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SUSITNA HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

INSTREAM FLOW RELATIONSHIPS REPORT SERIES

FISH RESOURCES AND HABITATS IN THE MIDDLE SUSITNA RIVER

TECHNICAL REPORT No. 1

PREPARED BY

WOODWARD-CLYDE CONSULTANTS

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

FINAL REPORT

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Prepared by
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Prepared for
Alaska Power Authority

Final Report
April 1985

The primary author of this report is T. R. Jennings. The draft version of this report was prepared while he was an employee of Woodward-Clyde Consultants. The final version was prepared while an employee of Entrix, Inc., under contract to Woodward-Clyde Consultants.

PREFACE

This report represents a volume of the Instream Flow Relationships Study technical report series prepared for the Susitna Hydroelectric Project. The primary purpose of the Instream Flow Relationships Report and its associated technical report series is to present technical information and data that reflect the relative importance of the various interactions among the primary physical and biological components of aquatic habitats within the Talkeetna-to-Devil Canyon reach of the Susitna River. The Instream Flow Relationships Report and its associated technical report series are not intended to be an impact assessment. However, these reports present a variety of natural and with-project relationships that provide a quantitative basis to compare alternative streamflow regimes, conduct impact analyses, and prepare mitigation plans.

The technical report series is based on the data and findings presented in a variety of baseline data reports prepared by the Alaska Department of Fish and Game (ADF&G) Su Hydro Aquatic Study Team, R&M Consultants, E. Woody Trihey and Associates (EWT&A) and the Arctic Environmental Information and Data Center (AEIDC). The Instream Flow Relationships Report and its associated technical report series provide the methodology and appropriate technical information for use by those deciding how best to operate the proposed Susitna Hydroelectric Project for the benefit of both power production and downstream fish resources. The technical report series is described below.

Technical Report No. 1. Fish Resources and Habitats in the Middle Susitna River. This report, prepared by Entrix, Inc. and Woodward-Clyde Consultants, consolidates information on the fish resources and habitats in the Talkeetna-to-Devil Canyon reach of the Susitna River available through January 1985 that is currently dispersed throughout numerous reports.

Technical Report No. 2. Physical Processes Report. This report, being prepared by Harza-Ebasco and R&M Consultants, describes such physical processes as: reservoir sedimentation, channel stability and groundwater upwelling.

Technical Report No. 3. Water Quality/Limnology Report. This report, being prepared by Harza-Ebasco, consolidates existing information on water quality in the Susitna Basin and provides technical discussions of the potential for with-project bioaccumulation of mercury, influences on nitrogen gas supersaturation, changes in downstream nutrients, and changes in turbidity and suspended sediments. A draft report based principally on data and information that were available through June 1984 was prepared in November 1984.

Technical Report No. 4. Instream Temperature. This report, prepared by AEIDC, consists of three principal components: (1) instream temperature modeling; (2) development of temperature criteria for Susitna River fish stocks by species and life stage; and (3) evaluation of the influences of with-project stream temperatures on existing fish habitats and natural ice processes. A final report describing downstream temperatures associated with various reservoir operating scenarios and an evaluation of these stream temperatures on fish was prepared in October 1984. A draft report addressing the influence of anticipated with-project stream temperatures on natural ice processes was prepared in November 1984.

Technical Report No. 5. Aquatic Habitat Report. This report, being prepared by EWT&A, describes the availability of various types of aquatic habitat in the Talkeetna-to-Devil Canyon river reach as a function of mainstem discharge. A preliminary draft of this report is scheduled for March 1985 with a draft final report prepared in FY86.

Technical Report No. 6. Ice Processes Report. This report being prepared by AEIDC, Harza-Ebasco, and R&M Consultants will describe naturally occurring ice processes in the middle river, anticipated changes in those processes due to project construction and operation, and discuss the effects of naturally occurring and with-project ice conditions on fish habitat.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

LIST OF TABLES (continued)

1.0 INTRODUCTION

This report summarizes the available information on the fishery resources and habitats of the Susitna River, with emphasis on the river reach between Talkeetna and Devil Canyon. It is based primarily on existing reports and analyses generated by the feasibility and licensing studies of the Susitna Hydroelectric Project, with a lesser dependence on additional pertinent information in the literature. The objective of the report is to synthesize and summarize information to describe the biology, relative abundance and seasonal habitat utilization of important fishery resources. As a part of the Instream Flow Relationships (IFR) report series, information summarized here will assist in defining the relationships between physical processes and fishery habitat in the Susitna River basin.

Since the report series provides important information relative to the decision making process, this report focuses on habitats and species most likely to be affected by the proposed project. Most of the report emphasizes the Talkeetna-to-Devil Canyon reach [river mile (RM) 98.6-152] of the Susitna River. This river reach extends from the proposed Devil Canyon dam site (RM 152) downstream to the confluence of the Susitna and Chulitna rivers (RM 98.6). Effects on habitats downstream of the proposed project are expected to be greatest within this reach. Downstream from Talkeetna, the inflow from the Talkeetna and Chulitna rivers is expected to reduce the magnitude of changes in physical processes under with-project conditions.

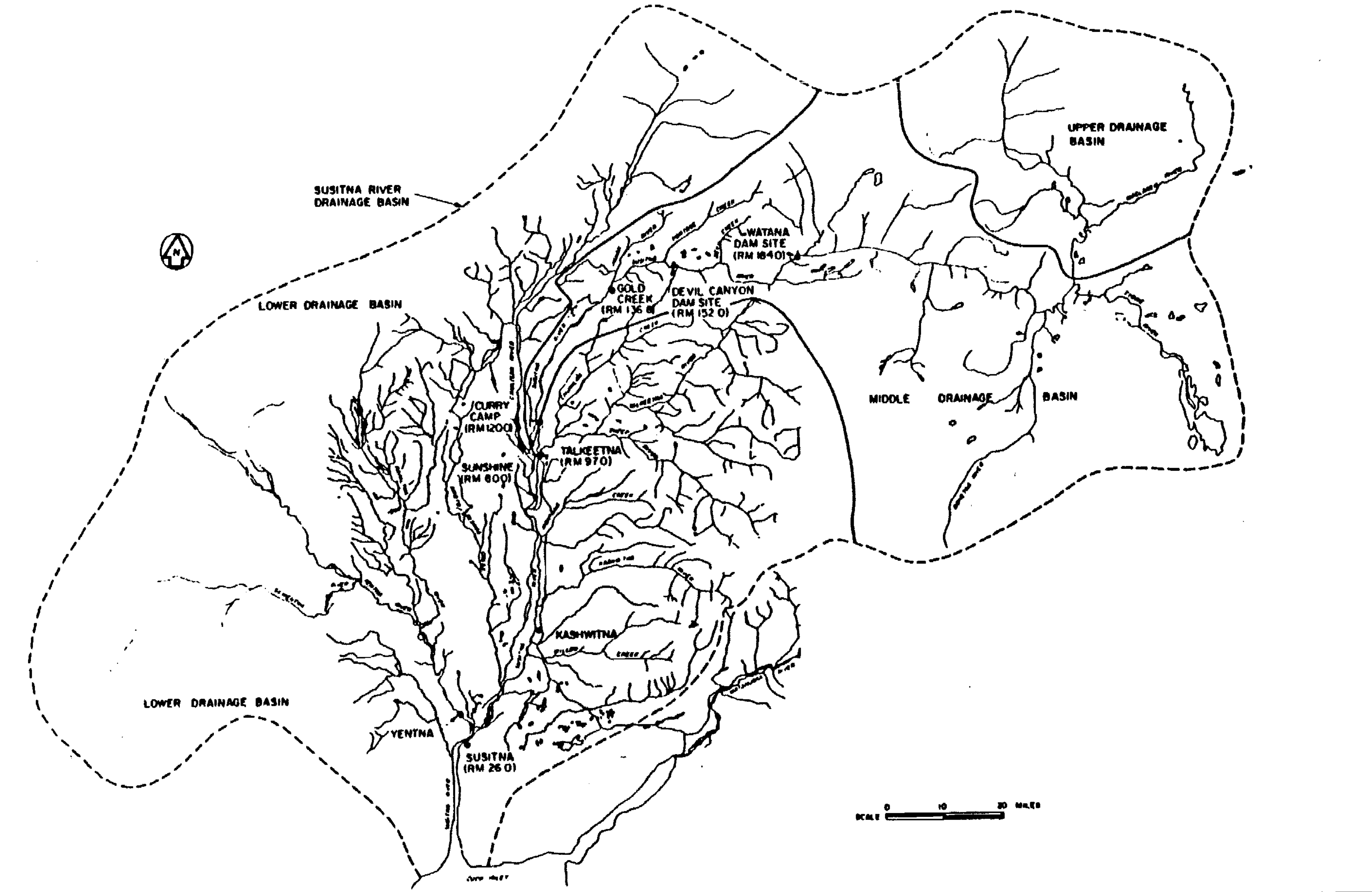
This report emphasizes salmon and important resident species, and their habitat utilization. Section 2.0 contains a brief description of the project and project area and a summary of the studies that have been conducted to date on the fish resources. In Section 3.0 the species of the Susitna River are introduced and their commercial, recreational and subsistence utilization and importance are discussed. Section 4.0 summarizes information on the species biology of the fish in the Susitna River. Habitat utilization by species/life stages is summarized in Section 5.0. Section 6.0 discusses some factors that may affect fish production in freshwater and the Susitna River drainage.

2.0 BACKGROUND

The Susitna River flows approximately 318 miles (530 km) and drains about 19,600 square miles (50,900 km^2) from the terminus of the Susitna Glacier in the Alaska Mountain Range to Cook Inlet (Figure 1). The study area for the Susitna Hydroelectric Project includes the Susitna River mainstem, side channels, sloughs, and tributaries. A diagram and description of habitat categories of the Susitna River is presented in Figure 2.

The Alaska Power Authority (APA) has proposed construction of two dams on the Susitna River: Watana Dam (RM 184) and Devil Canyon Dam (RM 152). The project would reduce streamflows during the summer and increase them during the winter. Suspended sediment levels, turbidity and water temperatures are expected to follow similar patterns (reduced levels in summer and increased levels in winter). Details of dam construction, operation and expected changes to aquatic habitats and fish resources were presented by Acres American (1983a,b) in the Federal Energy Regulatory Commission (FERC) license application. Additional studies and analyses have since taken place that further refine and update the license application. Any questions concerning the license application and studies in support of the application should be directed to the APA.

Beginning in 1974, detailed studies were conducted to describe and quantify fish resources, aquatic habitats and habitat utilization in the Susitna River. In 1980 the Susitna Hydroelectric Project Aquatic Studies Program was initiated and funded by the APA. Baseline data collection by ADF&G Su Hydro on fish and aquatic habitat resources was divided into three groups: Adult Anadromous Fish Studies (AA), Juvenile Anadromous and Resident Fish Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH).



SUSITNA RIVER DRAINAGE BASIN.

FIGURE 1

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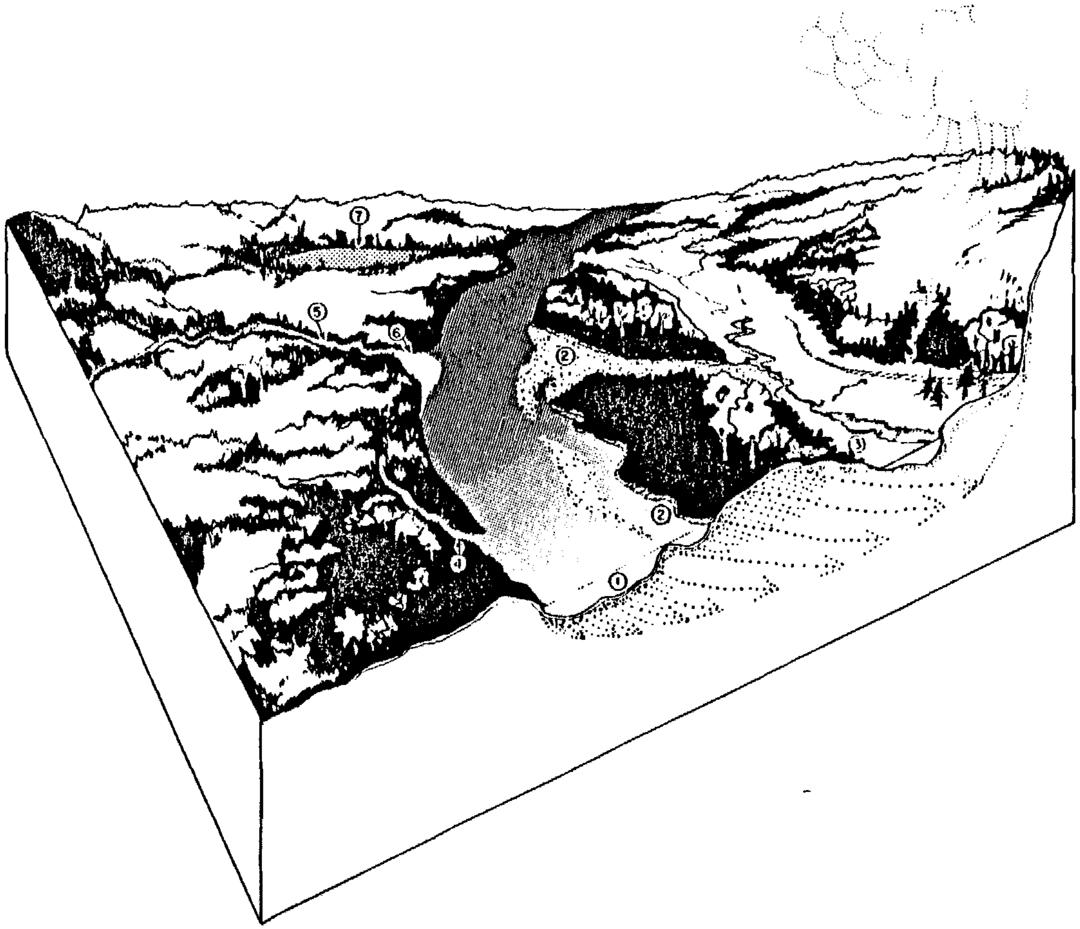

GENERAL HABITAT CATEGORIES OF THE SUSITNA RIVER

1) Mainstem Habitat consists of those portions of the Susitna River that normally convey streamflow throughoot the year. Both single and multiple channel reaches are included in this habitat category. Groundwater and tributary inflow appear to be inconsequential contributors to the overall characteristics of mainstem habitat. Mainstem habitat is typically characterized by high water velocities and well armored streambeds. Substrates generally consist of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sands. Suspended sediment concentrations and turbidity are high during summer due to the influence of glacial melt-water. Streamflows recede in early fall and the mainstem clears appreciably in October. An ice cover forms on the river in late November or December.

2) Side Channel Habitat consists of those portions of the Susitna River that normally convey streamflow during the open water season but become appreciably dewatered during periods of low flow. Side channel habitat may exist either in well defined overflow channels, or in poorly defined water courses flowing through partially submerged gravel bars and islands along the margins of the mainstem river. Side channel streambed elevations are typically lower than the mean monthly water surface elevations of the mainstem Susitna River observed during June, July and August. Side channel habitats are characterized by shallower depths, lower velocities and smaller streambed materials than the adjacent habitat of the mainstem river.

3) Side Slough Habitat is located in spring fed overflow channels between the edge of the floodplain and the mainstem and side channels of the Susitna River and is usually separated from the mainstem and side channels by well vegetated bars. An exposed alluvial berm often separates the head of the slough from mainstem or side channel flows. The controlling streambed/streambank elevations at the upstream end of the side sloughs are slightly less than the water surface elevations of the mean monthly flows of the mainstem Susitna River observed for June, July, and August. At intermediate and low-flow periods, the side sloughs convey clear water from small tributaries and/or upwelling groundwater (ADF&G 1981c, 1982b). These clear water inflows are essential contributors to the existence of this habitat type. The water surface elevation of the Susitna River generally causes a backwater to extend well up into the slough from its lower end (ADF&G 1981c, 1982b). Even though this substantial backwater exists, the sloughs function hydraulically very much like small stream systems and several hundred feet of the slough channel often conveys water independent of mainstem backwater effects. At high flows the water surface elevation of the mainstem river is sufficient to overtop the upper end of the slough (ADF&G 1981c, 1982b). Surface water temperatures in the side sloughs during summer months are principally a function of air temperature, solar radiation, and the temperature of the local runoff.

4) Upland Slough Habitat differs from the side slough habitat in that the upstream end of the slough is not interconnected with the surface waters of the mainstem Susitna River or its side channels. These sloughs are characterized by the presence of beaver dams and an accumulation of silt covering the substrate resulting from the absence of mainstem scouring flows.

5) Tributary Habitat consists of the full complement of hydraulic and morphologic conditions that occur in the tributaries. Their seasonal streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology, and climate of the tributary drainage. The physical attributes of tributary habitat are not dependent on mainstem conditions.

6) Tributary Mouth Habitat extends from the uppermost point in the tributary influenced by mainstem Susitna River or slough backwater effects to the downstream extent of the tributary plume which extends into the mainstem Susitna River or slough (ADF&G 1981c, 1982b).

7) Lake Habitat consists of various lentic environments that occur within the Susitna River drainage. These habitats range from small, shallow, isolated lakes perched on the tundra to larger, deeper lakes which connect to the mainstem Susitna River through well defined tributary systems. The lakes receive their water from springs, surface runoff and/or tributaries.

GENERAL HABITAT CATEGORIES OF THE SUSITNA RIVER - A CONCEPTUAL DIAGRAM (SOURCE: AEIDC, MODIFIED BY ADF&G 1982e.)

FIGURE 2

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The objectives of the three groups of this continuing program are:

(1) AA - determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the Susitna River drainage;

(2) RJ - determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the Susitna River drainage; and

(3) AH - characterize the seasonal habitat requirements of selected anadromous and resident fish species within the Susitna River drainage.

A summary of the significant accomplishments to date by the three sections of ADF&G's Su Hydro Group is outlined below.

<u>Adult Anadromous</u>

a. Documented migrational timing of salmon runs in the Susitna River.

b. Estimated population size and relative abundance of salmon in sub-basins of the Susitna River.

c. Estimated total slough escapements for salmon in sloughs upstream of RM 98.6.

d. Estimated relative abundance of spawning salmon in tributaries upstream of RM 98.6.

e. Quantified selected biological characteristics for salmon stocks in the Susitna River (i.e. sex ratio, fecundity, age and length).

f. Determined migrational timing, relative abundance, sex ratio, age composition and length of eulachon.

g. Documented migrational timing of Bering cisco.

Resident and Juvenile Anadromous

a. Estimated population size for Arctic grayling populations in the proposed impoundment areas.

b. Identified important spawning areas for selected resident species.

c. Estimated the relative utilization of macrohabitat types for juvenile salmon and selected resident species.

d. Developed habitat suitability criteria for juvenile salmon and selected resident species.

e. Estimated population size and survival for juvenile chum and sockeye.

f. Defined outmigration timing for juvenile salmon.

Aquatic Habitat and Instream Flow

a. Collected physical and chemical water quality data describing macrohabitat types.

b. Identified aquatic macrohabitat types within the middle reach of the Susitna River (RM 98.6 - 152).

c. Defined seasonal timing and utilization of adult salmon in macrohabitat types.

d. Developed site-specific habitat responses to mainstem discharge.

e. Developed habitat criteria for adult and juvenile salmon, eulachon, Bering cisco, and selected resident species.

f. Evaluated the passage of adult salmon into selected sloughs.

g. Confirmed the importance of ground water upwelling for spawning salmon in sloughs.

For a list of ADF&G Susitna Hydro references, see Appendix A.

3.0 INTRODUCTION TO FISH RESOURCES

3.1 OVERVIEW OF IMPORTANT SPECIES

Fishery resources in the Susitna River comprise a major portion of the Cook Inlet commercial salmon harvest and provide fishing opportunities for sport anglers. Anadromous species that form the base of these fisheries include five species of Pacific salmon: chinook, coho, chum, sockeye and pink. Other anadromous species present in the Susitna River include eulachon and Bering cisco.

The Susitna River is a migrational corridor, spawning area and juvenile rearing area for the five species of salmon from its point of discharge into Cook Inlet (RM 0) to Devil Canyon (RM 152), where salmon are usually prevented from moving upstream by a high velocity barrier. Sloughs and tributaries provide most of the spawning habitat for salmon, while the mainstem, sloughs, and tributary mouths are important habitats for juvenile salmon rearing and overwintering (Barrett et al. 1984, Schmidt et al. 1984).

Important resident species found in the Susitna River basin include Arctic grayling, rainbow trout, lake trout, burbot, Dolly Varden and round whitefish. Scientific and common names of all fish species observed in the Susitna River basin are listed in Table 1.

3.2 CONTRIBUTION TO COMMERCIAL FISHERY

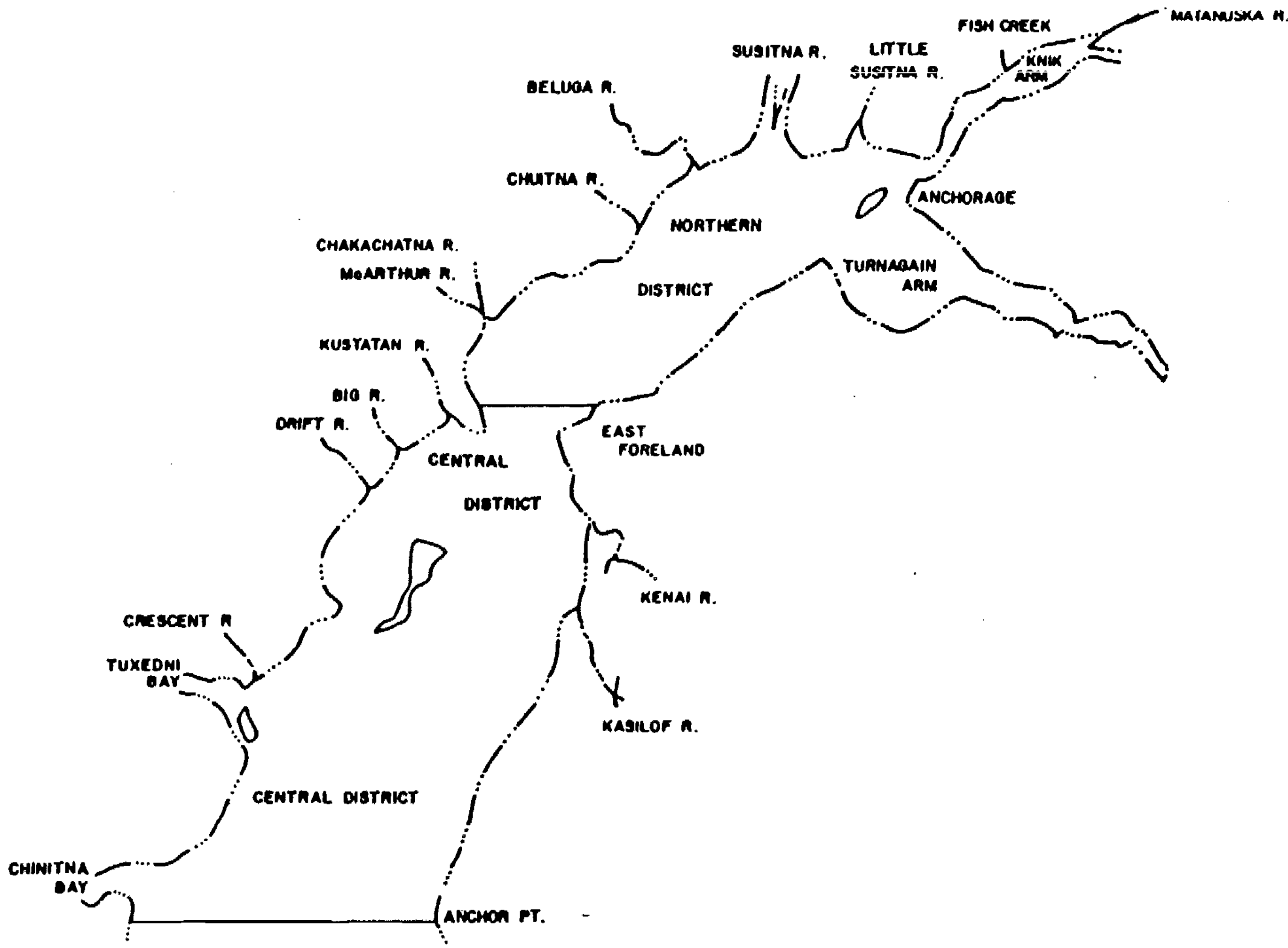
With the exception of sockeye and chinook salmon, the majority of the upper Cook Inlet commercial catch of salmon originates in the Susitna Basin (Barrett et al. 1984). The upper Cook Inlet area is that portion of Cook Inlet north of Anchor Point and Chinitna Bay (Figure 3). The long-term average annual catch of 3.0 million fish is worth approximately $17.9 million in 1984 dollars to the commercial fishery (K. Florey, ADF&G,

Table 1. Common and scientific names of fish species observed in the Susitna Basin.

Scientific Name	Common Name
Petromyzontidae	
Lampetra japonica	Arctic lamprey
Salmonidae	
Coregonus laurettae	Bering cisco
Coregonus pidschian	humpback whitefish
Oncorhynchus gorbuscha	pink salmon
Oncorhynchus keta	chum salmon
Oncorhynchus kisutch	coho salmon
Oncorhynchus nerka	sockeye salmon
Oncorhynchus tshawytscha	chinook salmon
Prosopium cylindraceum	round whitefish
Salmo gairdneri	rainbow trout
Salvelinus malma	Dolly Varden
Salvelinus namaycush	lake trout
Thymallus arcticus	Arctic grayling
Osmeridae	
Thaleichthys pacificus	eulachon
Esocidae	
Esox lucius	northern pike
Catostomidae	
Castostomus catostomus	longnose sucker
Gadidae	
Lota lota	burbot
Gasterosteidae	
Gasterosteus aculeatus	threespine stickleback
**Pungitius pungitius*	ninespine stickleback
Cottidae	
Cottus sp.	sculpin

Source: ADF&G 1981a,b; 1982a; 1983b; Barrett et al. 1984; Schmidt et al. 1984; Sautner and Stratton 1984.

* Unpublished data, ADF&G Su Hydro, Anchorage, Alaska.



