one mile before draining into Brushkana Creek (Figure 4). The stream flows through muskeg and is concealed by heavy vegetation in most of its lower reach. The flow in this area is dispersed over the muskeg and the stream channel becomes braided. Approximately 0.7 miles of the stream lies above the proposed crossing site.

Due to the small size of the stream and the dense vegetative cover, no onsite surveys were conducted. Aerial surveys indicate that fish habitat in the area of the proposed crossing site is poor. Fish sampling conducted on Brushkana Creek near the mouth of Stream 7

Plate 6. General vicinity of proposed stream crossing site on Stream 6.

Plate 7. General vicinity of proposed stream crossing site on Stream 8.

collected Arctic grayling and slimy sculpin. Sculpin and juvenile Arctic grayling probably utilize portions of Stream 7 during periods of high flows and return to Brushkana Creek when flows are reduced.

Stream 8 (Brushkana Creek)

Brushkana Creek is a large, meandering, low gradient stream in the Nenana River drainage approximately 26 miles in length. The stream originates in steep, mountainous terrain and flows northeast for approximately 3.0 miles where it enters a large, broad valley. The stream then flows east for approximately 10.0 miles, before turning northwest for another 13.0 miles to its confluence with Monahan Creek (Figure 4). The stream flows through several small lake systems along the way and is joined by numerous tributaries making it one of the largest watersheds along the proposed access corridor. Approximately 10 miles of the main channel of Brushkana Creek lie above the proposed crossing site. Several other tributaries to Brushkana Creek are also located above the stream crossing study site.

Brushkana Creek contains excellent fish habitat in the area of the proposed stream crossing site. The stream varies from 45-50 feet in width, and has a uniform substrate of boulder, cobble and rubble. Long riffle areas with moderate flows are interspersed with frequent small pools located mostly near the banks (Plate 7).

Arctic grayling and slimy sculpin were found in this area of the stream. The Arctic grayling were up to 385 mm in length indicating that Brushkana Creek has sport fishing potential for this species.

Stream 9

Stream 9 is a major tributary to Brushkana Creek. This large, clear water stream flows northeast for approximately 12 miles from its source in mountainous terrain to its confluence with Brushkana Creek (Figure 4). Most of the stream flows through a broad, shallow valley with frequently braided stream channels (Plate 8). Several small tributaries and lakes drain into the stream along its course. All except the lower 0.5 miles of stream lie above the proposed corridor crossing site.

Excellent fish habitat is available in the area of the proposed corridor crossing. The habitat is dominated by long riffles of moderate streamflow velocity with frequent pools found in the deeper, narrower channels. The stream varies in width from about 40 feet in the narrow channels to over 100 feet in the braided sections. The substrate is a relatively uniform composition of boulder, cobble and rubble. Arctic grayling, from 60 to 380 mm in length, and slimy sculpin were found within the study site. Presence of young-of-the-year Arctic grayling indicates that Stream 9 may provide spawning and rearing habitat for this species. This reach of the stream also has sport fishing potential for Arctic grayling.

Plate 8. General vicinity of proposed stream crossing site on Stream 9.

Stream 10

Stream 10 is a relatively large, clear water tributary to Brushkana Creek (Figure 4). Its source is several small drainages in the hilly terrain just east of the proposed access corridor crossing site. The stream is approximately eight miles in length with three miles lying above the proposed corridor crossing site. The stream flows east for approximately three miles beyond the crossing site and then flows north for the remainder of its length to Brushkana Creek. Most of the latter reach is situated on relatively flat, open tundra resulting in a meandering low gradient channel. Several small lakes drain into the stream in this reach.

Good fish habitat is available in the area of the stream crossing study site. The stream channel is from 15-20 feet wide with a uniform substrate of boulders, cobble and rubble (Plate 9). Long riffles with moderate flow dominate the habitat. Pools are few and small in size. Dolly Varden, Arctic grayling and slimy sculpin were found within the study site.

Stream 11

Stream 11 is a small, high gradient stream which drains off a ridge above the corridor crossing site. The stream is approximately 2.5 miles in length with 0.5 miles of stream above the crossing site. The stream flows east off the ridge and then flows north to its confluence with Stream 10 (Figure 4).

Fish sampling was not conducted on Stream 11 due to its small size. Stream habitat at the crossing site consists of a high gradient, narrow channel (2-3 feet) which is partially concealed by vegetation (Plate 10). The substrate is composed of boulders, cobble and rubble. Most of the flow is derived from rainwater and probably is intermittent during the season.

3.1.4 Deadman Creek drainage

The Deadman Creek system is the largest watershed crossed by the proposed Watana access corridor. Eleven streams within this drainage are crossed by the corridor from CM 19.7 to CM 37.8 (Figures 4 and 5). Seven of these streams (Streams 16-22) drain directly into Deadman Creek from CM 27.5 to 37.8 along a reach of stream that parallels the access corridor. Three streams are tributaries to Stream 16 and are located from CM 23.0 to 24.8. Deadman Creek itself is crossed at CM 19.7. Elevations of these proposed stream crossing sites are the highest among study sites along the access route and range from 2475 to 3900 feet.

Fish species found at proposed stream crossing study sites within the Deadman drainage included Arctic grayling, Dolly Varden and slimy sculpin. Other fish species found in Deadman Lake and sections of Deadman Creek included lake trout, burbot (*Lota lota*), round whitefish (*Prosopium cylindraceum*), and humpback whitefish (*Coregenus pidschian*).

Plate 9. General vicinity of proposed stream crossing site on Stream 10.

Plate 10. General vicinity of proposed stream crossing site on Stream 11.

Stream 12 (Deadman Creek)

Deadman Creek is a large, meandering, clear water tributary of the Susitna River (Figure 4). The stream flows south for approximately 40 miles from its source to its confluence with the Susitna River and has a total drainage basin area of 175 square miles. A large lake, Deadman Lake, is located approximately 19 miles upstream from the mouth. The basin above Deadman Lake is drained by several smaller streams which converge to form the main channel of Deadman Creek. A small channel branches off from the main stream and flows into the Brushkana drainage in this reach. Below the outlet of the lake the stream habitat alternates between long riffles and turbulent whitewater, and occasional areas of deep, slow flowing water with low stream gradients (Plate 11).

The stream crossing study site is located in the upper reaches of Deadman Creek approximately 15 miles above the lake. The study site is situated in a narrow, relatively deep ravine which limited access to the area. The stream channel is approximately 15 feet wide in the ravine and the habitat consists mainly of high gradient whitewater and small waterfalls. The substrate is composed mostly of large boulder and cobble. The habitat in this reach does not appear to be suitable for fish due to the high streamflow velocities. The ravine also appears to be a barrier to upstream fish migration.

Because access to the area was limited due to the steep terrain, sampling was conducted immediately below the ravine. Excellent fish habitat is available downstream of the ravine and Arctic grayling and slimy sculpin were captured in this area. The Arctic grayling were up to 365 mm in length indicating that the stream has potential to provide a sport fishery for this species.

Streams 13 and 14

Streams 13 and 14 are very small, high gradient streams approximately one mile in length. Both streams flow west and drain into a small, unnamed tributary of Stream 16 (Figure 5). The streams originate in steep, mountainous terrain and flow through small, narrow valleys for much of their lengths. The lower reach of Stream 13 flows across a low gradient region of open tundra (Plate 12).

The stream crossing study sites on each stream are located just above their mouths where the access corridor parallels the small tributary they drain into. Although gradients are less steep in these lower reaches, the overall fish habitat appears poor. Suitable fish habitat is confined to the area near the mouth of each stream. Fish sampling conducted on the small unnamed tributary which the streams drain into showed that Dolly Varden utilize this stream. It is probable that these Dolly Varden may use some portion of the lower reaches of each of these streams. However, the flows may be intermittent and long term use of these habitats by fish is unlikely. Fish habitat deteriorates quickly above the study sites, especially on Stream 14 where the gradient increases sharply.

Plate 11. General vicinity of proposed stream crossing site on Stream 12.

Plate 12. General vicinity of proposed stream crossing site on Stream 13 (upper left).

Stream 15

Stream 15 is a small, high gradient stream approximately 1.5 miles in length. The stream originates in mountainous terrain and flows west through a steep, narrow ravine to its confluence with Stream 16 (Figure 5). Most of the stream consists of high velocity riffles and cascading whitewater which results in very poor fish habitat.

Fish sampling was not conducted on this stream. The steep narrow ravine and high gradient stream channel presents a fish passage barrier to upstream reaches. Grayling and slimy sculpin, which are present in Stream 16, have access to the extreme lower reaches of Stream 15 and may utilize some of this habitat below the stream crossing site.

Stream 16

Stream 16 is a large, clear water tributary to Deadman Creek. The stream flows south for approximately 18 miles from its source to its confluence with Deadman Creek (Figure 5). The upper reaches of the stream flow through a broad valley with frequently braided channels and moderate gradients. Approximately two miles above its mouth a small, shallow lake drains into the stream (Plate 13). This reach of the stream is characterized by a low gradient, meandering channel with large, deep pools and low velocity riffles.

The stream crossing study site is located approximately one mile below the outlet of the lake. Since previous fish surveys had been conducted upstream of the lake and at the confluence with Deadman Creek, sampling was not conducted at the study site. Arctic grayling and slimy sculpin were captured in the reach of stream above the lake. Arctic grayling and lake trout were captured near the mouth. Aerial surveys show that Arctic grayling use the small lake as well as the reach of stream in the vicinity of the corridor crossing. These grayling are relatively large in size and offer good sport fishing potential. The lake appears to be too shallow for overwintering and these grayling probably overwinter in Deadman Lake.

Stream 17

Stream 17 is a very small, high gradient stream approximately 1.5 miles in length (Figure 5). The stream is intermittent in flow and at the time of sampling only a trickle of water was evident in the vicinity of the stream crossing study site. No flowing water was observed above the study site. No suitable fish habitat appeared to be available in this stream and it was not sampled.

Stream 18

Stream 18 is a small, shallow, high gradient tributary to Deadman Creek. The stream drains off a steep ridge and flows southeast for approximately four miles to its confluence with Deadman Creek (Figure 5).
The stream crossing study site is located approximately one mile above

Plate 13. Stream 16, and unnamed lake, in vicinity of the proposed stream crossing site.

the mouth. Stream habitat is composed mostly of high velocity riffles with a few small, shallow pools. The stream channel is 18-20 feet wide and contains substrates of boulder, cobble and rubble. Overall fish habitat is poor and only slimy sculpin and small Dolly Varden were found in the study site area.

Stream 19

Stream 19 is a relatively small, high gradient tributary to Deadman Creek and is approximately six miles in length (Figure 5). The stream originates from a small lake (Ridge Lake) and flows southeast. Below the lake the stream flows over a relatively steep ridge and then continues for two miles to its confluence with Deadman Creek.

The proposed stream crossing site is located approximately one mile above the mouth in a narrow, shallow valley. The stream channel at the study site is 15-20 feet wide and the substrate consists of boulder, cobble and rubble. This reach of the stream is characterized by high gradient riffles, infrequent pools and cascading whitewater. Some of these high gradient areas constitute potential fish passage barriers to upstream areas. Slimy sculpin were the only fish found in the study site area.

Although no fish were captured in Ridge Lake (see Section 3.4), a school of small unidentified fish approximately 6-10 inches in length were observed swimming near the shore. Because of the steep gradient below the lake it is doubtful that fish can migrate from Deadman Creek to the lake. However, it is possible that some downstream migration, past the stream crossing study site, may occur.

Streams 20, 21 and 22

Streams 20, 21 and 22 are small, low gradient streams which drain into Deadman Creek within a mile of each other (Figure 5). These streams are primarily small tundra drainages each flowing southeast for approximately one mile before entering Deadman Creek. Streams 20 and 21 each drain small lakes along their course. Stream 21 is the largest of these three streams and has a relatively deep channel with good streamflow from the lake outlet to Deadman Creek (Plate 14).

Proposed stream crossing sites on each stream are located within 0.25 miles of Deadman Creek. Arctic grayling, Dolly Varden and sculpin were found in Stream 20. Although no fish were found in Streams 21 and 22 these streams are accessible to fish in Deadman Creek and are probably utilized by fish to some extent, especially in their lower reaches, at various times during the year. The habitat above the proposed stream crossing sites on each stream is limited due to decreasing discharges in these upper reaches, especially on Stream 22 (Plate 15).

Burbot, Arctic grayling and slimy sculpin were collected in the small lake on Stream 21 (Beaver Lake). There may be some fish migration occurring between this lake and Deadman Creek. The lake on Stream 20 is a small, shallow muskeg lake. This lake was not sampled.

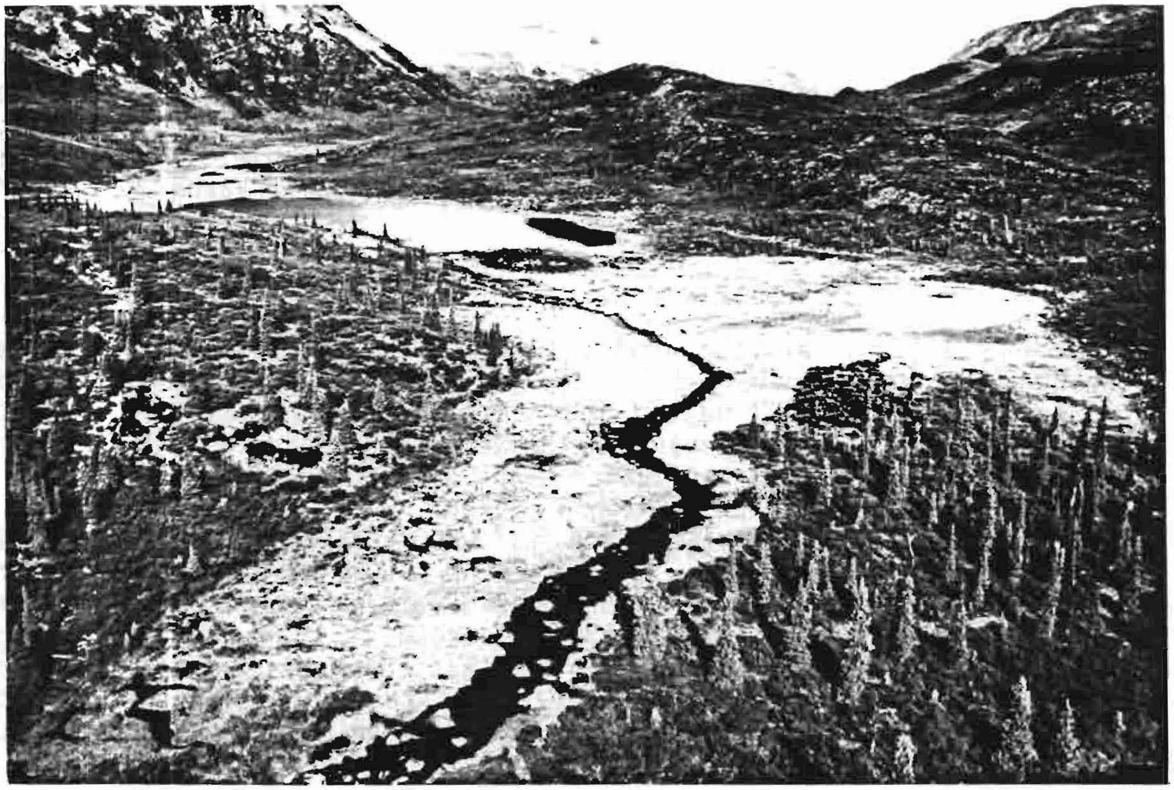

Plate 14. General vicinity of proposed stream crossing site (foreground), and small lake on Stream 21.

Plate 15. General vicinity of proposed stream crossing site (small stream) in center of picture) on Stream 22.

3.1.5 Tsusena Creek drainage

Tsusena Creek itself is the only creek within this drainage that is crossed by the proposed Devil Canyon access corridor. The crossing site is located at CM 2.2, approximately eight miles upstream from the mouth of Tsusena Creek at an elevation of 2,250 feet (Figure 6).

Extensive studies of the lower reaches of this stream were conducted by ADF&G during 1981 and 1982 (ADF&G 1981c, 1983c). Arctic grayling, Dolly Varden and slimy sculpin were found within this drainage.

Stream 23 (Tsusena Creek)

Tsusena Creek is a large, clear water stream originating in steep, mountainous terrain on the southern edge of the Alaska Range. The stream flows south for approximately 30 miles from its source to its confluence with the Susitna River and has a total drainage basin area of 144 square miles. Below its headwaters the stream flows across a region of open tundra of relatively moderate gradient. A large, waterfall, located three miles upstream from the mouth, divides the stream into an upper and lower area. The stream is situated in a deep "V" shaped canyon for approximately two miles in the vicinity of the falls. Below this area the stream valley broadens and gradient decreases to its confluence with the Susitna River.

The stream channel at the crossing site is located in a broad, shallow valley and is approximately 150 to 200 feet wide. The stream is composed mostly of long riffle areas of moderate flows and velocities. The substrate consists of large boulders and cobble embedded in sand with small gravel confined mainly to pool areas.

Although there appears to be some excellent fish habitat in this area, only slimy sculpin and a few small, stream resident Dolly Varden were found. Field investigations below the waterfall in 1981 and 1982 showed that Arctic grayling use the lower reach of the stream. Arctic grayling may not have established populations above the waterfall because it constitutes a fish passage barrier.

3.1.6 Swimming Bear Creek drainage

Eight streams (Streams 24-31) within the Swimming Bear Creek drainage are crossed by the proposed Devil Canyon access corridor from CM 8.0 to CM 15.7 (Figure 6). All study streams in this drainage flow south as they cross the proposed corridor before draining into Swimming Bear Creek. Swimming Bear Creek itself, which closely parallels the proposed access corridor for several miles, is not crossed by the corridor. Elevations of stream crossing study sites within the Swimming Bear Creek drainage range from 2,900 to 3,250 feet. Fish species found within the drainage include Dolly Varden and slimy sculpin.

Stream 24

Stream 24 is a relatively large, high gradient stream which flows for approximately 10 miles from its source to its confluence with Swimming Bear Creek (Figure 6). The proposed stream crossing site is located approximately three miles upstream of the mouth. Above the crossing site the stream flows through open tundra with moderate gradients. A short distance below the crossing site the stream enters a deep, high gradient, "V" shaped canyon. This canyon may present a barrier to upstream fish migration. Other, smaller barriers may also inhibit fish movement within the upper reaches.

Fish habitat at the crossing study site consists mainly of long, cascading, high velocity riffles with frequent small pools located behind large boulders. The stream channel is approximately 30 feet wide and has substrate composed of boulder, cobble and rubble. Dolly Varden and slimy sculpin were found in the study site area.

Stream 25

Stream 25 is a small, high gradient tributary to Stream 24 approximately two miles in length (Figure 6). The stream crossing study site is located approximately one mile upstream from its mouth. The stream is situated in a relatively deep ravine below the crossing site. Possible fish passage barriers exist in this reach (Plate 16).

The stream channel at the corridor crossing site is only 3-5 feet wide and contains a boulder, cobble and rubble substrate. The swift flows and shallow depths result in poor fish habitat. It appeared that streamflows are intermittent, being derived mostly from periods of moderate or heavy precipitation resulting in little useable fish habitat. Fish sampling was not conducted on this stream.

Streams 26 and 27

Streams 26 and 27 are both small, high gradient streams approximately one mile in length (Figure 6). Both streams drain directly into Swimming Bear Creek. The streams apparently depend on local precipitation and seepage for their main water source and may become intermittent in flow at certain times of the year. Possible fish passage barriers exist in the lower reaches of each creek. The substrate consists of boulders, cobble and sand. The stream channel is from 2-4 feet wide with very shallow depths (6-10 inches) and is often obscured by vegetation along the banks (Plates 17 and 18). Fish habitat appeared to be poor and fish sampling was not conducted on either of these streams.

Streams 28 and 29

Streams 28 and 29 are both relatively small, high gradient streams approximately three miles in length (Figure 6). The streams drain from a small ridge and flow through small, shallow ravines situated in open tundra (Plate 19). The stream channels become partially obscured by vegetation in the lower reaches. The streams join together approximate-

Plate 16. Lower reach of Stream 24 (lower right) and general vicinity of proposed stream crossing site on Stream 25 (center of picture).

Plate 17. General vicinity of proposed stream crossing site on Stream 26.

Plate 18. General vicinity of proposed stream crossing site on Stream 27.

Plate 19. General vicinity of proposed stream crossing sites on Streams 28 and 29.

ly 0.2 miles below the stream crossing study sites near their confluence with Swimming Bear Creek.

Fish habitat is limited on each stream in the vicinity of the corridor crossing site and consists mostly of high gradient riffles with swift flows and few pools. The stream channels are 10-12 feet wide and contain substrates of boulders, cobble, rubble and some sand. Slimy sculpin and small Dolly Varden were the only fish species found in each stream.

Stream 30

Stream 30 is an extremely small, shallow stream approximately 1.5 miles in length which drains directly into Swimming Bear Creek (Plate 20). It originates from various seepages in gently sloping tundra terrain and appears to be intermittent in flow. The stream channel, which is only 2-3 feet wide, is poorly defined in some areas and does not appear to contain suitable fish habitat. The stream crossing study site is located approximately 0.2 mile above the streams confluence with Swimming Bear Creek (Figure 6). A small ridge immediately below the crossing site may be a barrier to upstream fish migration. No fish sampling was conducted.