UPPER COOK INLET COMMERCIAL SALMON MANAGEMENT AREA

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FIGURE 3

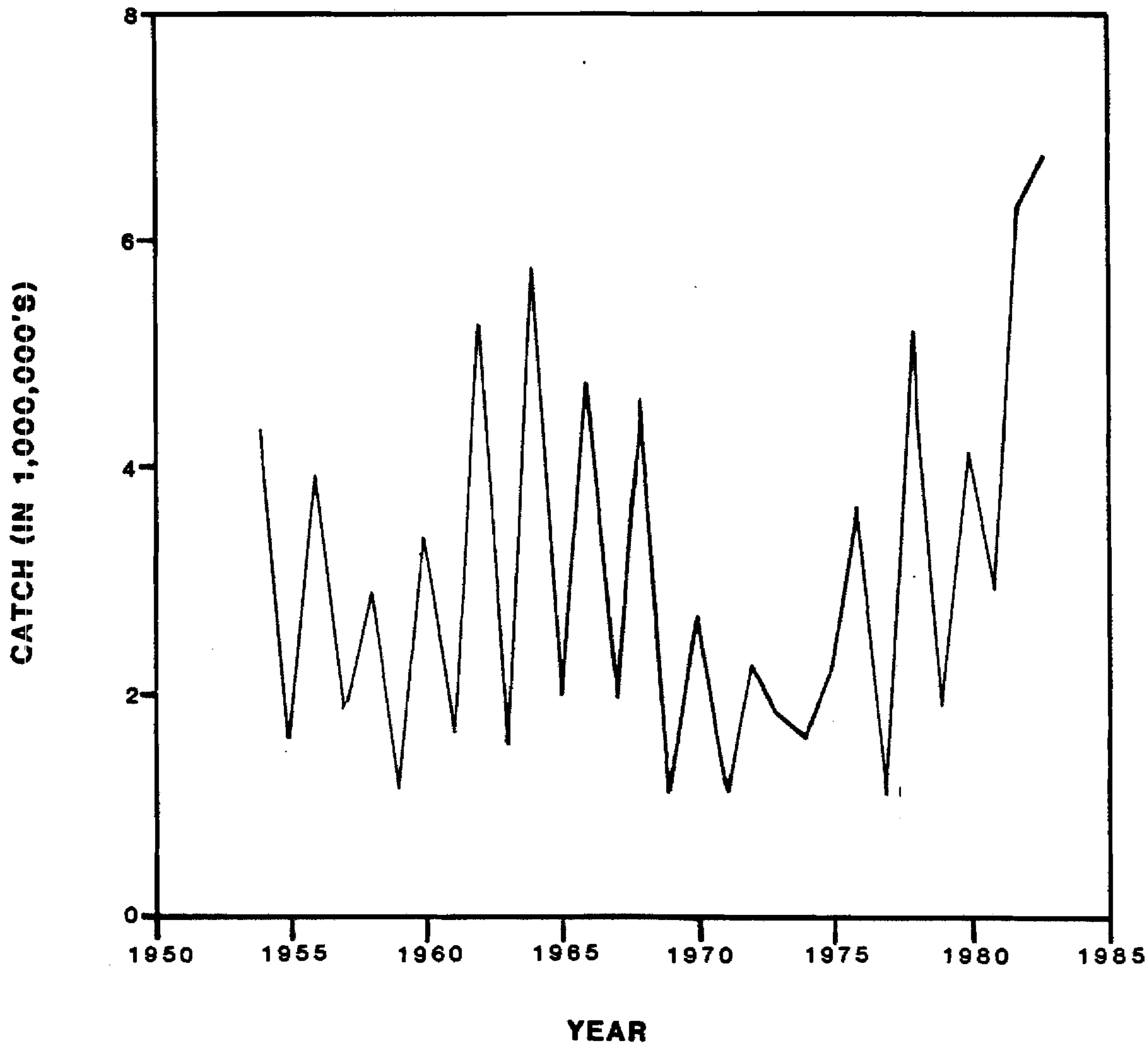
pers. comm. 1984). In recent years commercial fishermen have landed record numbers of salmon in the upper Cook Inlet fishery (Figure 4); over 6.7 million salmon were caught in 1983 and over 6.2 million fish in 1984. The Susitna River is the most important salmon-producing system in upper Cook Inlet (ADF&G 1982a; Barrett et al. 1984, 1985); however, the quantitative contribution of the Susitna River to the commercial fishery can only be approximated because of:

- o the high number of intra-drainage spawning and rearing areas;
- o the lack of data on other known and suspected salmon-producing systems in upper Cook Inlet;
- o the lack of stock separation programs (except for sockeye salmon); and
- o overlap in the migration timing of mixed stocks and species in the Cook Inlet harvest areas.

Therefore, the estimates of contributions of Susitna River salmon to the upper Cook Inlet fishery should be viewed as approximations.

3.2.1 Sockeye Salmon

The most important species in the upper Cook Inlet commercial fishery is sockeye salmon. In 1984, the total sockeye harvest of 2.1 million fish was valued at $13.5 million (K. Florey, ADF&G, pers. comm. 1984). The commercial sockeye harvest has averaged 1.34 million fish annually in upper Cook Inlet for the last 30 years (Table 2). The estimated contribution of Susitna River sockeye to the commercial fishery is between 10 to 30 percent (Barrett et al. 1984). This represents an estimated annual commercial harvest of between 134,000 to 402,000 Susitna River sockeye over the last 30 years. In 1983, Susitna River



COMMERCIAL CATCH OF UPPER COOK INLET SALMON, 1954-1983.

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FIGURE 4

Table 2. Commercial catch of upper Cook Inlet salmon in numbers of fish by species, 1954 - 1984.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1954	63,780	1,207,046	321,525	2,189,307	510,068	4,291,726
1955	45,926	1,027,528	170,777	101,680	248,343	1,594,254
1956	64,977	1,258,789	198,189	1,595,375	782,051	3,899,381
1957	42,158	643,712	125,434	21,228	1,001,470	1,834,022
1958	22,727	477,392	239,765	1,648,548	471,697	2,860,129
1959	32,651	612,676	106,312	12,527	300,319	1,064,485
1960	27,512	923,314	311,461	1,411,605	659,997	3,333,889
1961	19,210	1,162,303	117,778	34,017	349,628	1,683,463
1962	20,210	1,147,573	350,324	2,711,689	970,582	5,200,378
1963	17,536	942,980	197,140	30,436	387,027	1,575,119
1964	4,531	970,055	452,654	3,231,961	1,079,084	5,738,285
1965	9,741	1,412,350	153,619	23,963	316,444	1,916,117
1966	9,541	1,851,990	289,690	2,006,580	531,825	4,689,626
1967	7,859	1,380,062	177,729	32,229	296,037	1,894,716
1968	4,536	1,104,904	470,450	2,278,197	1,119,114	4,977,201
1969	12,398	692,254	100,952	33,422	269,855	1,108,881
1970	8,348	731,214	275,296	813,895	775,167	2,603,920
1971	19,765	636,303	100,636	35,624	327,029	1,119,357
1972	16,086	879,824	80,933	628,580	630,148	2,235,571
1973	5,194	670,025	104,420	326,184	667,573	1,773,396
1974	6,596	497,185	200,125	483,730	396,840	1,584,476
1975	4,780	684,818	227,372	336,359	951,796	2,205,135
1976	10,867	1,664,150	208,710	1,256,744	469,807	3,610,278
1977	14,792	2,054,020	192,975	544,184	1,233,733	1,049,704
1978	17,303	2,622,487	219,234	1,687,092	571,925	5,118,041
1979	13,738	924,415	265,166	72,982	650,357	1,926,658
1980	12,497	1,584,392	283,623	1,871,058	387,078	4,138,648
1981	11,548	1,443,294	494,073	127,857	842,849	2,919,621
1982	20,636	3,237,376	777,132	788,972	1,428,621	6,252,737
1983	20,396	5,003,070	520,831	73,555	1,124,421	6,742,273
1984 (1)	8,800	2,103,000	443,000	623,000	684,000	3,861,800
Average	19,247	1,340,339	263,785	even-1,576,646 odd- 120,416	659,190	3,059,170

(1) ADF&G Preliminary Data.

Source: ADF&G Commercial Fisheries Division, Anchorage, Alaska.

sockeye contributed approximately 500,000 fish to the total catch of 5 million (Table 3). The 1983 commercial sockeye catch was the highest in 30 years of record (Figure 5).

3.2.2 Chum Salmon

Chum salmon and coho salmon are about equal in importance in the upper Cook Inlet commercial fishery and rank second and third in value after sockeye (K. Florey, ADF&G, pers. comm. 1984). The upper Cook Inlet chum salmon catch has averaged 659,000 fish annually since 1954 (Table 2). The contribution of Susitna River chum to the upper Cook Inlet fishery is about 85 percent (Barrett et al. 1984). This contribution represents an estimated annual chum harvest of 560,000 Susitna River fish in the commercial harvest over the last 30 years. In 1982, the Susitna River contributed approximately 1.21 million fish (Table 3) of the record harvest of 1.43 million chum salmon taken in the upper Cook Inlet fishery (Table 2; Figure 6). In 1984, the total chum salmon harvest of 684,000 fish in the commercial fishery was valued at $2.0 million (K. Florey, ADF&G, pers. comm. 1984).

3.2.3 Coho Salmon

Since 1954, the upper Cook Inlet coho salmon commercial catch has averaged 264,000 fish annually (Table 2). Approximately 50 percent of the commercial coho harvest in upper Cook Inlet is from the Susitna River (Barrett et al. 1984). This contribution represents an average annual Susitna River coho harvest of 132,000 fish in the commercial fishery over the last 30 years. In 1982, the Susitna River contributed an estimated 388,500 fish (Table 3) to a record harvest of 777,000 coho taken by the upper Cook Inlet fishery (Figure 7). In 1984, the total coho salmon harvest of 443,000 fish in upper Cook Inlet had a worth of $1.8 million (K. Florey, ADF&G, pers. comm. 1984).

Table 3. Summary of commercial and sport harvests on Susitna River basin adult salmon returns.

	Commercial Harvest						Sport Harvest	
Species	Upper Cook Inlet Harvest[1]	Estimated Percent Susitna[2]		Estimated Susitna Harvest	Estimated Susitna Escapement	Estimated Total Run	Susistna Basin Sport Harvest[4]	Percent of Escapement
		Mean	Range					
Sockeye								
81	1,443,000	20	(10-30)	288,600	287,000[3]	575,600	1,283	0.4
82	3,237,000	20	(10-30)	647,400	279,000[3]	926,400	2,205	0.8
83	5,003,000	10	(10-30)	500,300	185,000[3]	685,300	5,537	3.0
84	2,103,000	20	(10-30)	420,600	605,800[5]	1,026,400	---	---
Pink								
81	128,000	85		108,800	127,000[3]	235,800	8,660	6.8
82	789,000	85		670,650	1,318,000[3]	1,988,650	16,822	1.3
83	74,000	85		62,900	150,000[3]	212,900	4,656	3.1
84	623,000	85		529,550	3,629,900[5]	4,159,450	---	---
Chum								
81	843,000	85		716,550	297,000[3]	1,013,550	4,207	1.4
82	1,429,000	85		1,214,650	481,000[3]	1,695,650	6,843	1.4
83	1,124,000	85		955,400	290,000[3]	1,245,400	5,233	1.8
84	684,000	85		581,400	812,700[5]	1,394,100	---	---
Coho								
81	494,000	50		247,000	68,000[3]	315,000	9,391	13.8
82	777,000	50		388,500	148,000[3]	536,500	16,664	11.3
83	521,000	50		260,500	45,000[3]	305,500	8,425	18.7
84	443,000	50		221,500	190,100[5]	411,600	---	---
Chinook								
81	11,500	10		1,150	---	---	7,576	---
82	20,600	10		2,060	---	---	10,521	---
83	20,400	10		2,040	---	---	12,420	---
84	8,800	10		880	250,000[6]	251,000	---	---

1 Source: ADF&G Commercial Fisheries Division

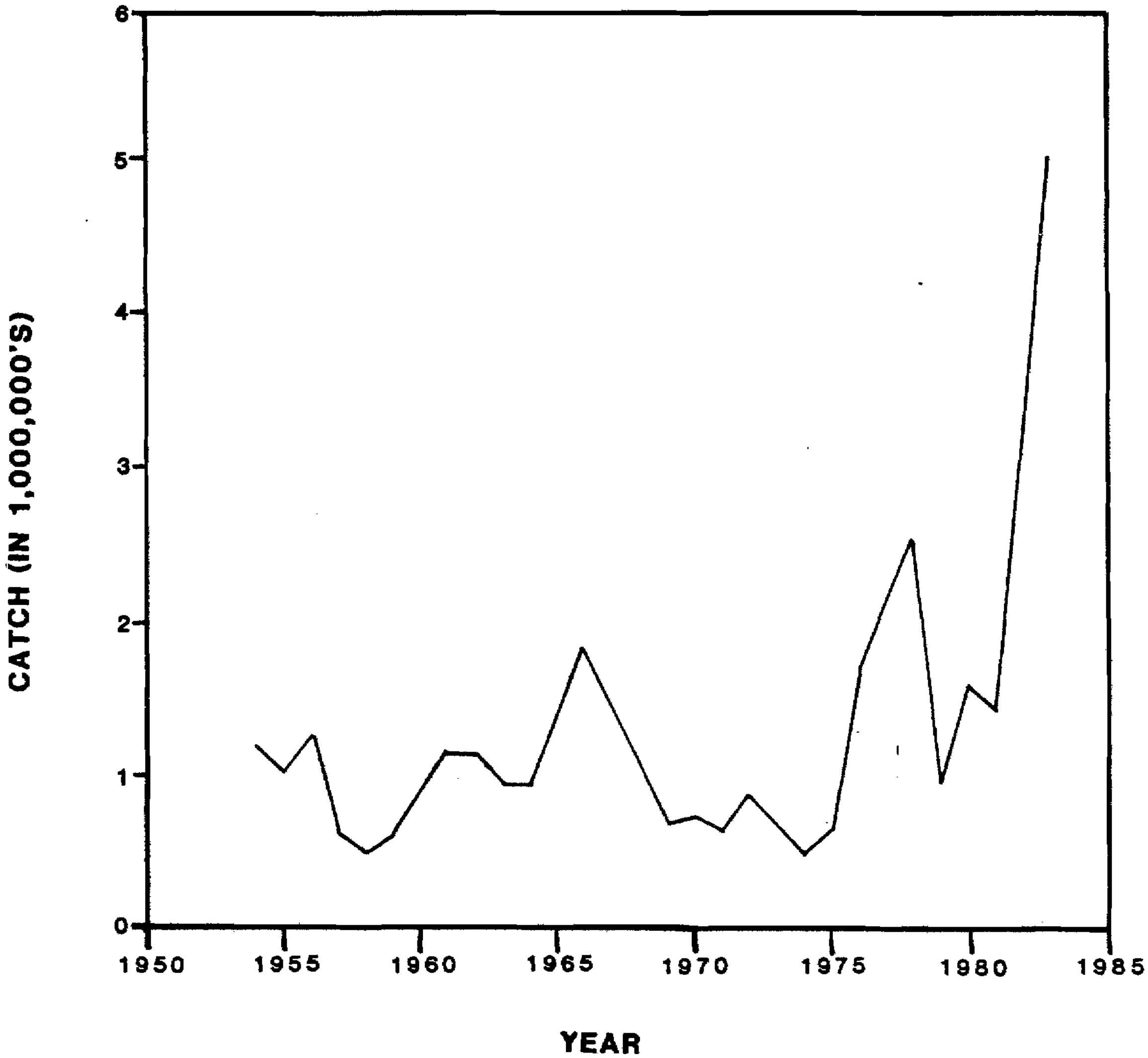
2 B. Barrett, ADF&G Su Hydro, February 15, 1984 Workshop Presentation

3 Yentna station + Sunshine Station estimated escapement + 5% for sockeye, + 48% for pink, + 5% for chum + 85% for coho (Source: B. Barrett, ADF&G Su Hydro, February 15, 1984 Workshop Presentation).

4 Mills 1982, 1983, 1984

5 Flathorn Station (RM 22) Escapements (Barrett et al. 1985)

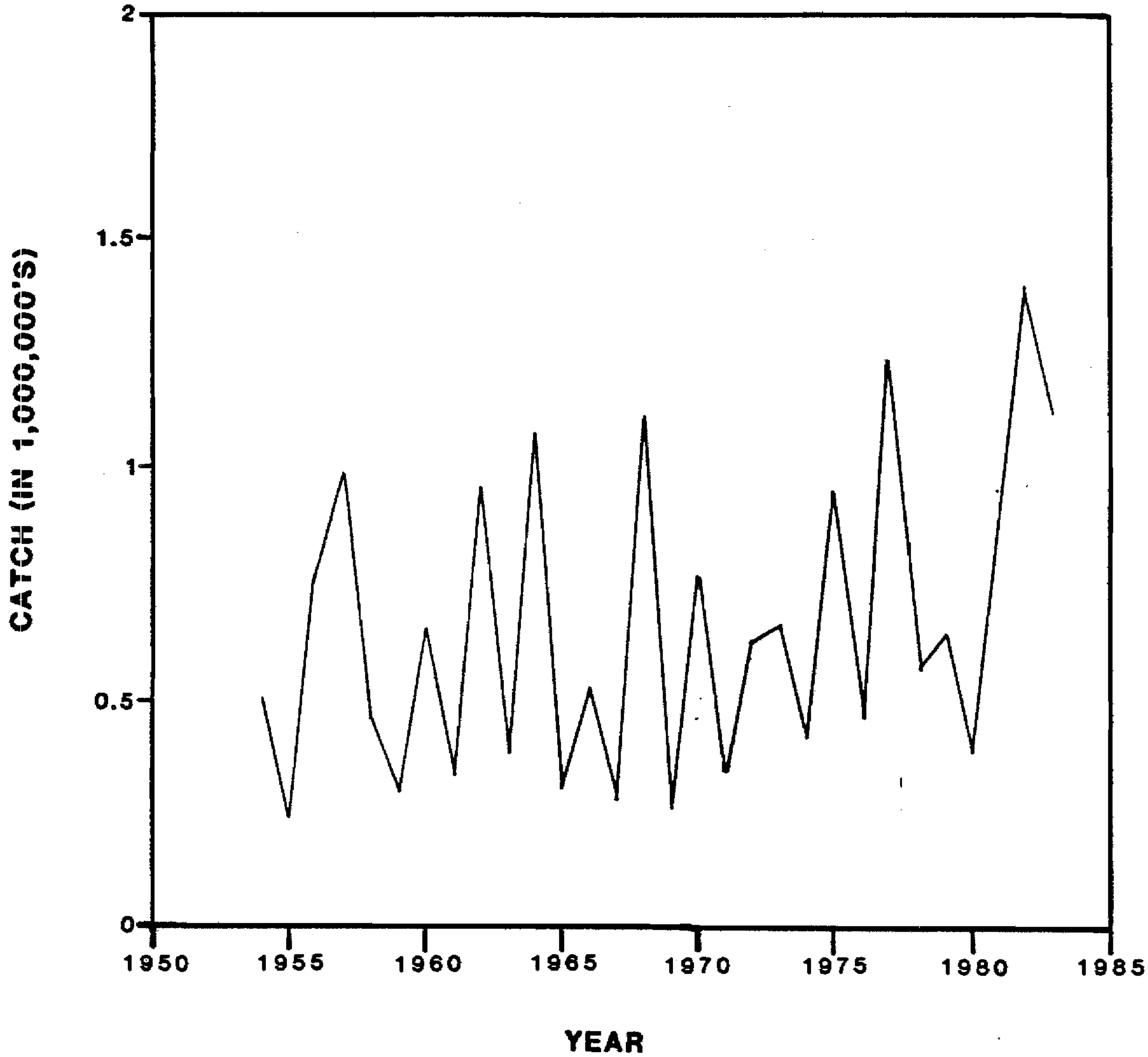
6 Source: Barrett et al. 1985



COMMERCIAL CATCH OF UPPER COOK INLET SOCKEYE, 1954-1983.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants and ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 5



COMMERCIAL CATCH OF UPPER COOK INLET CHUM, 1954-1983.

FIGURE 6

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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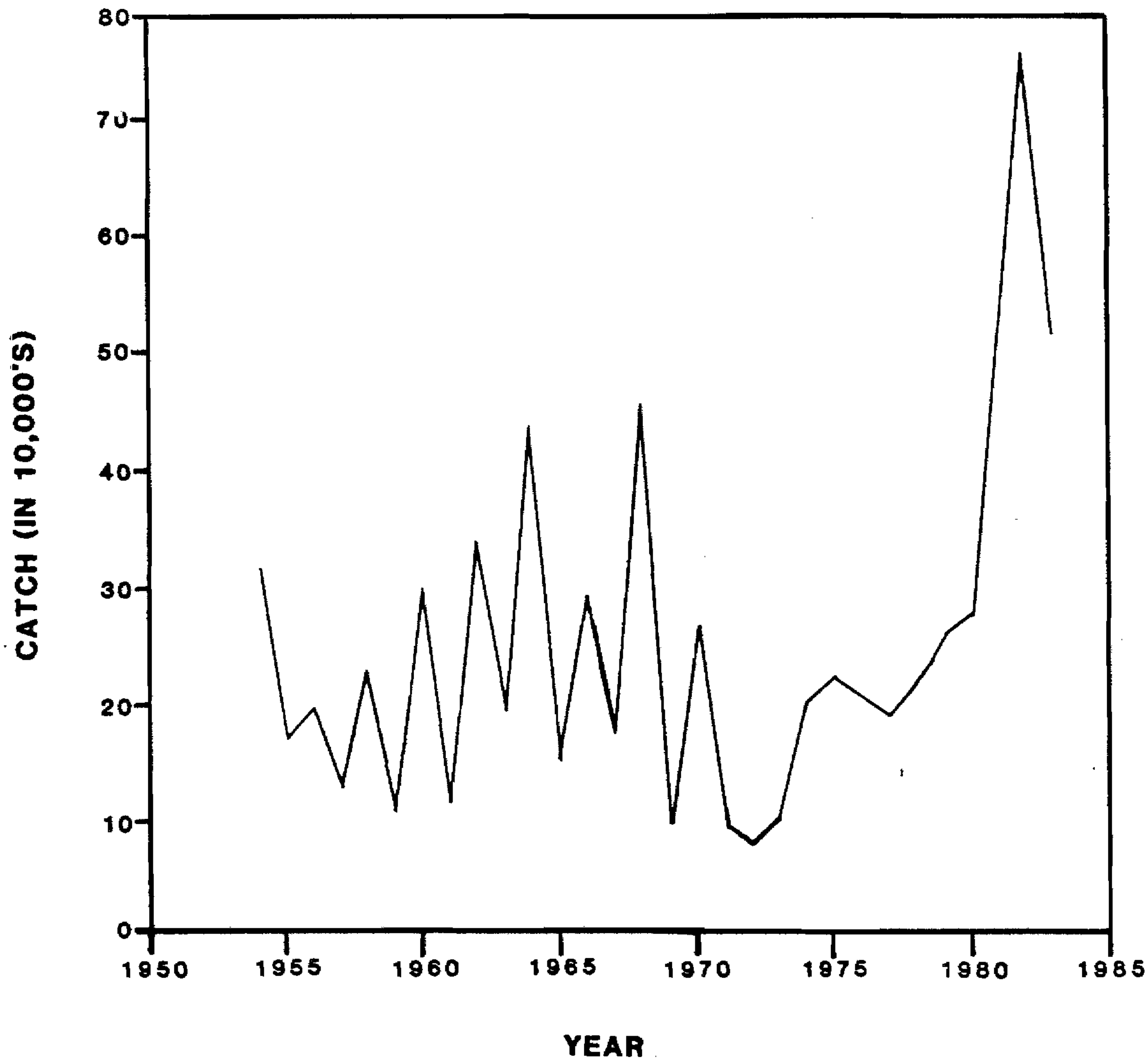
HARZA-EBASCO
SUSITNA JOINT VENTURE



COMMERCIAL CATCH OF UPPER COOK INLET COHO, 1954-1983.

FIGURE 7

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants
and
ENTRIX, INC.

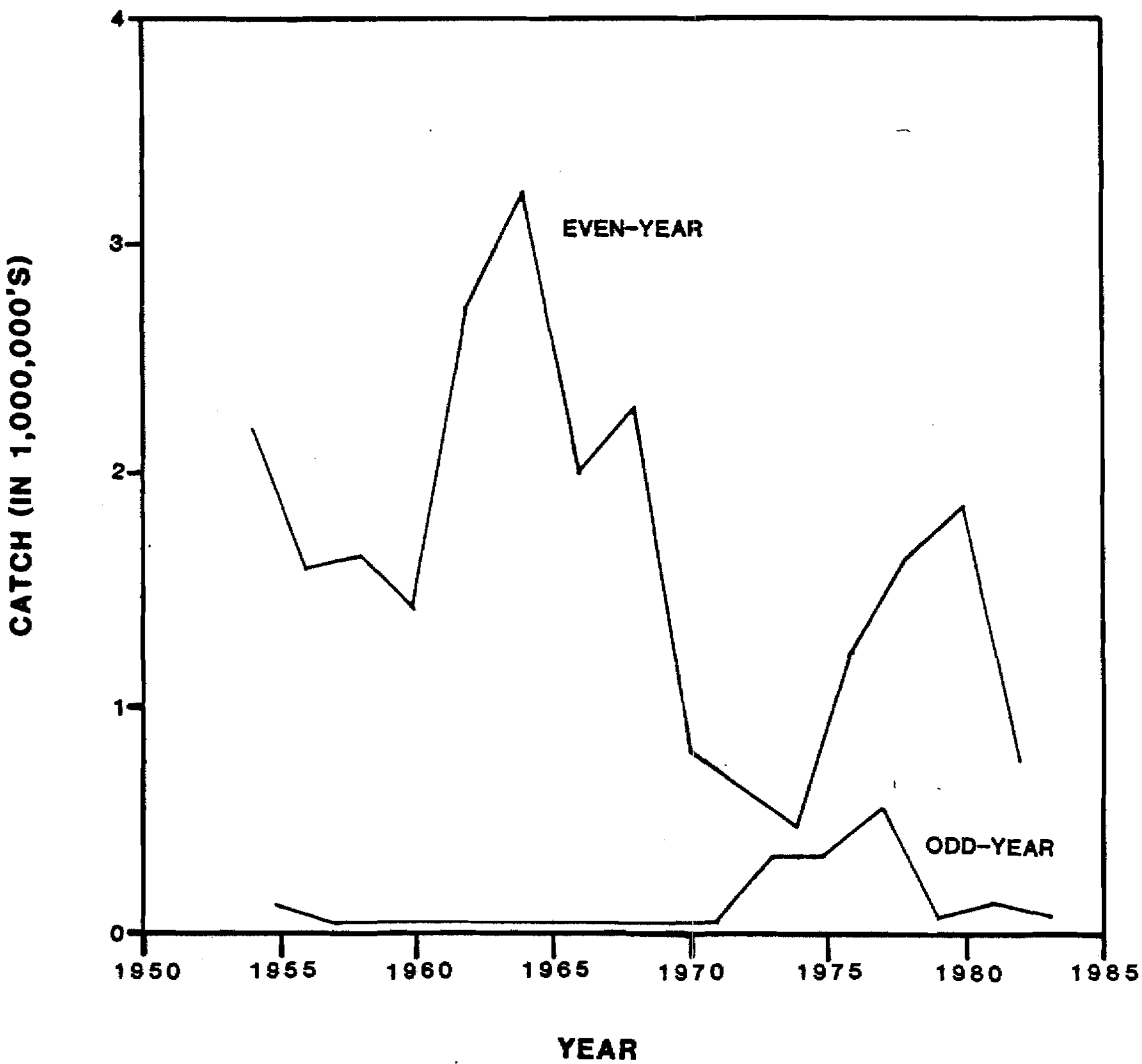
HARZA-EBASCO
SUSITNA JOINT VENTURE

3.2.4 Pink Salmon

Pink salmon is the least valued of the commercial species in upper Cook Inlet. The upper Cook Inlet average annual odd-year harvest of pink salmon since 1954 is about 120,000 fish, with a range of 12,500 to 544,000 fish. The average annual even-year harvest is approximately 1.58 million pink salmon with a range of 0.48 to 3.23 million fish (Table 2; Figure 8). The estimated contribution of Susitna River pink salmon to the upper Cook Inlet pink fishery is 85 percent (Barrett et al. 1984). This represents an average annual Susitna River contribution of 0.10 million odd-year and 1.34 million even-year pink salmon to the upper Cook Inlet fishery over the last 30 years. In 1984, the total pink salmon harvest of 623,000 fish in upper Cook Inlet was worth an estimated $0.5 million (K. Florey, ADF&G, pers. comm. 1984).

3.2.5 Chinook Salmon

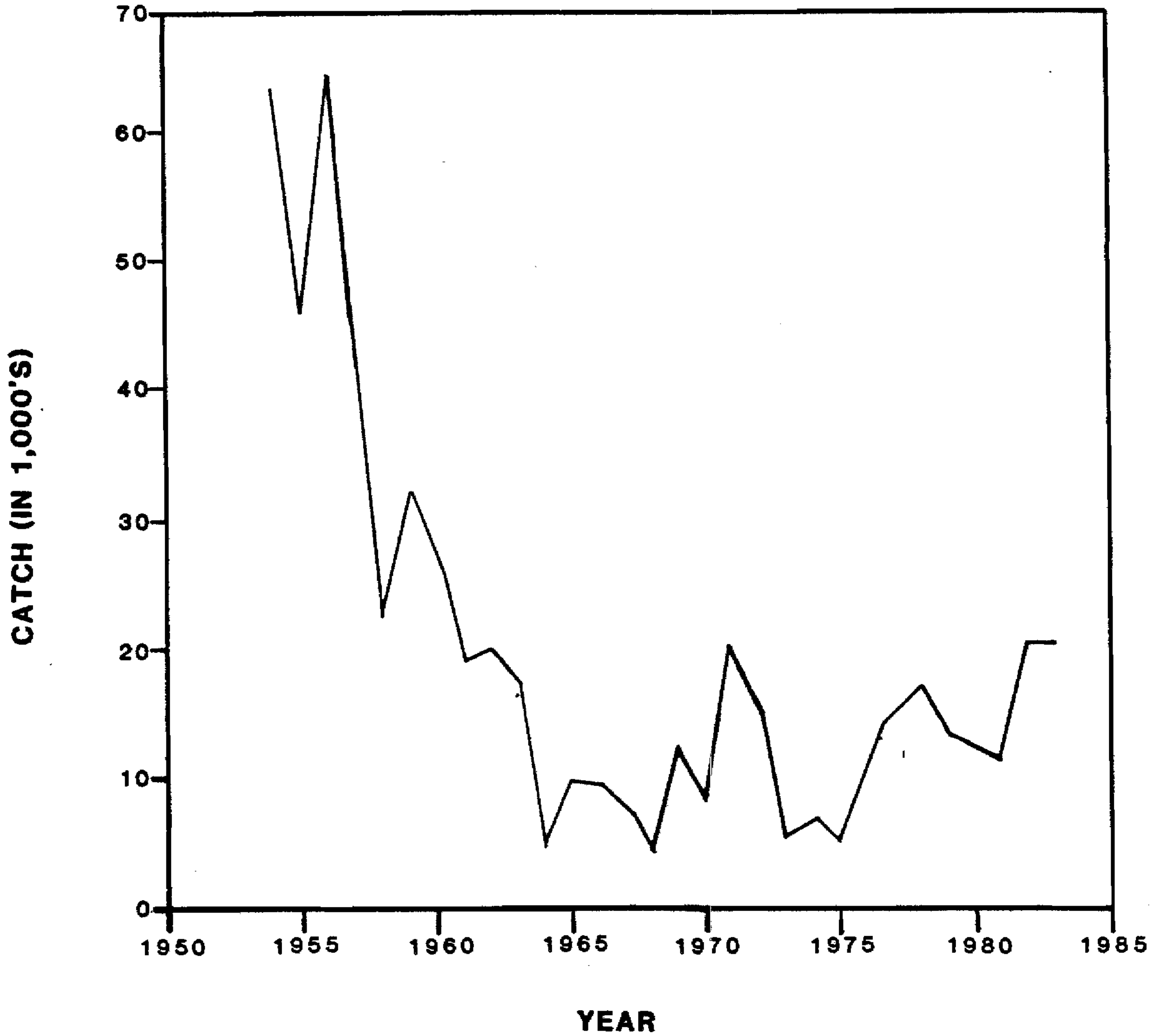
The commercial chinook harvest has averaged 19,200 fish annually in the upper Cook Inlet fishery over the last 30 years (Table 2; Figure 9). Since 1964, the opening date of the commercial fishery has been June 25. The Susitna River chinook run begins in late May and peaks in mid-June. Thus, by June 25 the majority of chinook have already passed through the area subject to commercial fishing. Catches of chinook salmon have averaged 11,600 fish annually for the 20 year period of 1964-1983. Approximately, 10 percent of the total chinook harvest in upper Cook Inlet are Susitna River fish (Barrett et al. 1984). This represents an average annual contribution of 1,960 chinook to the upper Cook Inlet fishery for the last 30 years, or 1,160 fish for 1964-1983. In 1984, the 8,800 chinook caught in the upper Cook Inlet fishery were valued at $0.3 million (K. Florey, ADF&G, pers. comm. 1984).



COMMERCIAL CATCH OF UPPER COOK INLET PINK, 1954-1983.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants and ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 8



COMMERCIAL CATCH OF UPPER COOK INLET CHINOOK, 1954-1983.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants and ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 9

3.3 SPORT FISHING

Increases in population and tourism in Alaska have resulted in a growing demand for recreational fishing. Recreational fishing is now considered a significant factor in total fisheries management, particularly in Cook Inlet where commercial and non-commercial user conflicts have developed (Mills 1980). The Susitna River and its major salmon and resident fish-producing tributary streams provide a multi-species sport fishery. Since 1978, the drainage has accounted for an average of 127,100 angler days of sport fishing effort, which is approximately 9 percent of the 1977-1983 average of 1.4 million total angler days for Alaska and 13 percent of the 1977-1983 average of 1.0 million total angler days for the Southcentral region (Mills 1979, 1980, 1981, 1982, 1983, 1984).

The sport fish harvests for 1978 through 1983 from the Susitna Basin, based on mail surveys to a sample of license holders, are shown in Table 4 (Mills 1979, 1980, 1981, 1982, 1983 and 1984). The estimates represent the sport fishing harvests throughout the Susitna Basin and include an area that is larger than that which could be affected by the proposed project (see Figures 10 and 11 for locations of most of the major tributaries listed in Table 4).

3.3.1 Arctic Grayling

The annual Arctic grayling sport harvest has averaged 18,200 fish in the Susitna Basin and 61,500 fish in Southcentral Alaska over the last six years (Table 5). The largest sport harvest of Arctic grayling on record in the Susitna Basin occurred in 1980 when an estimated 22,100 fish were caught. This represents about 32 percent of the total Southcentral Arctic grayling harvest in 1980 (Mills 1981).

Table 4. Susitna Basin sport fish harvest and effort by fishery and species - 1978, 1979, 1980, 1981, 1982 and 1983.

Locations	Days Fished	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1978											
Willow Creek	22,682	47	905	56	18,901	2,458	913	280	0	208	9
Caswell Creek	---										
Montana Creek	25,762	408	2,451	85	15,619	4,429	1,193	633	0	958	9
Sunshine Creek	---										
Clear (Chunilna) Creek	5,040	12	2,200	28	2,074	1,912	1,501	1,817	0	859	27
Sheep Creek	11,869	256	478	14	6,981	1,697	470	108	0	461	18
Little Willow Creek	5,687	0	151	28	3,142	1,015	334	63	0	334	0
Deshka River	9,111	850*	1,798	0	697	0	3,634	0	0	579	0
Lake Creek	8,767	326*	2,212	254	2,833	1,015	2,721	154	36	2,115	45
Alexander Creek	6,914	769*	2,401	183	1,146	215	2,640	136	0	1,871	0
Talachulitna River	732	12*	88	141	31	234	0	235	0	99	0
Lake Louise, Lake Susitna, Tyone River	13,161	0	0	0	0	0	0	0	2,522	2,278	2,947
Others	14,970	163	2,388	56	3,994	2,692	1,519	2,739	877	3,770	208
1978 Total	124,695	2,843	15,072	845	55,418	15,667	14,925	6,165	3,435	13,532	3,263
1979											
Willow Creek	18,911	459	462	94	3,445	582	1,500	618	0	1,654	18
Caswell Creek	3,710	156	624	0	100	9	282	91	0	354	0
Montana Creek	22,621	312	1,735	346	2,472	745	1,536	527	0	791	9
Sunshine Creek	3,317	10*	774	157	700	55	382	264	0	0	45
Clear (Chunilna) Creek	5,125	312	1,248	31	645	355	1,373	827	0	1,045	9
Sheep Creek	6,728	10	462	31	2,418	682	573	127	0	645	64
Little Willow Creek	5,171	0	262	141	745	118	345	336	0	1,091	0
Deshka River	13,236	2,811	973	0	109	0	3,182	0	0	1,463	82
Lake Creek	13,881	1,796	2,671	440	882	136	4,527	164	9	1,963	109
Alexander Creek	8,284	712	1,560	79	236	45	1,182	182	0	745	145
Talachulitna River	2,185	293	125	47	100	55	0	155	0	664	45
Lake Louise, Lake Susitna, Tyone River	12,199	0	0	0	0	0	0	0	2,618	2,936	2,363
Others	12,639	39	1,997	220	664	1,245	3,472	909	472	4,918	282
1979 Total	128,007	6,910	12,893	1,586	12,516	4,072	18,354	4,200	3,099	13,342	3,171

* Chinook less than 20 inches

Table 4. (Continued)

Locations	Days Fished	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1980											
Willow Creek	29,011	289	1,207	83	23,638	989	1,168	636	0	1,868	0
Caswell Creek	4,963	215	1,124	77	1,663	19	154	83	0	353	26
Montana Creek	19,287	559	2,684	257	8,230	571	854	167	0	655	13
Sunshine Creek	5,208	132	1,534	116	2,408	225	193	39	0	0	39
Clear (Chunilna) Creek	4,388	172	661	6	622	385	950	751	0	1,348	32
Sheep Creek	8,041	45*	430	9	6,362	648	385	83	0	725	45
Little Willow Creek	8,190	32*	494	77	6,420	270	353	122	0	1,156	0
Deshka River	19,364	3,685	2,290	0	689	0	4,305	0	0	1,817	224
Lake Creek	8,325	775	2,351	267	2,101	69	2,144	121	9	1,972	0
Alexander Creek	6,812	1,438	999	52	809	121	1,945	353	0	1,145	0
Talachulitna River	2,542	121	491	112	276	17	379	982	0	1,713	0
Lake Louise, Lake Susitna, Tyone River	10,539	0	0	0	0	0	0	0	2,609	4,477	6,612
Others	12,216	45*	2,234	257	3,403	1,445	2,658	790	267	4,854	212
1980 Total	138,886	7,389	16,499	1,304	56,621	4,759	15,488	4,127	2,876	22,083	7,203

Locations	Days Fished	Chinook Salmon*	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1981												
Willow Creek	14,060	144	441	747	77	2,797	1,533	1,475	249	0	1,188	48
Caswell Creek	3,860	77	172	901	38	335	0	326	38	0	144	0
Montana Creek	16,657	239	422	2,261	182	1,782	805	1,111	240	0	891	0
Sunshine Creek	3,062	57	0	968	220	958	125	249	10	0	57	115
Clear (Chunilna) Creek	3,584	86	287	422	29	19	57	1,226	1,418	0	996	0
Sheep Creek	6,936	0	0	326	105	1,236	987	201	57	0	872	0
Little Willow Creek	3,845	0	0	29	67	604	192	374	48	0	623	0
Deshka River	13,248	738	2,031	632	0	19	0	3,631	10	0	1,255	96
Lake Creek	6,471	163	632	1,035	211	412	48	2,874	67	19	1,600	29
Alexander Creek	6,892	278	843	891	67	57	10	2,290	287	0	1,130	29
Talachulitna River	1,378	57	0	240	172	29	0	0	0	0	479	0
Lake Louise, Lake Susitna, Tyone River	14,397	0	0	0	0	0	0	0	0	4,093	4,892	5,292
Others	7,850	277	0	939	115	412	450	3,851	814	287	7,089	57
1981 Total	102,240	2,748	4,828	9,391	1,283	8,660	4,207	13,757	3,238	4,399	21,216	5,666

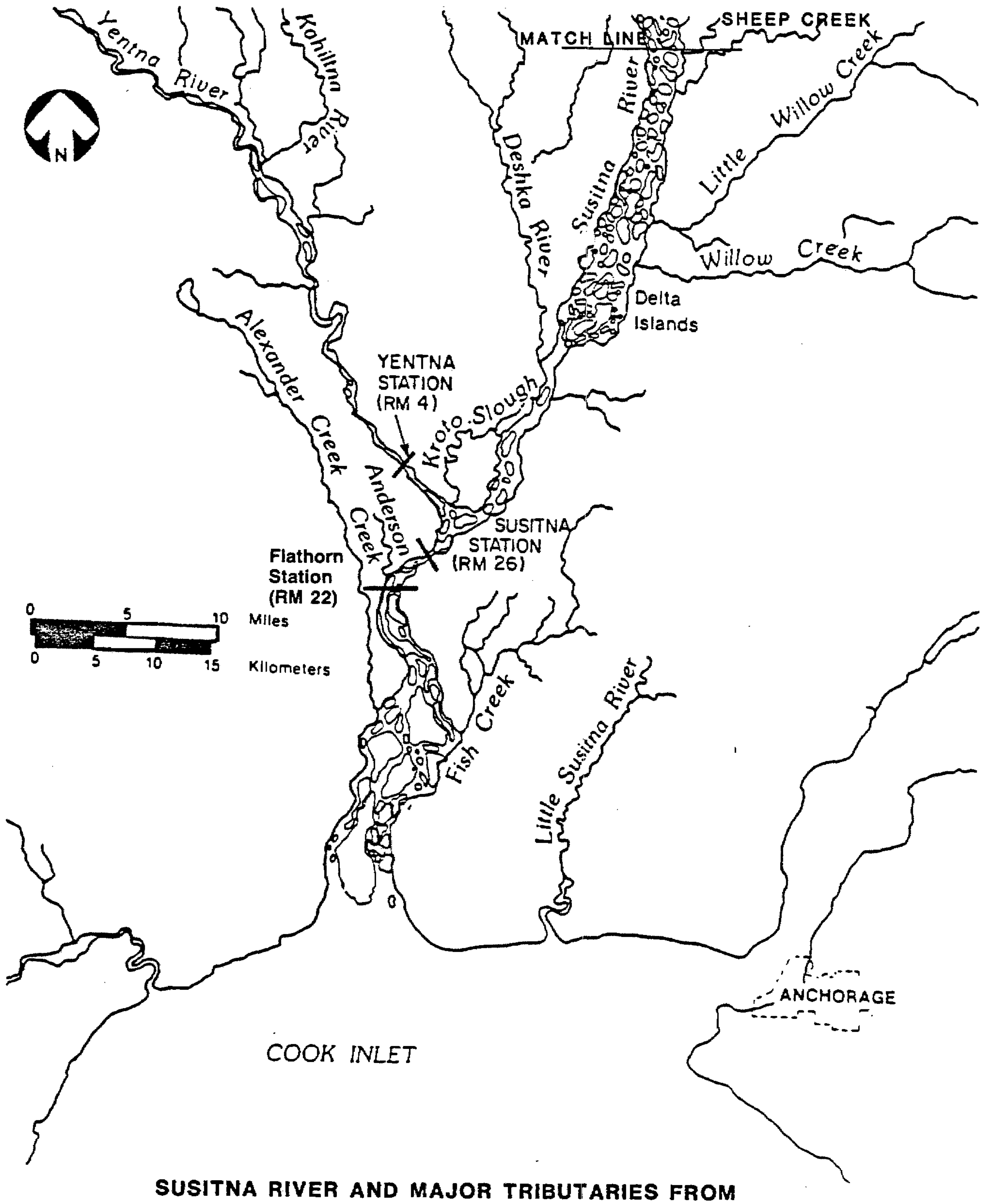
* Chinook less than 20 inches.

Table 4. (Continued)

Locations	Days Fished	Chinook Salmon*	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1982												
Willow Creek	19,704	220	409	1,069	94	4,789	2,086	891	262	0	1,520	63
Caswell Creek	5,101	178	293	776	52	1,092	0	189	73	0	252	0
Montana Creek	23,645	126	115	3,060	514	3,595	1,708	2,243	356	0	849	0
Sunshine Creek	3,787	52	0	1,719	189	1,132	231	545	42	0	42	73
Clear (Chunilna) Creek	3,856	52	398	996	115	220	31	608	1,069	0	943	0
Sheep Creek	9,093	0	0	367	88	2,599	1,750	325	409	0	723	0
Little Willow Creek	5,579	0	0	398	105	1,520	199	335	189	0	377	0
Deshka River	18,391	1,142	3,165	2,463	0	377	0	3,804	0	0	1,457	252
Lake Creek	8,649	356	1,289	1,603	252	398	199	3,134	482	0	1,955	0
Alexander Creek	10,748	681	1,825	1,907	335	482	0	2,505	42	0	1,582	84
Talachulitna River	1,911	0	0	524	63	220	0	0	31	0	587	0
Lake Louise, Lake Susitna, Tyone River	14,024	0	0	0	0	0	0	0	0	4,056	3,532	5,565
Others	9,980	220	0	1,782	398	398	639	2,400	1,666	335	5,041	63
1982 Total	134,468	3,027	7,494	16,664	2,205	16,822	6,843	16,979	4,621	4,391	18,860	6,100
1983												
Willow Creek	13,405	136	398	576	425	1,647	1,490	1,689	336	0	1,794	21
Caswell Creek	5,048	10	262	408	151	126	0	231	157	0	315	31
Montana Creek	17,109	199	305	1,402	534	902	1,311	1,332	325	0	336	0
Sunshine Creek	3,429	105	0	722	685	241	42	178	84	0	31	367
Clear (Chunilna) Creek	7,564	252	682	836	534	73	650	1,836	1,962	0	1,553	84
Sheep Creek	6,237	0	0	596	370	682	902	409	52	0	839	10
Little Willow Creek	2,791	0	0	52	110	157	147	514	73	0	84	0
Deshka River	23,174	934	3,955	1,036	0	21	0	2,434	0	0	1,280	126
Lake Creek	14,749	535	1,888	1,392	726	430	52	2,287	262	0	2,224	283
Alexander Creek	9,425	672	1,039	408	69	126	0	608	136	0	483	0
Talachulitna River	4,556	63	273	84	41	0	0	0	105	0	3,178	0
Kashwitna River	1,344	231	0	52	0	0	0	357	304	0	514	0
Lake Louise, Lake Susitna, Tyone River	12,948	0	0	0	0	0	0	0	0	3,210	4,217	4,070
Others	12,367	303	178	861	1,892	251	639	4,625	1,067	287	3,387	534
1983 Total	134,156	3,440	8,980	8,425	5,537	4,656	5,233	16,500	4,863	3,497	20,235	5,526

* Chinook less than 20 inches

Source: Mills (1979-1984)



SUSITNA RIVER AND MAJOR TRIBUTARIES FROM MOUTH TO SHEEP CREEK.

FIGURE 10

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants
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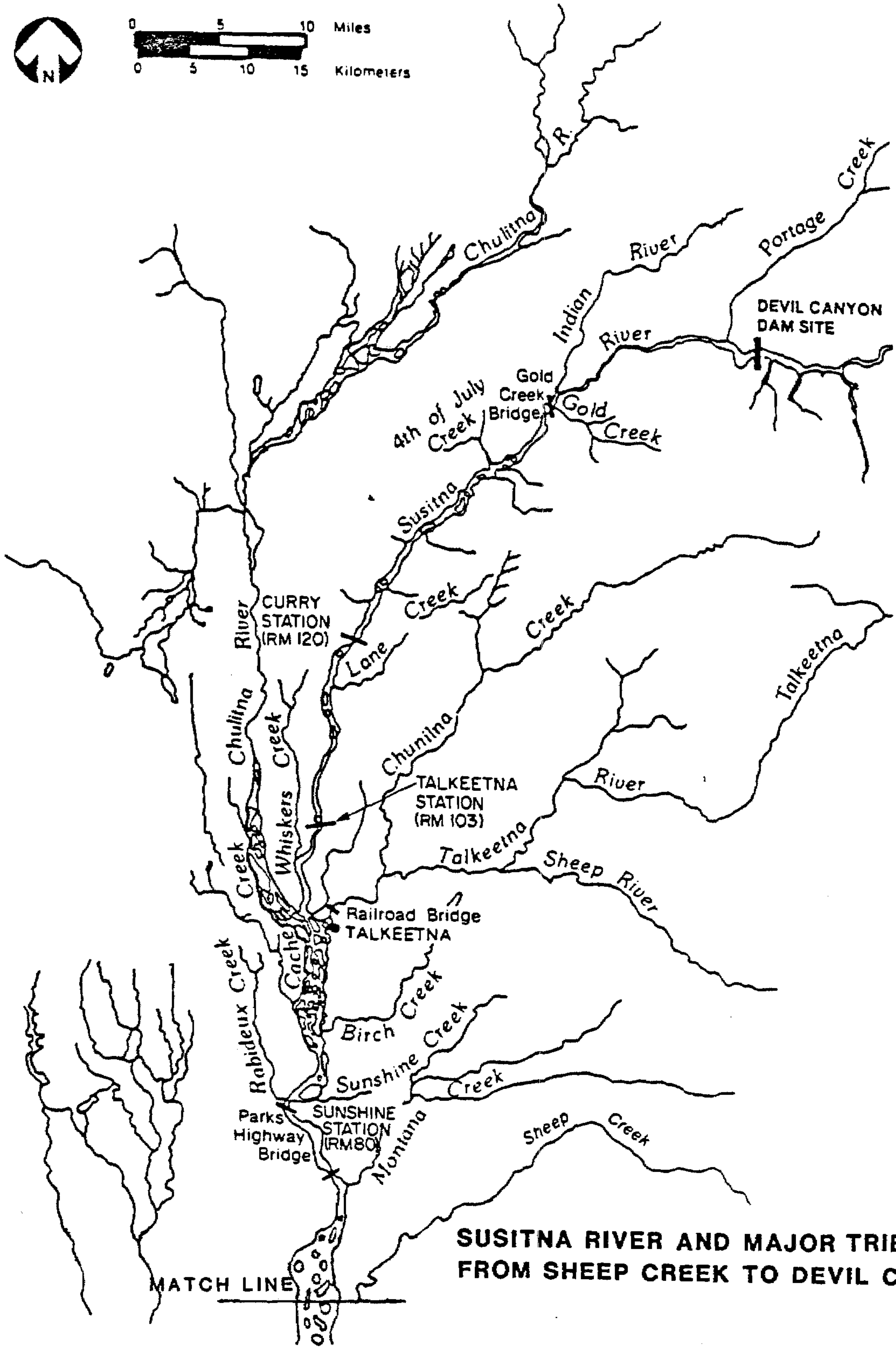
HARZA-EBASCO
SUSITNA JOINT VENTURE



SUSITNA RIVER AND MAJOR TRIBUTARIES FROM SHEEP CREEK TO DEVIL CANYON.

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

FIGURE 11

Woodward-Clyde Consultants
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ENTRIX, INC.

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SUSITNA JOINT VENTURE

Table 5. Sport fish harvest for Southcentral Alaska and Susitna Basin in numbers of fish by species, 1978-1983.

	Arctic Grayling		Rainbow Trout		Pink Salmon		Coho Salmon		Chinook Salmon		Chum Salmon		Sockeye Salmon	
Year	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin
1978	47,866	13,532	107,243	14,925	143,483	55,418	81,990	15,072	26,415	2,843	23,755	15,667	118,299	845
1979	70,316	13,342	129,815	18,354	63,366	12,516	93,234	12,893	34,009	6,910	8,126	4,072	77,655	1,586
1980	69,462	22,083	126,686	15,488	153,794	56,621	127,958	16,499	24,155	77,389	8,660	4,759	105,914	1,304
1981	63,695	21,216	149,460	13,757	64,163	8,660	95,376	9,391	35,822	7,576	7,810	4,207	76,533	1,283
1982	60,972	18,860	142,579	16,979	105,961	16,822	136,153	16,664	46,266	10,521	13,497	6,843	128,015	2,205
1983	56,896	20,235	141,663	16,500	47,264	4,656	87,935	8,425	57,094	12,420	11,043	5,233	170,799	5,537
Average	61,535	18,211	132,908	16,000	even-134,413 odd-58,264	even-42,954 odd-8,611	103,774	13,157	37,294	7,943	12,149	6,797	112,869	2,128

Source: Mills (1979-1984)

3.3.2 Rainbow Trout

The Susitna Basin and Southcentral Alaska annual rainbow trout sport harvests have averaged 16,000 and 132,900 fish respectively since 1978 (Table 5). In 1979, about 18,350 rainbow trout were harvested by anglers in the Susitna Basin, which represents approximately 14 percent of the Southcentral region rainbow trout sport catch in 1979 (Mills 1980).

3.3.3 Pink Salmon

The annual even-year pink salmon sport harvest has averaged 42,950 fish in the Susitna Basin and 134,400 fish in Southcentral Alaska since 1978 (Table 5). The annual odd-year pink salmon sport catch has averaged 8,600 fish in the Susitna Basin and 58,300 fish in Southcentral Alaska since 1979 (Table 5). The largest sport harvest of pink salmon on record in the Susitna Basin occurred in 1980 when an estimated 56,600 fish were caught (Mills 1981). In 1981, the estimated odd-year pink salmon sport harvest of 8,700 fish represented about 6.8 percent of the estimated Susitna escapement of 127,000 pink salmon (Table 3).