Stream 31

Stream 31 is a large, high gradient stream which flows for approximately 2.5 miles from its source to its confluence with Swimming Bear Creek (Figure 6). The stream crossing study site is located approximately 0.5 miles above the mouth. Stream gradient is less steep below the crossing site but increases sharply above the crossing site where the stream channel descends through a small, narrow ravine (Plate 21).

Fish habitat is available in the vicinity of the stream crossing study site. The stream channel is approximately 25 feet wide and has substrates of boulders, cobble and rubble. Long, cascading riffles are frequently interspersed with small, deep pools. Dolly Varden up to 190 mm in length and slimy sculpin were found in the study site area.

3.1.7 Devil Creek drainage

Streams 32 and 36 within the Devil Creek drainage are crossed by the proposed access corridor from CM 18.9 to CM 24.5 (Figure 6). Elevations of these proposed stream crossing sites range from 2,525 to 3,200 feet. Fish species found in streams within this drainage were Dolly Varden and slimy sculpin.

Stream 32

Stream 32 flows northwest for approximately two miles from the outlet of Swimming Bear Lake to its confluence with Devil Creek (Figure 6). The first 0.5 mile reach of stream below the lake is situated in a meandering, low gradient channel containing several large, deep pools. Below this reach, the stream flows through a deep, high gradient canyon before draining into Devil Creek. The canyon below the stream crossing study

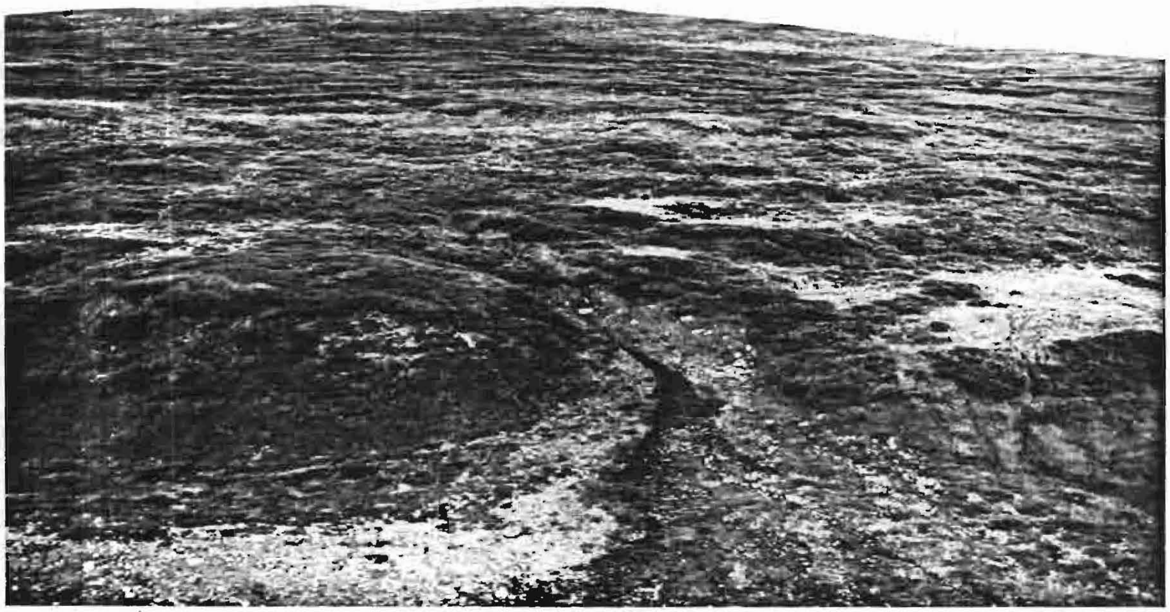

Plate 20. General vicinity of proposed stream crossing site on Stream 30.

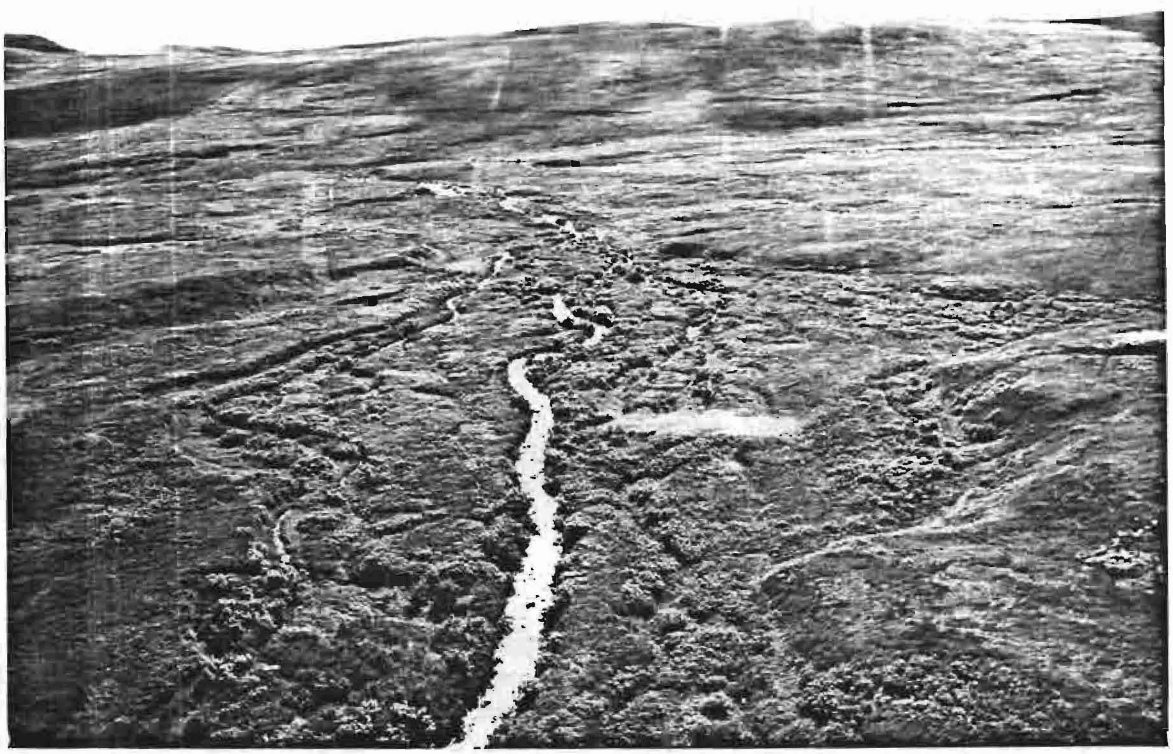

Plate 21. General vicinty of proposed stream crossing site on Stream 31.

site presents a potential barrier to upstream fish migration. The stream channel at the crossing site is approximately 50 feet wide and contains a substrate of boulder, cobble and rubble (Plate 22). Dolly Varden and slimy sculpin were found in the study site area.

A population of relatively large Dolly Varden, up to 375 mm in length, were found in the reach of stream above the crossing site. Most of these fish were found in the large, deep pools within this reach and were in spawning condition. These fish apparently use this reach for spawning and rearing during the open water season and overwinter in Swimming Bear Lake.

Stream 33

Stream 33 is a small, relatively high gradient tributary to Devil Creek approximately two miles in length. The stream drains to the northwest off a steep ridge, approximately one mile above its mouth, and then flows through a relatively shallow valley to its confluence with Devil Creek (Plate 23). The steep ridge appears to create a barrier to upstream fish migration. Fish habitat above the ridge is limited.
The proposed stream crossing site is located only a few hundred feet upstream of the mouth. The stream is only 5-6 feet wide in this area and fish habitat consists mostly of riffles of moderate flow and few small, shallow pools. The substrate is composed of cobble, rubble and boulders. Slimy sculpin were the only fish species identified in the study site area.

Stream 34 (Devil Creek)

Devil Creek is a large, clear water tributary to the Susitna River approximately 15 miles in length (Figures 6 and 7). It originates in mountainous terrain south of the Alaska Range and then flows south through a broad, shallow valley of open tundra for most of its length. Approximately 1.5 miles above its mouth the stream descends into a deep canyon by means of a large waterfall which presents a barrier to upstream fish migration.

The stream crossing study site is located approximately seven miles upstream from the mouth of Devil Creek and only a few hundred feet downstream of the mouth of Stream 33. The stream is wide and deep in this area with a moderate gradient and relatively high streamflow velocities (Plate 23). The substrate consists of boulders, cobble and rubble. Slimy sculpin were the only fish species identified in the study site area.

Stream 35 and 36

Streams 35 and 36 are crossed by the proposed Devil Canyon access corridor within 0.25 miles of each other (Figure 7). Both streams are relatively narrow (10-15 feet), high gradient streams approximately two miles in length. Stream 35 drains from a small lake just above the study site area. The streams join together a short distance downstream of their crossing study sites creating a single channel which flows another 0.5 miles to its confluence with Devil Creek (Plate 24).

Plate 22. General vicinity of proposed stream crossing site on Stream 32.

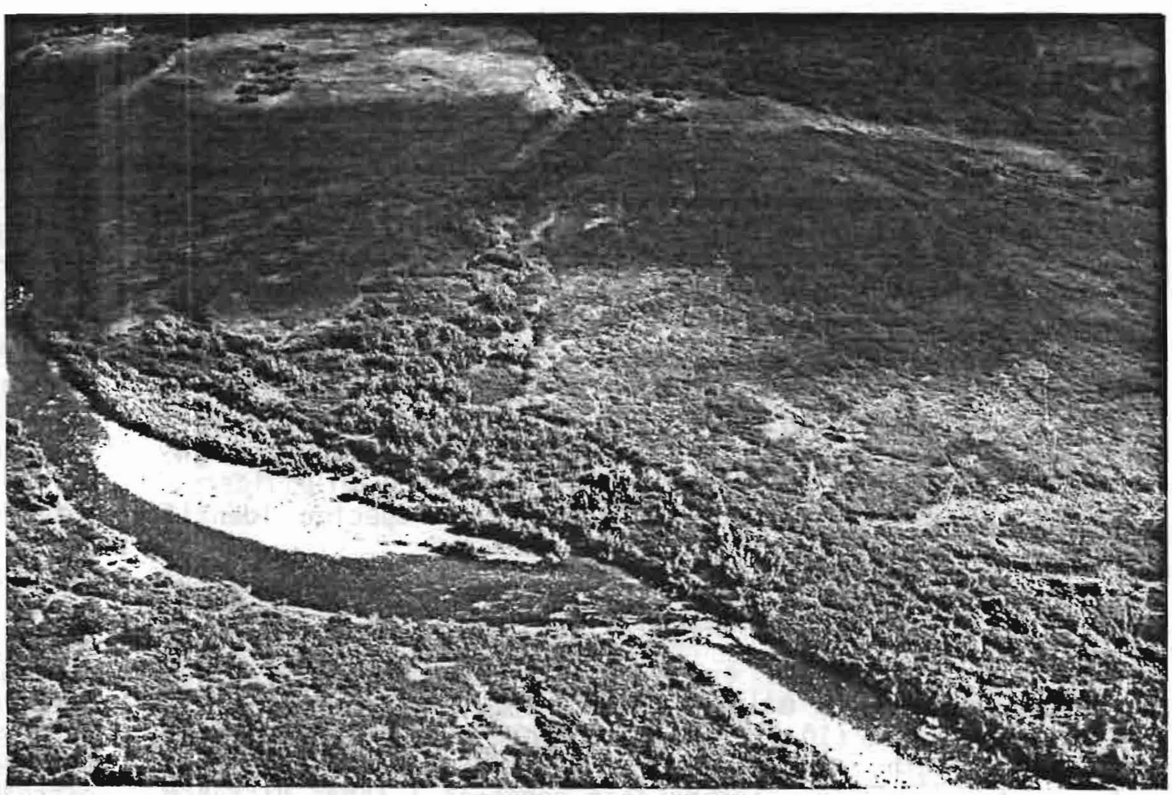

Plate 23. General vicinity of proposed stream crossing sites on Stream 33 (small stream in center obscured by vegetation) and Stream 34 (Devil Creek).

Plate 24. General vicinity of proposed stream crossing sites on Stream 35 and 36.

Stream habitat in the study area of each stream consists mostly of cascading riffles with a few pools. Substrates are composed of boulder, cobble and gravel. The stream channel of each stream is often obscured by thick vegetation along its banks. Dolly Varden and slimy sculpin were found in Stream 35 while only Dolly Varden were identified in Stream 36.

3.1.8 Jack Long Creek drainage

Streams 37-39 in the Jack Long Creek drainage cross the proposed Gold Creek rail corridor from CM 37.3 to CM 39.9 (Figure 7). The study sites on Streams 38 and 39 were not accessible by helicopter and could only be surveyed from the air. Elevations of these proposed stream crossing sites range from 1,300 to 1,425 feet. Fish species known to utilize this drainage include chinook, pink (Oncorhynchus gorbuscha), chum (O. keta), and coho (O. kisutch) salmon and rainbow trout (Salmo gairdneri), Arctic grayling and slimy sculpin.

Stream 37

Stream 37 is a very small, shallow, low discharge stream which drains off a steep ridge into Jack Long Creek (Figure 7). The stream is approximately two miles in length. Most of the stream is situated in a small, high gradient valley located just above the crossing site. The crossing site is approximately 150 feet upstream of Jack Long Creek. The steep ridge above the crossing site results in a high gradient stream channel which may prevent upstream fish migration due to increased flow velocities.

Stream habitat at the proposed crossing site consists of a narrow (1-3 feet), meandering, low gradient stream channel. This reach of the stream flows over spongy muskeg terrain and is partially concealed by vegetation along its banks. The substrate is composed of sand and small gravel. Fish habitat is marginal and only slimy sculpin were found here.

Stream 38

Stream 38 originates in steep, mountainous terrain and flows south for approximately 4.0 miles to its confluence with Jack Long Creek (Figure 7). The stream is situated in a deep, high gradient valley for most of its length above the corridor crossing site. The crossing site is located immediately upstream of the mouth. Aerial surveys of the stream crossing site could not be done because of dense tree cover in the area. Previous investigations by ADF&G of the lower reaches of Jack Long Creek have shown that adult chinook, pink, chum and coho salmon utilize this stream for spawning (ADF&G 1981a, 1983b; Barret et al. 1984). Portions of Stream 38 are also accessable to fish and may also be utilized by adult or juvenile salmon.

Stream 39

Stream 39 is a small stream less than 0.5 miles in length which drains from a small muskeg lake into Jack Long Creek (Figure 7). No data were collected on this stream due to its inaccessibility. Aerial surveys indicate that fish habitat is marginal in this stream.

3.1.9 Additional streams

Stream 40

Stream 40 flows northwest for approximately five miles from its source to its confluence with the Slough 21 complex of the Susitna River (Figure 7). It is the largest stream within a relatively small drainage system. The stream crosses the proposed access corridor at CM 43.3 at an elevation of approximately 900 feet. The proposed crossing site is located adjacent to a steep ridge and was not accessible by helicopter. Therefore, sampling activities were conducted in the vicinity of the mouth where access was available.

Aerial surveys indicate that the lower 0.5 mile reach of Stream 40 contains good fish habitat. The relatively low gradient stream channel consists mostly of riffle areas of moderate flow and is between 15 and 20 feet wide. The substrate consists of boulder, cobble and rubble. The gradient increases sharply above the crossing site and associated flow characteristics may create a hydraulic barrier which could restrict upstream migration of fish beyond this point.

Chinook salmon fry and slimy sculpin use the lower reaches of the stream and have access to the reach of stream just above the crossing site. Adult sockeye (Oncorhynchus nerka), pink and chum salmon have been observed in Slough 21 (ADF&G 1982, 1983; Barrett et al. 1984) and may also use the lower reaches of Stream 40.

Stream 41 (Waterfall Creek)

Waterfall Creek is a small stream approximately 2.5 miles in length which drains into Slough 20 of the Susitna River (Figure 7). The stream crossing study site at CM 44.5 is located above a large waterfall approximately 0.2 miles upstream of the mouth at an elevation of 900 feet. The waterfall presents a barrier to upstream fish migration. Due to the steep terrain and inaccessibility of the study site area, sampling was conducted below the waterfall at the mouth of the stream.

Excellent juvenile fish habitat is available in the reach of stream just below the waterfall. The habitat in the reach below the falls consists of low gradient riffle areas with a few small, shallow pools. Stream channel width is approximately ten feet. The substrate consists of boulders, cobble and rubble. Arctic grayling, slimy sculpin and 30 juvenile chinook salmon were found within the study site area.

The proposed access corridor also closely parallels Slough 20 for a short distance in the vicinity of Waterfall Creek. Adult pink, chum, and chinook salmon have been observed in Slough 20 during previous studies by ADF&G (ADF&G 1981a, 1983b; Barrett et al. 1984).

The ADF&G collected stage and discharge data at the mouth of Waterfall Creek during the 1983 field season. This data is presented in the Su Hydro Aquatic Studies Phase II Final Draft Report (Estes and Vincent-Lang 1984).

Stream 42 (Gold Creek)

Gold Creek originates in steep, mountainous terrain and flows west for approximately seven miles to its confluence with the Susitna River (Figure 7). It is crossed by the proposed access corridor at CM 47.9 at an elevation of 725 feet. The stream crossing site is located only a few hundred feet upstream from its mouth. Detailed investigations of this stream were conducted by the ADF&G during 1982 and 1983. Results of these investigations are presented in the Su Hydro Aquatic Studies Phase I and Phase II Final Draft Reports (ADF&G 1981a, 1981c, 1981d, 1983a, 1983b, 1983d; Schmidt et al. 1984; Barrett et al. 1984; Estes and Lang 1984). Due to the work conducted on this stream in previous years, fish sampling was not conducted during the access and transmission corridor study.

The lower reach of Gold Creek near the proposed crossing site contains excellent fish habitat. Long riffle areas with moderate flows dominate the relatively low gradient stream channel. The substrate consists of boulder, cobble and rubble. The stream channel is approximately 25-30 feet wide at the crossing site. Previous studies by the ADF&G have shown that pink and chinook salmon use portions of the lower four miles of Gold Creek for spawning (ADF&G 1981a, 1983b; Barrett et al. 1984).

3.2 Transmission Corridor Stream Crossing Studies

Fifteen stream crossing sites were identified along the proposed transmission corridor from CM 1.2 to CM 34.0 (Table 10). All streams crossed by the proposed transmission corridor are located within the Tsusena, Swimming Bear, Devil or Jack Long Creek drainages (Figures 6 and 7). Tsusena and Devil Creeks are the two largest streams along the proposed corridor. The majority of these stream crossing sites are located on small, high gradient streams at elevations ranging from 1,200 to 3,500 feet.

Investigations conducted on many of these same streams in association with the access corridor studies, indicate that sculpin and Dolly Varden are the major fish species presently using these habitats. The lower reaches of Jack Long Creek are also used by adult chinook, pink, chum and coho salmon (ADF&G 1981a, 1983b; Barrett et al. 1984) and rainbow trout and Arctic grayling.

3.3 Deadman Creek Studies

The 18.5 miles of Deadman Creek between the lake and the falls was divided into three sections, upper, middle, and lower, with one study reach in each section. The upper section is characterized by swift

Table 10. Stream crossing study sites along the proposed transmission line corridor, 1983.

Stream Number and/or Name	Geographic Code	Corridor Mile	Approximate Elevation at Crossing Site
1 - Tsusena Creek	S32N05E20DCB	1.2	1675
2	S32N04E10DAC	4.3	2550
3	S32N04E08DCD	7.6	3175
4	S32N04E07DDA	8.3	3300
5	S32N03E12DAC	9.3	3500
6	S32N03E02CDB	11.1	3375
7	S33N03E32BAB	14.4	2900
8 - Devil Creek	S33N03E30CCA	16.2	2650
9	S33N02E25DBD	16.4	2700
10	S33N02E25CCD	16.8	2650
11	S33N02E35ABB	17.5	2700
12	S32N02E04DAD	19.7	2650
13	S32N02E04DCA	20.0	2700
14 - Jack Long Creek	S31N01W04ADA	33.2	1200
15	S31N01W04BDB	34.0	1425

flows, braided channels, numerous large, deep pools, and a substrate ranging from sand to cobble. Depths range from one foot in the smaller braided channels to seven feet in the larger pools. The middle section meanders through a low gradient valley, draining numerous beaver ponds and large marshes. The longer reaches of slow flowing water are frequently interspersed with short rapids. Depths range from 1.0 to 1.5 feet between the riffles and up to 15 feet in the pools immediately below the rapids. The substrate is composed mainly of sand, with boulders present in the rapids. Aquatic vegetation is present throughout this middle section. The lower section is below a small canyon located between mile 6.5 and 10.5. This section is characterized by swift flows, braided channels, numerous small pools and a substrate ranging from sand to boulders. Depths range from approximately two feet in the swifter, braided channels to over seven feet in the backed up, sandy bottomed side sloughs.

Selected water quality data collected from the three study reaches in Deadman Creek are presented in Table 11.