3.3.4 Coho Salmon

Since 1978, the Susitna Basin and Southcentral Alaska annual coho salmon sport harvests have averaged 13,200 and 103,800 fish respectively (Table 5). In 1982, about 16,664 coho were landed by anglers in the Susitna Basin (Mills 1983), which is the largest annual catch on record. In 1983, almost one of every five coho entering the basin was caught by sport anglers (Table 3).

3.3.5 Chinook Salmon

The annual chinook salmon sport harvest has averaged 37,300 fish in Southcentral Alaska and 7,950 fish in the Susitna Basin since 1978 (Table 5). This represents an annual Susitna Basin contribution of 21 percent to the Southcentral chinook sport harvest over the six year period. The largest Susitna Basin sport harvest of chinook salmon on record occurred in 1983, when 12,420 fish were caught by fishermen (Mills 1984).

3.3.6 Chum Salmon

The Susitna Basin and Southcentral Alaska annual chum salmon sport harvests have averaged 6,800 and 12,150 fish respectively since 1978 (Table 5). The largest sport catch of chum salmon on record in the Susitna Basin occurred in 1978 when 15,700 fish were landed (Mills 1979). For the years 1981 to 1983, chum salmon sport harvests have averaged between 1.4 and 1.8 percent of the estimated Susitna Basin chum salmon escapement (Table 3).

3.3.7 Sockeye Salmon

The annual sockeye salmon sport harvest has averaged 112,900 fish in Southcentral Alaska and 2,100 fish in the Susitna Basin for the years 1978 through 1983 (Table 5). In 1983 over 5,500 sockeye salmon were caught by fishermen in the Susitna Basin, which is the largest annual catch on record (Mills 1984). The sport catch of sockeye from 1981 through 1983 has averaged 3 percent or less of the estimated Susitna Basin sockeye escapement (Table 3).

3.4 SUBSISTENCE FISHING

The only subsistence fishery on Susitna River fish stocks that is officially recognized and monitored by the Alaska Department of Fish and Game is near the village of Tyonek, approximately 30 miles (50 km) southwest of the Susitna River mouth. The Tyonek subsistence fishery was reopened in 1980 after being closed for sixteen years. From 1980 through 1983, the annual Tyonek subsistence harvest averaged 2,000 chinook, 250 sockeye and 80 coho salmon (ADF&G 1984).

4.0 SPECIES BIOLOGY

4.1 ADULT SALMON

Adult salmon escapements have been monitored at various sampling stations in the Susitna Basin. The locations of these stations are shown in Figures 10 and 11. The methodology used by ADF&G to monitor salmon escapements can be found in reports cited in the text.

4.1.1 Sockeye Salmon

(i) Timing of Runs

Sockeye salmon enter the Susitna River in two distinct runs (Barrett et al. 1984, 1985). The first run of fish enters the river in late May to early June and passes Sunshine Station (RM 80) between the first and third weeks of June (Barrett et al. 1984, 1985). The escapement of first-run sockeye at Sunshine Station was about 5,800 fish in 1982, 3,300 fish in 1983 and 4,800 fish in 1984 (Barrett et al. 1984, 1985). First-run sockeye spawn upstream of RM 80 in the Papa Bear lake system in the Talkeetna River drainage (RM 97.1) (ADF&G 1982a, Barrett et al. 1984). Peak spawning activity in the Papa Bear Lake inlet stream was between the third week of July and the first week of August in 1982 and between the second and fourth weeks of July in 1983 and 1984 (ADF&G 1982a; Barrett et al. 1984, 1985). Because first-run sockeye salmon spawn upstream of RM 80 exclusively in the Talkeetna River drainage, which will not be influenced by the project, they are not discussed in further detail.

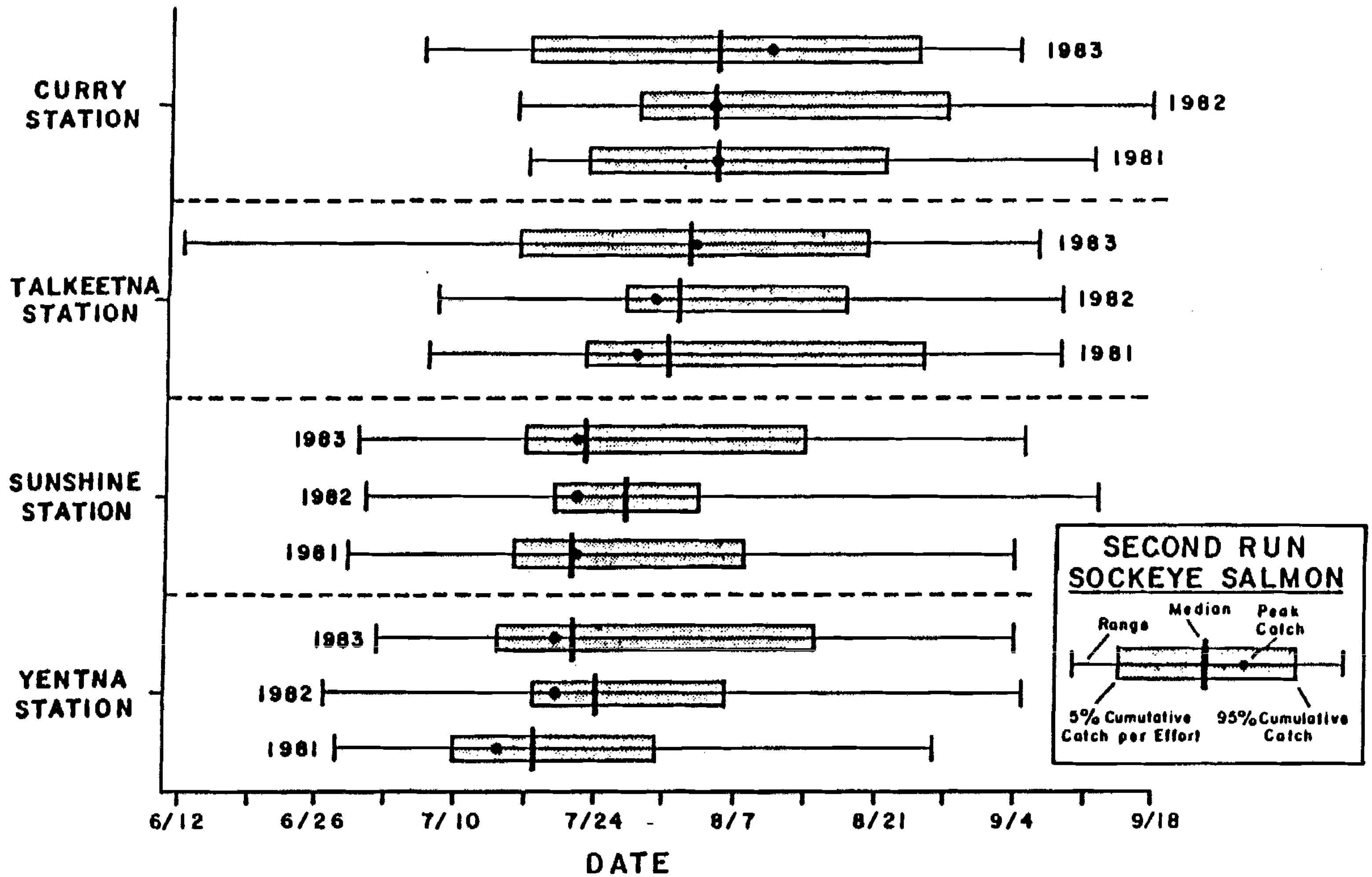
Second-run sockeye enter the Susitna River about the last of June. In 1981 through 1984 fish passed Sunshine Station between the third week of July and the second week of August (Barrett et al. 1984, 1985). These fish are abundant in the mainstem of the Talkeetna-to-Devil Canyon reach (RM 98.6-152) from about the third week of July to the fourth week of August (Barrett et al. 1984, 1985). A summary of second-run sockeye migration timing in the Susitna River basin for 1981, 1982 and 1983 is presented in Figure 12.

Second-run sockeye salmon migration timing is likely influenced by river discharge. In 1981 river discharge was declining from over 150,000 cfs when most second-run sockeye passed Sunshine Station (Figure 13). In 1982 a discharge spike above 80,000 cfs coincided with reduced ADF&G fishwheel catches (Figure 13). In 1983 river discharge was below 80,000 cfs at Sunshine Station during most of the second-run sockeye migration and the run passed Sunshine Station in one major peak (Figure 13). Based on this analysis, it appears that spikes in discharge over 100,000 cfs at Sunshine Station can delay sockeye salmon migration timing.

(ii) <u>Escapement</u>

The total annual minimum escapement of second-run sockeye salmon in the Susitna River averaged 248,000 fish for 1981 through 1984 (Table 6). This estimate is considered a minimum because it is based on the summation of escapements at Sunshine and Yentna stations and does not include escapements downstream of RM 80, excluding the Yentna River (RM 28). In 1984, approximately 605,800 second-run sockeye reached Flathorn Station (RM 22) (Barrett et al. 1985). This estimate is based on data from the first year of monitoring at this location and does not include escapements downstream of RM 22 (Barrett et al. 1985). Most second-run sockeye salmon spawn in the Yentna (RM 28), Talkeetna (RM 97.1) and Chulitna (RM 98.6) drainages (Barrett et al. 1984, 1985).

For 1981 through 1984, second-run sockeye escapements averaged 6,300 fish annually at Talkeetna Station (RM 103) (Table 6),



MIGRATIONAL TIMING OF SECOND-RUN SOCKEYE SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: BARRETT et al. 1984)

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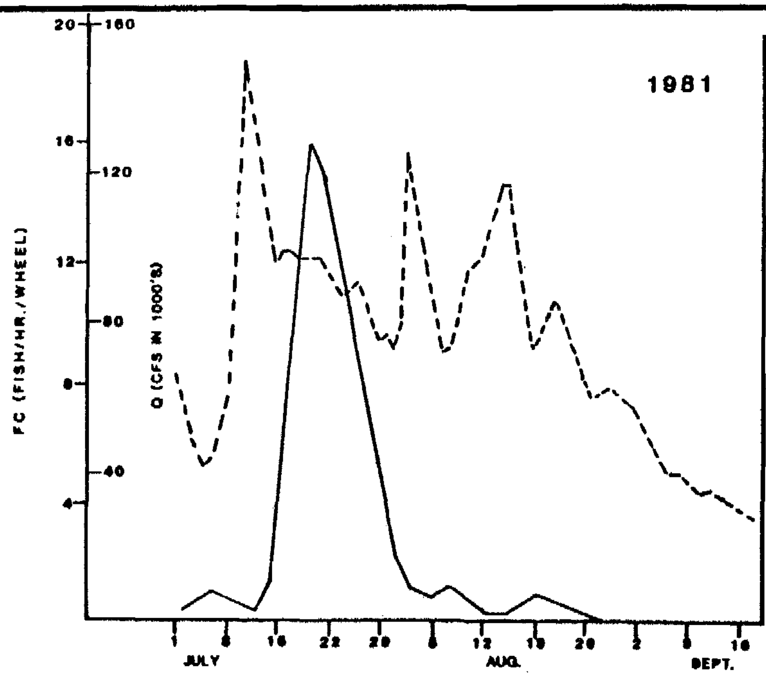
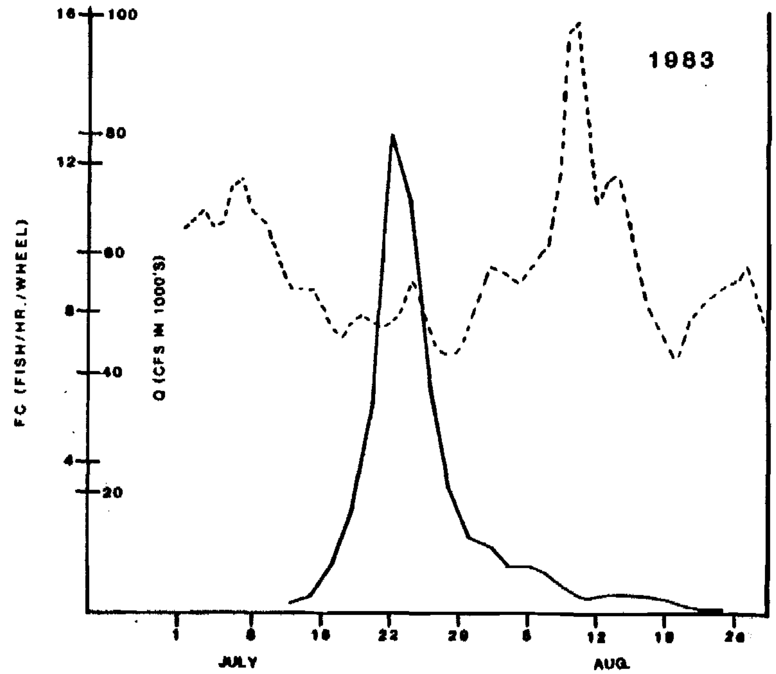
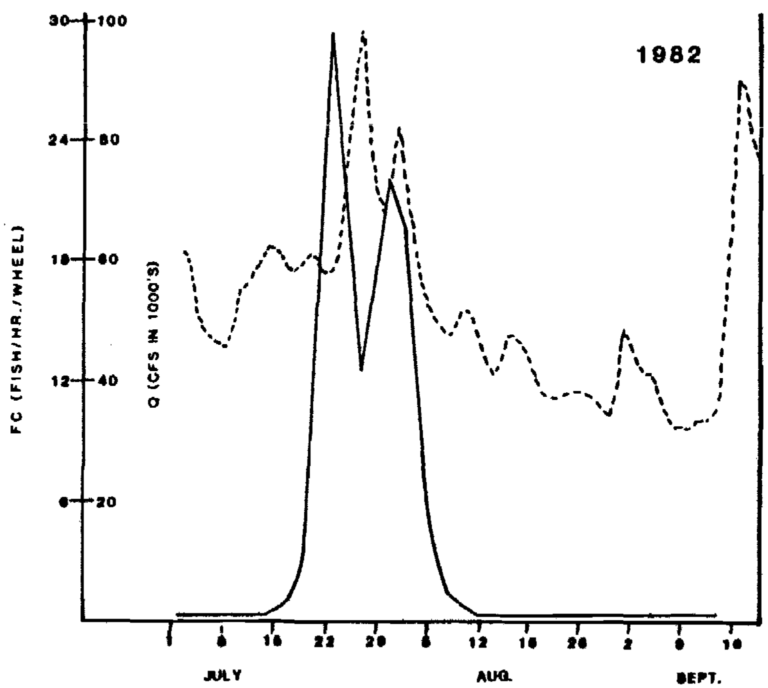
FIGURE 12







FISHWHEEL CATCH (FC) ————

DISCHARGE (Q) --------

COMPARISON OF SECOND-RUN SOCKEYE FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION (RM 80), 1981-1983.

FIGURE 13

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Table 6. Average salmon escapements in the Susitna River by species and location.

Location/ River Mile	Sockeye[1]	Chum[2]	Coho[2]	Pink[3]	Chinook[4]	Total
Yentna Station RM 28, TRM 04	126,750	21,200	19,600	odd 48,400 even 408,300	---	odd 215,950 even 575,850
Sunshine Station RM 80	121,650	431,000	43,900	odd 45,000 even 730,100	88,200	odd 729,750 even 1,414,850
Talkeetna Station RM 103	6,300	54,600	5,700	odd 5,900 even 125,500	16,700	odd 89,200 even 208,800
Curry Station RM 120	2,400	28,200	1,600	odd 3,300 even 87,900	13,000	odd 48,500 even 133,100
Minimum Susitna River[5]	248,400	452,200	63,400	odd 93,400 even 1,138,400	---	odd 857,500 even 1,902,500

1 Second-run sockeye escapements. Four-year average of 1981, 1982, 1983 and 1984 escapements.

2 Four-year average of 1981, 1982, 1983 and 1984 escapements.

3 Odd is average of 1981 and 1983 escapements. Even is average of 1982 and 1984 escapements.

4 Three-year average of 1982, 1983 and 1984 escapements.

5 Summation of Yentna Station and Sunshine Station average escapements. Does not include escapement to the Susitna River and its tributaries below RM 80 (excluding the Yentna River).

Source: Barrett et al. 1984, 1985

with a range of 3,100 to 13,100 (Barrett et al. 1984, 1985). These escapements are overestimates of the number of fish that spawn upstream of RM 103 because a significant number of fish return downstream of Talkeetna Station (Barrett et al. 1984, 1985). In 1984, about 83 percent of the sockeye escapement at Talkeetna Station were milling fish that returned downstream to spawn (Barrett et al. 1985). If the 1984 escapement (13,100 fish) to Talkeetna Station is reduced to account for this milling component of the run, spawning sockeye salmon in the Talkeetna-to-Devil Canyon reach accounted for about 0.5 percent of the 1984 second-run sockeye escapement to Flathorn Station (Barrett et al. 1985). In 1983 about 72 percent of the sockeye escapement to Talkeetna Station (4,200 fish) were considered milling fish that returned downstream of Talkeetna Station to spawn. The milling components of the sockeye escapements to Talkeetna Station were not estimated in 1981 or 1982.

(iii) Migration Rate

Tagged, second-run sockeye salmon migrated the 23 miles between Sunshine Station (RM 80) and Talkeetna Station (RM 103) at an average rate of travel of 4.6 miles per day (mpd) in 1981, 2.7 mpd in 1982, 2.4 mpd in 1983 and 5.8 mpd in 1984 (Barrett et al. 1984, 1985). The average rate of travel for tagged, second-run sockeye between Talkeetna Station and Curry Station (RM 120) was: 3.5 mpd in 1981, 2.4 mpd in 1982, 3.0 mpd in 1983 and 8.5 mpd in 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

(iv) Spawning Locations

Almost all sockeye salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) spawn in slough habitat (Barrett et al. 1984, 1985). Relatively few sockeye spawn in the mainstem and tributaries. One main channel spawning site was identified during the 1983 survey and seven sites were located in 1984

(Barrett et al. 1984, 1985). The 1983 mainstem site (RM 138.6-138.9) was used by eleven spawning sockeye on September 15. Mainstem spawning sites were located between RM 131 and 142 in 1984. The peak count for all seven sites was 33 fish (Barrett et al. 1985). About 50 percent of these fish were spawning in Side Channel 11 (RM 134.5-135.3) (Barrett et al. 1985). Six sockeye were observed in streams during the 1981 through 1984 surveys. However, all six were considering milling fish that did not spawn in streams (ADF&G 1981a, 1982a, Barrett et al. 1984). In 1984, 13 sockeye were observed in streams (Barrett et al. 1985).

During slough spawning surveys in 1981 through 1984, sockeye were observed in 23 sloughs upstream of RM 98.6 (Table 7). Three sloughs contained most of the fish in all four years. Sloughs 8A, 11 and 21 accounted for 89 percent of the peak counts in 1981, 95 percent in 1982, 92 percent in 1983 and 88 percent in 1984 (Table 7).

The peak of the sockeye spawning activity in sloughs occurred between the last week of August and the end of September in all four years (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). A portion (24-44 percent) of the sockeye salmon monitored in sloughs in 1983 and 1984 did not spawn in the slough of first recorded entry (Barrett et al. 1984, 1985). These fish suffered mortality from either bear predation or stranding, or departed the slough and presumably spawned elsewhere (Barrett et al. 1984).

Total slough escapement of sockeye salmon upstream of RM 98.6 was estimated by calculating the total fish days in slough habitat and then dividing by the average slough life (Barrett et al. 1984, 1985). The total slough escapement was about 2,200 fish in 1981, 1,500 fish in 1982, 1,100 fish in 1983 and 2,200 fish in 1984 (Table 8).

Table 7. Second-run sockeye salmon peak survey counts in sloughs upstream of RM 98.6, 1981-1984.

Slough	River Mile	1981	1982	1983	1984	Four-Year Average
1	99.6	0	0	0	10	3
2	100.2	0	0	0	7	2
3B	101.4	1	0	5	20	7
3A	101.9	7	0	0	11	5
5	107.6	0	0	0	1	0
6A	112.3	1	0	0	0	0
8	113.7	0	0	0	2	1
8C	121.9	0	2	0	0	1
8B	122.2	0	5	0	1	2
Moose	123.5	0	8	22	8	10
8A	125.1	177	68	66	128	110
B	126.3	0	8	2	9	5
9	128.3	10	5	2	6	6
9B	129.2	81	1	0	7	22
9A	133.8	2	1	1	0	1
10	133.8	0	0	1	0	0
11	135.3	893	456	248	564	540
15	137.2	0	0	0	1	0
17	138.9	6	0	6	16	7
19	139.7	23	0	5	11	10
20	140.1	2	0	0	0	1
21	141.1	38	53	197	122	103
22	144.5	0	0	0	2	1
Total		1,241	607	555	926	832 (1)

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

(1) Four-year average of totals

Table 8. Second-run sockeye salmon total slough escapement upstream of RM 98.6, 1981-1984.

Slough	River Mile	1981	1982	1983	1984	Four-Year Average
1	99.6	0	0	0	26	7
2	100.2	0	0	0	18	5
3B	101.4	0	0	10	36	12
3A	101.9	13	0	0	29	11
5	107.6	0	0	0	3	1
8	113.7	0	0	0	5	1
8C	121.9	0	5	0	0	1
8B	122.2	0	13	0	0	3
Moose	123.5	0	20	31	0	13
8A	125.1	195	131	130	532	247
B	126.3	0	20	10	23	13
9	128.3	18	13	0	16	12
9B	129.2	212	0	0	18	58
9A	133.8	4	0	0	0	1
11	135.3	1,620	1,199	564	1,280	1,166
15	137.2	0	0	0	3	1
17	138.9	11	0	11	26	12
19	139.7	42	0	10	29	20
21	141.1	63	87	294	154	150
22	144.5	0	0	0	5	1
Total		2,178	1,488	1,060	2,203	1,732 (1)

Source: Barrett et al. 1984, 1985

(1) Four-year average of totals

(v) Access

The upstream passage of salmon into sloughs and side channels is dependent primarily on water depth and length of the passage reaches that are restrictive to the upstream movement of fish (Sautner et al. 1984). Hydraulic velocity barriers do not exist in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) (Trihey 1982). The mainstem discharge level directly influences passage into sloughs because of its influence on backwater at the mouths of sloughs and breaching at the upstream (head) ends of them. Under low mainstem discharge conditions (unbreached), the backwater at the mouths of sloughs and side channels may not be of sufficient depth to allow successful passage. As mainstem discharge increases, the backwater area generally increases in depth and extends its length upstream, which increases the depths within those reaches affected by the backwater. The elimination of passage restrictions within a reach by backwater inundation continues in the upstream direction with increasing mainstem discharge. When breaching occurs, depths become adequate for passage at all passage reaches in most sloughs and side channels (Sautner et al. 1984).

Mainstem discharge levels in the Susitna River at Gold Creek (RM 136.7) commonly range between 20,000 and 30,000 cfs during June, July and August when adult salmon are migrating upstream and 15,000 to 20,000 cfs during peak spawning periods (20 August to 20 September) (Sautner et al. 1984). Passage into sloughs varies considerably at a mainstem discharge level because of the diversity in the morphology of individual sloughs. Breaching of most sloughs in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) occurs at relatively high mainstem discharges (19,000 to 42,000 cfs) (Sautner et al. 1984). During the August 20 to September 20 period, mainstem discharge at Gold Creek is less than 15,000 cfs 50 percent of the time (Sautner et al. 1984). Therefore, passage into sloughs and side channels is often controlled by the backwater at the slough mouth and the local flow from groundwater and runoff sources.

Sloughs 8A, 11 and 21 have accounted for over 90 percent of the sockeye salmon total peak counts in slough habitat (Table 7). At Slough 8A, successful passage conditions occur for all passage reaches when the northeast channel is overtopped at 33,000 cfs (Sautner et al. 1984). When the northwest channel breaches (27,000 cfs), the three lowermost reaches have successful passage conditions (Sautner et al. 1984). At lower mainstem discharges, Passage Reaches I and II have successful passage conditions due to backwater effects at mainstem discharges of 10,600 and 15,600 cfs, respectively (Sautner et al. 1984). Slough 11 is overtopped at a higher than normal mainstem discharge of 42,000 cfs (Sautner et al. 1984). Below breaching flows, the first three passage reaches have successful passage conditions at 16,200, 33,200 and 39,600 cfs, respectively (Sautner et al. 1984). None of the passage reaches in Slough 21 are influenced by backwater below the breaching discharge of the left fork (25,000 cfs) (Sautner et al. 1984). The local flows required for successful passage conditions at specific passage reaches have not been determined. Analyses are currently being done to determine these values in sloughs 8A, 9, 9A, 11 and 21.

(vi) Fecundity and Sex Ratio

The mean fecundity for Susitna River second-run sockeye is 3,350 eggs per female (Barrett et al. 1984). This estimated fecundity is derived from the regression analysis of fecundity as a function of length and from the mean length of sockeye salmon measured at Sunshine Station (Barrett et al. 1984).

The average egg retention from a sample of 56 sockeye salmon was about 250 eggs per female in 1983 (Barrett et al. 1984).

Almost 80 percent of the carcasses had retained 25 or fewer eggs, while only seven percent of the fish sampled had retained more than 1,000 eggs each. In 1984, the average egg retention was 64 eggs per female (Barrett et al. 1985). Most fish examined (67 of 76 females) had completely spawned (Barrett et al. 1985).

The sex ratio (male to female) of second-run sockeye salmon in the Susitna River was 1.0:1 in 1981, 1.2:1 in 1982, 1.2:1 in 1983 and 1.0:1 in 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Sex ratios varied considerably between some locations and years (Table 9). Sex ratios of sockeye salmon by age were reported by ADF&G (ADF&G 1981a, 1982a; Barrett et al. 1984a, 1985). Some males matured at an earlier age than females. Most returning adult sockeye were four or five year fish that had gone to sea after one year in freshwater (Barrett et al. 1984, 1985).

4.1.2 Chum Salmon

(i) Timing of Run

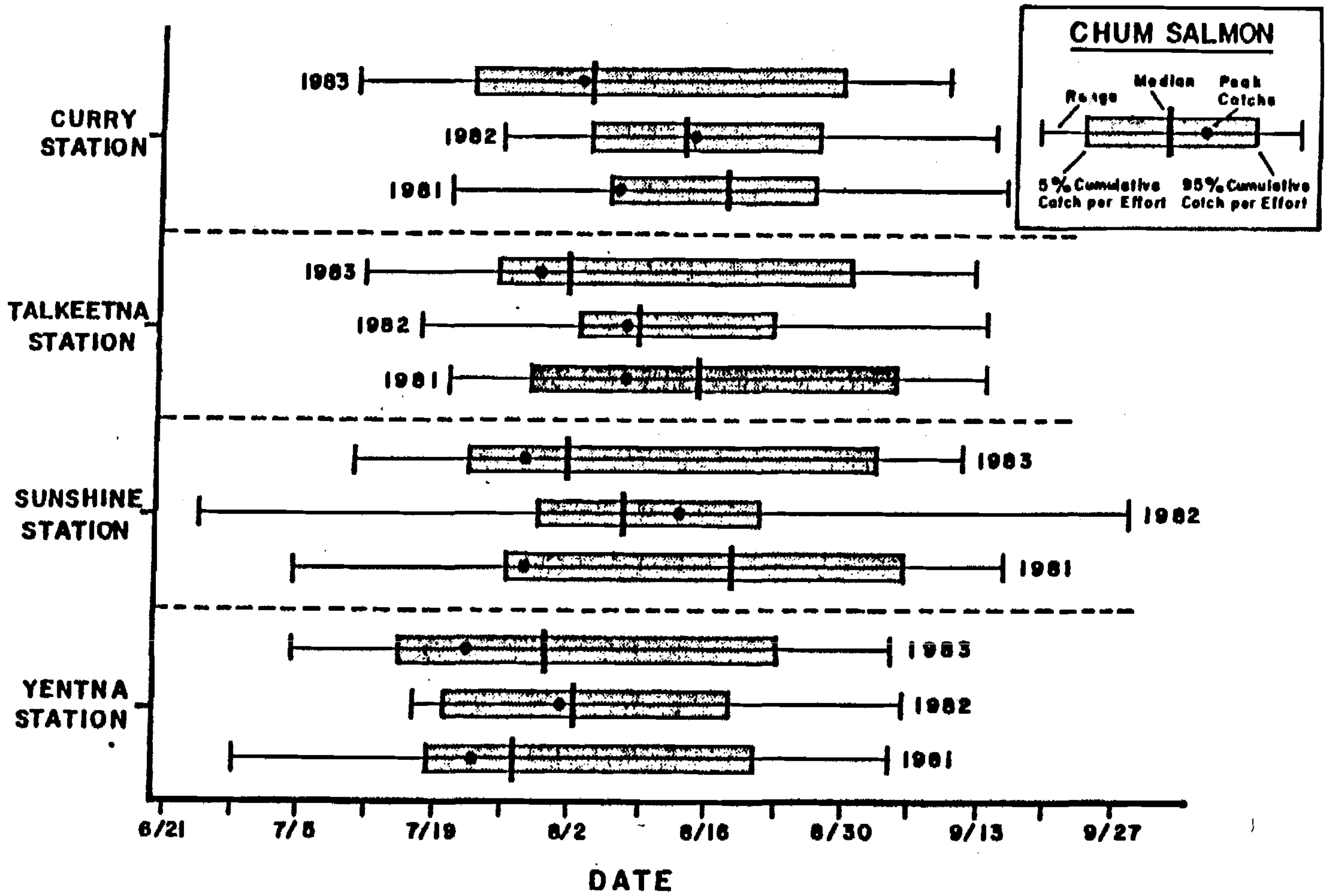
Chum salmon enter the Susitna River in late June to early July and are numerous in the lower river at Yentna Station (RM 28, TRM 04) by the third week of July (Barrett et al. 1984, 1985). The chum migration lasts about one month in the lower river, with most fish passing Yentna Station by the third week of August (Barrett et al. 1984, 1985). The migration passes Sunshine Station (RM 80) from the end of July to early September. In the Talkeetna-to-Devil Canyon reach (RM 98.6-152), the migration begins about the end of July and continues until the end of August. A summary of chum migration timing in the Susitna River for 1981, 1982 and 1983 is presented in Figure 14.

Table 9. Sex ratios of second-run sockeye at Flathorn, Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1984.

Location	Sex ratio (M:F)[1] 1981	1982	1983	1984
Flathorn Station RM 22	—	—	—	1.5:1
Susitna Station RM 26	0.9:1	1.0:1	—	—
Yentna Station RM 28, TRM 04	1.2:1	2.1:1	1.5:1	0.9:1
Sunshine Station RM 80	1.0:1	0.9:1	0.9:1	0.6:1
Talkeetna Station RM 103	0.6:1	1.3:1	1.6:1	0.6:1
Curry Station RM 120	0.8:1	2.1:1	1.6:1	1.4:1

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Includes all aged and non-aged fish
Dashes indicate no survey



MIGRATIONAL TIMING OF CHUM SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: BARRETT et al. 1984)

FIGURE 14

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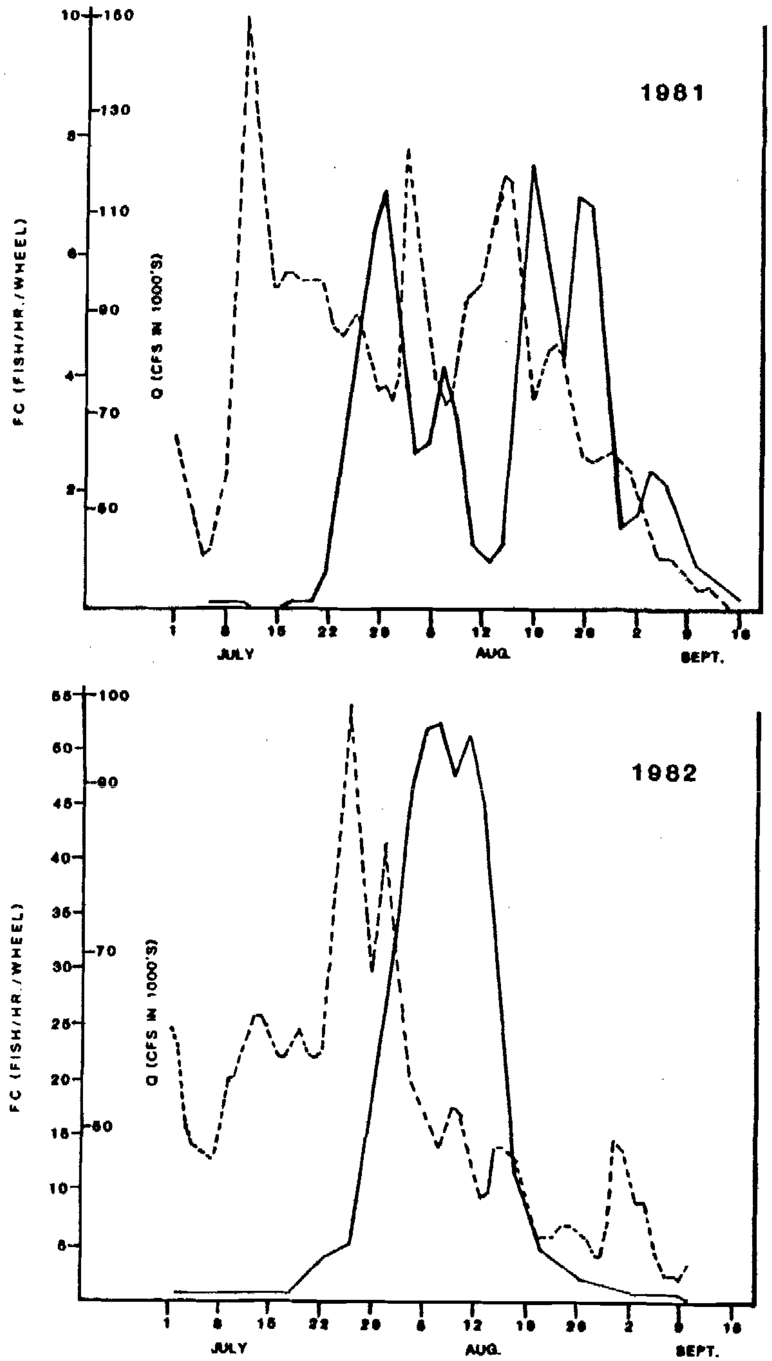
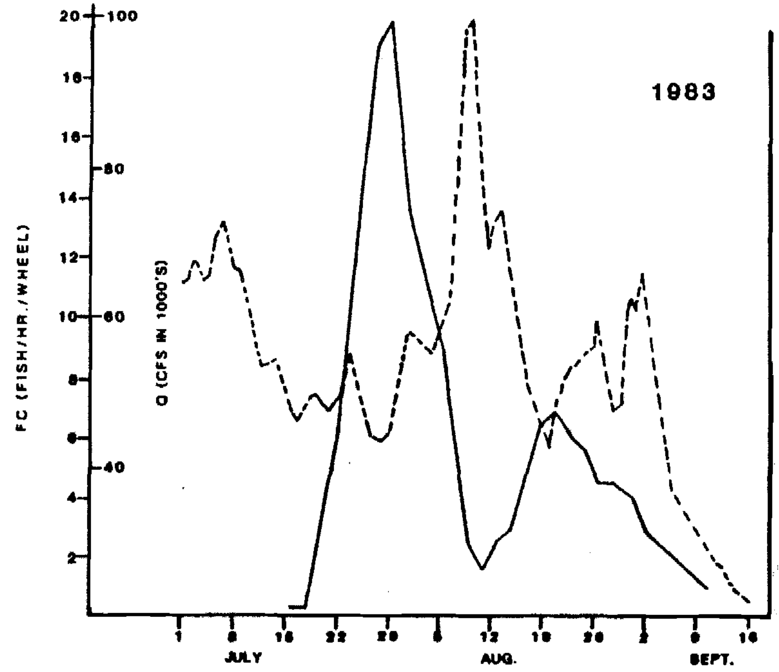
Chum salmon migration timing is likely influenced by river discharge (Barrett et al. 1984). Peak river discharge levels of 100,000 cfs or greater at Sunshine Station in 1981 and 1983 coincided with reduced fishwheel catches at Sunshine Station and apparently delayed upstream movement (Figure 15).

(ii) Escapement

For the last four years, the chum salmon minimum escapement in the Susitna River has averaged 452,200 fish (Table 6). This estimate is considered a minimum because it is based on the summation of escapements at Sunshine and Yentna stations and does not include escapements downstream of RM 80, excluding the Yentna River (RM 28). In 1984, about 812,700 chum salmon reached Flathorn Station (RM 22) (Barrett et al. 1985). This estimate can be considered the total Susitna River chum escapement because spawning downstream of RM 22 is minimal (Barrett et al. 1985). Most chum salmon spawn in the Talkeetna River drainage (RM 97.1) (Barrett et al. 1985).

The annual chum salmon escapement for 1981 through 1984 averaged 54,600 fish at Talkeetna Station (RM 103) (Table 6), with a range of 20,800 to 98,200 (Barrett et al. 1984, 1985). These escapements overestimate the number of fish that spawn upstream of RM 103 because a significant portion of the escapement returns downstream of Talkeetna Station (Barrett et al. 1984, 1985). In 1984, about 75 percent of the chum escapement to Talkeetna Station returned downstream to spawn (Barrett et al. 1985). If the 1984 escapement (98,200 fish) to Talkeetna Station is reduced to account for the milling factor, the Talkeetna-to-Devil Canyon reach accounted for about 3 percent of the 1984 total Susitna River chum escapement of 812,700 fish (Barrett et al. 1985). The milling components of the chum escapements to Talkeetna Station were not estimated in 1981, 1982, or 1983.





FISHWHEEL CATCH (FC) ————

DISCHARGE (Q) - - - - - -

COMPARISON OF CHUM SALMON FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION (RM 80), 1981-1983.

FIGURE 15

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants and ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

(iii) Migration Rate

Tagged chum salmon migrated between Sunshine Station (RM 80) and Talkeetna Station (RM 103) at an average rate of travel of 4.1 miles per day (mpd) in 1981, 4.9 mpd in 1982, 3.8 mpd in 1983 and 5.8 mpd in 1984 (Barrett et al. 1984, 1985). Chum salmon migrated between Talkeetna Station and Curry Station (RM 120) at the following rates: 4.5 mpd in 1981, 7.7 mpd in 1982, 6.3 mpd in 1983 and 8.5 mpd in 1984 (Barrett et al. 1984, 1985).

(iv) Spawning Locations

Most chum salmon spawning in the Talkeetna-to-Devil Canyon reach occurs in either slough or tributary stream habitats. In 1983 peak index counts in stream and slough habitats were about equal, while in 1981, 1982 and 1984 counts were higher in sloughs (Table 10).

Chum salmon peak index counts in sloughs upstream of RM 98.6 were: 2,596 fish in 1981, 2,244 fish in 1982, 1,467 fish in 1983 and 7,556 fish in 1984 (Table 11). Ten sloughs were occupied by spawning chum salmon in all four years (Table 11). Five of the ten (sloughs 21, 11, 8A, 9A and 9) accounted for over 70 percent of the chum salmon counted (Table 11).

Total slough escapements of chum salmon in sloughs upstream of RM 98.6 were estimated by dividing the total fish days in slough habitat by the average slough life of chum salmon (Barrett et al. 1984, 1985). The total slough escapement was about 4,500 fish in 1981, 5,100 fish in 1982, 2,950 fish in 1983 and 14,650 fish in 1984 (Table 12).

Chum salmon peak index counts in streams upstream of RM 98.6 were: 241 fish in 1981, 1,737 fish in 1982, 1,500 fish in 1983 and 3,814 fish in 1984 (Table 13). In 1981, Indian River,

Table 10. Chum salmon peak index counts by habitat type upstream of RM 98.6, 1981-1984.

Habitat Type	1981	1982	1983	1984	Four-Year Average
Mainstem[1]	14	550	219	1,266	512
Streams	241	1,737	1,500	3,814	1,823
Sloughs[2]	2,596	2,244	1,467	7,556	3,466
Total	2,851	4,531	3,186	12,636	5,802[3]

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Includes main channel and side channel habitats

[2] Includes upland slough and side slough habitats

[3] Four-year average of totals

Table 11. Chum salmon peak index counts in sloughs upstream of RM 98.6, 1981-84.

Slough	River Mile	1981	1982	1983	1984	Four-Year Average
1	99.6	6	0	0	12	5
2	100.2	27	0	49	129	51
3B	101.4	0	0	3	56	15
3A	101.9	0	0	0	17	4
4	105.2	0	0	0	0	0
5	107.6	0	2	1	0	1
6	108.2	0	0	0	0	0
6A	112.3	11	2	6	0	5
7	113.2	0	0	0	0	0
8	113.7	302	0	0	65	92
Bushrod	117.8	0	0	0	90	23
8D	121.8	0	23	1	49	18
8C	121.9	0	48	4	121	43
8B	122.2	1	80	104	400	146
Moose	123.5	167	23	68	76	84
A'	124.6	140	0	77	111	82
A	124.7	34	0	2	2	10
8A	125.1	620	336	37	917	478
B	126.3	0	58	7	108	43
9	128.3	260	300	169	350	270
9B	129.2	90	5	0	73	42
9A	133.8	182	118	105	303	177
10	133.8	0	2	1	36	10
11	135.3	411	459	238	1,586	674
12	135.4	0	0	0	0	0
13	135.9	4	0	4	22	8
14	135.9	0	0	0	1	0
15	137.2	1	1	2	100	26
16	137.3	3	0	0	15	5
17	138.9	38	21	90	66	54
18	139.1	0	0	0	11	3
19	139.7	3	0	3	45	13
20	140.0	14	30	63	280	97
21	141.1	274	736	319	2,354	921
22	144.5	0	0	114	151	66
21A	145.3	8	0	0	10	5
Total		2,596	2,244	1,467	7,556	3,466[1]

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Four-year average of totals

Table 12. Chum salmon total slough escapement upstream of RM 98.6, 1981-1984.

Slough	River Mile	1981	1982	1983	1984	Four-Year Average
1	99.6	10	0	0	46	14
2	100.2	43	0	96	188	82
3B	101.4	0	0	0	109	27
6A	112.3	19	5	0	0	6
8	113.7	695	0	0	217	228
Bushrod	117.8	0	0	0	161	40
8D	121.8	0	53	0	60	28
8C	121.9	0	108	8	207	81
8B	122.2	0	99	261	860	305
Moose	123.5	222	59	86	284	163
A'	124.6	200	0	155	217	143
A	124.7	81	0	4	8	23
8A	125.1	480	1,062	112	2,383	1,009
B	126.3	0	104	14	168	72
9	128.3	368	603	430	304	426
9B	129.2	277	12	0	132	105
10	133.8	0	0	0	90	23
9A	133.8	140	86	231	528	246
11	135.3	1,119	1,078	674	3,418	1,572
13	135.9	7	0	8	16	8
14	135.9	0	0	0	4	1
15	137.2	0	0	4	67	18
16	137.3	5	0	0	20	6
17	138.9	135	23	166	204	132
18	139.1	0	0	0	42	11
19	139.7	5	0	6	102	28
20	140.0	24	28	103	329	121
21	141.1	657	1,737	481	4,245	1,780
22	144.5	0	0	105	187	73
21A	145.3	14	0	0	38	13
Total		4,501	5,057	2,944	14,634	6,784[1]

Source: Barrett et al. 1984, 1985

[1] Four-year average of totals

Table 13. Chum salmon peak index counts in streams upstream of RM 98.6, 1981-84.

Stream	River Mile	1981	1982	1983	1984	Four-Year Average
Whiskers Creek	101.4	1	0	0	0	0
Chase Creek	106.9	1	0	0	1	1
Lane Creek	113.6	76	11	6	31	31
Lower McKenzie Creek	116.2	14	0	1	23	10
Little Portage Creek	117.7	0	31	0	18	12
Fifth of July Creek	123.7	0	1	6	2	2
Skull Creek	124.7	10	1	0	4	4
Sherman Creek	130.8	9	0	0	6	4
Fourth of July Creek	131.1	90	191	148	193	156
Indian River	138.6	40	1,346	811	2,247	1,111
Jack Long Creek	144.5	0	3	2	4	2
Portage Creek	148.9	0	153	526	1,285	491
Total		241	1,737	1,500	3,814	1,823[1]

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Four-year average of totals

Fourth of July Creek and Lane Creek accounted for 85 percent of the 241 chum salmon counted during peak surveys (Table 13). In 1982, 1983 and 1984 over 95 percent of the chum salmon counted in streams were observed in Indian River, Fourth of July Creek and Portage Creek.

Less than 10 percent of the peak survey counts of chum salmon used mainstem spawning areas in 1981 through 1984 (Table 10). Peak counts at mainstem spawning sites were: 16 fish in 1981, 550 fish in 1982, 219 fish in 1983 and 1,266 fish in 1984 (Table 10). During 1981 through 1984, 38 mainstem spawning sites were identified. Most of these were sites located during 1984. Three sites were used in three or more of the four years (Table 14).

Generally, the peak spawning activity of chum salmon occurred during the last week of August in streams and the first two weeks of September in sloughs and mainstem spawning sites in 1981 through 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

(v) <u>Access</u>

Access and passage of salmon into tributaries is controlled by conditions at stream mouths. As the stage in the mainstem decreases, the tributary mouths may become perched above the river. That is, steep deltas may form. If these steep deltas were to remain under low mainstem conditions, the upstream passage of fish into tributaries could be inhibited. Based on the analyses by R&M Consultants (1982), Trihey (1983) and Harza-Ebasco (1984), most tributaries in the Talkeetna-to-Devil Canyon reach will adjust to lower mainstem flows without detrimental effects on fish access.

Access and passage conditions into selected sloughs for chum salmon are similar to the conditions described for sockeye

Table 14. Chum salmon peak spawner counts in mainstem habitats upstream of RM 98.6, 1981-1984.

Location River Mile	Bank[1]	1981	1982	1983	1984
100.9	R				89
110.1	L				4
114.0	C				46
114.6	R		10		69
115.0	R				15
115.1	R			20	50
118.9	L			17	21
119.1	L				15
119.4	L				2
121.6	R				2
124.0	L				18
124.9	C				8
128.3	R				73
128.6	R		10		77
129.2	R	2			
129.8	R		5		18
130.0	R				5
130.5	R	3			36
131.1	L	3			81
131.3	L		12	4	57
131.5	L				102
131.7	L				20
131.8	L				18
134.6	L				2
135.1	R				8
135.2	R				40
136.1	R	6	50	110	131
136.3	R				31
136.8	R			12	6
137.4	R		25		
138.7	L				36
139.0	L		16	56	87
140.5	R				6
140.8	R				2
141.4	R				45
141.6	R				1
143.3	L		22		45
148.2	C		400		
Total		14	550	219	1,266

[1] L = Left, R = Right, C = Center as facing upstream.

Source: Barrett et al. 1984, 1985

salmon in Section 4.1.1,v. Sloughs 8A, 9, 9A, 11 and 21 have accounted for over two-thirds of the total peak counts of chum salmon in slough habitats during 1981 through 1984 (Table 11). Breaching and backwater effects at sloughs 8A, 11 and 21 have been mentioned previously (Section 4.1.1). At Slough 9, breaching occurs at 16,000 cfs (Sautner et al. 1984). Below the breaching discharge, Passage Reach I has successful passage conditions at a discharge less than 12,000 cfs (Sautner et al. 1984). The breaching and backwater effects on passage conditions have not been evaluated at Slough 9A (Sautner et al. 1984).

(vi) Fecundity and Sex Ratio

The mean fecundity for Susitna River chum salmon is 2,850 eggs per female (Barrett et al. 1984). This estimated fecundity is derived from the regression analysis of fecundity as a function of length and from the mean length of females sampled at Sunshine Station (Barrett et al. 1984).

The egg retention of chum salmon was estimated in 1983 from sampling 229 female carcasses in 12 sloughs and one main channel spawning site between river miles 98.6 and 161 (Barrett et al. 1984). The median retention was about 114 eggs per female (Barrett et al. 1984). Almost 75 percent of the carcasses had retained 25 or fewer eggs, while less than four percent of the fish sampled had retained more than 1,000 eggs each (Barrett et al. 1984). In 1984, the average egg retention for 215 fish was 463 eggs per female (Barrett et al. 1985). Over 75 percent of the fish sampled had completed spawning (Barrett et al. 1985).

The sex ratio (male to female) of chum salmon in the Susitna River was 1.0:1 in 1981, 1.1:1 in 1982, 1.2:1 in 1983 and 1.2:1 in 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Sex ratios varied between locations and years (Table 15). Sex

Table 15. Sex ratios of chum salmon at Flathorn, Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1984.

Location/ River Mile	Sex ratio (M:F)[1]			
	1981	1982	1983	1984
Flathorn Station RM 22	----	----	----	1.1:1
Susitna Station RM 26	0.6:1	0.7:1	----	----
Yentna Station RM 28, TRM 04	1.0:1	1.3:1	1.3:1	0.7:1
Sunshine Station RM 80	0.8:1	1.0:1	1.0:1	1.1:1
Talkeetna Station RM 103	1.3:1	1.9:1	1.5:1	1.4:1
Curry Station RM 120	1.1:1	1.1:1	1.9:1	2.0:1

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Includes all aged and non-aged fish
Dashes indicate no survey

ratios by age are reported by ADF&G (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Most returning adult chum were four or five year old fish that had gone to sea during their first summer of life.

4.1.3 Coho Salmon

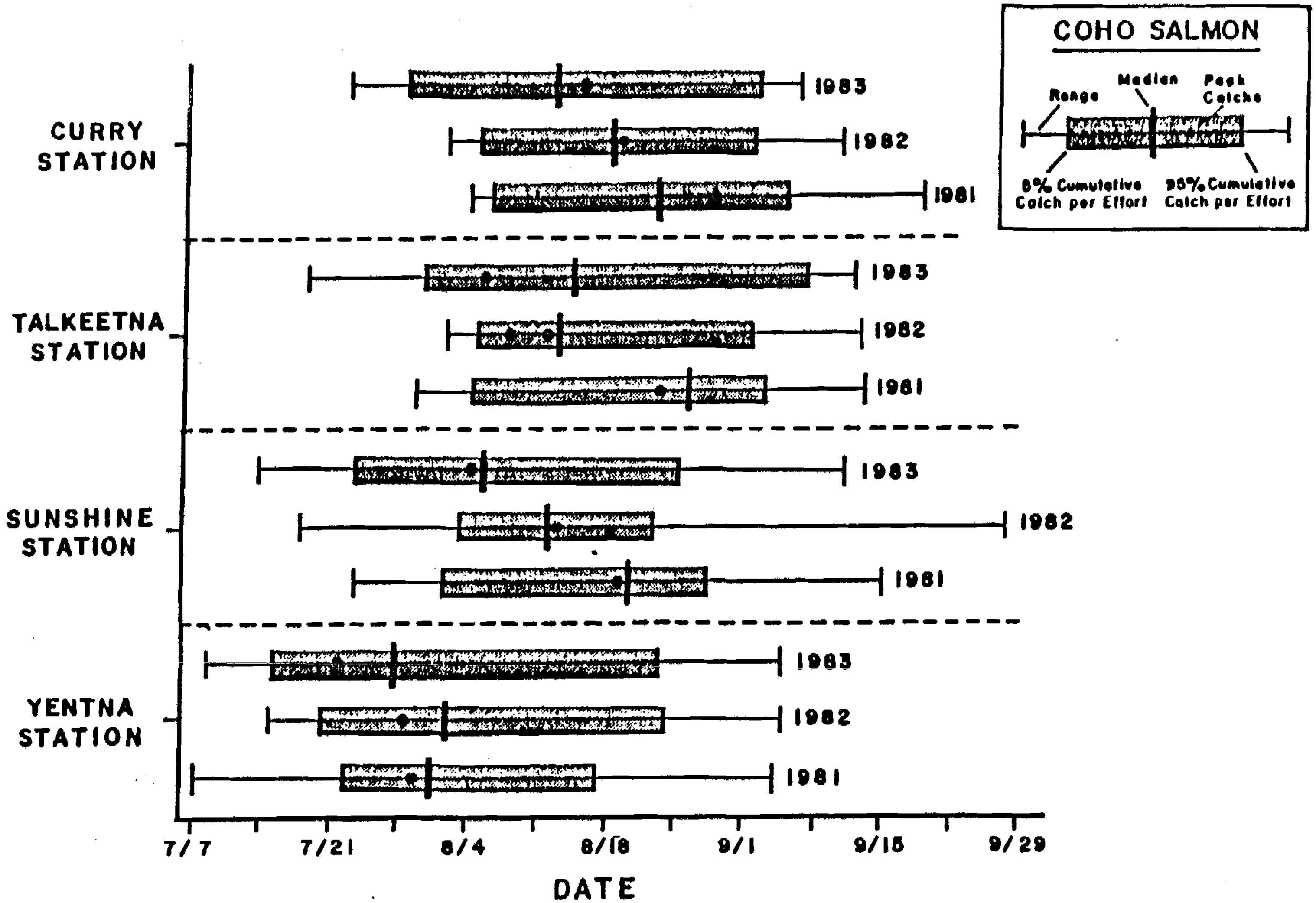
(i) Timing of Run

Coho salmon enter the Susitna River about mid-July and are abundant in the lower river at Yentna Station (RM 28, TRM 04) from the third week of July until the third week of August (Barrett et al. 1984, 1985). Coho salmon are numerous in the mainstem of the Talkeetna-to-Devil Canyon reach (RM 98.6-152) from the last week of July to the first week of September (Barrett et al. 1984, 1985). A summary of coho migration timing in the Susitna River for 1981, 1982 and 1983 is presented in Figure 16.