3.3.1 Arctic grayling

A total of 393 Arctic grayling were captured in the three study reaches of Deadman Creek (Figure 8). Of the 43 grayling recaptured in Deadman Creek only one was recaptured more than once and this fish had moved to another study site.

Distribution and relative abundance

Grayling were captured at all three study reaches at catch rates ranging from 3.75 to 8.75 fish per hour (Figure 9). Catch rates in the riffle and pool areas were similar in both the upper and lower reaches. In the middle reach, grayling were found almost exclusively in the pools immediately below the scattered riffle areas.

Age-length composition

Otoliths and scales were collected from a total of 69 grayling from the three study reaches. Otoliths were found to be much easier to prepare and read (Plate 25) and are thought to be more accurate in determining age than scales. Aging by scales tends to underestimate the age (Figure 10) and raise the growth rate (Figure 11) of older grayling. For this report, ages will refer to those determined by otolith unless otherwise stated.

The Age 7 grayling were dominant in the sample which also coincides with the dominance of the 345-355 mm range (Figure 12). Similar age frequencies were found after applying the length and age frequencies found in the 69 fish subsample to the entire 383 fish sampled (Figure 13).

Length frequencies varied significantly between the three study reaches, with the smallest fish being found in the lower reach and the larger fish in the upper reach. Mean lengths also increased in the middle and upper reaches (Figure 14).

Table 11. Selected water quality data collected from three study sections of Deadman Creek, 1983.

Section	Geographic Code	Date	Time	DO (mg/l)	pH	Conductivity (umho/cm)	Water Temp. °C
Lower	S 32N 05W 11	830718	1410	10.2	7.1	074	11.1
		830820	1430	10.3	7.2	076	9.8
		830913	1335	11.7	6.8	069	5.9
Middle	S 33N 04W 17 + 19	830718	1420	10.3	7.3	072	10.9
		830820	1440	10.3	7.1	078	9.9
		830913	0930	11.4	7.0	069	5.0
Upper	F 22S 04W 21	830718	1435	10.6	7.5	088	10.8
		830820	1455	10.1	7.3	083	10.1
		830913	0935	11.5	7.3	085	5.6

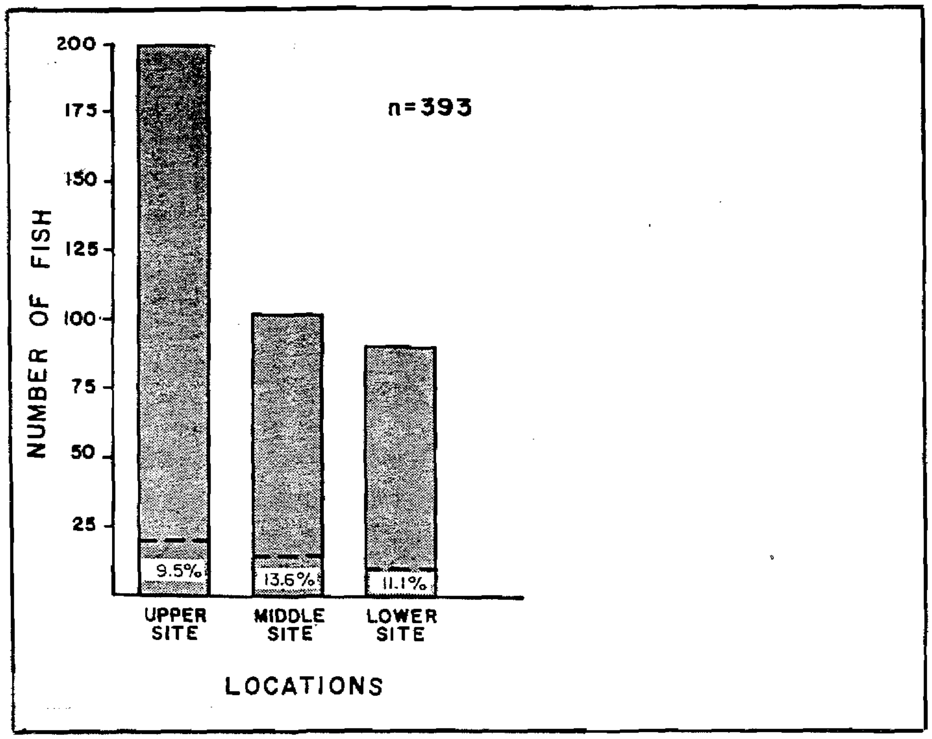

Figure 8. Arctic grayling catches and percent recaptures for the three study reaches in Deadman Creek, 1983.

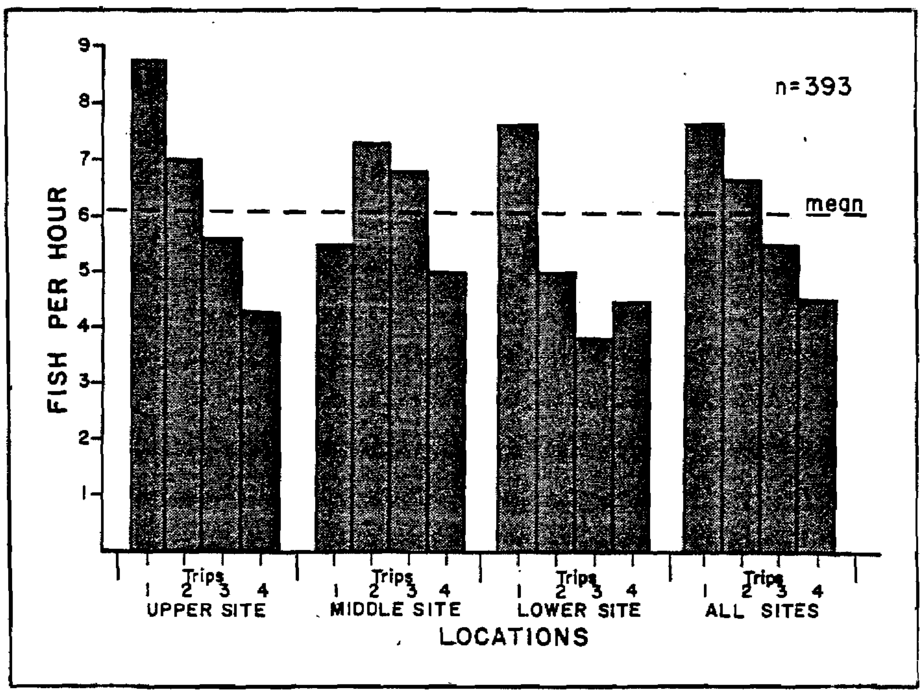

Figure 9. Arctic grayling catches per angler hour during July from the three study reaches in Deadman Creek, 1983.

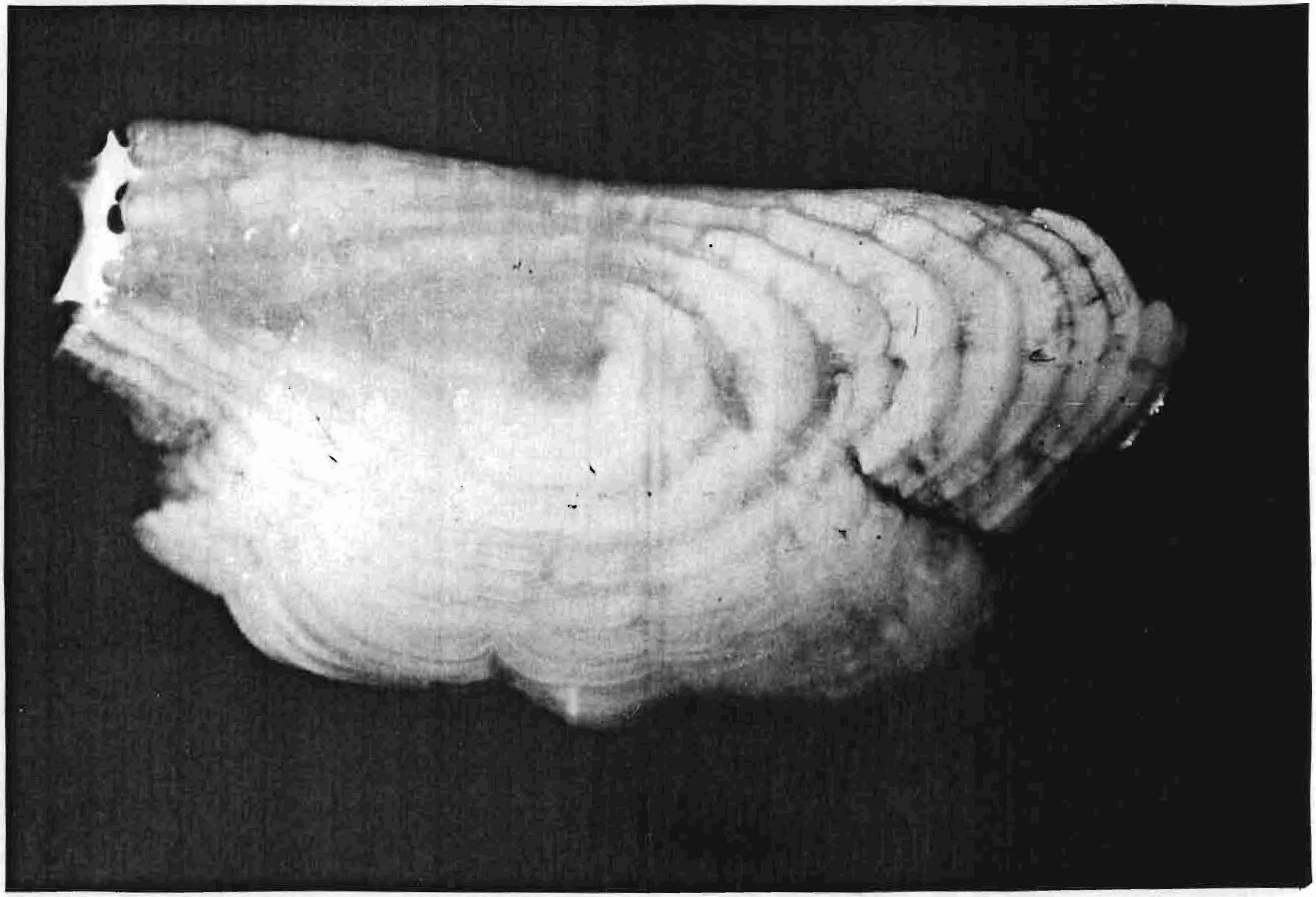

Plate 25. Otholith from an Arctic grayling (Age 10) captured in Deadman Creek, 1983.

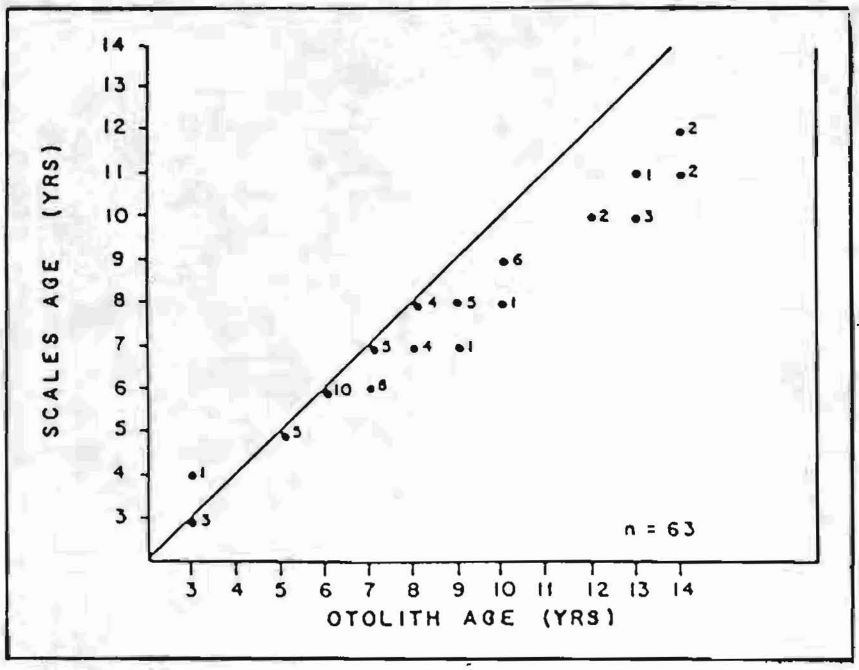

Figure 10. Comparison of Arctic grayling ages, scales vs. otoliths, in Deadman Creek, 1983.

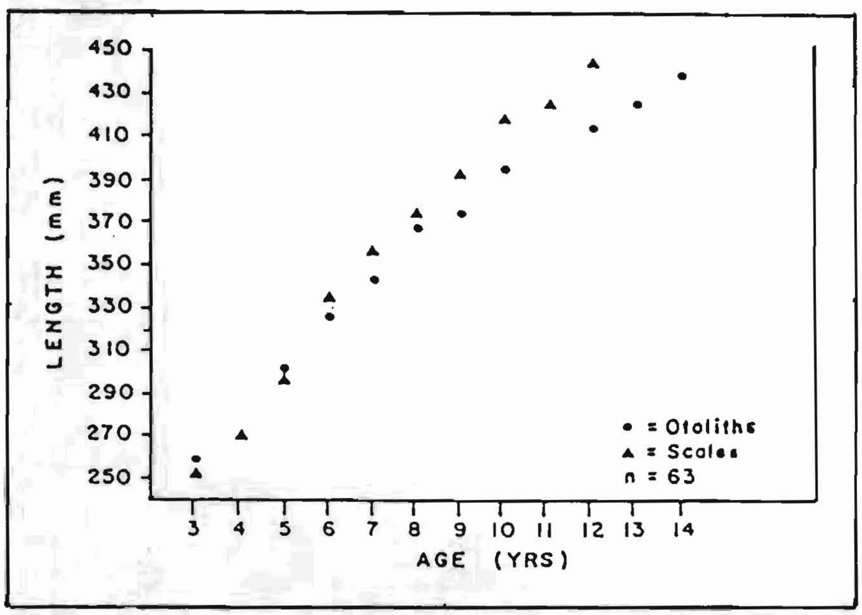

Figure 11. Comparison of Arctic grayling age-length composition, scales vs. otoliths, in Deadman Creek, 1983.

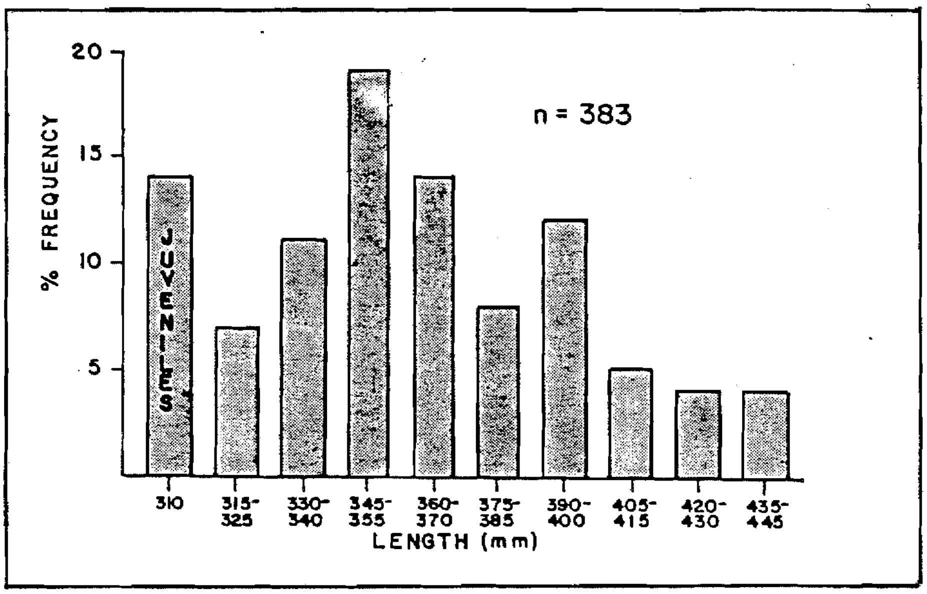

Figure 12. Length frequency composition for Arctic grayling sampled in Deadman Creek, 1983.

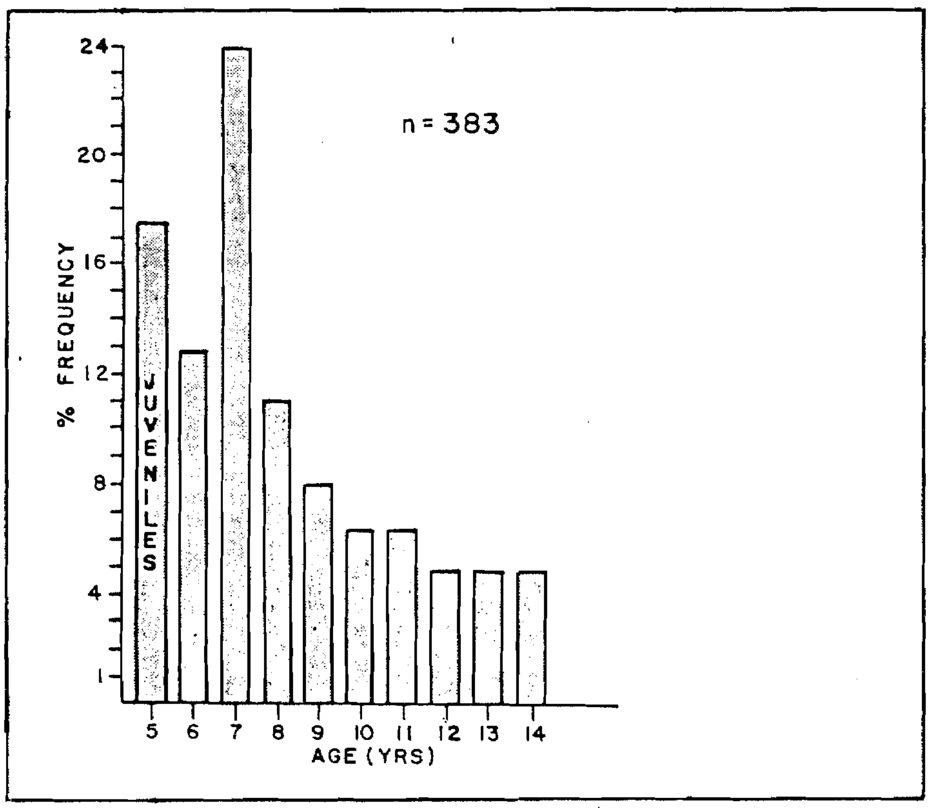

Figure 13. Age frequency composition for all Arctic grayling sampled in Deadman Creek, 1983.

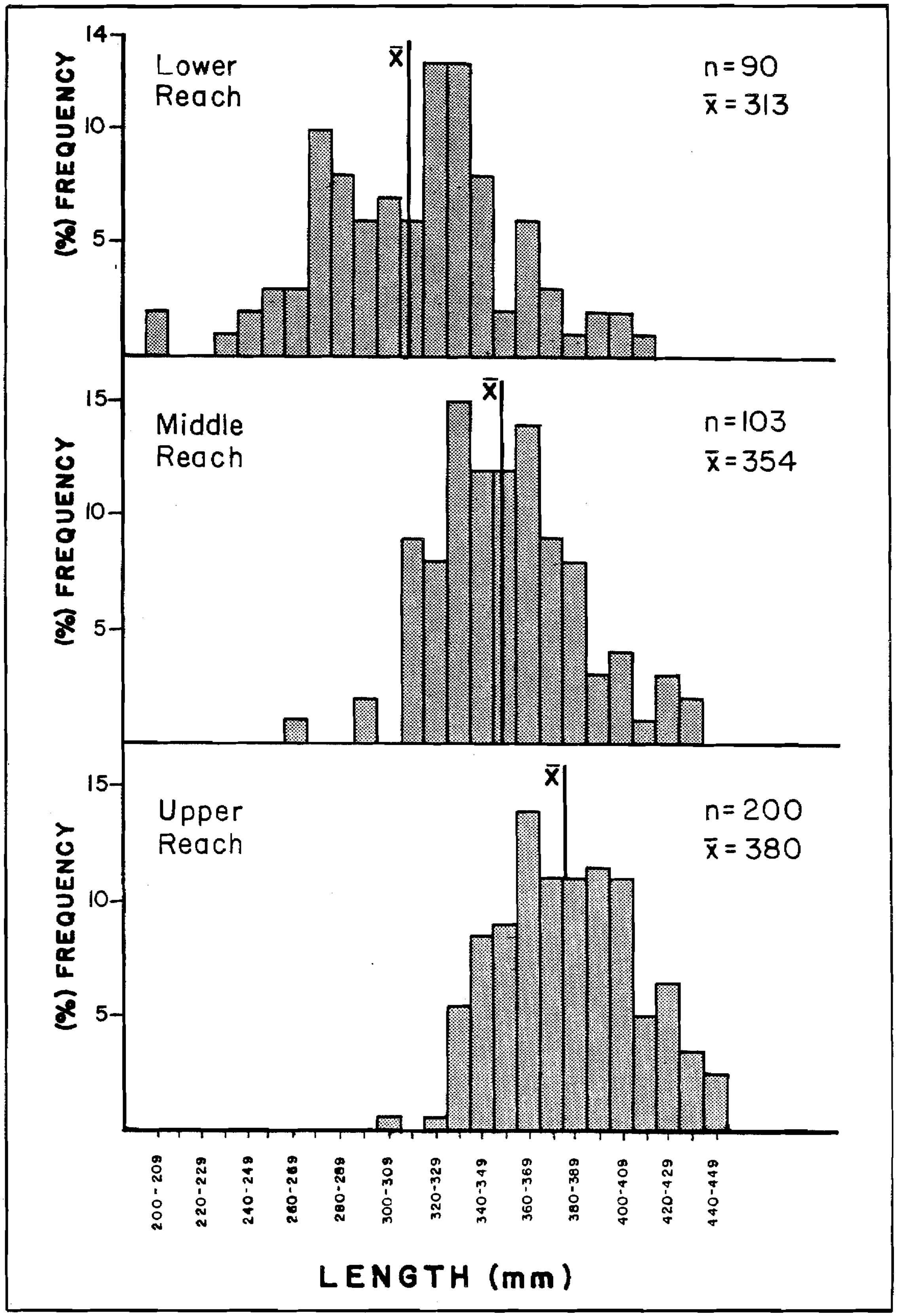

Figure 14. Arctic grayling length frequency composition for the three study reaches in Deadman Creek, 1983.

Population estimates

Population estimates, based on the data collected in July, were calculated for each of the three study reaches and for all three reaches combined (Table 12). Recapture information and pre-study tag tests showed no tag loss over this short period of time. Of the four estimates given in Table 12, the Schnabel method has the most assumptions satisfied and is therefore considered to give the best estimate.

Radio telemetry

Radio transmitters were implanted subcutaneously in five Arctic grayling and esophageally in one Arctic grayling during June. Throughout the summer, the radio-tagged Arctic grayling moved 0.5 - 6.5 miles downstream from their tagging location. During freeze up, when Arctic grayling were entering Deadman Lake, there was no movement from five of the six fish.

During December, a ground survey was conducted to determine the status of these six radio tagged Arctic grayling. Five of the six radio tagged fish were dead or had shed their radio tags. One radio tagged Arctic grayling was still alive and was residing in a large pool in Deadman Creek Canyon at mile 9.0.

3.3.2 Lake trout

A total of six lake trout were captured and tagged in the middle and upper study reaches of Deadman Creek. Three lake trout were captured in both the upper and middle reaches. No lake trout were captured in the lower reach. In the upper reach, the lake trout were found in large, deep pools below swift riffles. Lake trout in the middle reach were found in deep, slow-moving areas associated with beaver lodges. In the upper reach, lake trout were inhabiting the same areas as Arctic grayling. In the middle reach lake trout occupied areas where no Arctic grayling were found.

The lake trout captured in the upper reach averaged 420 mm with a range of 405-430 mm, while the fish from the middle reach averaged 535 mm with a range of 460-625 mm.

No population estimates were calculated because the catch sample was too small and no tagged fish were recaptured.

3.3.3 Other species

Small Dolly Varden (120-185 mm) and slimy sculpin (45-100 mm) were observed and captured in all three study reaches.

3.4 Selected Lake Studies

Surveys of nine lakes near the proposed access and transmission corridors were conducted between September 15 and September 20, 1983 to

Table 12. Arctic grayling population estimates at Deadman Creek, July 1983.

					Original Schnabel		Modified Schnabel		Schumacher-Eschemeyer		CAPTURE (Model M_T)	
Reach Sampled	Dates Sampled	Total Catch	Total Marked	Total Recaptured	fish/mile	95% confidence interval	fish/mile	95% confidence interval	fish/mile	95% confidence interval	fish/mile	95% confidence interval
Lower (Mile 3.7-4.6)	17, 20, 24, 26	99	75	10	358	194 to 760	324	184 to 627	360	334 to 389	352	164 to 540
Middle (Mile 10.6-11.6)	16, 20, 24, 26	114	90	14	315	187 to 572	294	180 to 506	307	219 to 515	310	174 to 446
Upper (Mile 16.6-17.5)	15, 19, 23, 25	206	159	19	858	550 to 1417	814	532 to 1303	870	514 to 1398	864	570 to 1209
Combined Total		419	324	43	510	379 to 705	499	372 to 683	512	380 to 784	511	377 to 645

determine the presence or absence of fish species (Table 13). These lakes were selected to provide a representative sample of lakes in the study area. The lakes ranged in size from 2 acres (Beaver Lake) to 160 acres (Island Lake). The approximate distance of these lakes from the proposed access corridor ranged from less than 0.1 miles for Beaver Lake to 1.0 miles for Highest Lake (Figures 5, 6 and 7).

Fish were captured in all lakes except Ridge Lake and Round Lake. Fish species found in these lakes included burbot, sculpin, Arctic grayling, Dolly Varden and rainbow trout. In Ridge Lake a school of unidentified fish, 6-10 inches in length, was observed swimming near the shore. Populations of relatively large Dolly Varden were found in Swimming Bear Lake, Island Lake and Highest Lake. Rainbow trout up to 430 mm were captured in High Lake. Age, length and sex frequency data for Dolly Varden from Island Lake and Highest Lake and for rainbow trout from High Lake are presented in Tables 14, 15 and 16 respectively.

A subsample of Dolly Varden from Stream 31 was collected for morphological comparisons of stream resident Dolly Varden with those found in the lakes. Stream 31 is located very near to Swimming Bear Lake but is not connected to it in any way. The Dolly Varden in Stream 31 are representative of the Dolly Varden found in other small streams along the corridor route which are not connected to lakes. Age, length and sex frequency data for Stream 31 Dolly Varden are presented in Table 17.

Comparisons of several morophological characteristics indicated no differences in morophology between the Stream 31 and Swimming Bear Lake Dolly Varden.

3.5 Deadman Lake Studies

A contour map and a list of estimated morphometric characteristics for Deadman Lake are presented in Figure 15. Figure 16 illustrates the vertical distribution of selected water quality parameters measured in the lake.

A total of 32 lake trout, 61 Arctic grayling, 48 humpback whitefish, 52 round whitefish, two burbot, and one Dolly Varden were captured in Deadman Lake. Many sculpin were also observed around the lake shore.

3.5.1 Lake trout

Distribution and relative abundance

During early June, as the lake was breaking up, lake trout were found in shallow water along the shoreline. Hook and line catches at this time averaged 2.75 fish per hour. From June through early September lake trout were found in waters ranging from 15 to 75 feet, and hook and line catches dropped to less than 0.25 fish per hour. During September and early October, lake trout moved into the shallow waters along the shorelines to spawn, and hook and line catches rose to 1.5 fish per hour.

Table 13. Fish data collected at lake study sites along the proposed access and transmission corridors, 1983.

Lake	Geographic Code	Date	Species Observed	Number Captured	Length Range (mm)
Ridge Lake	F 22S 05W 25 DCA	830917	[a]		
Beaver Lake	S 33N 05W 34 DDC	830917	Burbot	1	275
			Arctic grayling	3	260 - 335
			Sculpin	3	65 - 90
Long Lake	S 32N 05W 15 CAC	830915	Sculpin	1	85
Round Lake	S 32N 05W 15 CCC	830915	NONE		
Swimming Bear Lake	S 32N 07W 04 BAB	830916	Dolly Varden	13	125 - 380
			Sculpin	7	65 - 95
High Lake	S 32N 02E 20 DBB	830918	Rainbow Trout	15	160 - 430
			Sculpin	2	60 - 85
Little High Lake	S 32N 02E 19 AAC	830918	Rainbow Trout	7	160 - 285
			Sculpin	1	65
Island Lake	S 32N 01E 25 ABD	830918	Dolly Varden	20	300 - 445
			Sculpin	2	65 - 95
Highest Lake	S 32N 01E 14 ADD	830920	Dolly Varden	7	115 - 245
			Sculpin	1	75

[a] Observed school of fish 6-10" long.

Table 14. Age, length and sex frequency data for Dolly Varden caught in Island Lake, September 20, 1983.

Age	Total No. of Fish Sampled	Mean Length (mm)	Range of Length (mm)	Males #/%	Females #/%
4	1	300	-	0/0	1/100
5	3	318	315-325	0/0	3/100
6	5	358	345-365	2/40	3/60
7	3	380	370-395	2/67	1/33
8	4	401	395-405	4/100	0/0
9	3	432	410-445	2/67	1/33

Table 15. Age, length and sex frequency data for Dolly Varden caught in Highest Lake, September 20, 1983.

Age	Total No. of Fish Sampled	Mean Length(mm)	Range of Length(mm)	Males #/%	Females #/%
3	1	115	-	N/A	N/A
4	0	-	-	-	-
5	0	-	-	-	-
6	4	217	205-225	1/25	3/75
7	1	245	-	0/0	1/100

N/A = not available

Table 16. Age, length and sex frequency data for rainbow trout caught in High Lake, September 18, 1983.

Age	Total No. of Fish Sampled	Mean Length(mm)	Range of Length(mm)	Males #/%	Females #/%
4	4	263	255-275	3/75	1/25
5	1	340	-	1/100	0/0
-	1	430	-	1/100	0/0

N/A = not available

Table 17. Age, length and sex frequency data for Dolly Varden caught in Stream 31, August 15, 1983.

Age	Total No. of Fish Sampled	Mean Length(mm)	Range of Length(mm)	Males #/%	Females #/%
2	3	80	70-90	N/A	N/A
3	0	-	-	-	-
4	2	133	125-140	0/0	2/100
5	0	-	-	-	-
6	3	172	160-180	0/0	3/100

N/A = not available

Morphometric Parameters	Estimates
Surface area	379 acres
Volume	12,614 acre-feet
Maximum depth	92 feet
Mean depth	31.7 feet
Shoreline length	22,120 feet
Maximum length/orientation, main axis	7,724 feet/NW-SE
Maximum width/orientation	3,145 feet/NW-SW

DEADMAN LAKE

MORPHOMETRIC MAP

AUGUST 21, 22, and 23, 1983

Geographic Code : F22S04W14

ALASKA DEPT. OF FISH AND GAME
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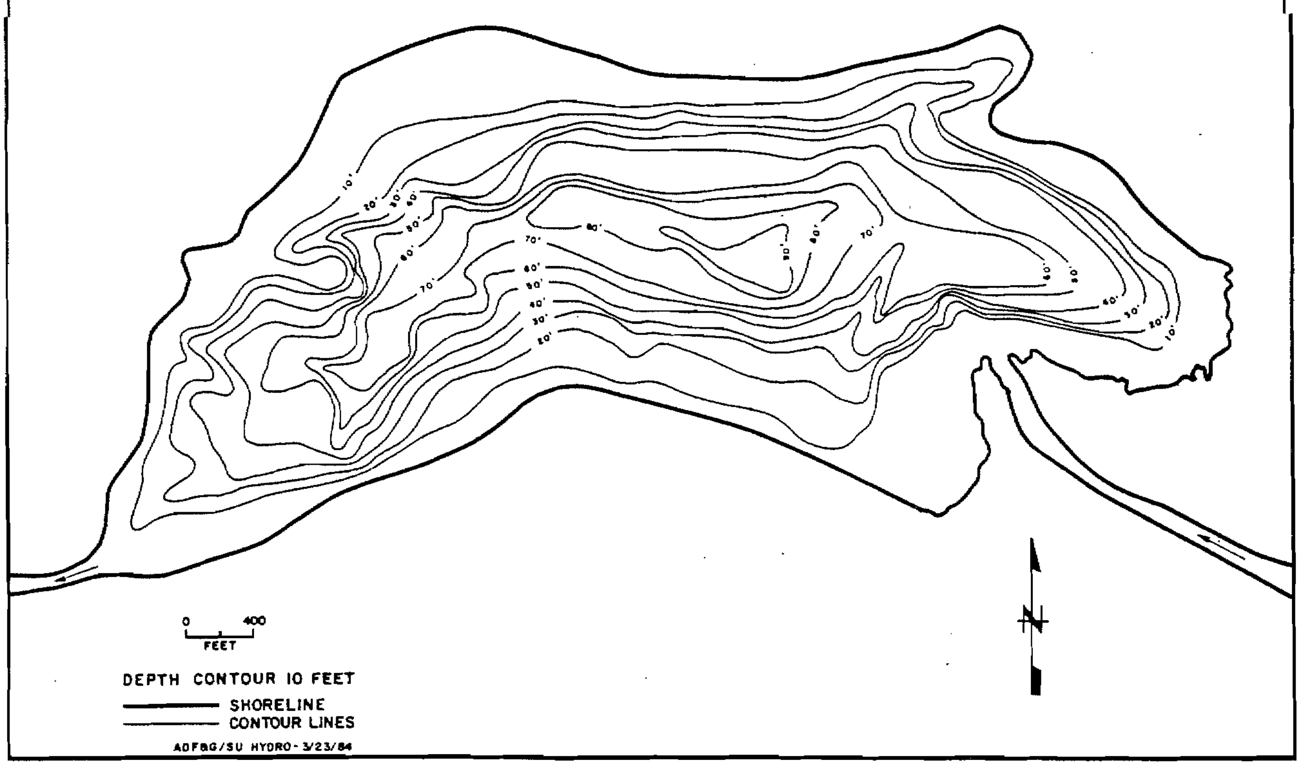

Figure 15. Deadman Lake, morphometric map, August 1983.

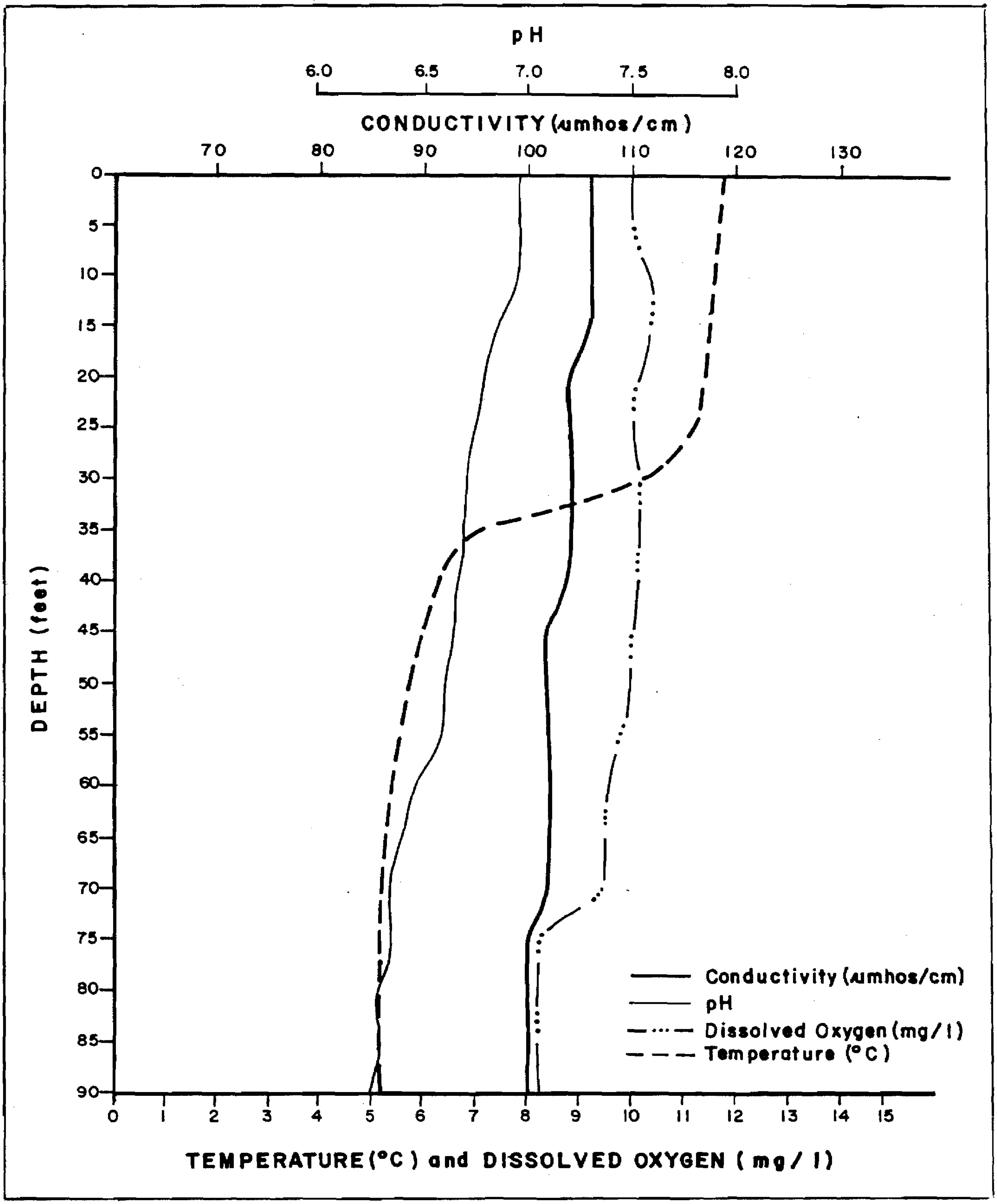

Figure 16. Vertical distribution of temperature, oxygen, pH, and conductivity in Deadman Lake, July 19, 1983.

Throughout the sampling season, concentrations of lake trout were found just below the thermocline at the inlet stream by using a depth finder. These lake trout may have been feeding on a large concentration of whitefish that were also found in this area.

Age-length composition

The mean length of the 32 lake trout captured by hook and line and trotline was 525 mm with a range of 285 to 795 mm.

Otoliths (Plate 26) and scales were taken from five lake trout. The scales were not readable, however, otoliths from four of the fish were read and the length, sex and ages of these fish were: 755 mm (F)-22 years, 410 mm (F)-21 years, 500 mm (m)-15 years, and 685 mm (m)-26 years.

Population estimate

A population estimate could not be generated for lake trout in Deadman Lake because not enough fish were captured and only one tagged lake trout was recaptured.

3.5.2 Humpback whitefish

Modal gill raker counts of humpback white fish from Deadman Lake indicate that these humpback whitefish are Coregonus pidschian. This is the same species which is found in the Susitna River both above and below Devil Canyon.

Distribution and relative abundance

Humpback whitefish were present in Deadman Lake throughout the summer. Schools of 50 to 100 humpback whitefish were seen during early June along the shoreline. From mid-June through early September the fish dispersed throughout the lake with frequent sitings of small schools of up to 50 fish. Concentrations of humpback whitefish were found throughout the summer just above the thermocline at the inlet stream. Large schools of approximately 250-500 fish were seen by helicopter and boat in shallow waters (1-3 feet) in the east end of the lake during September. Sexually ripe male and female humpback whitefish were captured in gill nets at these sites, indicating that they were using these cobble substrate areas for spawning.

Age-length composition

Forty-six humpback whitefish captured by gill net and trap net were sampled for lengths. Lengths ranged from 320 to 405 mm with a mean of 370 mm.

Otoliths and scales were taken from 26 humpback whitefish in Deadman Lake for age determination. Ages of humpback whitefish based on otolith readings ranged from 8 (320 mm) to 14 years (400 mm).

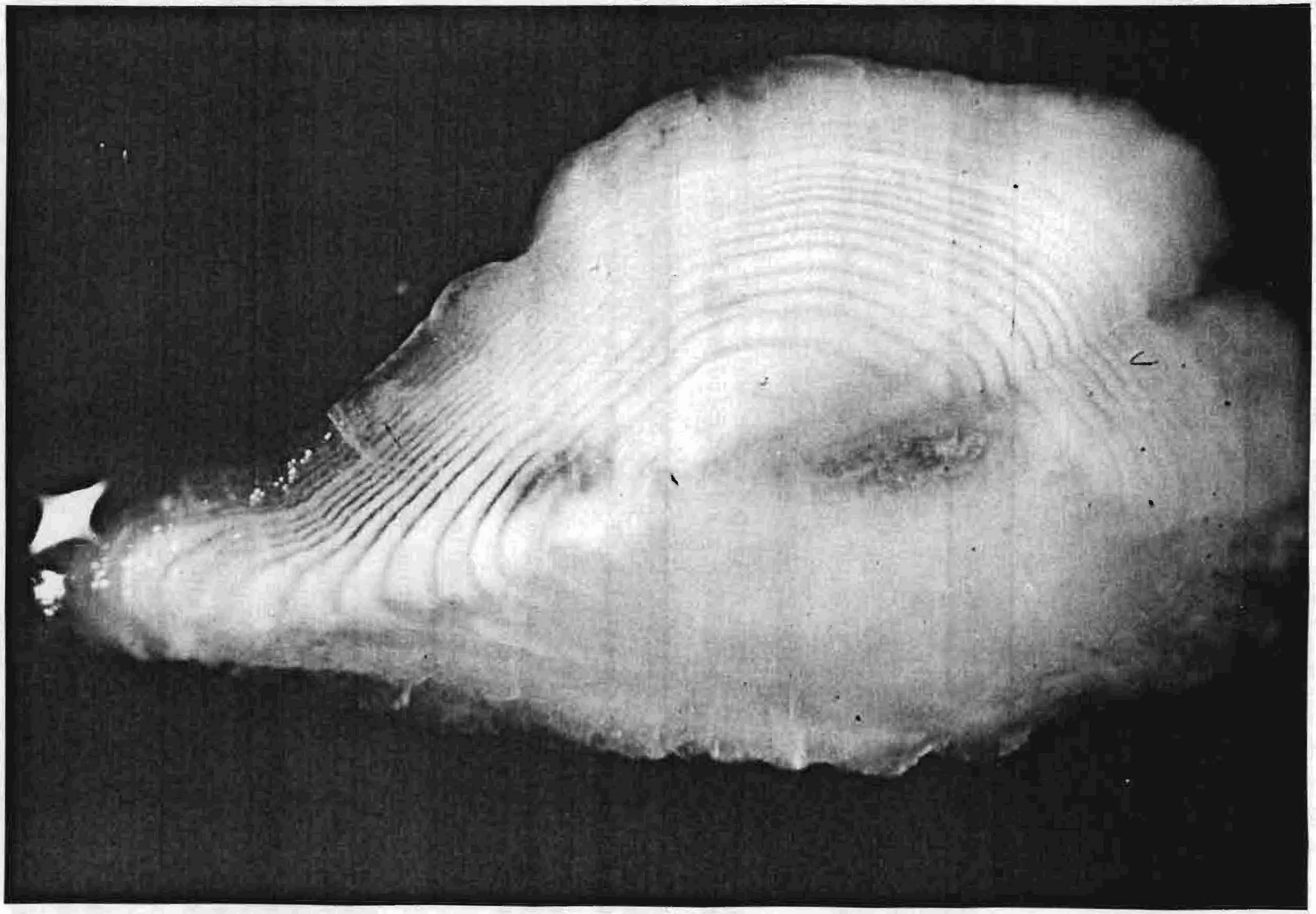

Plate 26. Otholith from a lake trout (Age 21) captured in Deadman Lake, 1983.