Coho salmon migration timing may be influenced by river discharge (Barrett et al. 1984). In 1981 and 1983 discharge levels of 100,000 cfs or greater at Sunshine Station coincided with reduced fishwheel catches at Sunshine Station and apparently delayed the upstream migration of coho salmon (Figure 17).

(ii) Escapement

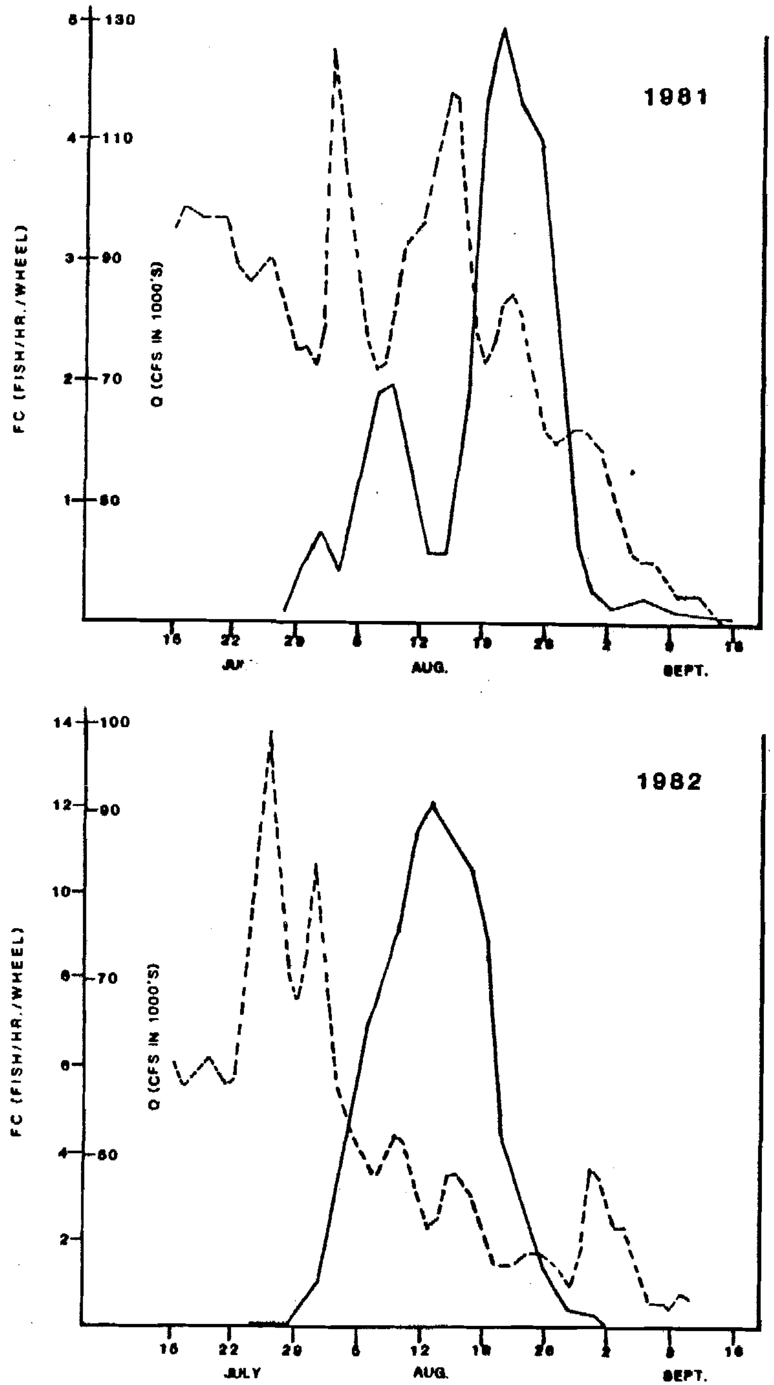
The minimum coho salmon total escapement in the Susitna River basin has averaged 63,400 fish for 1981 through 1984 (Table 6). This estimate is based on the summation of escapements at Sunshine and Yentna stations and does not include escapements downstream of RM 80, excluding the Yentna River (RM 28). In 1984, about 190,100 coho salmon reached Flathorn Station (RM 22) (Barrett et al. 1985). This estimate is based on data from the first year of monitoring at this location and does not

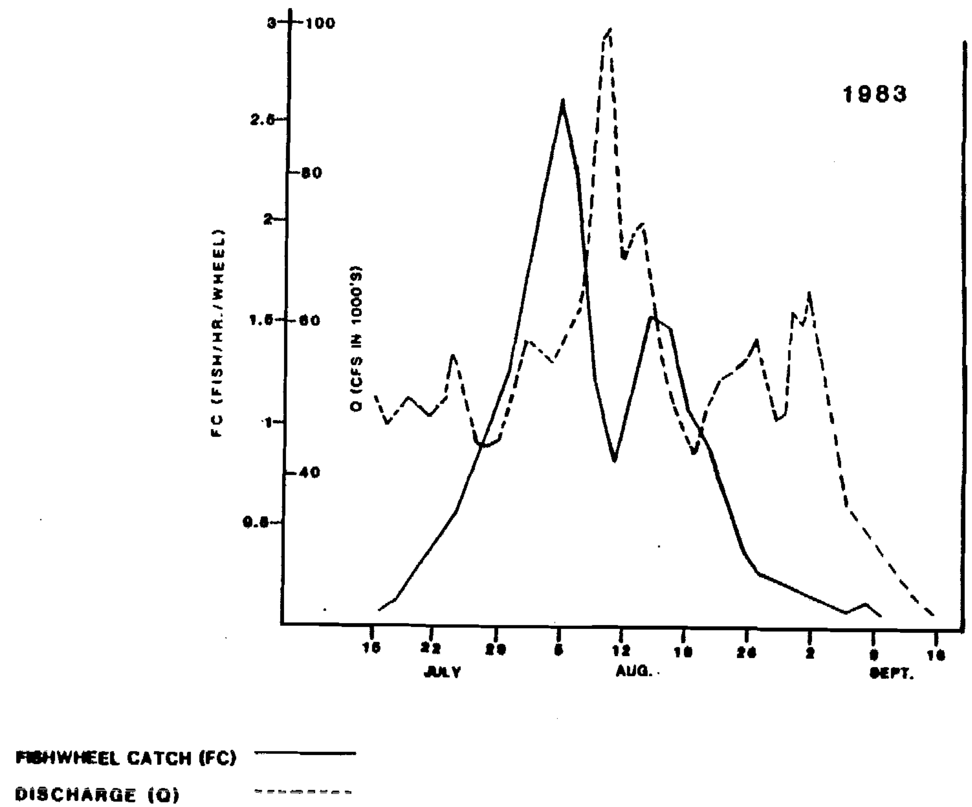


MIGRATIONAL TIMING OF COHO SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: BARRETT et al. 1984)

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants **and** **ENTRIX, INC.**	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 16





COMPARISON OF COHO SALMON FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION (RM 80), 1981-1983.

FIGURE 17

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include escapements downstream of RM 22 (Barrett et al. 1985). Most coho salmon in the Susitna River spawn in tributaries downstream of RM 80 (Barrett et al. 1985).

The annual coho salmon escapement for 1981 through 1984 averaged 5,700 fish at Talkeetna Station (RM 103) (Table 6), with a range of 2,400 to 11,800 (Barrett et al. 1984, 1985). These escapements overestimate the number of fish that spawn upstream of RM 103 because a significant number of fish return downstream below Talkeetna Station (Barrett et al. 1984, 1985). In 1984, approximately 75 percent of the coho escapement to Talkeetna Station returned downstream to spawn (Barrett et al. 1985). If the 1984 escapement (11,800 fish) to Talkeetna Station is reduced to account for the milling component of the run, the Talkeetna-to-Devil Canyon reach accounted for less than 2 percent of the 1984 coho escapement to Flathorn Station (Barrett et al. 1985). The milling components of the coho escapements to Talkeetna Station were not estimated in 1981, 1982, or 1983.

(iii) Migration Rate

Tagged coho salmon traveled from Sunshine Station (RM 80) to Talkeetna Station (RM 103) at average rates of 4.0 miles per day (mpd) in 1981, 5.3 mpd in 1982, 1.4 mpd in 1983 and 2.9 mpd in 1984 (Barrett et al. 1984, 1985). Coho salmon migrated between Talkeetna Station and Curry Station (RM 120) at an average rate of: 11.3 mpd in 1981, 10.0 mpd in 1982, 5.7 mpd in 1983 and 2.8 mpd in 1984 (Barrett et al. 1984, 1985).

(iv) Spawning Locations

Almost all coho salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) spawn in tributaries (Barrett et al. 1984, 1985). Only seven coho salmon have been observed spawning in mainstem and slough habitats. In 1981, one fish was captured in the mainstem at RM 129.2, in 1983 two coho salmon were observed spawning in the mainstem at RM 131.1 and in 1984 two fish were observed in the mainstem at RM 131.5. Two fish were observed spawning in Slough 8A (RM 125.1) on October 2, 1982 (ADF&G 1982a).

Coho salmon peak index counts in tributary streams upstream of RM 98.6 were: 458 fish in 1981, 633 fish in 1982, 240 fish in 1983 and 1,434 fish in 1984 (Barrett et al. 1984, 1985). Twelve tributary streams upstream of RM 98.6 contained coho salmon during index surveys in 1981 through 1984. Peak index counts greater than 10 fish in all four years were recorded in: Whiskers Creek, Chase Creek, Gash Creek, Lower McKenzie Creek, Indian River and Portage Creek (Table 16). The two most important tributary streams for coho spawning were: Gash Creek and Indian River in 1981, Whiskers Creek and Lower McKenzie Creek in 1982, Whiskers Creek and Indian River in 1983 and Indian River and Whiskers Creek in 1984.

Coho spawning in tributary streams upstream of RM 98.6 usually occurred between the last week of August and the first week of October in 1981, 1982, 1983 and 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

(v) Access

Passage conditions into tributaries for coho salmon are similar to the conditions described for chum salmon (see Section 4.1.2,v).

(vi) Fecundity and Sex Ratio

The mean fecundity of coho salmon in the Susitna River is 2,800 eggs per female (Barrett et al. 1985). This estimated fecundity is derived from the regression analysis of fecundity

Table 16. Coho salmon peak index counts in streams upstream of RM 98.6, 1981-1984.

Stream	River Mile	1981	1982	1983	1984	Four-Year Average
Whiskers Creek	101.4	70	176	115	301	166
Chase Creek	106.9	80	36	12	239	92
Slash Creek	111.2	0	6	2	5	3
Gash Creek	111.6	141	74	19	234	117
Lane Creek	113.6	3	5	2	24	9
Lower McKenzie Creek	116.2	56	133	18	24	58
Little Portage Creek	117.7	0	8	0	0	2
Fourth of July Creek	131.1	1	4	3	8	4
Gold Creek	136.7	0	1	0	0	0
Indian River	138.6	85	101	53	465	176
Jack Long Creek	144.5	0	1	1	6	2
Portage Creek	148.9	22	88	15	128	63
Total		458	633	240	1,434	691[1]

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Four-year average of totals

as a function of length and from the mean length of coho salmon females sampled at Sunshine Station (Barrett et al. 1985).

The sex ratio (male to female) of coho salmon in the Susitna River was 0.9:1 in 1981, 1.4:1 in 1982, 1.3:1 in 1983 and 1.2:1 in 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). The sex ratios varied between years and sites (Table 17). Sex ratios of coho salmon by age are reported by ADF&G (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Most returning adult coho were three or four year old fish that had gone to sea after one or two years in freshwater (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

4.1.4 Pink Salmon

(i) Timing of Run

Pink salmon enter the Susitna River in late June to early July and are present in the lower river at Yentna Station (RM 28, TRM 04) between the second week of July and the third week of August (Barrett et al. 1984, 1985). In the Talkeetna-to-Devil Canyon sub-basin (RM 98.6-152), the pink salmon migration in the mainstem lasts about 4 weeks from the fourth week of July to the third week of August (Barrett et al. 1984, 1985). A summary of pink migration timing in the Susitna River for 1981, 1982 and 1983 is presented in Figure 18.

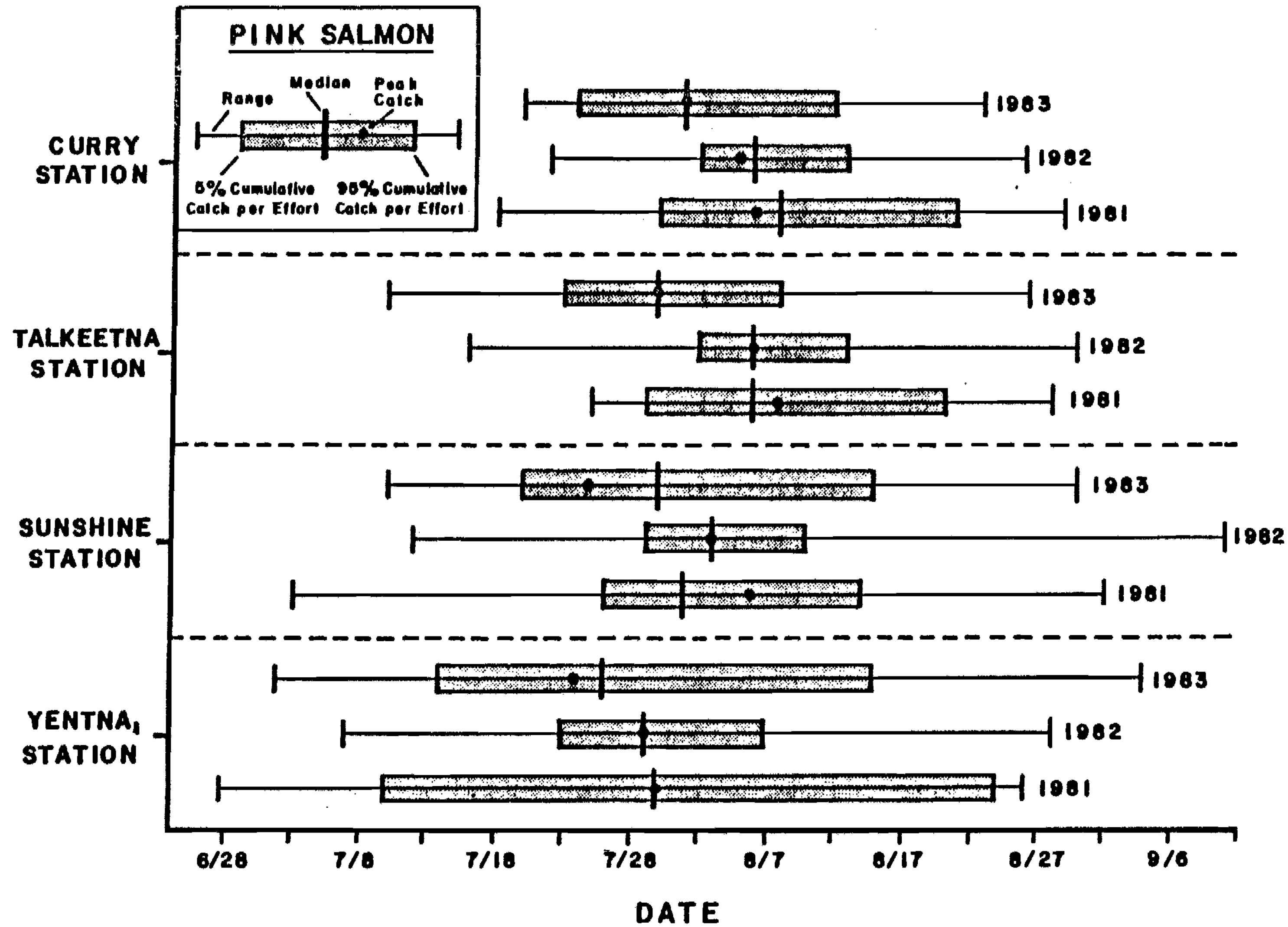
Upstream movements of pink salmon are likely influenced by peak discharge levels. River discharge levels of 100,000 cfs or greater at Sunshine Station coincided with reduced fishwheel catches at Sunshine Station in 1981 and 1983 and apparently delayed the migrations (Figure 19).

Table 17. Sex ratios of coho salmon at Flathorn, Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1984.

Location/ River Mile	Sex ratio (M:F)[1]			
	1981	1982	1983	1984
Flathorn Station RM 22	---	---	---	1.4:1
Susitna Station RM 26	0.8:1	0.6:1	---	---
Yentna Station RM 28, TRM 04	0.9:1	2.4:1	2.3:1	0.8:1
Sunshine Station RM 80	0.7:1	1.4:1	1.2:1	1.2:1
Talkeetna Station RM 103	1.5:1	1.5:1	1.7:1	1.1:1
Curry Station RM 120	2.0:1	1.3:1	2.0:1	1.1:1

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Includes all aged and non-aged fish
Dashes indicate no survey



MIGRATIONAL TIMING OF PINK SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: BARRETT et al. 1984)

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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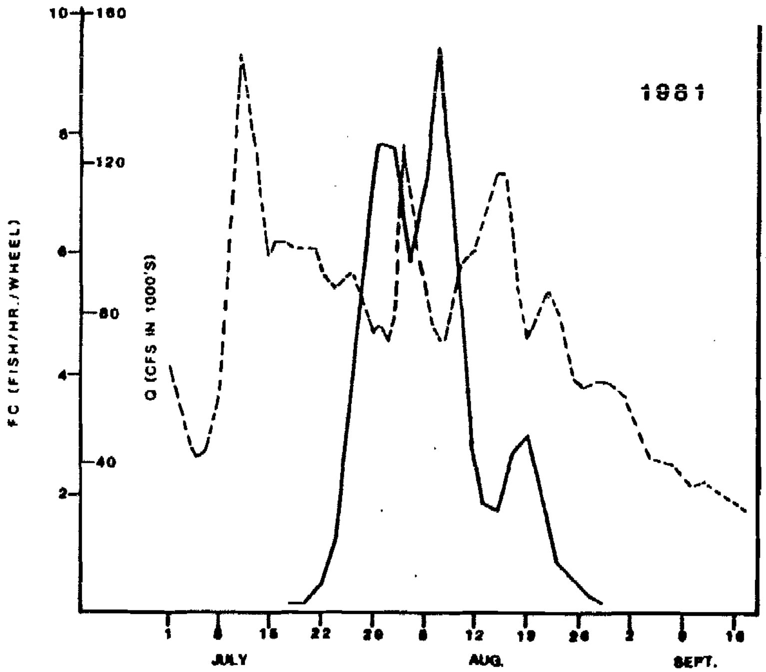
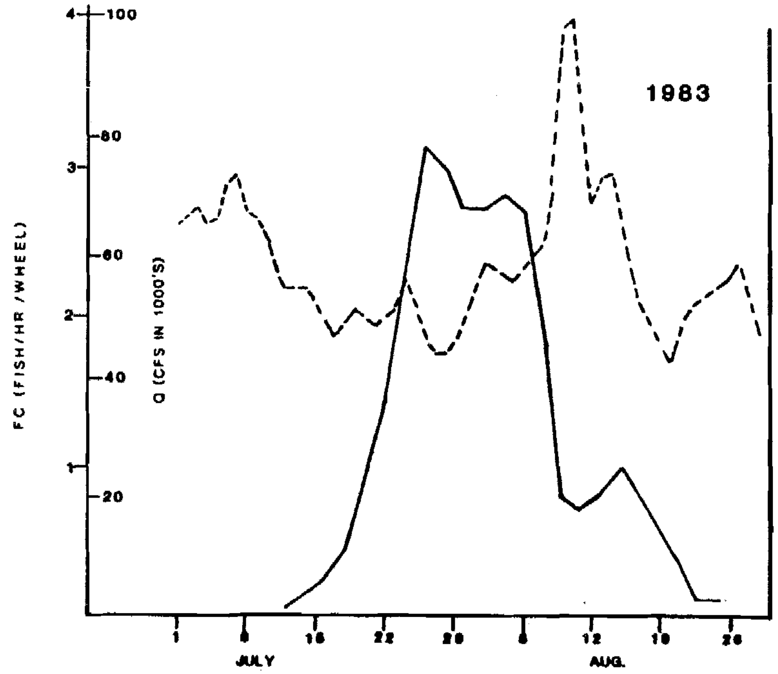
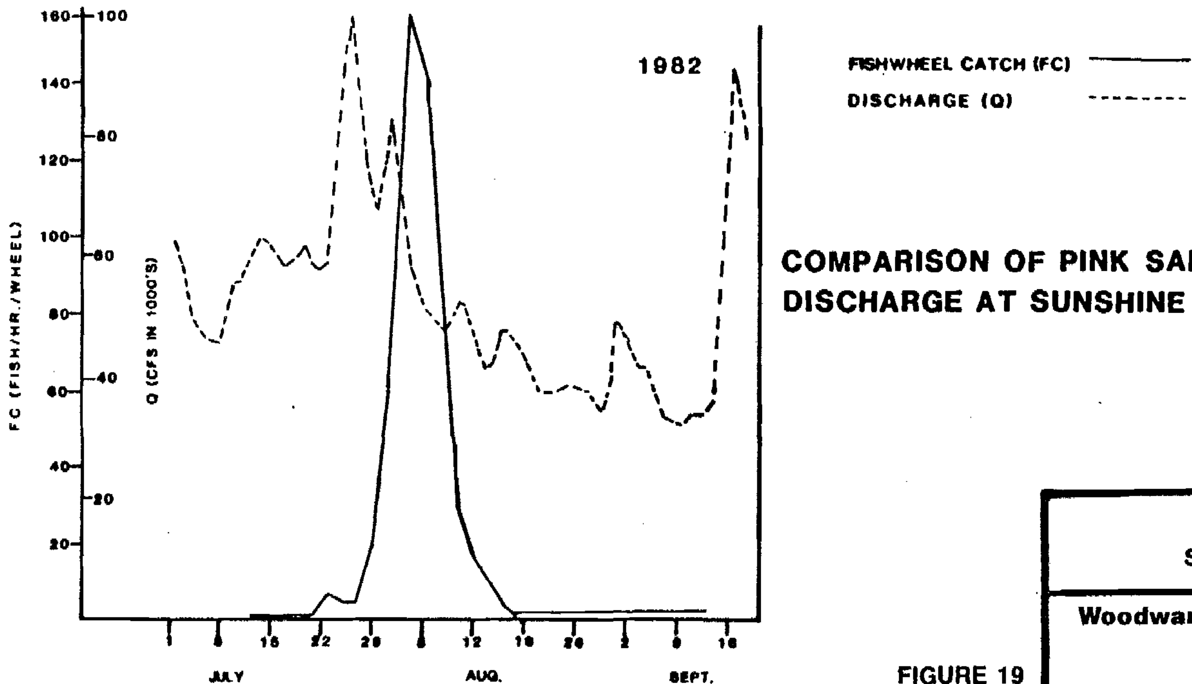
FIGURE 18







COMPARISON OF PINK SALMON FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION (RM 80), 1981-1983.

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FIGURE 19

(ii) Escapement

Pink salmon have a two-year life cycle that results in two genetically distinct stocks occurring in each stream. In the Susitna Basin, the even-year runs are numerically dominant (Barrett et al. 1984, 1985). The odd-year pink salmon minimum escapement in the Susitna River averaged 93,400 fish for 1981 and 1983, while the even-year minimum escapement averaged 1,138,400 fish for 1982 and 1984 (Table 6). These estimates are based on the summation of escapements at Yentna and Sunshine Stations and do not include escapements downstream of RM 80, excluding the Yentna River (RM 28). In 1984, about 3,629,900 pink salmon reached Flathorn Station (RM 22) (Barrett et al. 1985). This estimate is based on data from the first year of monitoring at this location and does not include escapements downstream of RM 22 (Barrett et al. 1985). Most pink salmon in the Susitna River spawn downstream from the Chulitna River confluence (RM 98.6) (Barrett et al. 1984, 1985).

The 1981 and 1983 odd-year pink salmon escapements averaged 5,900 fish annually at Talkeetna Station (RM 103) (Table 6), with a range of 2,300 to 9,500 fish (Barrett et al. 1984, 1985). The even-year escapement at Talkeetna Station was 177,900 fish in 1982 and 73,000 fish in 1984 (Barrett et al. 1984, 1985). The escapements at Talkeetna Station overestimate the number of fish that spawn upstream of RM 103 because a significant number of fish return downstream below Talkeetna Station (Barrett et al. 1984, 1985). In 1984, about 85 percent of the pink escapement to Talkeetna Station returned downstream to spawn (Barrett et al. 1985). If the 1984 escapement (177,900 fish) to Talkeetna Station is reduced to account for the milling factor, the Talkeetna-to-Devil Canyon reach accounted for less than 1 percent of the 1984 pink escapement to Flathorn Station (Barrett et al. 1985). The milling components of the pink escapements to Talkeetna Station were not estimated in 1981, 1982, or 1983.

(iii) Migration Rate

Tagged pink salmon migrated from Sunshine Station (RM 80) to Talkeetna Station (RM 103) at average rates of speed of 2.6 miles per day (mpd) in 1981, 7.4 mpd in 1982, 5.9 mpd in 1983 and 5.9 mpd in 1984 (Barrett et al. 1984, 1985). The average rates of travel increased between Talkeetna Station and Curry Station (RM 120): 6.0 mpd in 1981, 10.0 mpd in 1982, 7.1 mpd in 1983 and 9.4 mpd in 1984 (Barrett et al. 1984, 1985).

(iv) Spawning Locations

The majority of pink salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) spawn in tributaries (Barrett et al. 1984, 1985). Peak index counts for streams upstream of RM 98.6 were 378 fish in 1981, 2,855 fish in 1982, 1,329 fish in 1983 and and 17,505 fish in 1984 (Table 18). In 1981, Lane Creek, Chase Creek and Fourth of July Creek accounted for almost 95 percent of the total peak counts of 378 fish. In 1982, when the pink salmon escapement in the Susitna River was at an even-year high, eight streams accounted for almost 93 percent of the total count of 2,855 fish (Table 18). Indian River, Portage Creek and Fourth of July Creek were the most important pink salmon spawning streams in 1983; the three streams collectively had a peak index count of 1,249 fish, or about 94 percent of the total peak count of 1,329 fish. In 1984, 85 percent of the total peak count in streams was observed in Indian River, Portage Creek, Fourth of July Creek, and Lower McKenzie Creek (Barrett et al. 1985). Spawning activity in streams occurred primarily during the first three weeks of August in all four years (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

Table 18. Pink salmon peak index counts in streams upstream of RM 98.6, 1981-1984.

Stream	River Mile	1981	1982	1983	1984	Odd-Year Average	Even-Year Average
Whiskers Creek	101.4	1	138	0	293	1	216
Chase Creek	106.9	38	107	6	438	22	273
Slash Creek	111.2	0	0	0	3	0	2
Gash Creek	111.6	0	0	0	6	0	3
Lane Creek	113.6	291	640	28	1,184	160	912
Clyde Creek	113.8	0	0	0	34	0	17
Maggot Creek	115.6	0	0	0	107	0	54
Lower McKenzie Cr.	116.2	0	23	17	585	9	304
McKenzie Creek	116.7	0	17	0	11	0	14
Little Portage Cr.	117.7	0	140	7	162	4	151
Fromunda Creek	119.3	0	0	0	40	0	20
Downunda Creek	119.4	0	0	0	6	0	3
Deadhorse Creek	120.8	0	0	0	337	0	169
Tulip Creek	120.9	0	0	0	8	0	4
Fifth of July Cr.	123.7	2	113	9	411	6	262
Skull Creek	124.7	8	12	1	121	5	67
Sherman Creek	130.8	6	24	0	48	3	36
Fourth of July Cr.	131.1	29	702	78	1,842	54	1,272
Gold Creek	136.7	0	11	7	82	4	47
Indian River	138.6	2	738	886	9,066	444	4,902
Jack Long Creek	144.5	1	21	5	14	3	18
Portage Creek	148.9	0	169	285	2,707	143	1,438
Total		378	2,855	1,329	17,505	854[1]	10,180[2]

Source: Barrett et al. 1984, 1985

[1] Odd-year average of totals

[2] Even-year average of totals

Pink salmon were observed spawning in slough habitat in 1981, 1982 and 1984. Total slough escapement upstream of RM 98.6 in 1981 was 38 fish in Slough 8 (Table 19). In 1982, total slough escapement upstream of RM 98.6 was 297 fish in seven sloughs (Table 19). Two of the seven sloughs (11 and 20) accounted for over 80 percent of the escapement. No pink salmon were observed spawning in sloughs in 1983; fish counted in slough habitat during spawning surveys were considered milling fish (Barrett et al. 1984). In 1984, the total pink salmon escapement upstream of RM 98.6 was 647 fish (Table 19). The three most important sloughs were: 8A, 11 and 20. In 1981 the peak of spawning activity in sloughs occurred about the last week of August, in 1982 it occurred during the first three weeks of August and in 1984 it ranged from the second week of August to the first week of September (ADF&G 1981a, 1982a; Barrett et al. 1985).

(v) Access

Passage conditions of salmon into sloughs and tributaries in the Talkeetna-to-Devil Canyon reach have been discussed previously (see Sections 4.1.1,v and 4.1.2,v).

Sloughs 8A, 11 and 20 appear to be important pink salmon spawning areas (Table 19). Breaching and backwater effects at Sloughs 8A and 11 have been discussed previously (see Section 4.1.1,v). The upstream passage of salmon into Slough 20 is apparently provided for by the local flow from Waterfall Creek (Sautner et al. 1984). Most pink salmon spawning occurs below Waterfall Creek (Sautner et al. 1984, 1985).

(vi) Fecundity and Sex Ratio

The predicted fecundity for Susitna River pink salmon is about 1,350 eggs per female, which is based on the regression

Table 19. Pink salmon total slough escapement upstream of RM 98.6, 1981-1984.

Slough	River Mile	1981	1982	1983	1984	Odd-Year Average	Even-Year Average
3B	101.4	0	0	0	34	0	17
3A	101.9	0	0	0	67	0	34
5	107.6	0	0	0	5	0	3
8	113.7	38	0	0	0	19	0
Bushrod	117.8	0	0	0	12	0	6
8B	122.2	0	0	0	82	0	41
Moose	123.5	0	2	0	0	0	1
A'	124.6	0	0	0	29	0	15
8A	125.1	0	5	0	161	0	83
B	126.3	0	18	0	0	0	9
9	128.3	0	18	0	0	0	9
11	135.3	0	170	0	145	0	158
20	140.0	0	75	0	102	0	89
21	141.1	0	9	0	10	0	10
Total		38	297	0	647	19[1]	472[2]

Source: Barrett et al. 1984, 1985

[1] Odd-year average of totals

[2] Even-year average of totals

analysis of fecundity as a function of length and the mean length of all female pink salmon measured at Sunshine Station in 1983 (Barrett et al. 1984).

The sex ratio (male to female) of all pink salmon sampled in the Susitna River was: 0.8:1 in 1981, 1.4:1 in 1982, 0.9:1 in 1983 and 1.3:1 in 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Sex ratios at sampling locations in the Susitna River for 1981 through 1984 are presented in Table 20. All pink salmon returning to the Susitna River are two year old fish that went to sea in their first summer of life (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

4.1.5 Chinook Salmon

(i) Timing of Run

Chinook salmon enter the Susitna River in late May to early June. In the lower river, most chinook (over 90 percent) have migrated past Susitna Station (RM 26) by July 1 (ADF&G 1972). The chinook salmon migration at Sunshine Station (RM 80) lasts for about one month between early June and early July (Barrett et al. 1984, 1985). In the Talkeetna-to-Devil Canyon reach (RM 98.6-152), the chinook migration in the mainstem lasts for about one month from mid-June to mid-July. A summary of chinook migration timing in the Susitna River for 1981, 1982 and 1983 is presented in Figure 20.

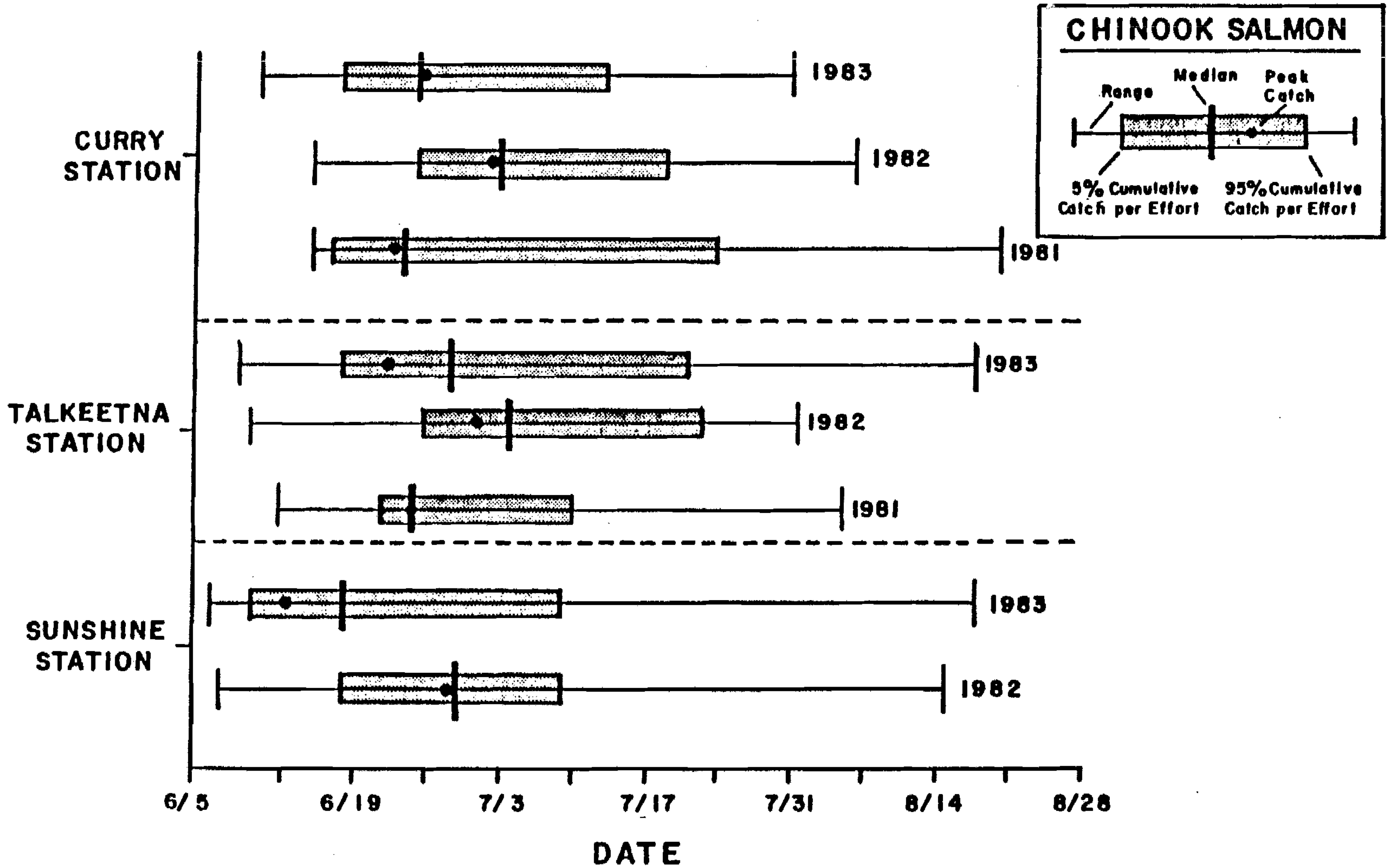
Chinook migration timing may be influenced by river discharge (ADF&G 1982a). During 1981 and 1982 river discharge peaks coincided with reduced fishwheel catches at Sunshine Station

Table 20. Sex ratios of pink salmon at Flathorn, Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1984.

Location/ River Mile	Sex ratio (M:F) 1981	1982	1983	1984
Flathorn Station RM 22	---	---	---	1.3:1
Susitna Station RM 26	0.4:1	0.9:1	---	---
Yentna Station RM 28, TRM 04	0.8:1	1.0:1	0.9:1	1.2:1
Sunshine Station RM 80	0.8:1	1.8:1	1.0:1	1.1:1
Talkeetna Station RM 103	1.2:1	1.6:1	0.8:1	1.1:1
Curry Station RM 120	0.8:1	1.5:1	1.0:1	1.6:1

Source: Barrett et al. 1984, 1985

Dashes indicate no survey



MIGRATIONAL TIMING OF CHINOOK SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: BARRETT et al. 1984)

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FIGURE 20

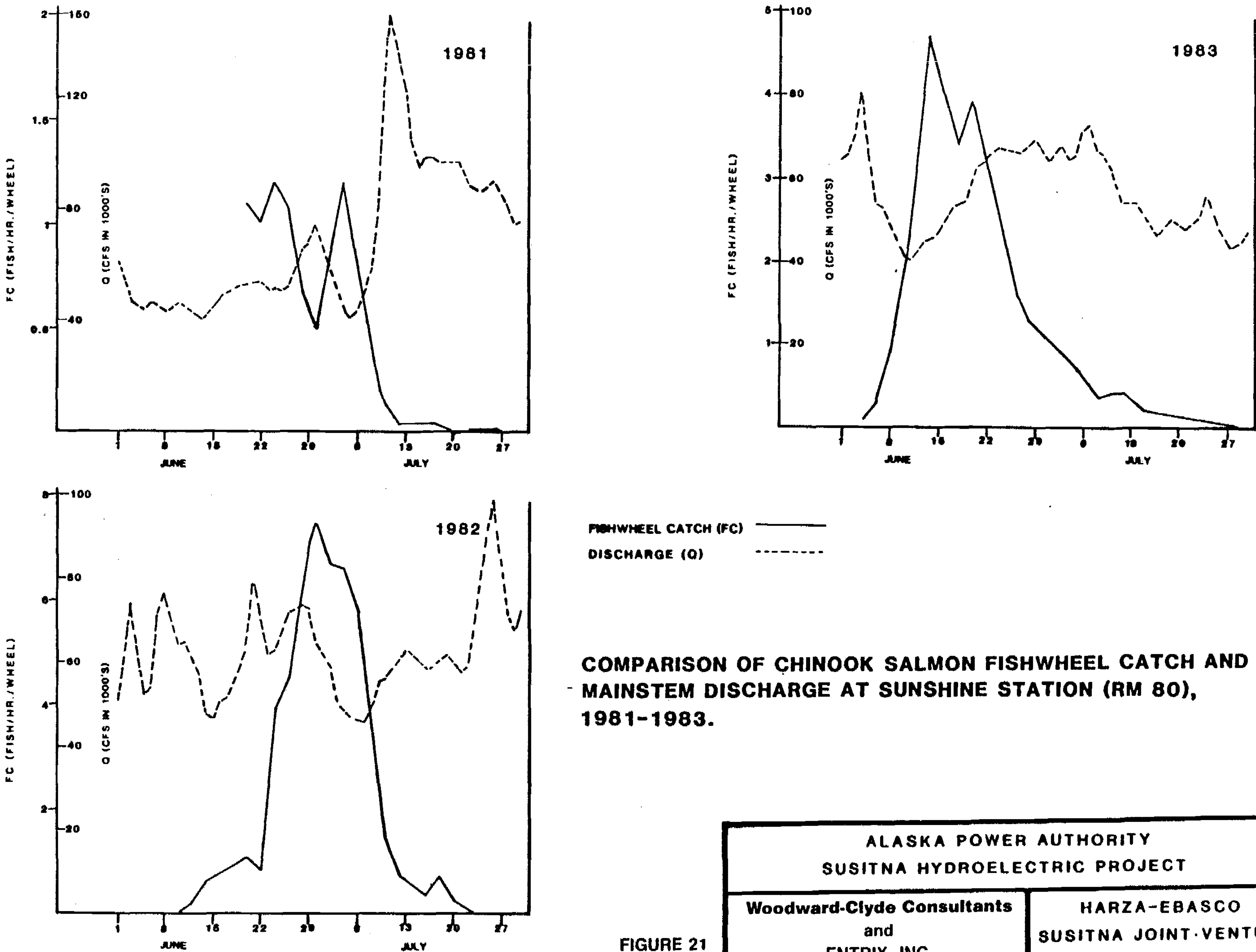
(Figure 21). However, in 1983 reduced fishwheel catches during the chinook migration did not coincide with the peak river discharges. The relationship of river discharge (above 100,000 cfs) with reduced fishwheel catches at Sunshine Station is not as clear for chinook salmon as it is for sockeye, chum, coho and pink salmon.

(ii) Escapement

The minimum chinook salmon escapement in the Susitna River in 1983 was approximately 125,000 fish. This estimate is based on 1983 chinook stream surveys (Table 21) (Barrett et al. 1984) and the relationship that a peak chinook survey count represents at most 52 percent of the total escapement (Neilsen and Geen 1981). The total escapement derived by this method should be viewed as an approximation because: (1) the 1983 surveys did not include all known chinook spawning streams in the Susitna Basin (Barrett et al. 1984); (2) counts may not represent peak numbers as some streams were surveyed only once; and (3) the relationship that a peak survey count represents at most 52 percent of the total escapement may not apply to Susitna River chinook. In 1984, the chinook salmon total escapement in the Susitna River was about 250,000 fish (Barrett et al. 1985). This estimate is based on the estimated escapement to Sunshine Station (RM 80) of 121,700 fish and stream surveys (Barrett et al. 1985).

The annual chinook salmon escapements at Talkeetna Station (RM 103) for 1982 through 1984 averaged 16,700 fish (Table 6), with a range of 10,900 to 24,800 (Barrett et al. 1984, 1985). These escapements overestimate the number of fish that spawn upstream of RM 103 because a significant part of the escapement returns downstream below Talkeetna Station (Barrett et al. 1984, 1985).

In 1984, about 45 percent of the chinook escapement to Talkeetna station (RM 103) returned downstream to spawn



COMPARISON OF CHINOOK SALMON FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION (RM 80), 1981-1983.

FIGURE 21

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Table 21. Chinook salmon peak survey escapement counts of Susitna River streams by sub-basin from 1976 to 1984.

Sub-basin	1976	1977	1978	1979	1980	1981	1982	1983	1984
Lower Susitna sub-basin[1]									
Alexander Creek	5,412	9,246	5,854	6,215	a	a	2,546	3,755	4,620
Deshka River	21,693	39,642	24,639	27,385	a	a	16,000[e]	19,237	16,892
Goose Creek	160	133	283	b	a	262	140[d]	477	258
Kashwitna River (North Fork)	203	336	362	457	a	557	156[d]	297	111[c]
Little Willow Creek	833	598	436	324[c]	a	459	316[d]	1,042	b
Montana Creek	1,445	1,443	881	1,094[c]	a	814	887[d]	1,641	2,309
Sheep Creek	455	630	1,209	778	a	1,013	527[d]	945	1,028
Sucker Creek (Alexander Creek)	b	b	b	b	b	b	b	597	b
Willow Creek	1,660	1,065	1,661	1,086	a	1,357	592[d]	777	2,789
Wolverine Creek (Alexander Creek)	b	b	b	b	b	b	b	491	b
Subtotal	31,861	53,093	35,325	37,339	----	4,462	21,164	29,259	28,007
Yentna sub-basin[2]									
Camp Creek (Lake Creek)	b	b	b	b	b	b	b	1,050	b
Canyon Creek	44	135	b	b	b	84	b	575	b
Lake Creek	3,735	7,391	8,931	4,196	a	a	3,577	7,075	a
Peters Creek	2,280	4,102	1,335	a	a	a	a	2,272	a
Quartz Creek	b	8	b	b	b	8	b	b	b
Red Creek	b	1,511	385	b	b	749	b	b	b
Sunflower Creek (Lake Creek)	b	b	b	b	b	b	b	2,250	b
Talachulitna River	1,319	1,856	1,375	1,648	a	2,129	3,101	10,014	6,138[c]
Subtotal	7,378	15,003	12,026	5,844	----	2,970	6,678	23,236	6,138
Talkeetna-Chulitna sub-basin[3]									
Bunco Creek	112	136	a	58	a	a	198	523	51[d]
Byers Creek	53	69	a	28	a	a	7[d]	b	39
Chulitna River	124	229	62	a	a	a	100[d]	b	b
Chulitna River (East Fork)	112	168	59	a	a	a	119[d]	b	b

Table 21. (Continued)

Sub-basin	1976	1977	1978	1979	1980	1981	1982	1983	1984
Chulitna River (Middle Fork)	1,870	1,782	900	a	a	a	644[d]	3,846	4,191
Clear Creek (Chunilna)	1,237	769	997	864[c]	a	a	982	806	1,520[c]
Honolulu Creek	24	36	13	37	a	a	27[d]	b	b
Prairie Creek	6,513	5,790	5,154	a	a	1,900	3,844	3,200[e]	9,000
Troublesome Creek	92	95	a	a	a	a	36[d]	b	b
Subtotal	10,137	9,074	7,185	987	---	1,900	5,957	8,375	14,801
Talkeetna-Devil Canyon sub-basin[4]									
Chase Creek	b	b	b	b	b	b	15	15	3
Cheechako Creek[5]	b	b	b	b	b	b	16	25	29
Chinook Creek[5]	b	b	b	b	b	b	5	8	15
Devil Creek[5]	b	b	b	b	b	b	b	1	0
Fifth of July Creek	b	b	b	b	b	b	b	b	17
Fog Creek[5]	b	b	b	b	b	b	b	b	2
Fourth of July Creek	b	b	b	b	b	b	56	6	92
Gold Creek	b	b	b	b	b	b	21	23	23
Indian River	537	393	114	285	a	422	1,053	1,193	1,456
Jack Long Creek	b	b	b	b	b	b	2	6	7
Lane Creek	b	b	b	b	b	40	47	12	23
Portage Creek	702	374	140	190	a	659	1,253	3,140	5,446
Whiskers Creek	b	b	b	b	b	b	b	3	67
Subtotal	1,239	767	254	475	---	1,121	2,474	4,432	7,180
TOTAL	50,615	77,937	54,790	44,645	---	10,453	36,273	65,302	56,126

[a] No total count due to high turbid water
[b] Not counted
[c] Poor counting conditions
[d] Counts conducted after peak spawning
[e] Estimated peak spawning count

[1] RM 0-80, excluding the Yentna sub-basin
[2] RM 28, Yentna River drainage
[3] RM 80-98.6
[4] RM 98.6-152
[5] Above RM 152

(Barrett et al. 1985). If the 1984 escapement (24,800) to Talkeetna Station is reduced to account for the milling factor, the Talkeetna-to-Devil Canyon reach accounted for about 5 percent of the 1984 Susitna River chinook escapement (Barrett et al. 1985). The milling components of the chinook escapements to Talkeetna Station were not estimated in 1982 and 1983. Chinook salmon escapements at Talkeetna Station (and at the other sampling locations in the Susitna River) were not estimated in 1981.

(iii) Migration Rate

Tagged chinook salmon migrated between Sunshine Station (RM 80) and Talkeetna Station (RM 103) at an average rate of travel of 2.1 miles per day (mpd) in 1982, 1.8 mpd in 1983 and 3.3 mpd in 1984 (Barrett et al. 1984, 1985). The average rate of travel between Talkeetna Station and Curry Station (RM 120) was 2.2 mpd in 1982, 2.7 mpd in 1983 and 4.3 mpd in 1984 (Barrett et al. 1984, 1985).

(iv) Spawning Locations

In the Talkeetna-to-Devil Canyon reach (RM 98.5-152) chinook salmon spawn exclusively in tributaries (Barrett et al. 1984, 1985). Peak index counts in streams upstream of RM 98.6 were: 1,121 fish in 1981, 2,474 fish in 1982, 4,432 fish in 1983 and 7,180 fish in 1984 (Table 22).

The total chinook salmon escapement to streams upstream of RM 98.6 was estimated by the relationship that a maximum survey count represents at most 52 percent of the total escapement (Nielson and Geen 1981). Based on this method, the total escapement to streams upstream of RM 98.6 was about 2,150 fish in 1981, 4,750 fish in 1982, 8,500 fish in 1983 and 13,800 fish in 1984. These escapements should be viewed as approximations because: (1) in 1981 not all chinook salmon spawning streams

Table 22. Chinook salmon peak index counts in streams upstream of RM 98.6, 1981-1984.

Stream	River Mile	1981	1982	1983	1984	Four-Year Average
Whiskers Creek	101.4	—	0	3	67	—
Chase Creek	106.9	—	15	15	3	—
Lane Creek	113.6	40	47	12	23	31
Fifth of July Creek	123.7	—	3	0	17	—
Sherman Creek	130.8	—	3	0	0	—
Fourth of July Creek	131.0	—	56	6	92	—
Gold Creek	136.7	—	21	23	23	—
Indian River	138.6	422	1,053	1,193	1,456	1,031
Jack Long Creek	144.5	—	2	6	7	—
Portage Creek	148.9	659	1,253	3,140	5,446	2,625
Cheechako Creek	152.5	—	16	25	29	—
Chinook Creek	156.8	—	5	8	15	—
Devil Creek	161.0	—	0	1	0	—
Fog Creek	176.7	—	0	0	2	—
Total		1,121	2,474	4,432	7,180	3,802[1]

Source: ADF&G 1981a, 1982a; Barrett et al. 1984, 1985

[1] Four-year average of totals

Dashes indicate no survey in 1981; no four-year average were surveyed upstream of RM 98.6; and (2) more importantly, the relationship that a peak count represents at most 52 percent of the total escapement may not be valid for Susitna River chinook salmon.

Portage Creek and Indian River are the two most important tributary streams for chinook salmon spawning in the Susitna River upstream of RM 98.6 (Barrett et al. 1984). The two streams accounted for over 90 percent of the peak index counts in 1981 through 1984 (Table 22).

The peak of the spawning activity in tributaries upstream of RM 98.6 was between the last week of July and the first week of August in 1981, 1982 and 1983 (ADF&G 1981a, 1982a, Barrett et al. 1984).

(v) <u>Access</u>

Salmon are usually prevented from migrating upstream of Devil Canyon (RM 152) because of the high water velocity. Low flows in 1982, 1983 and 1984 allowed a few chinook salmon to pass through Devil Canyon. In 1982, 21 chinook salmon were observed in two tributaries in upper Devil Canyon (ADF&G 1982a). In 1983, 34 chinook salmon were observed in three tributaries in upper Devil Canyon (Table 22). In 1984, 46 fish were observed in three tributaries in upper Devil Canyon (Table 22).

Trihey (1983) examined the hydraulic conditions supporting fish passage into Indian River and Portage Creek, which are the two most important streams for chinook spawning in the Talkeetna-to-Devil Canyon sub-basin. Trihey's analysis indicated that passage of salmon into these two tributaries is not likely to be impeded at low mainstem discharge.

(vi) Fecundity and Sex Ratio

The fecundity of chinook salmon has not been estimated in the Susitna River, but is expected to be in the range of 4,200 to 13,600 eggs per female, as reported by Morrow (1980).

The sex ratio (male to female) of chinook salmon in the Susitna River was 2.8:1 in 1981, 1.4:1 in 1982, 1.5:1 in 1983 and 1.1:1 in 1984 (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Sex ratios at sampling locations in the Susitna River for 1981 through 1984 are presented in Table 23. Sex ratios by age are reported by ADF&G (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Most returning adult chinook salmon were five, six, or seven year old fish that had gone to sea after one year in freshwater (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

4.2 INCUBATION

Salmon egg incubation in the middle reach (RM 98.6-152) of the Susitna River begins in July with chinook spawning in tributaries and tributary mouths. This is followed by pink salmon in mid- to late August and chum and sockeye in late August to early September. Chum incubation begins about one week earlier in the tributaries than in the sloughs. Incubation of sockeye in sloughs begins at about the same time as chum incubation. The last species to spawn are coho salmon, which spawn almost exclusively in tributaries in September (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

Successful incubation and emergence is dependent on numerous biological, chemical, and physical factors. These factors include dissolved oxygen, water temperature, surface water discharge, and intragravel permeability (Reiser and Bjornn

Table 23. Sex ratios of chinook salmon at Yentna, Sunshine, Talkeetna and Curry stations, 1981-1984.

Location/ River Mile	Sex ratio (M:F)[1] 1981	1982	1983	1984
Yentna Station RM 28, TRM 04	---	6.4:1	2.3:1	1.1:1
Sunshine Station RM 80	3.5:1	1.2:1	1.2:1	1.0:1
Talkeetna Station RM 103	2.7:1	2.3:1	2.4:1	1.1:1
Curry Station RM 120	1.9:1	1.5:1	1.4:1	1.2:1

Source: Barrett et al. 1984, 1985

[1] Includes all aged and non-aged fish
Dashes indicate no survey

1979). Droughts, floods, freezing temperatures, superimposition of redds, and predators can also affect successful incubation (McNeil 1969). The following sections discuss these factors. The information is derived from studies on the Susitna River and other locations.

4.2.1 Dissolved Oxygen

Dissolved oxygen is needed during incubation to facilitate metabolic reactions. A literature review by Reiser and Bjornn (1979), concluded that:

(1) Sac fry incubated in low and intermediate oxygen concentrations were smaller and weaker than sac fry reared at higher concentrations;

(2) Low oxygen concentrations in the early stages of development may delay hatching, increase the incidence of anomalies, or both; and

(3) Low oxygen concentrations during the latter stages of development may stimulate premature hatching.