All humpback whitefish sampled were sexually mature. On September 21, nine of 26 fish captured had spawned, while on October 2, eight of nine fish had spawned.

Population estimate

A population estimate for humpback whitefish in Deadman Lake could not be generated because the sample size was too small and no recaptures were made.

3.5.3 Round whitefish

Distribution and relative abundance

Round whitefish were present in Deadman Lake throughout the summer. Small schools (10-25 fish) were seen along the shoreline during breakup. Individuals and small schools were also seen throughout the lake during the mid-summer months. During September and early October, larger schools of 50 to 100 fish were seen spawning along the northern shoreline in 1-5 feet of water over a sand and gravel substrate.

Age-length composition

The mean length of the fifty-two round whitefish captured by gill net and trap net was 275 mm with a range of 160 mm to 330 mm.

Otoliths taken from two 320 mm round whitefish indicated that both were 10 years old. Both round and humpback whitefish in Deadman Lake were considerably older than fish of the same size in the Susitna River.

One of three sexually mature round whitefish captured on September 21 had spawned. All of the round whitefish captured after this date were sexually immature.

3.5.4 Arctic grayling

Distribution and relative abundance

Arctic grayling hook and line catches averaged 8.75 fish per hour along the shoreline and at the inlet and outlet streams of Deadman Lake during early June. From mid-June through early September, only one Arctic grayling was caught in the lake despite over 100 hours of hook and line sampling. During late September and early October, Arctic grayling were once again found at the inlet and outlet streams, presumably returning from the streams to overwinter in Deadman Lake.

Age-length composition

The mean length of 61 Arctic grayling captured by hook and line and trap net was 300 mm with a range of 175 mm to 465 mm.

No scales or otoliths were collected from these fish because the sample taken earlier from Deadman Creek was considered representative for the Deadman system.

3.5.5 Other species

Slimy sculpin are plentiful throughout the shallow areas of Deadman Lake. A single Dolly Varden was captured at the mouth of a small inlet stream on the northeast shore of the lake. Examination of an otolith cross section indicated that this 245 mm, female Dolly Varden was 6 years old. Two small (180 mm and 220 mm) burbot were also captured in a trap net set at the outlet of Deadman Lake.

4.0 DISCUSSION

4.1 Access Corridor Stream Crossing Studies

Streams along the proposed access corridors are typically small, shallow, variable discharge streams with substrates dominated by rubble, cobble and boulders. The majority of these smaller streams are high gradient tributaries which drain the upper reaches of large watersheds such as the Brushkana Creek, Deadman Creek, and Devil Creek drainages. Major streams crossed by the proposed access corridor include Seattle Creek, Brushkana Creek, Deadman Creek, Tsusena Creek, and Devil Creek. A few small, low gradient muskeg streams are also crossed at various locations along the route. Peak flows in these streams usually occur in late spring as a result of melting snow and ice, and low flows occur during the ice covered season, generally from November to April. Peak flows may also occur in summer during periods of heavy precipitation. Limited available data indicate that all are cold, clearwater streams and most have dissolved oxygen values near saturation.

Arctic grayling, Dolly Varden, chinook salmon, and sculpin were the only fish species found at stream crossing study sites along the proposed access corridors. Dolly Varden and sculpin are widely distributed along the entire route. The majority of the stream resident Dolly Varden did not exceed 200 mm in length. Arctic grayling were confined to streams in the Seattle, Brushkana and Deadman drainages. However it is likely that Arctic grayling are more widespread along the route than these present surveys indicate. Previous investigations by the ADF&G have shown that Arctic grayling are widely distributed in the Susitna River watershed (ADF&G 1981c, 1983a,1983c.) Chinook salmon fry were found only in Streams 40 and 41. Salmon do not have access to those reaches of tributaries located above Devil Canyon in vicinity of the proposed access corridors. In the Nenana watershed the relatively high elevations and gradients of streams along the access corridor appear to preclude the presence of salmon in this area. Therefore, the distribution of salmon was limited to streams along the Gold Creek rail corridor which is located below Devil Canyon on the Susitna River.

Potential direct impacts to fish habitats associated with construction, operation and maintenance of the access corridors include alterations of streamflows, deterioration of water quality and removal or shifting of substrates.

Alterations of streamflows could have significant impacts on the migrational patterns of fish utilizing these habitats. This could be especially critical to species that undertake seasonal migrations to summer and winter rearing areas or spawning grounds. Higher than normal streamflow velocities at culverts could prevent fish from moving to upstream habitats during certain times of the year. Culverts may also become perched over a period of time by filling in with gravel and/or sand resulting in restrictions to fish passage. Blockage of culverts by ice or debris could also become a problem and require routine maintenance throughout the year.

If culverts and/or bridges are properly designed, installed, and maintained they should not cause significant changes in streamflows which could influence fish movements. Elliot (1982), in his study of stream crossings along the Trans-Alaska Pipeline, recommends that culverts be designed to allow upstream movement of fish during a mean annual flood discharge. According to the APA (Acres 1983b) present plans for development of the access corridors indicate that bridges will be preferred over culverts and that adequate fish passage will be maintained according to AS-16.05-840. More recent guidelines regarding design flows for fish passage at stream crossing sites are presented in Ashton and Carlson (1983).

Construction activities at stream crossing sites could result in changes in water quality on some streams. Installation of bridges and culverts, construction of the main roadbed, and crossing of streams by heavy equipment may cause temporary increases in turbidity and suspended sediments. Leakage or spills of gas and oil may also have adverse effects on water quality. More long term changes in water quality may be associated with increased erosion and subsequent runoff into streams due to removal of vegetation from stream banks. Increased siltation of streams may also occur as a result of drainage from the roadbed.

Other impacts related to stream crossing sites may be associated with removal or shifting of substrates. These impacts should be localized and not result in an extensive or permanent loss of habitat. However, alterations of substrate could be critical in areas considered to be important fish spawning sites.

Arctic grayling and Dolly Varden are the two most important fish species that may be affected by development of the access corridors. This is mainly due to their potential importance as sport fish species and the increased fishing pressure that may result due to increased access to the area. The following discussion of impacts on fish species along the access corridors are limited to these two species.

4.1.1 Arctic grayling

Arctic grayling were found in seven of the 42 streams crossed by the proposed access corridors (Tables 7, 8 and 9). All Arctic grayling were captured within the Seattle Creek, Brushkana Creek and Deadman Creek drainages. Arctic grayling over 300 mm in length were taken from Seattle Creek , Brushkana Creek, Deadman Creek, and Stream 9 which indicates that these streams contain populations of catchable size fish that may support a recreational fishery.

Increased sport fishing pressure caused by increased access to remote drainages as the access and transmission corridors are developed could result in overharvest of Arctic grayling populations in these areas (see Part 2 of this report). Due to the slow growth and development rate of Arctic grayling in the upper Susitna Basin, increased sport fishing pressure could eventually reduce the average size and numbers of grayling within these drainages. Similar findings were reported by Falk and Gillman (1974) on Arctic grayling populations in the Northwest Territory.

Arctic grayling populations along the proposed access and transmission corridors could also be affected by alterations or blockage of flows at culverts. This could be especially critical to Arctic grayling during the spring when fish are moving upstream to spawn or rear, and in fall when they are outmigrating from these small, shallow tributaries to overwintering areas. Restrictions to fish passage during spring could delay timing of spawning activity or force Arctic grayling to spawn in less desirable habitats.

Investigations need to be conducted in spring to determine if fish are spawning in the proximity of proposed stream crossing sites. Construction activities could conflict with Arctic grayling spawning periods and reduce the quantity or quality of available spawning habitat.

4.1.2 Dolly Varden

Dolly Varden were captured in 15 of 42 streams crossed by the proposed access corridors (Tables 7, 8 and 9). These fish were widely distributed in pools of small, shallow, high gradient streams. These stream resident fish generally did not exceed 200 mm in length. According to Morrow (1980), stream resident Dolly Varden, rarely, if ever, exceed 300 mm in length. However, in Stream 32, Dolly Varden up to 375 mm in length were captured within a half mile reach of the outlet stream immediately below Swimming Bear Lake. These were the largest Dolly Varden taken from streams along the proposed access corridor. Large Dolly Varden were also captured in Swimming Bear Lake, Highest Lake, and Island Lake (see Section 4.4).

Large Dolly Varden in spawning condition found at the stream crossing site on Stream 32 most likely use the stream for spawning and return to the lake to overwinter. It is not known if they use the stream for purposes other than spawning. The large, deep pools within this reach may provide summer rearing habitat for some of these fish. However, it is likely that the majority of Dolly Varden reside in Swimming Bear Lake since this reach of Stream 32 doesn't appear to provide adequate overwintering habitat. This would help explain the relatively large size of these fish occupying a stream habitat compared to smaller Dolly Varden found in streams with no available lake system.

Dolly Varden which have access to lakes in the upper Susitna Basin are much larger than the smaller stream dwelling Dolly Varden. Examination of the morphological characteristics of lake and stream resident Dolly Varden in the study area failed to reveal any differences, indicating that they are the same species. A dwarfed northern form and larger southern form of Dolly Varden have been identified in Alaska (Armstrong and Morrow 1980) and the ranges of these two forms of Dolly Varden overlap in the Nenana and Susitna River watersheds.

The smaller size of the stream dwelling fish can be attributed to low food availability in these small streams and the need to expend more energy on a year round basis in order to obtain enough food to survive.

Possible impacts to Dolly Varden associated with construction of the access corridors are similar to those listed previously for Arctic grayling. Fish need to be able to traverse culverts at all times during the year. Although increased access to the area will probably not affect the smaller, stream dwelling Dolly Varden, the larger lake populations could come under considerable pressure from increased sport fishing activity. The Dolly Varden in Stream 32 were readily caught by hook and line and may provide a recreational sport fishery. Special consideration should be given to these larger fish since they are not widely distributed in the study area and less is known about their life history.

4.2 Transmission Corridor Stream Crossing Studies

Fifteen streams are crossed by the proposed Devil Canyon and Watana transmission corridors from the Watana dam site to the Anchorage-Fairbanks Intertie (Figures 6 and 7). The majority of these streams are small, shallow, high gradient tributaries draining the Swimming Bear and Devil Creek watersheds. Two major streams, Tsusena and Devil Creeks are also crossed by the proposed corridor. All but three of these streams are also crossed by either the proposed Devil Canyon or Gold Creek rail access corridors in relatively close proximity to each other. On site surveys were not conducted at stream crossing sites along the proposed transmission corridor. Information on fish species within these drainages is available from investigations conducted at stream crossing sites during the access corridor studies. These studies show that Dolly Varden, sculpin and juvenile chinook salmon are the only species utilizing streams along the proposed transmission corridor. Dolly Varden and sculpin were widely distributed among these streams. Juvenile chinook salmon were found only in the lower reaches of Jack Long Creek (Stream 14).

Previous investigations by the ADF&G (ADF&G 1981c, 1983c) have identified a population of relatively large Arctic grayling in the lower reaches of Tsusena Creek in the vicinity of the proposed transmission corridor stream crossing site. Increased access to this reach of stream could result in an increase in sport fishing pressure for this species.

Impacts to fish habitats associated with construction and maintenance of the transmission corridor may result from crossing of streams by heavy equipment and other vehicles. This could result in displacement or alteration of the present substrates and/or an increase in turbidity and suspended sediments. Removal of streamside vegetation along the 510 foot right-of-way may also contribute to increased erosion and subsequent runoff.

4.3 Deadman Creek Studies

4.3.1 Arctic grayling population estimates

During the 1981 and 1982 aquatic studies of selected tributaries in the upper Susitna River, biases and assumptions relating to Arctic grayling population estimates were identified (ADF&G 1983c). For the 1983 studies of Deadman Creek reaches, these biases and assumptions were once again addressed. All of the data used to generate the 1983 population estimates were collected between July 15th and 26th. By sampling each reach four times, a larger sample was collected and a multiple census estimator could be used. The Schnabel estimator was chosen as the method which best fit the data as the short time period (allowing no natural mortality, recruitment or migration) (Everhart et al.1975) and the recapture of 43 tagged fish [well over the minimum of 4 suggested by Ricker (1975)] completely satisfy the requirements.

The population estimates and 95% confidence intervals given in Table 12 are the numbers of fish per mile found in the three study reaches which are representative of the entire area of each habitat type section. Other reaches within these three sections were spot sampled and catches per angler hour were similar to the respective study reach. These estimates are well within the range of estimates found during the 1981 and 1982 aquatic studies of selected tributaries of the upper Susitna River (ADF&G 1981c, 1983c). Fish density is similar to that reported by Tack (1971, 1972, 1973, 1974, 1975, 1976), Hallberg (1977, 1978, 1979) and Pearse (1974) in the Chena, Goodpaster, and Delta Clearwater rivers, respectively, in interior Alaska.

The density values generated (numbers/mile) are reflective of the relative abundance of Arctic grayling in the three study reaches and can be used as a comparison between the reaches. The upper reach, with its abundance of large, deep, pool-type habitats and its nearness to the lake, had the highest population of the three reaches with an estimate of 858 grayling per mile. No information was available on Arctic grayling populations in the middle reach as no sampling had previously been done on these long, placid, sandy bottomed stretches. Grayling were found in this reach only in areas immediately above and below the small rapids. Sometimes, long, sandy stretches of up to 0.5 mile were sampled and no grayling were collected. With an estimate of 315 grayling per mile, it can be seen that the fish were concentrated in small rapid/pool areas. The shallow depth and lack of cover in the sandy areas could be major factors in the absence of Arctic grayling. The lower reach had been sampled in previous years and was known to be good habitat for grayling. The numerous small, deep pools behind boulders and in backed up side slough areas provide excellent cover for the estimated 324 grayling per mile.

The total estimate of catchable sized grayling for the 18.5 miles of Deadman Creek between the falls (mile 0.6) and the outlet of Deadman Lake (mile 19.1) is 8,000 fish. This takes into account the varying estimates in the three reaches sampled and applies these estimates to the total area which these reaches represented. This gives an overall stream average of over 400 grayling per mile.

4.3.2 Arctic grayling age-length composition

The grayling in the Deadman Creek system were known to be larger than the grayling found in the rest of the upper Susitna River basin. During the 1983 study, grayling up to 475 mm long were captured by Fish and Game biologists. Grayling up to 500 mm in length were reportedly caught in Deadman Creek during 1981 and 1982 by other project personnel.

Average lengths and associated ranges were significantly different between the three study reaches on Deadman Creek. In the upper reach, average lengths were large (380 mm) and the range of lengths was small (300-445 mm), while in the middle and lower reaches, average lengths were smaller (354 and 315 mm) and length ranges became larger (260-430 mm and 200-410 mm). The mean length in the lower reach was equal to the smallest grayling captured in the upper reach (Figure 14).

Arctic grayling exhibit strong territoriality and social hierarchy which could contribute to this phenomenon. The strongest and largest fish occupy the best habitat at the head of pools and slowly drive the smaller fish to the foot of the pools and eventually out of the pool habitat (Morrow 1980). As grayling come down out of the lake in the spring, the larger fish would occupy the prime habitat and slowly force the smaller fish further downstream.

Overwintering habitat in the stream documented by the presence of a live, radio tagged grayling in Deadman Creek canyon in December, would allow some of the larger grayling to establish permanent territories and would account for the presence of some large fish throughout the system. Possible fish passage barriers in the Deadman Creek Canyon may be size restrictive, allowing only the larger fish to return upstream to overwinter in the lake. Smaller fish would have to overwinter in the lower stretch. The presence of active beaver lodges in the banks and side channels of the lower reach indicates that sufficient water is present throughout the year. These smaller, overwintering fish combined with the fish forced downstream by territoriality would explain the large range of lengths of fish in the lower reaches.

Young of the year grayling were present in all three reaches, indicating that spawning does take place throughout the stream.

The grayling in the Deadman Creek system were found to be both larger and older than the grayling in the remainder of the upper Susitna River basin. Deadman Creek grayling averaged 30 mm larger at each age than the upper basin fish (Figure 17), while maximum ages were 15 and 13 in Deadman Creek and the upper basin, respectively.

The survival rate of the grayling in the Deadman Creek system is also much higher than that found during the 1982 studies of selected tributaries; .76 vs .39 (ADF&G 1983c). A major factor in this difference is the use of otoliths for aging during the 1983 studies. Otoliths are much easier to read which lowers the probability of errors. Scales tended to underestimate and "lump" the older fish (over Age 7) which lowered the maximum age and dropped the estimated survival rate. But otolith aging is not the only factor contributing to this large difference in survival. The survival for the impoundment streams based on otoliths collected during spring 1983 spawning surveys is still significantly lower than Deadman Creek grayling survival (.76 vs .56).

One possible explanation for the higher survival rate, larger size and older fish in the Deadman Creek system is Deadman Lake. Along with buffering the entire system by narrowing the range of the physical parameters (temperature, flow, dissolved oxygen), the lake also provides

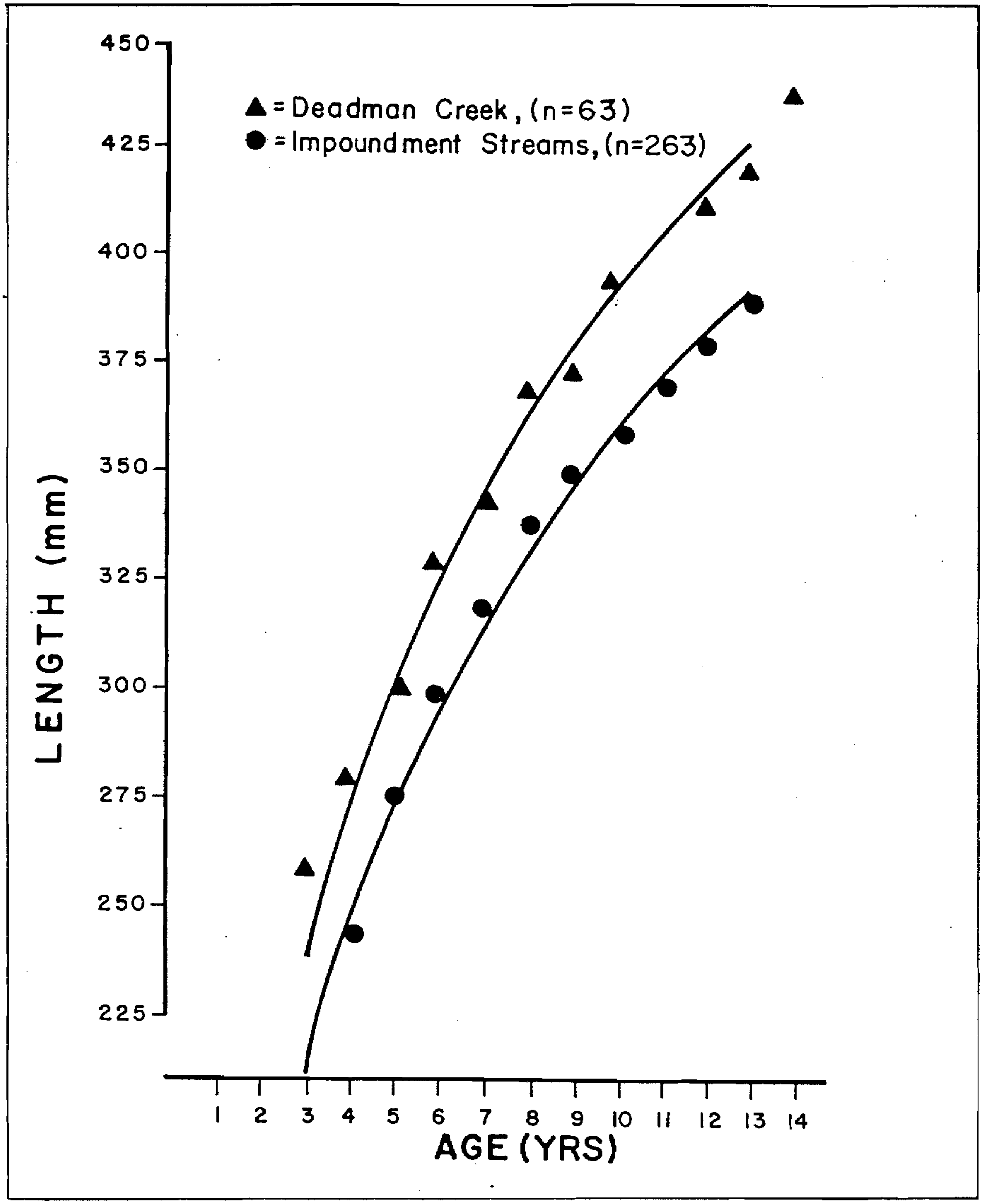

Figure 17. A comparison of the age length structure of Arctic grayling in Deadman Creek and the impoundment streams using 1983 otolith data.

a stable overwintering environment. An abundant supply of food during the entire year and reduced overwintering mortality would tend to allow fish to grow larger and live longer than those fish having to contend with these and other problems in the Susitna River.

Another explanation for relatively high survival rates could be reduced competition. Few juvenile grayling have been captured or observed in the Deadman Creek system. A high mortality rate during the younger ages would tend to allow an increase in the sizes of the territories of the remaining older fish allowing a higher survival rate for the older age classes.

At present the Deadman Creek system has been virtually unexploited and the Arctic grayling population is in equilibrium with the biological, physical and chemical factors which govern the population. Increased fishing pressure brought about by the development of a new access road in this area will change the current age structure, length composition, and size of the Arctic grayling populations in Deadman Creek.

Falk and Gillman (1974) present convincing evidence that even in a body of water as large as Great Slave Lake, sport fishing pressure over a seven year period has caused a decrease in both the average size and age of Arctic grayling, with the new modal age approaching the age at first sexual maturity. Possible effects on the grayling population by varying levels of fishing effort will be presented later in Series 4, Part 2, under Population Dynamics of Arctic Grayling in the Upper Susitna Basin.

Inundation of the falls on Deadman Creek at mile 0.6, the only major fish passage barrier between the Susitna River and Deadman Lake, will allow Susitna River fish into this system for spawning, feeding, and overwintering purposes. Arctic grayling which were tagged in 1981 and recaptured during 1982 studies show that a considerable amount of interstream migration takes place [(12% of the recaptures were found in streams other than their tagging stream (ADF&G 1983c)]. Studies conducted to learn the effects of placing catchable sized rainbow trout into an already populated habitat have shown that the population does not benefit, but instead, both population size and average lengths decreased (Vincent 1972). By placing more stress on the already filled territories in the Deadman Creek system, both the trophy class quality of the fishery and the population size of these larger fish may decrease.

4.3.3 Arctic grayling radio telemetry

The Advanced Telemetry Systems (ATS) radio tags used during the 1983 studies were much smaller than those used in Arctic grayling during 1982 studies. This smaller size, combined with new techniques of subcutaneous implantation, was thought to be the key to a successful Arctic grayling radio telemetry program. However, problems were encountered both with the tags and techniques which limited the success of the study.

Dummy radio tags were implanted under the skin on the back or abdomens of 10 Arctic grayling. These fish were kept in a large live box in Deadman Creek. After one month, the tags on the backs of the grayling had caused the skin surrounding the tag to die and slough off. The tags were shed and the fish had large, ulcerated sores from which they did not recover. The tags implanted on the abdomens of the grayling were still in place and the skin showed few signs of dying after one month.

At this time, it was decided to implant the actual radio transmitters under the skin on the abdomens of five newly caught grayling. The fish were collected (all being over 400 mm in length), the radio transmitters implanted (in less than five minutes on each fish), and then released.

Subsequent monitoring of remaining fish in the live box, showed that after 50 days the tags implanted under the skin of the abdomen caused the skin to die and the tags were shed. The sores on the abdomens of these fish did eventually heal as two of the dummy tagged fish that were released were recaptured and examined.

The grayling with the actual radio tags were tracked throughout the summer and after an initial downstream migration of 0.1 to 6.5 miles, little further movement was observed. The tagged fish were located in large pools and remained there throughout the summer and winter. One tagged fish was relocated during December surveys.

Due mostly to the large size of the tags and the apparent inability of grayling to heal the incision and retain the radio tag, the 1983 study was not successful. Similar problems were encountered during ADF&G radio telemetry studies during 1982. Of all the species tagged during the ADF&G Susitna River studies, Arctic grayling have shown the highest incidence of infection and non-healing of the tagging wound.

One Arctic grayling was also radio tagged by esophageal implant. The fish was large (465 mm) and the tag was easily inserted. The fish was held for three days and then released after no signs of stress appeared. This tag was also found to have been shed during the December surveys.

Of the six Arctic grayling radio tagged, only the data from one is valid, as it is not known when the other fish shed their tags. But, from monitoring the movement of this single fish, it is apparent that Arctic grayling can overwinter in the large pools in Deadman Creek.

4.4 Selected Lake Studies

Many lakes are located within one mile of the proposed access and transmission corridors. The majority of these are small, shallow tundra/bog lakes less than five acres in size. The largest, Deadman Lake, has a surface area of 379 acres with depths of over 90 feet (Deadman Lake is discussed separately in Section 4.5). Aerial surveys conducted on many of these lakes indicate that they are mostly clearwater, oligotrophic environments.

The nine selected lakes investigated by ADF&G between September 15 and September 20, 1983 ranged in size from two acres (Beaver Lake) to 160 acres (Island Lake). The lakes were located at elevations ranging from 2,250 (Island Lake) to 3,619 (Ridge Lake) feet.

Fish species found in these lakes included burbot, slimy sculpin, Arctic grayling, Dolly Varden and rainbow trout (Table 13). Fish were caught or observed in all lakes except Round Lake. Slimy sculpin were the most widely distributed species and were found in seven of the nine lakes. Burbot and Arctic grayling were found only in Beaver Lake. Rainbow trout were found in High Lake and Little High Lake. Populations of large Dolly Varden were taken from Swimming Bear Lake, Island Lake and Highest Lake.

The rainbow trout taken from High Lake and Little High Lake are not believed to be an indigenous population. Reports from local residents of the area suggest that these fish were planted in these lakes to increase the variability of sport fishing in the vicinity of High Lake Lodge, a hunting and fishing lodge, located on High Lake. Rainbow trout have not been found farther upstream in the Susitna watershed and the High Lakes complex is believed to be the northernmost extent of their distribution in the Susitna Basin.

Age and length data were collected from a limited sample of Dolly Varden from Island Lake, Highest Lake, and Stream 31. These data were used to show the relative differences in growth between lake and stream resident Dolly Varden. Due to the limited data collected, only the Age 6 group can be compared between all three sites. However, these data show that the average size of Age 6 fish taken from Island Lake and Highest Lake is much larger than the same age fish taken from Stream 31. The mean length for the sample of Age 6 fish taken from Island Lake is 358 mm while those from Stream 31 have a mean length of 172 mm. These data support the idea that the stream dwelling fish are stunted compared to those residing in lakes. Possible explanations for this are discussed in Section 4.1.

The major impact to fish in lakes along the proposed access and transmission corridors would probably result from an increase in sport fishing pressure due to increased access into the area. Previous studies have shown that an increase in sport fishing pressure on lake populations of Arctic grayling eventually reduced the average size and numbers of these fish (Falk and Gillman 1974).

Present surveys indicate that Dolly Varden and rainbow trout are the species most likely to be affected in lakes along the proposed access and transmission corridors (excluding Deadman Lake). However, Arctic grayling and burbot may also be more widely distributed than present studies indicate, and it is likely that lake trout are present in some of the deeper lakes within the study area. All these species could be adversely impacted by an increase in sport fishing pressure.

4.5 Deadman Lake Studies

The 1983 studies of Deadman Lake identified the presence of seven species of fish. Three of these, burbot, round whitefish and humpback whitefish, were not known to inhabit Deadman Lake. Because of the ineffectiveness of standard gear types (due to the physical characteristics of the lake, i.e. size, depth, bottom vegetation) and the late arrival of the South Dakota trap nets, generation of population estimates for the fish species present was unsuccessful.

4.5.1 Lake trout

The initial study plan for generation of lake trout population estimates was to capture the fish in South Dakota trap nets, during June and September, when this species is known to inhabit the shallow portions of lakes (Scott and Crossman 1973; Morrow 1980).

Aerial observations and depth finder recordings (during the lake mapping transects) confirmed the presence of lake trout in the shallower areas at these times. After it was found that the trap nets would be late in arriving, hook and line sampling was substituted for the trap nets in hopes of capturing a large enough sample to calculate a population estimate. By this time, July and August, the lake trout had migrated to the deeper, cooler waters of the lake and catches had fallen to less than 0.25 fish per angler hour.

The capture of 32 lake trout with only one recapture was not enough to generate a valid population estimate, but the limited data from these fish did suggest a few things about the population. Scales from lake trout are extremely hard to read, while otoliths are relatively easy to age. Otolith ages were consistently at least double the scale ages. No literature has been found to disprove these otolith ages. These ages fall well within the ages of lake trout found in Alaska by Morrow (1980) and Bendock (1983) based on otoliths.

The limited otolith age-length data suggests that the population is relatively small and comprised of very old fish. Also, the tapes of the approximately 30 transects conducted for the contour map recorded few (less than 50) lake trout. The capture of no juvenile lake trout and only one under Age 15 suggests that mortality is high during the younger age classes and levels off in the older age classes.

Adult lake trout are solitary wanderers for much of the year (Morrow 1980), schooling only during the fall spawning time and at spring breakup. This characteristic makes it very difficult to capture a large enough sample to generate a valid population estimate, except during times of concentrations.

4.5.2 Humpback whitefish

Humpback whitefish were first identified in mid-July, when a dead fish was found along the east shore. Limited gillnetting proved that what had been thought to be large schools of grayling observed in June, were actually humpback whitefish. These large schools were extremely noticeable during August and September as they swam the eastern shoreline of the lake in less than three feet of water. The seasonal pattern of movement observed in Deadman Lake closely followed that described by Morrow (1980); travel from deep to shallow water in the spring; movement back into deep water during summer as the shallower waters warm; movement back to the shallow waters in fall to spawn; and postspawning movement back to deeper water to overwinter.

The identification of this species as humpback whitefish (Coregonus pidschian) was also unexpected, as the species in Paxson Lake, and Crosswind Lake in the Copper River drainage and Lake Louise and Tyone Lake in the Susitna drainage have been identified as lake whitefish (Coregonus clupeaformis)(Williams 1968; VanWhye and Peck 1969).

Growth patterns on otolithes and scales indicated that the humpback whitefish in Deadman Lake are an old, slow growing population. The youngest fish aged was Age 8 (320 mm) and all fish over 345 mm were Age 10 or older. In comparison, Morrow (1980) reported that humpback whitefish in arctic rivers such as the Colville River, Kobuk River, and the Agiakpuk River had average lengths of 267 mm at Age 5+ and 405 mm at Age 10+. Morrow also stated that humpback whitefish in the Kuskokwim River and the lower Yukon River had average lengths of 347 mm and 445 mm at the same age groups. Lower Susitna River humpback whitefish were an average of three age groups younger at a given length than the Deadman Lake fish (Series 2, Part 3.3.2).

4.5.3 Round whitefish

Round whitefish were first identified in Deadman Lake during June, when a dead fish was found on the beach at the outlet of the lake. Round whitefish are not as large or plentiful in Deadman Lake as humpback whitefish, but autopsies of several lake trout and personal communications with several sport fishermen indicate that round whitefish are a major summer food item of lake trout in Deadman Lake.

The round whitefish population in Deadman Lake is older and smaller than round whitefish in the lower Susitna River (Volume 2, Section 3.3.2).

The presence of round whitefish in Deadman Lake may account for the size difference between lake trout found in Deadman Lake and Sally Lake (a smaller lake about two miles east of Watana Creek mouth). Lake trout found in Sally Lake are much smaller than those in Deadman Lake (ADF&G 1981c). This may be due to the absence of round whitefish as a forage fish. In Lake Minnewanka in Banff National Park, Canada, an impoundment caused the absence of forage fish at depths where lake trout were present and subsequently, the trout rarely obtained lengths over 100 mm (Cuerrier, 1954).

4.5.4 Arctic grayling

Arctic grayling were found in Deadman Lake only during the spring and fall. By mid-June, Arctic grayling had migrated out of the lake and did not return until early September. Only one Arctic grayling was captured during midsummer despite over 100 hours of sampling with hook and line and gill nets . Catches in a trap net and by hook and line at the lakes outlet in early October, showed an in-migration of Arctic grayling to Deadman Lake in September and October but not as large a return as had been expected. Possible explanations include: the majority of Arctic grayling which use Deadman Lake for overwintering returned to the lake before or after our sampling effort in October or perhaps Deadman Creek also has a substantial population of Arctic grayling which overwinter in the creek. We believe that Arctic grayling use the lake for overwintering, but it appears that a portion of the Arctic grayling population also overwinters in Deadman Creek below the lake.

4.5.5 Other species

Sculpin, Dolly Varden, and burbot are the three other fish species known to inhabit Deadman Lake. Sculpin are numerous in the lake. Further studies would be required to determine the abundance of Dolly Varden and burbot.

5.0 CONTRIBUTORS

Parts of the study design provided by Dana Schmidt. Sally Donovan, Carol Kerkvliet, and Carol Hepler drafted the figures. Typing was done by Skeers Word Processing Services.

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PART 2

Population Dynamics of Arctic Grayling in the Upper Susitna Basin

POPULATION DYNAMICS OF ARCTIC GRAYLING IN THE UPPER SUSITNA BASIN

1984 Report No. 4, Part 2

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ABSTRACT

The effects of an anticipated sport fishery for Arctic grayling on the tributary streams of the upper Susitna basin are examined by modelling the effects of hypothetical harvest. The increased levels of mortality created by a sport fishery cause a rapid shift in the age structure and consequently the size of the fish caught. To maintain a "trophy" fishery on a sustained yield basis, a catch and release fishery appears to be warranted. Under the assumptions of the model, the total number of all fish caught is not substantially reduced with comparatively high levels of fishing. Possible explanations of the differences in population structures of the Deadman Creek drainage and the impoundment tributaries are discussed.

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1.0 INTRODUCTION

During the 1983 studies on the upper Susitna basin Arctic grayling populations, data were obtained that are useful in revision of the population dynamics model which was constructed from 1982 data (ADF&G 1983a). We obtained refined data on age estimates by examination of otoliths in addition to a broader sample of spawners during the spring of 1983. In addition, a study was conducted on Deadman Creek outside of the proposed impoundment boundaries (see Part 1 of this volume). In this report, we examine the effects of reclassification of the ages of fish collected during 1982 on the conclusions of the earlier model. We also explore effects of various levels of exploitation on the reproduction of these populations. The effects of catch and release management strategies on harvest of these fish and comparisons of the Deadman Creek population with the other tributaries are included. The information presented should be useful in developing a management plan for dealing with the effects of increased exploitation of the fish stocks associated with improved access.

2.0 METHODS

2.1 Study Locations

The approximate locations of the sampling sites are depicted in Figure 1. The data collected for the tributaries within the impoundment zone were primarily obtained during the summer of 1982, with spawning data and otoliths obtained from these tributaries during late May and early June of 1983. Detailed descriptions of the sampling sites and study locations were described in ADF&G (1983b) and in Appendix I of ADF&G (1983a). The remainder of the data were obtained from the Deadman Creek drainage during the summer of 1983. These data are reported in Part 1 of this report.

2.2 Fish Data Collection

All data collection methods are described in ADF&G (1983a, 1983b) and in Part 1 of this report. The only data not previously described are the otolith collections from tributaries within the impoundment zone. These otoliths were collected along with scales, in an identical method with the collection procedures employed on Deadman Creek (Part 1). In addition, length, sex, and spawning condition were also recorded.

2.3 Data Analysis

Data summaries from the collection efforts of the open water field season of 1982 and 1983 were used to estimate different parameters of the Arctic grayling populations under study. These parameters include length-age relationships using scales or otoliths, instantaneous rates of natural mortality from catch curves, density estimates from mark and recapture studies, instantaneous rates of mortality from fishing pressure, and percentage spawners of each age group. We independently calculated these estimates from the Deadman Creek drainage study sites and from the impoundment tributary studies, with the exception of the instantaneous mortality rates from sport fishing. The sport fishing mortality rates measured from the impoundment tributaries in 1982 were used to describe projected fishing pressure mortality for both Deadman Creek and the impoundment tributaries.

Fecundity estimates were derived from Tack(1974) which reflected fecundity rates from Arctic grayling on the Goodpaster River.

$$E = 28.676 \times L - 4254.537$$

Where:

E = number of eggs
L = length in millimeters.

These relationships were applied to both the impoundment tributary and the Deadman Creek fish populations.

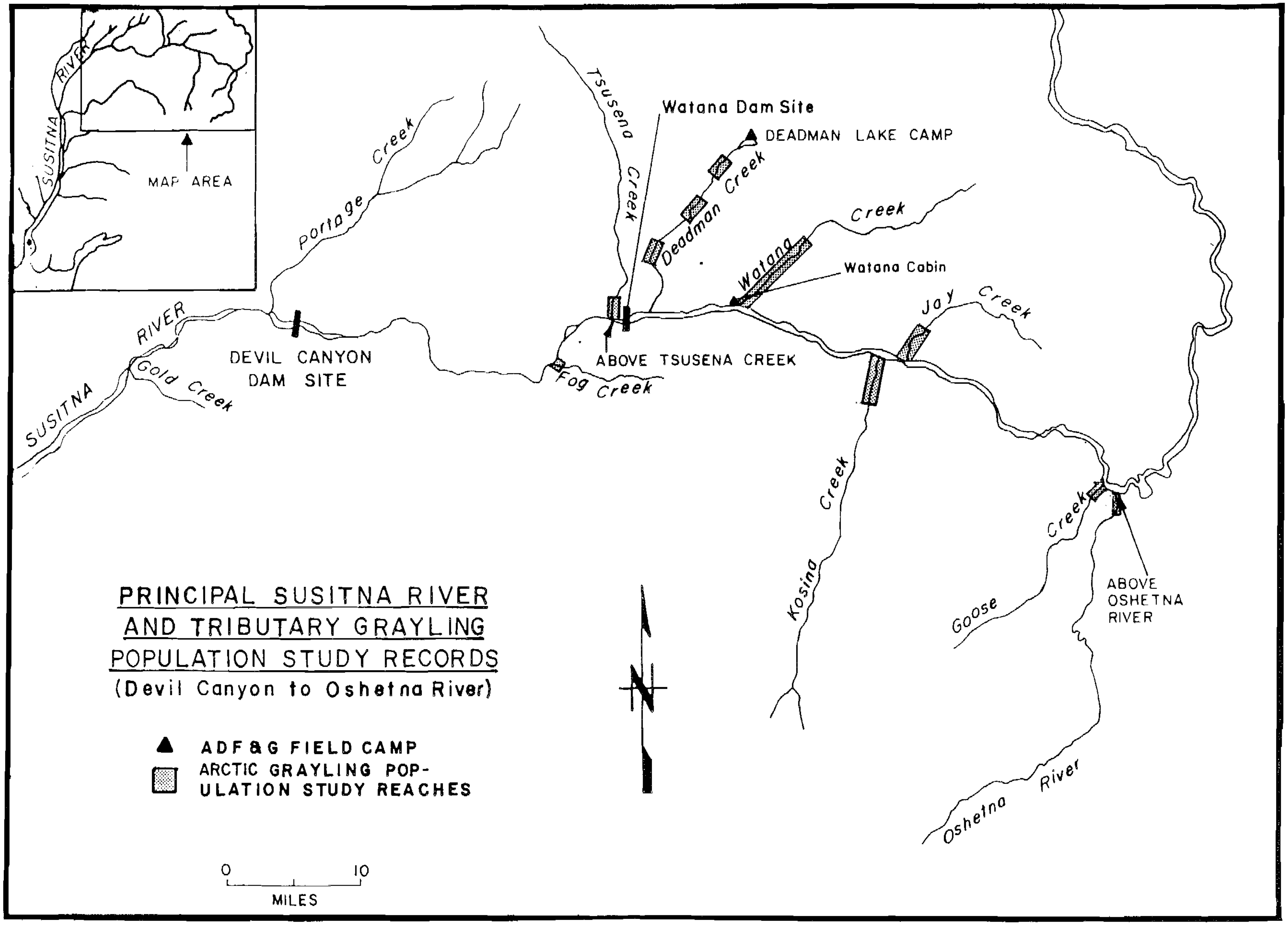

Figure 1. Study reaches used for modelling the population and harvest of Arctic grayling in the upper Susitna Basin.

A population model which included incremental sport fishing exploitation as a component was developed using the approach described by Clark (1983) and also used by Allen (1955a, 1955b), Beverton and Holt (1957), and Jensen (1981). The methods duplicated Clark's study except that differential mortality rates were assigned to each of the age groups of the populations. Equations used in the model are listed in Appendix A. The equations were entered into a commercial spreadsheet program which features interactive graphics (1-2-3 by Lotus Inc.). Most of the illustrations of output of the model in this report are produced directly from this program.

This model does not address density dependent mortality of the egg to recruit portion of the life cycle. Constant recruitment was assumed.

3.0 RESULTS

3.1 Population Dynamics of Arctic Grayling

During the spring of 1983, we obtained additional information on the age to maturity of the Arctic grayling populations within the tributary streams adjacent to the reach of river to be inundated by the Watana and Devil Canyon impoundments. Arctic grayling ages obtained from analysis of scales and otoliths were compared for a range of different size fish (Figure 2). This figure illustrates the consistent pattern of underestimating age by scale analysis after Age 5. The ages obtained from otolith readings are assumed to be the more accurate of the two. This shift in age structure has altered the estimates of the populations previously recorded from the 1982 study (ADF&G 1983a). Figure 3 illustrates the differences using both scales and otoliths for estimating populations of the impoundment grayling. The population estimates for the youngest aged fish considered as part of the catchable population have shifted one year with the four year old fish now being the youngest cohort of the population. The new population estimate for each age class using the revised age structure information is depicted in Figure 4. This adjustment was made to consider spring- caught fish to be beginning the year rather than ending the year. Although the shift in age structure is quite large, the total estimate of the population after accounting for this change is similar to the 1983 report (14,174 versus 13,750). The natural survival rate for the Age 6 to Age 12 fish was estimated to be 0.56 by using a least squares fit to the catch curve data from all of the tributaries combined. For purposes of modelling the population, a survival rate of 0.75 was used for the Age 3, 4, and 5 cohorts of this population. These values were obtained iteratively so that the model approximated the age group specific populations observed in the field. The model reached a steady state after simulation of approximately 13 generations. This method of estimation of natural survival rates replaced the estimates used in the previous report which relied on population differentials between each age group for survival estimates. The revised population estimates suggested that the constant recruitment assumptions were sufficiently violated that actual population estimates of the younger cohorts could not be used to estimate age specific survival rates.

The contribution of each age cohort to the spawning population is depicted in Figure 5. This analysis suggests some four year old females became sexually mature and a higher percentage of females remained mature until Age 7. The three fish collected over Age 12 were all males. Because otolith aging required killing the fish, we did not sample large numbers of the older age groups. The larger Arctic grayling captured in both the impoundment tributaries and in Deadman Creek were usually males, which suggests higher mortality rates for females.

The population parameters of the representative reaches of Deadman Creek have been reported in Part 1 of this report. The presence of Deadman Creek falls provides a barrier that has isolated this population from the Arctic grayling population of the tributaries within the proposed

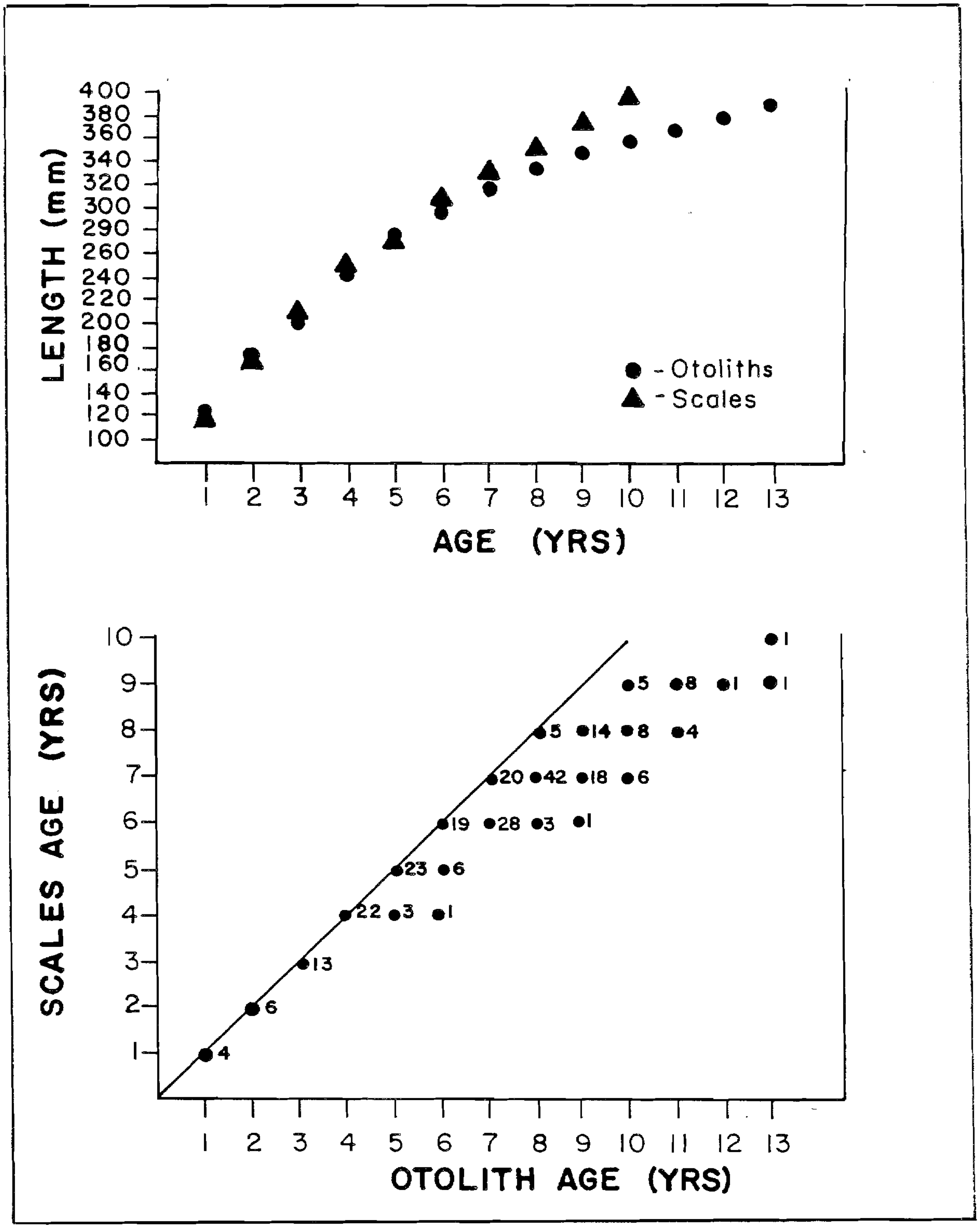

Figure 2. Comparison of age estimates obtained from the same fish using otoliths and scales. Numbers of fish are indicated next to the dots in the lower figure. The upper figure illustrates the effect of correction for age by otolith analysis on growth determinations. Data are from combined samples of impoundment tributaries.

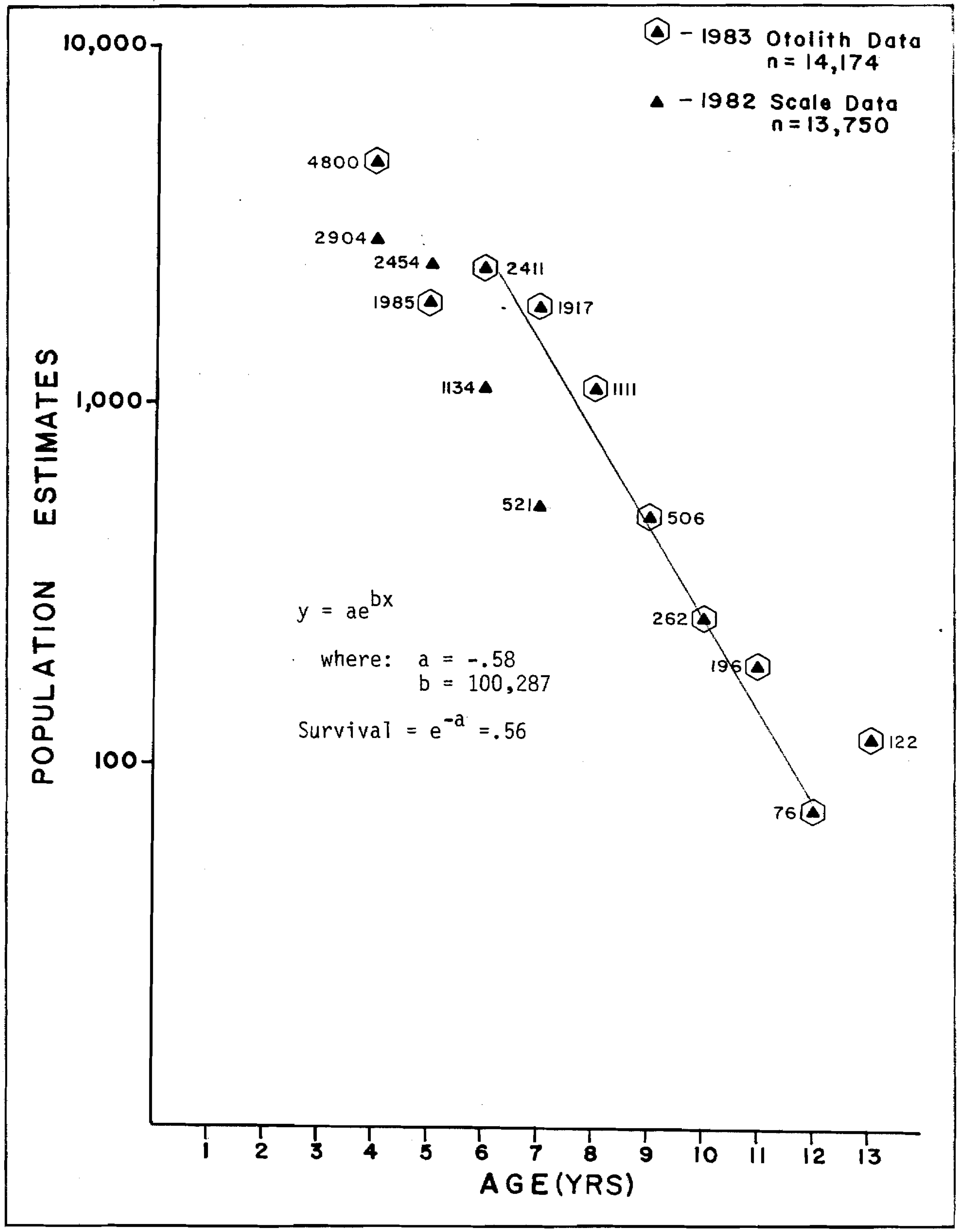

Figure 3. Comparison of the age specific populations when length data were used to estimate age from the length/age relationships developed from scale data and from otolith data. Total population estimates of age 4 and older fish are included. Data are from combined samples of impoundment tributaries.

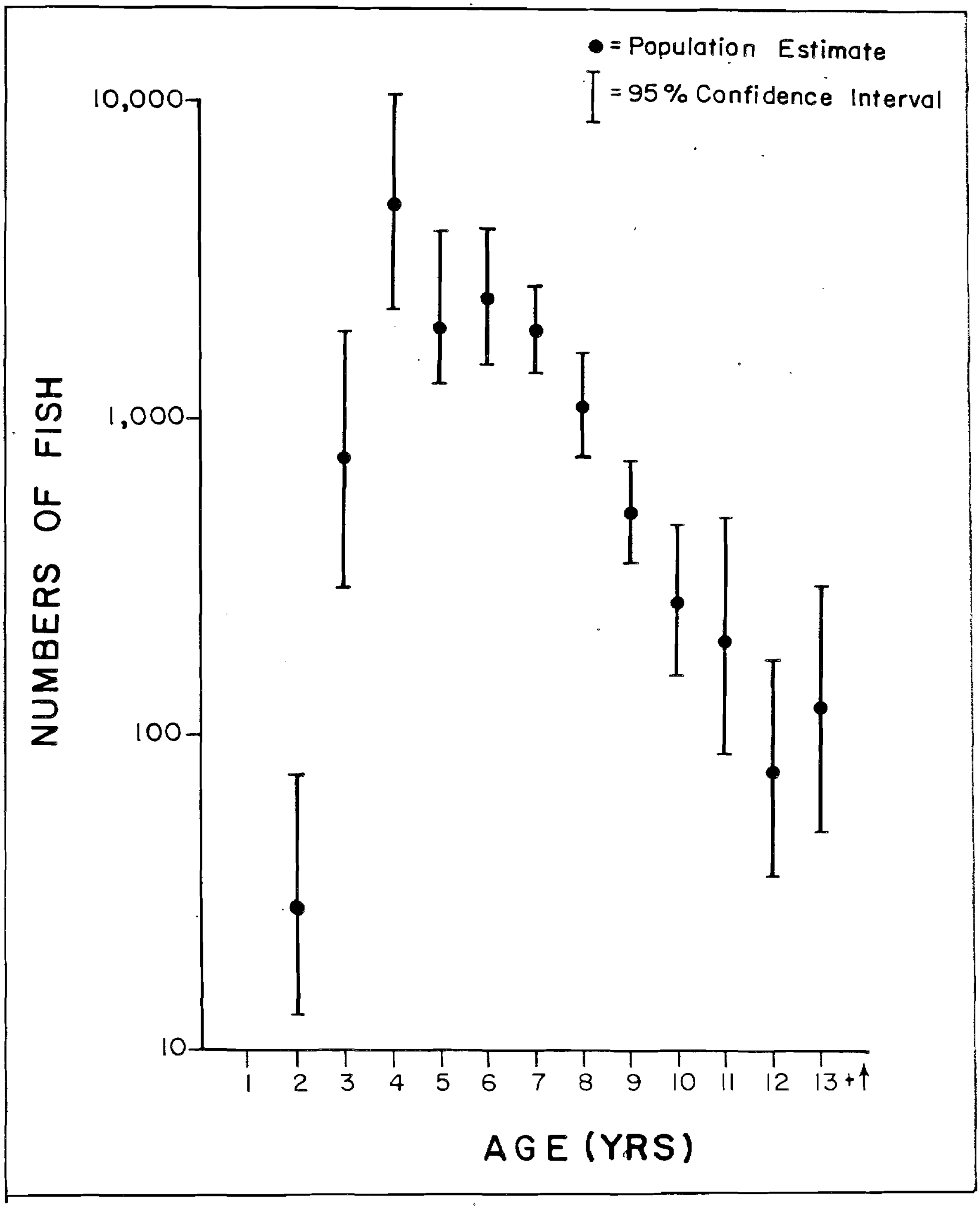

Figure 4. Population estimates of each age group of combined impoundment tributary fish and the 95% confidence interval. Estimates of 2 and 3 year olds reflect only the portion of the population that was subject to capture by hook and line.

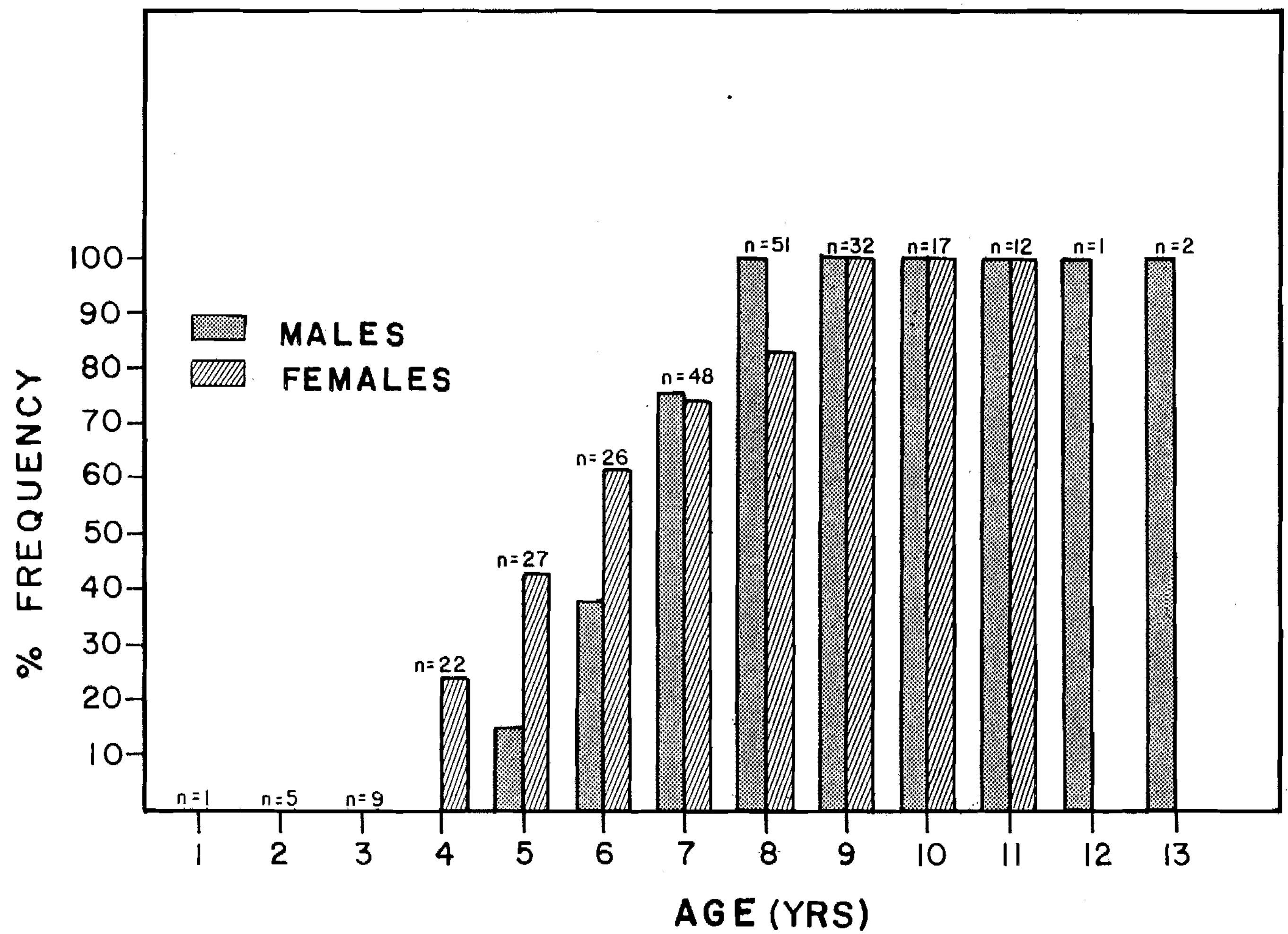

Figure 5. Percentages of sexually mature Arctic grayling of each age group. All ages were determined by otolith examination.

impoundment boundaries. Population estimates by age group were not possible because of the comparatively small numbers of fish that were marked and recaptured in the population estimates conducted on specific reaches. Survival rates calculated from the least squares fit of the catch curve data were 0.76. This value was applied to the Age 6 and older cohorts of this population. This value was also applied to the Age 3, 4, and 5 cohorts for simulation of the population by the model. The population estimates for the baseline year of each age group were approximated by choosing an initial recruitment of Age 3 fish that would provide a population estimate of Age 4 and older fish similar to the number estimated by the mark and recapture methods reported in Part 1. This value is approximately 8000 fish for the reach of Deadman Creek that is under consideration in this study.

3.2 Sport Fishing Harvest Model

The sport fishing model originally reported (ADF&G 1983a) has had minor modifications to incorporate catch and release fishing. Also, we used the egg production and percent spawner data developed from field data obtained during 1983 and from the literature sources described earlier as input to the model. The model has been operated independently for the impoundment tributaries and for Deadman Creek. In all cases, the numbers of fish harvested refer to populations within the reaches of all of the tributaries within the boundaries of the proposed Devil Canyon and Watana impoundments or, in the case of Deadman Creek, the reach between Deadman Creek falls and Deadman Lake. Only the catch data from the July 1982 sampling of impoundment tributaries was used in both models to estimate fishing rates. All other parameters used in the models were specific to either the Deadman drainage data base or the impoundment data base. Under the constant recruitment assumption of the models, sustained yield projections were obtained after ten generations of constant natural mortality accompanied with the type of fishing mortality being examined. Comparison of the effects on egg production of sustained harvest (assuming 100% mortality of all caught fish) with a catch and release fishery that produces only 10% mortality (90% survival) of the fish that were captured is depicted on Figure 6. This mortality level simulates the expected mortality level of a 100% catch and release program. Because of the average larger size and older age of the Deadman Creek fish, a more rapid decrease in the spawning cohort (and consequently, egg production) occurs than under similar harvests in the impoundment tributaries. The simulations of harvests of Deadman Creek and the impoundment tributaries demonstrated similar trends so only the Deadman Creek simulation plots for numbers caught under alternative catch and release strategies are provided.

Figure 7 illustrates the effect of increased harvest pressure on grayling assuming 100% mortality of all caught fish in the Deadman Creek study area. Note that the maximum sustained yield of all fish occurs at about 40 hours per mile annually whereas the maximum yield of Age 9 and older fish occurs at less than 10 hours per mile. The effects of catch and release of sport caught fish of 90%, 80%, 70%, 60%, 50%, and 0% of the numbers actually caught (assuming releases of fish without mortality) is illustrated in the simulation output plot on Figure 8. The optimal catch rate is clearly a function of the percentage of the caught fish successfully returned.

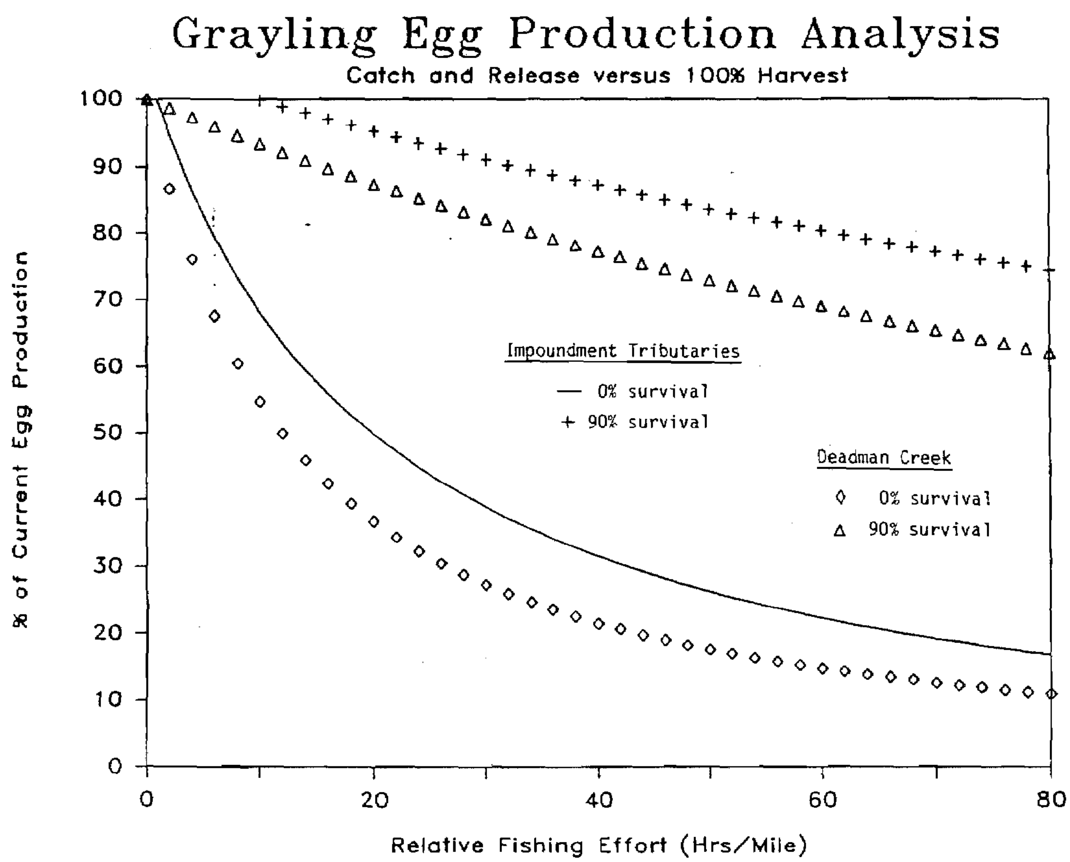

Figure 6. Percentage change in total egg production of Arctic grayling populations of the impoundment tributaries and the Deadman Creek drainage with and without simulated catch and release fisheries. The catch and release fishery assumed 10% mortality of the captured fish.

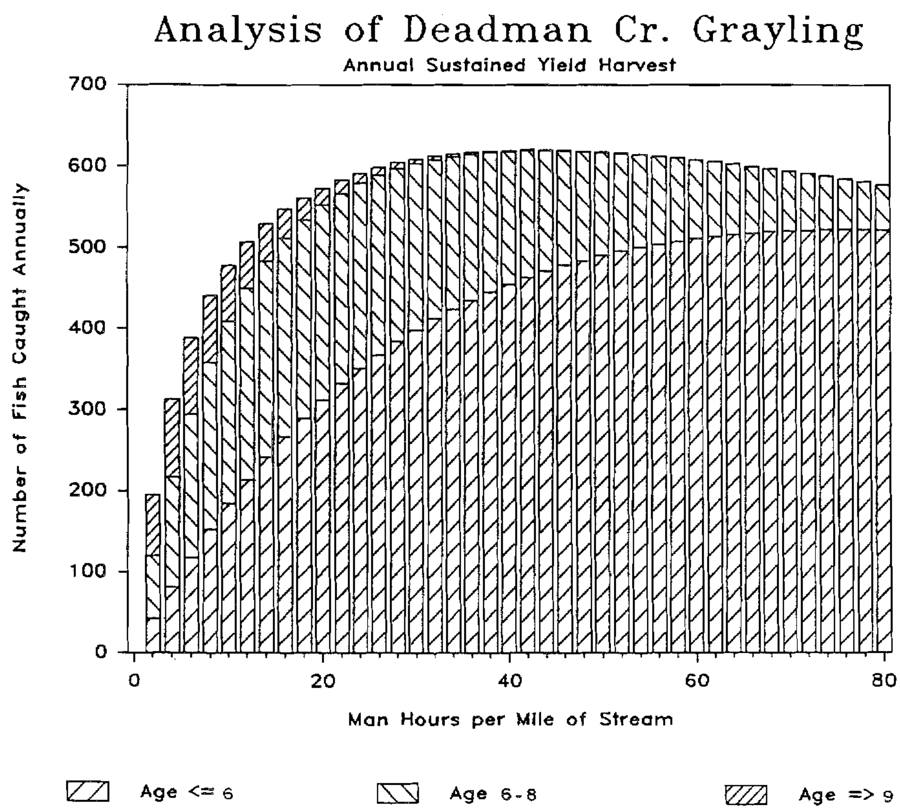

Figure 7. Effects of increasing sport fish harvests (100% mortality) on the sustained yield catch of various age cohorts of the Deadman Creek grayling population.

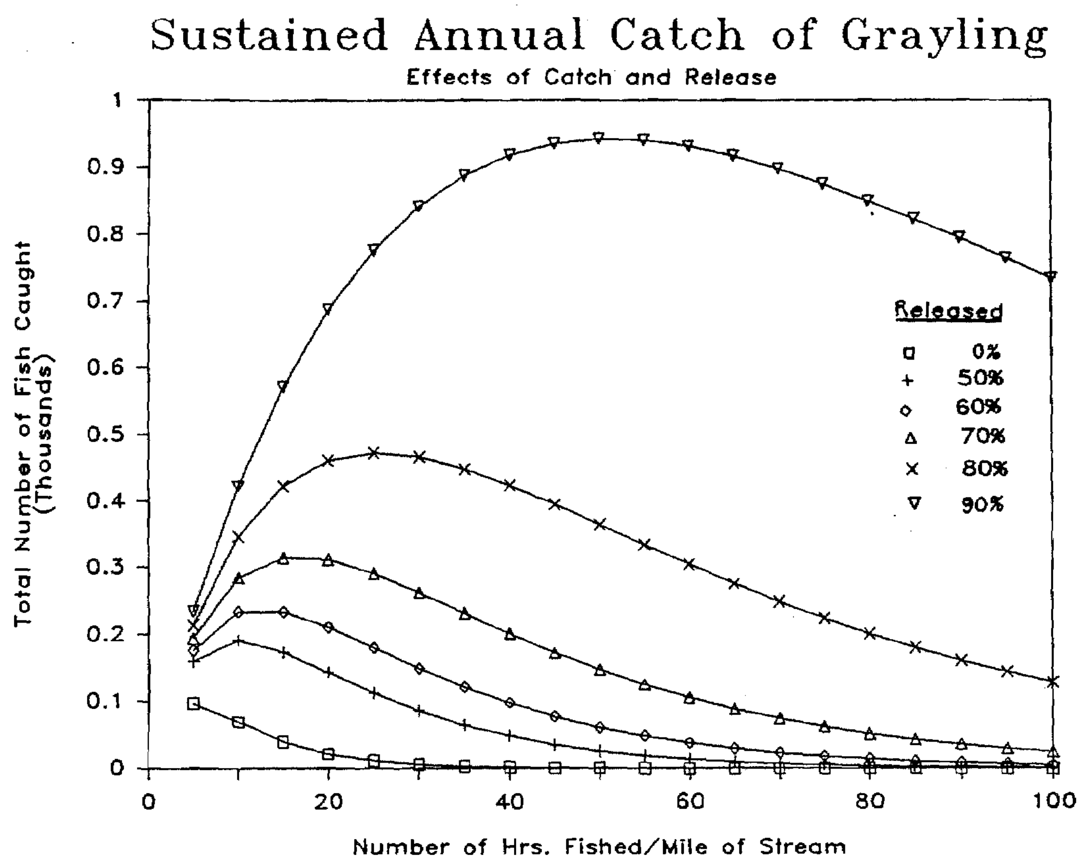

Figure 8. Comparison of the effects of incrementally increasing the percentage of sport caught fish that are released unharmed on the sustained annual total catch.

Finally, Figure 9 depicts the number of fish of each age group caught each year beginning at the present (and assuming negligible fishing pressure prior to the present) and continuing for the next ten years, assuming 100 hours of fishing per mile of stream. Figure 9 also illustrates the effects of assuming 90%, 50% and no successful return on the catch over this period.

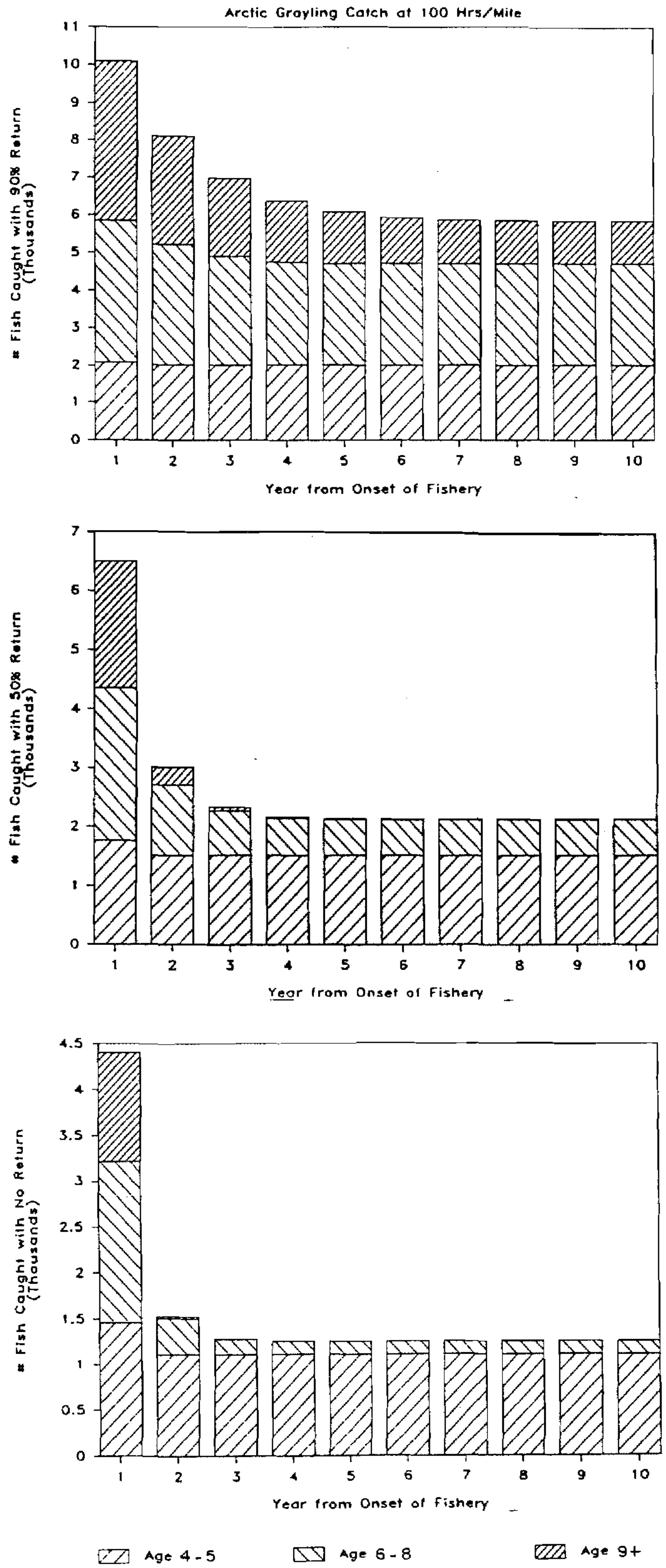

Figure 9. The effect of sport harvest on the Deadman Creek grayling population for a ten year period after the onset of a fishery with 90%, 50%, and no return catch and release.

4.0 DISCUSSION

The refinement of the population and age structure data presented in previous studies, in addition to new information on Deadman Creek and on the spawning and maturity of the impoundment Arctic grayling populations, has provided a more precise look at the effects of simulated sport fishing harvests on the impoundment tributaries and on Deadman Creek. The development of the project may provide additional access and harvest pressure on the clear water tributaries draining into the Susitna River because of easy boat access into areas where now helicopters or, in a small number of areas, float planes are the only means by which harvest of these fish is possible. Although the tributaries that were studied will be inundated, the areas above the impoundment zone provide similar habitat and, consequently, these populations will be subjected to increased harvests under a post project scenario. The Deadman Creek drainage is a likely candidate to have the access road for the development of Watana dam paralleling its length between the lower portion of the creek near the falls and Deadman Lake. The relatively large average size of Arctic grayling in this creek currently provides a quality fishery that is unusual for the upper Susitna basin. Additionally, the barrier falls near the mouth of Deadman Creek will be inundated, allowing free passage and mixing of the populations of the impoundment tributaries and Deadman Creek.

The analysis presented and the following discussion will attempt to estimate the results of various management alternatives on the long term sport fishery within these streams. In addition, we will explore the possible reasons why Deadman Creek produces larger Arctic grayling than other impoundment tributaries and how the removal of passage barriers may affect this population.

The effects of sport fishing harvests on the population structure of Arctic grayling has been investigated by Grabacki (1981) in the Chena River. Additionally, computer models have been used to describe stream fisheries for a variety of species in the lower forty-eight (Clark et al. 1980; Clark 1981, 1983). The model developed by Clark is similar to the one used by us in these studies with minor exceptions. We did not use the length structure of an age cohort as a component in the model. Simulation of sizes of fish was approximated by applying harvest rates to specific age groups. The slow growth and reasonable predictability of the age group of a fish by its length allowed harvests to be evaluated using age groups directly with interpretation of the results by examination of the age length data relationships. We also used age specific fishing mortality rates. Our data from hook and line collection suggests a differential probability of capture of the different sizes of fish which is significant enough to affect the results.

Grabacki (1981) did not model the harvests but did provide comparative data on the structure of the population of heavy and lightly fished portions of the Chena River. This information is primarily of use in comparing the outcomes of our model with actual results of exploitation.

The models provide some insight as to why these streams appear to the casual sport fishermen as high quality or "trophy" streams. Without any mortality from sport harvests, the population structure that has developed in both the tributaries and in Deadman Creek supports relatively larger numbers of older fish than in populations with fishing mortality. Also, the density of fish per mile or unit area exceeds that of other areas (ADF&G 1983b). However, our simulations suggest that even small increases in mortality caused by sport fishing will create rapid changes in the population structure. Catch rates per annum (reflecting fish densities) at a 100 hour per mile rate of exploitation decrease by two-thirds in the first several years after such a fishery is started. The large fish essentially disappear after the first two years (Figure 9). The densities per mile and the age structure of the populations are then much more reflective of the heavily exploited populations of the Chena River (Grabacki 1981; Armstrong 1982). The Deadman Creek population and the impoundment population apparently respond similarly, with the Deadman Creek population showing the most effect because of the average older age of the fish. The disappearance of the older fish is apparently caused by their increased vulnerability to exploitation and their increased probability of being harvested at a younger age. It appears that the sensitivity of the older fish to exploitation would necessitate a catch and release fishery if the quality of the fishery is to be maintained. Regulations on slot size (allowed mortality of a selected size range) or other combinations of regulations can be evaluated by use of the model. The general pattern and effect of these types of regulations on other species have been evaluated by Clark (1981). Optimal catches of large fish are obtained by keeping sport fishing mortality rates of all age groups at a minimum.

One of the more interesting aspects of comparisons of the Arctic grayling population structure of Deadman Creek with the impoundment tributaries is the effect of removal by inundation of the waterfall passage barrier that currently separates the populations.

Two hypotheses can be developed from the existing data base as to what factors contribute to the differences in the populations. First, Deadman Creek could provide inherently superior rearing and overwintering habitat. The creek has a more constant discharge and temperature than the other tributaries because of the buffering effects of Deadman Lake. These factors reduce anchor ice development and provide winter flows that are comparatively higher. In addition, the summer rearing qualities of portions of the stream may be superior in food production. The populations in Deadman Creek are older with an apparent higher survival rate, in addition to growing faster as depicted in Part 1 of this report. These observations are consistent with the above hypothesis. However, if winter habitat conditions are the dominant component in maintaining survival rates that are higher, one must ask why the Kosina Creek population below Clarence Lake is not also occupied by larger fish. We have not sampled the uppermost reach, immediately below Clarence Lake, but the populations in this system do not appear to be composed of fish that are any older than other tributaries. Growth rate comparisons are generally not possible because of the small sample sizes obtained. Clarence Lake and the upper portion of Kosina Creek may be subjected to significantly more fishing pressure than Deadman Creek because of the publicity this lake received during the presidential tour of Jimmy Carter. The department has reduced the bag limit to two fish per day on this lake. Increased fishing mortality on the system could not be separated from natural mortality with the data base we have available.

The second hypotheses, and one that may have implications for removal of the fish passage barrier, suggests that the current population structure is created by high density dependent mortality of the mature fish. This may occur because the falls prevent the immigration of fish from the large mainstem reserve into the creek. Fish occur in habitats associated with the mainstem Susitna in both the upper and lower portions of the Susitna River. With such an area to act as a reserve of immigrating fish, mortality rates of the older age groups may be considerably higher because of density dependent competition. Less competition for territories in the Deadman Creek population may result in an improved growth rate. By inadvertently adding fish to the system by removal of the barrier falls, the population structure could change if the current population structure of older fish is driven by density dependent mortality.

Regardless of which hypothesis is correct, the inherent productivity of the stream should not be affected, and consequently the sustained yield of fish, total biomass should not change, assuming reduced populations caused by fishing mortality could emulate any density dependent mortality effects on population survival and growth rates. Careful monitoring of the system after inundation of the falls, coupled with a highly regulated sport fishery, may provide some insights onto how to manage and maintain a trophy sport fishery.

5.0 CONTRIBUTORS

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APPENDIX A

Equation Used to Model Population Changes

The following equations were used to project population changes:

(1) $N_{t+1} = N_t \times S_{tn}$ where:

N_{t+1} = Population number of age class t plus one year.

N_t = Population number of age class t fish

S_{tn} = Natural survival rate of age t fish

N_t and N_{t+1} are known for each age class and give estimates for S_{tn} for each age class.

In an exploited fishery then,

(2) $N_{t+1} = N_t \times S_{tn+F}$ where:

S_{tn+F} = Survival rate of age t fish after combined natural and fishing mortalities.

The annual total mortality rate, A, is related to S, as:

(3) $A_{tn+F} = 1 - S_{tn+F}$ and,

(4) $S_{tn+F} = e^{-Z_t}$ and, where:

Z_t = Instantaneous rate of total mortalities of age t fish.

(5) $Z_t = F_t + M_t$ and, where: F_t = Instantaneous rate of fishing mortality of age class t fish.

(6) $M_t = -\ln S_{tn}$ where: M_t = Instantaneous rate of natural mortalities of age class t fish.

Since M_t is available from N_t and N_{t+1} data, it is possible to substitute (model) values of F_t for a hypothetical fishery and predict the resulting age structure of the population with time. To do this, the following assumptions are made. (1) The rate of catch for each age class of fish per unit of fishing effort experienced by ADF&G will hold true for the general public. (2) Only grayling of age III and older are subject to increased mortality by (hook and line) fishing. (3) Recruitment of age II class fish is constant.

In an exploited system then, F_t is viewed as:

(7) $F_t = q_t \times f$ where: q_t = catchability of age class t; proportioned fish per unit time fished.

f = fishing effort, (98.25 hrs or 6.05 hrs/mile stream).

and q_t is estimated from:

(8) $q_t = -\ln (1-u_t)$ using,

(9) $u_t = \frac{R_t}{M'_t}$ where: R_t = number of grayling marked in July 1982 that were recaptured in August 1982 by age class t.

M'_t = number of grayling marked in July 1982, by age class t.

The term u_t is called the rate of exploitation and was calculated from the mark-recapture fishing data found in ADF&G (1983).

Calculation of the annual total mortality rate (A_{tn+F}) n equation (3) thus allows calculation of predicted catch at different levels of exploitation.

(10) $A_{tF} = A_{tn+F} - (1-S_{tn})$ where: A_{tF} = annual fishing mortality

$A_{tn} = 1-S_{tn}$ = annual natural mortality

(11) $C_t = \sum_{t = IV}^{t = XIII+} A_{tF} \times N_t$ C_t = total catch

The effects of catch and release on total numbers caught were simulated by reduction of the F_t by the percentage of fish released without mortality. The catch then included the value from equation 11 in addition to the numbers of fish released, the difference between Ft assuming 100% mortality and F_t assuming the appropriate level of successful catch and release.