Brannon (1965) found apparent differences in characteristics of alevins that had been incubated at oxygen concentrations ranging from 3.0 to 11.9 mg/l. Slowed development was evident at low concentrations, but these fish eventually attained a weight similar to those raised in higher concentrations by the time they reached the fry stage.

The intragravel flow of water is important in assuring that dissolved oxygen is made available to the incubating eggs and that metabolic wastes are removed. Reiser and Bjornn (1979) recommend that the apparent velocity through the gravel should be more than 20 cm/hour, while Bell (1980) recommends a rate of 110 cm/hour. Specific studies on intragravel flow have not been performed in the Susitna River.

In studies on four sloughs (8A, 9, 11, and 21) in the middle river in April and May of 1983, ADF&G (1983a) found that mean concentrations of intragravel dissolved oxygen were consistently lower than mean concentrations for overlying surface waters. Means for intragravel concentrations ranged from 4.6 to 8.5 mg/l, whereas the surface waters ranged from 9.1 to 11.2 mg/l. The lowest intragravel concentrations occurred in Slough 8A and the highest in Slough 11. Assuming that low dissolved oxygen levels occurred throughout the incubation period (rather than only the April and May sampling period), the low concentrations in Slough 8A may have caused some delay in chum and sockeye development. Diversion of cold mainstem water through this slough as a result of an ice jam may also have contributed to delayed development. Development at the other three sloughs (9, 11 and 21) for embryos and alevins was generally uniform.

McNeil and Bailey (1975) recommend a dissolved oxygen threshold of at least 6.0 mg/l for incubation, while Reiser and Bjornn (1979) recommend concentrations at or near saturation with temporary reductions to 5.0 mg/l. In general, for the Susitna River sloughs studied thus far, these recommendations are usually met. The exception is the lower values found in Slough 8A and some concentrations in Slough 9 (ADF&G 1983a).

Biochemical oxygen demand (BOD), resulting from excessive amounts of organic material in the stream, can reduce dissolved oxygen levels (Reiser and Bjornn 1979). BOD levels have not been measured in the Susitna River. Under existing conditions, dissolved oxygen levels remain at or greater than saturation in the mainstem. Therefore, it is suspected that BOD is at low levels. Habitats adjacent to the mainstem may have higher BOD levels due to the high organic content of waters (e.g., upland sloughs), concentrations of dead post-spawned salmon (e.g., in side sloughs) or movement of water through the groundwater system.

4.2.2 Temperature

Temperature and salmon embryo development are strongly interrelated, with higher temperatures resulting in more rapid development. Development is also related to species, time of egg deposition, and the temperature regime over the period of incubation. In general, the lower and upper limits for successful initial incubation of salmon embryos are 4.5 and 14.5°C (AEIDC 1984). Incubation can occur at lower temperatures if the initial temperature is greater than approximately 4.0°C. This initial sensitivity to low temperatures is apparently related to embryo developmental phases because once the blastopore is closed on the developing embryo, the sensitivity is reduced (Combs and Burrows 1957).

For most species in the Susitna River, the timing of egg deposition is sufficiently early in the season to avoid low initial temperatures. The relationship between temperature and embryo development is frequently measured in temperature units (TUs). These are defined as the difference between the average temperature and 0°C over 24 hours. For example, if eggs were incubated at 7°C for 5 days, the accumulated TU'S would be 35. If an embryo has accumulated 140 temperature units (the approximate developmental stage needed to achieve closing of the blastopore), then it probably has passed the temperature-sensitive stage (Combs and Burrows 1957). The peak spawning activity for most salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) occurs prior to September 1. This is the case for chinook and pink salmon (Barrett et al. 1984). Chum and sockeye salmon overlap this period. However, they utilize areas of groundwater upwelling in the mainstem and sloughs that have temperatures throughout the winter that vary between 2 to 4°C. Coho salmon spawn late in the season. If they do not spawn in upwelling areas (this is not known at the present time), embryos theoretically do not accumulate sufficient temperature units during this sensitive stage for proper development. Additional studies would be needed to fully understand if this species has different initial temperature requirements for successful incubation.

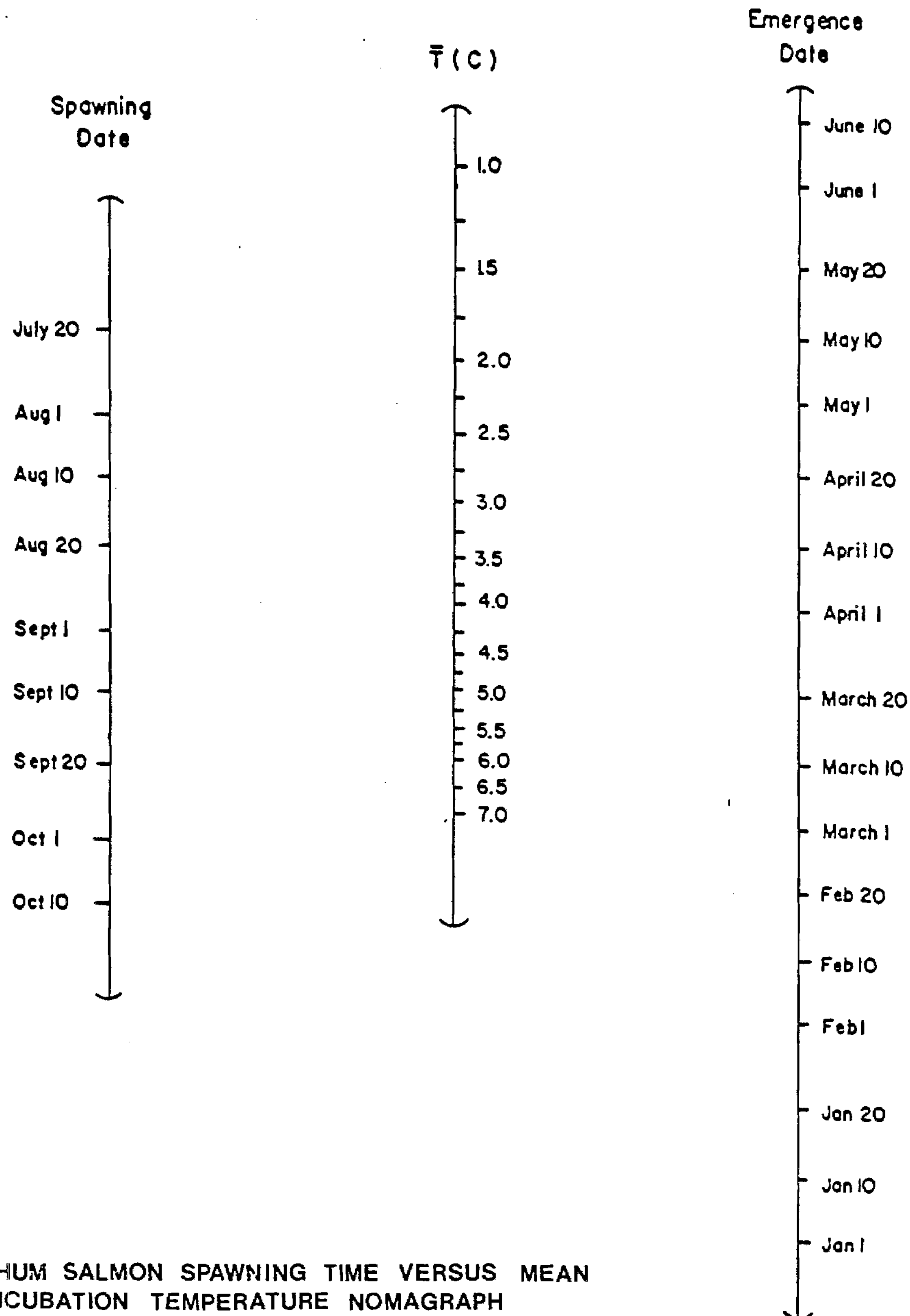
Studies by Wangaard and Burger (1983) have shown that the time to emergence (complete yolk absorption) can vary considerably at different temperatures. In laboratory tests at average temperatures between 2.1 and 4.0°C, these authors found that lower temperature would extend the time to complete yolk absorption for Susitna River chum and sockeye eggs from 30 to 60 days. There are some weak compensatory mechanisms that tend to counteract but not eliminate these differences. For example, Dong (1981) suggested that the accumulation of one temperature unit at low temperatures results in a greater amount of development than the accumulation of one temperature unit at high temperature. However, this does not necessarily provide enough compensation so that eggs incubated under different regimes hatch at the same time. This was evident from the 30 to 60 day difference in complete yolk absorption shown in the studies of Wangaard and Burger (1983). Embryos incubated in colder water hatched at shorter lengths and required fewer TU's for hatching. However, mean alevin length at complete yolk absorption did not reveal the corresponding differences. In summary, alevins at yolk absorption may be of similar size between two temperature ranges (in the 0 to 4°C range), but alevins in the colder regime would take longer to reach that stage while requiring fewer temperature units.

The temperature/time of emergence relationship has been studied on the Skagit River in Washington (Graybill et al. 1979). This river has been affected by hydropower development for at least

60 years. Present year-round water temperatures are generally warmer by several degrees than pre-project temperatures (no actual pre-project temperatures have been recorded, however modeling has established a likely pre-project scenario). For chinook salmon, the timing for spawning has not been noticeably altered, at least through records that date back to 1948. However, it appears that emergence timing of Skagit River chinook has advanced by about one month. Pink salmon emergence has advanced by about 4 to 11 weeks and chum salmon by 0 to 5 weeks. The implications of this advancement in the Skagit River are not clear.

Numerous authors have speculated that an advancement of emergence in any river system would not be specifically patterned to natural peak abundances in food organisms and therefore would not be advantageous to survival. Wangaard and Burger's (1983) finding of a 30 to 60 day delay in chum salmon emergence could mean that embryos incubated at the lower temperatures would result in fish that are out of phase with the normal parr-smolt transformation (this transformation is the salmonid life phase when they undergo a physiological change so that they can adapt to a saltwater environment) and therefore, fish would not be viable. However, Wangaard and Burger state that the effect of early emergence on sockeye salmon was unclear because sockeye rear for one to two years in freshwater before they outmigrate.

To simplify the predictions for chum salmon incubation from fertilization to emergence, AEIDC (1984) has developed a nomograph with the variables of date of fertilization, average incubation temperature, and date of emergence (Figure 22). If the date of spawning were known and an average incubation temperature assumed, the date at which emergence would occur could be predicted. This nomograph is useful for examining and estimating potential changes in chum salmon incubation periods under a wide range of temperature regimes in the Susitna River.



CHUM SALMON SPAWNING TIME VERSUS MEAN INCUBATION TEMPERATURE NOMAGRAPH (SOURCE: AEIDC 1984)

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FIGURE 22

4.2.3 Substrate

Salmon require certain substrate characteristics for successful spawning and incubation. The substrate must be capable of allowing sufficient flow to deliver dissolved oxygen to the embryos and carry away metabolic wastes. It also must not contain a high percentage of fine sediments which could cut off the flow or prevent emergence of fry. As a general guideline, Reiser and Bjornn (1979) recommend that the substrate used for incubation should contain less than 25 percent by volume of fines $\leq$6.4 mm.

Substrate also cannot be excessively large because adult salmon generally are unable to excavate large rocks or solid substrate. Instead, they require intermediate-sized gravels. The substrate size used depends to some extent on the size and species of fish and the substrate that is available to the fish. Based on extensive field studies on the Susitna River by Vincent-Lang et al. (1984), chum salmon in sloughs can utilize substrates between 1 in. and 10 in. in diameter. Sockeye in sloughs also utilize a similar size range of substrates. Silt is not used nor is sand. Chinook salmon spawn in tributaries and most often utilize rubble (3-5 in. diameter) and cobble (5-10 in.). Based on literature review and extrapolation from other river systems, AD&FG (Vincent-Lang et al. 1984) indicates that pink salmon utilize substrates from small gravel (1/8-1 in. in diameter) to rubble (3-5 in.) with large gravel (1-3 in.) being preferred. Using a similar method of analysis, Vincent-Lang et al. (1984) found that coho would mainly use small (1/8 to 1 in.) to large (1-3 in.) gravel.

4.2.4 Streamflow

(i) High Streamflow

During periods of high streamflow, McNeil (1969) found that disappearance of embryos due to streambed scouring often exceeded 50 percent for chum and pink salmon eggs and alevins in streams that he studied in southeast Alaska. On one occasion, McNeil recorded a loss that exceeded 90 percent. High flows can also cause deposition of fine sediment on the redds, which can reduce permeability or entrap emerging fry (Hale 1981).

A clear definition of the flows that result in loss is ill-defined because moderately high flows may be beneficial in assuring adequate interchange of intragravel and surface waters and improving the oxygen supply to embryos (Reiser and Bjornn 1979) and, depending on conditions, may remove fine sediments. In general, velocities should be less than those that displace spawning bed materials (Reiser and Bjornn 1979).

In the Susitna River and its tributaries, high streamflows and bed material movement predominantly occur during the open water season either due to high discharge from rain events or ice/snow melting. Increases in streamflow in side channels and slough habitats can also occur during the ice covered period, when ice jams and staging cause overflows from the mainstem (R&M Consultants 1984). The mainstem bed material appears to be relatively stable compared to side channels and sloughs.

(ii) Low Streamflow

Once embryos have begun incubation, reductions in discharge can lead to dessication of embryos, low oxygen levels, high temperatures, or during cold weather, freezing (Hale 1981).

McNeil (1969) found that freezing could be a cause of high mortality, but that its occurrence was erratic in streams that he studied in southeast Alaska.

Responses of incubating embryos and behavioral characteristics of alevins to dewatering have been studied by Stober et al. (1982) on the Skagit River, Washington. Using chinook, chum, coho, and pink embryos, the authors found that various periods of daily dewatering (with maintenance of humidity and temperature) for up to 24 hrs per day in several substrate types maintained prehatching survival for all species with a decrease in post-hatching survival in direct relationship to the length of daily dewaterings. Also, tolerance to single dewatering events of various times decreased as development of alevins progressed. Stober et al. (1982) qualified these results to state that they should be used cautiously during extrapolation to field conditions. Such extrapolation would probably not be valid for the severe conditions (particularly cold) that occur on the Susitna River. The Skagit River studies do point out, however, that alevins have some ability to avoid severe conditions by moving through the gravel.

4.2.5 Superimposition

Superimposition can occur if salmon excavate existing redds that were developed by previous spawners. In addition to mechanical injury that can occur, existing embryos can be removed from the redd, thus exposing them to light (which can kill incubating embryos) and predators. Superimposition becomes more prevalent when the density of spawning adults increases. No specific studies have been undertaken to determine effects of superimposition on the Susitna River. However, because competition exists both within and between salmon species in certain limited areas of spawning (e.g., sloughs), it is suspected that superimposition does occur.

4.2.6 Predators on Live Eggs

Numerous species of predators can consume live eggs. McNeil (1969) suggests that sculpins (Cottus sp.) and possibly other fish predators may be involved. Potential predators, such as rainbow trout and Dolly Varden, are present in the Susitna River, but no information is available on the effects of egg and embryo predation.

4.3 JUVENILE SALMON

4.3.1 Sockeye Salmon

(i) Emergence

The emergence of sockeye salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) occurs during the month of March (ADF&G 1983b,c). In late April most sockeye juveniles of age 0+ have reached 33 mm in length. This observed emergence timing is similar to the April to June emergence reported for sockeye by Morrow (1980) and Scott and Crossman (1973).

(ii) Seasonal Movements

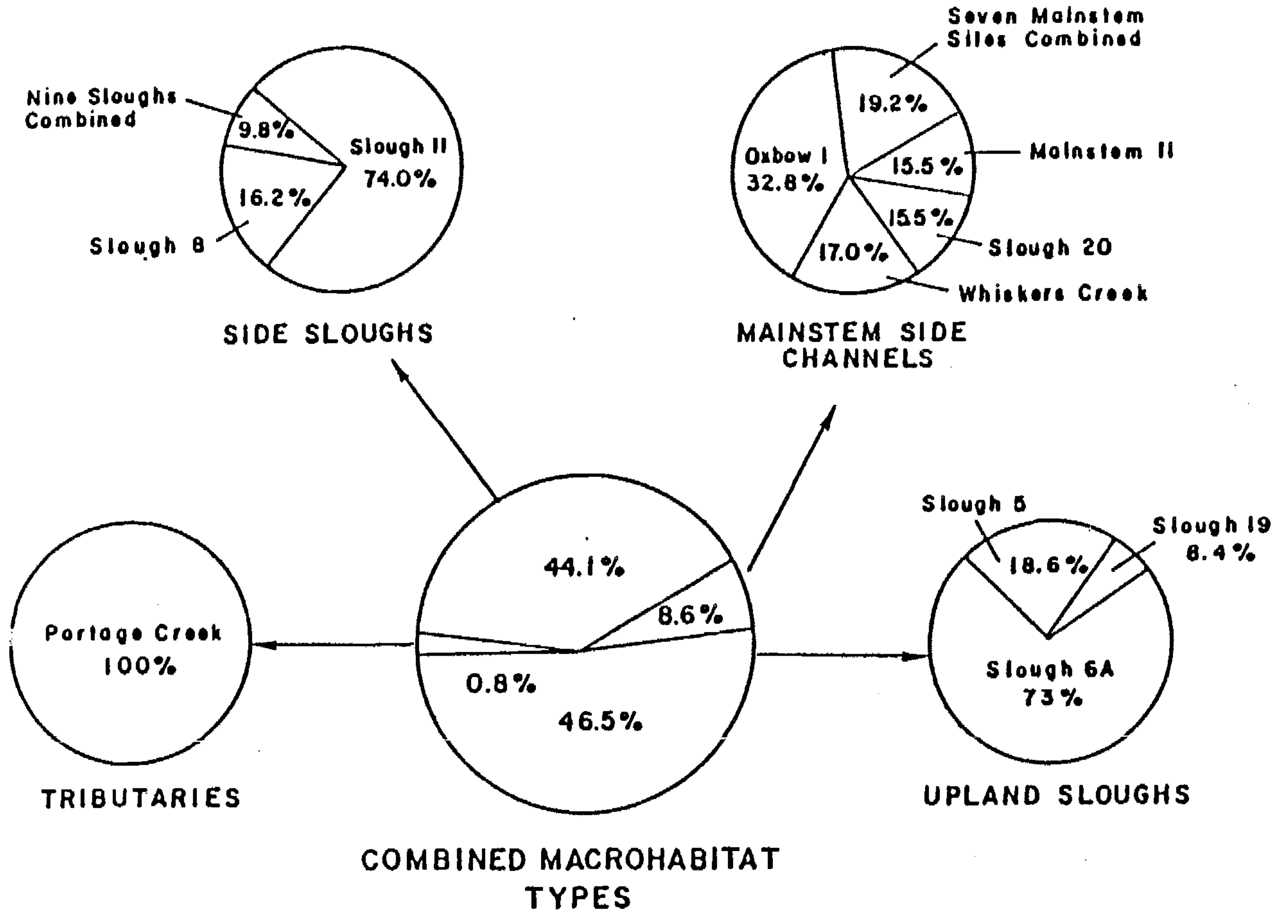
In other river systems, sockeye usually spend one to two years in lakes before going to sea (Morrow 1980, Scott and Crossman 1973). However, in the Talkeetna-to-Devil Canyon reach (RM 98.6-152), suitable lakes are not available for rearing sockeye. Therefore, juvenile sockeye either rear in sloughs or leave the Talkeetna-to-Devil Canyon reach during their first year of life (ADF&G 1984b). It is unknown if the age 0+ sockeye leaving this reach of river go directly out to sea as smolts or move to rearing habitats in other sub-basins of the Susitna river. If they do go directly to the ocean, their survival is low (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

For those juvenile sockeye that rear and overwinter in the Talkeetna-to-Devil Canyon reach, upland sloughs and side sloughs are used most frequently. In 1982, over 90 percent of the 1325 juvenile sockeye collected were in upland and side slough habitats (ADF&G 1983b). Similarly, in 1983 densities were highest in side slough and upland slough habitats (Schmidt et al. 1984). In 1983 rearing sockeye were about equally distributed between upland slough and side slough habitats (Figure 23). The most important upland slough was Slough 6A, while Slough 11 was the most important side slough.

The importance of Slough 11 for rearing sockeye is likely due to two factors. First, Slough 11 is an important slough for sockeye spawning, accounting for over 75 percent of the total slough escapement for adult sockeye salmon in 1982 (Barrett et al. 1984). And secondly, Slough 11 is breached only at high discharges (over 42,000 cfs) (Sautner et al. 1984). This condition provides more favorable rearing conditions than breached sloughs. There have been decreased catches in natal side sloughs after breaching transforms the side slough to side channel habitat (Schmidt et al. 1984).

During July and August 1983 there was a redistribution of juvenile sockeye from natal side slough habitat to upland slough habitat (Schmidt et al. 1984). Slough 6A was the most important upland slough for juvenile sockeye in 1982 and 1983 (ADF&G 1983b, Schmidt et al. 1984). This slough has low water velocity, clear water, adequate depth and abundant cover and is quite different from the majority of sloughs in the Talkeetna-to-Devil Canyon sub-basin (Schmidt et al. 1984).

Some juvenile sockeye overwinter in the Talkeetna-to-Devil Canyon sub-basin. This has been documented by winter sampling and the downstream outmigrant trap catches of age 1+ fish at RM 103 (ADF&G 1983b, Schmidt et al. 1984). However, catches of age 1+ sockeye have been low (less than 1 percent of the



DISTRIBUTION OF JUVENILE SOCKEYE SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH OCTOBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL. (SOURCE: SCHMIDT et al. 1984)

FIGURE 23

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outmigrant trap catches), which indicates that this reach of river is not used extensively for overwintering. Age 1+ sockeye have been observed in sloughs 9 and 11 (Schmidt et al. 1984).

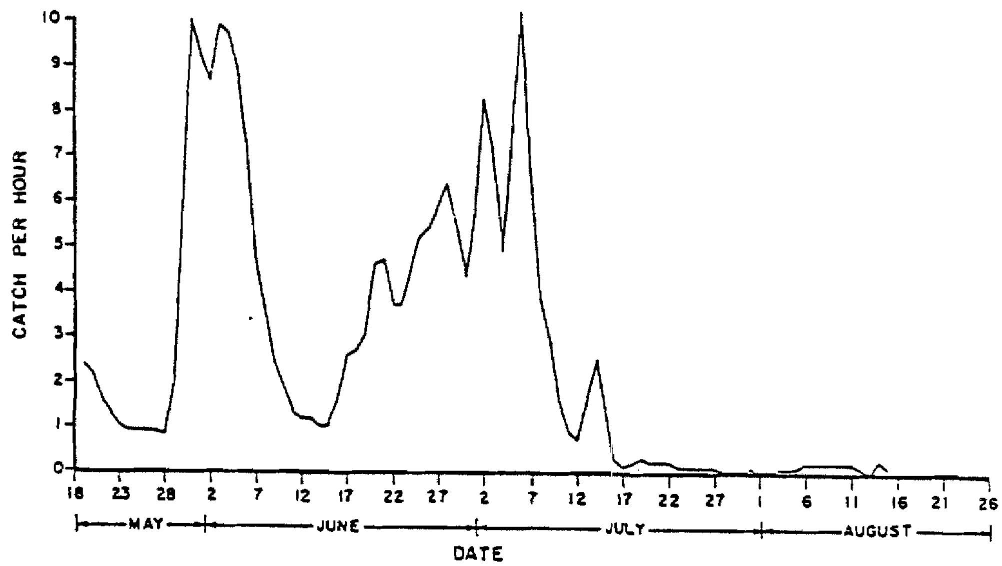
(iii) Food Habits

Juvenile sockeye food habits were examined in July and August 1982 at sloughs 8A and 11 (ADF&G 1983b). Fish were found to be feeding primarily on chironomid larvae, pupae and adults. However, dominance of food items is based on numbers not biomass or volume. Since chironomids are small, their volumetric contribution may be overemphasized by the numerical method. Electivity indices suggested a positive selection for chironomid larvae. Cladocerans and copepods were important food items of juvenile sockeye in Slough 11 during August. A variety of aquatic and terrestrial insects were also consumed.

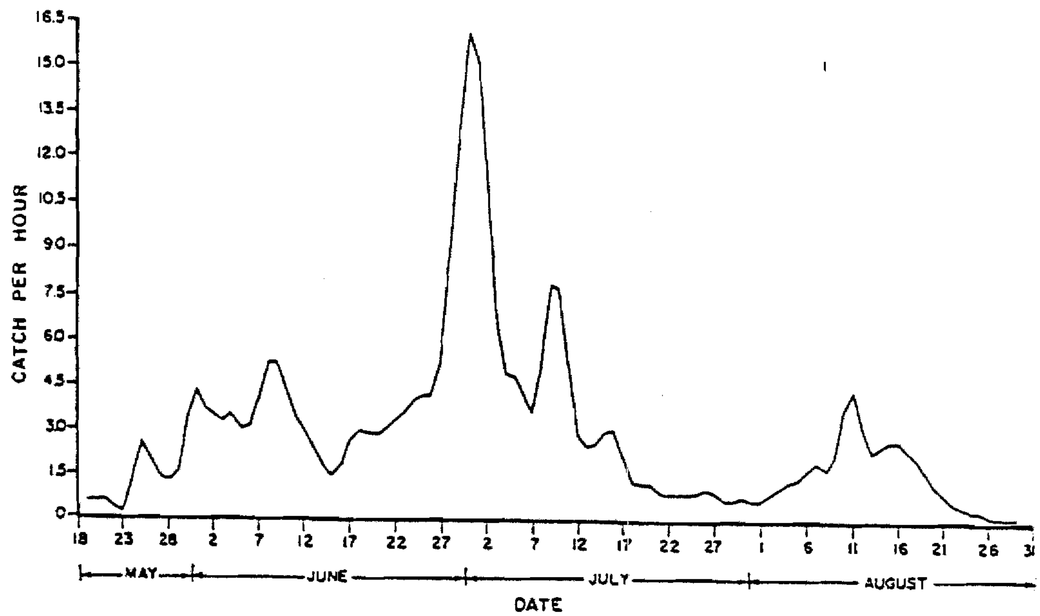
(iv) Outmigration Timing

Most juvenile sockeye salmon leave the Talkeetna-to-Devil Canyon reach (RM 98.6-152) during their first year of life. Over 99 percent (12,312) of the 12,395 juvenile sockeye caught in outmigrant traps at RM 103 in 1983 were age 0+ fish, while only 83 fish were age 1+ (Schmidt et al. 1984). If age 0+ sockeye go directly to the ocean their survival is low, because less than one percent of returning adult sockeye at Curry Station (RM 120) outmigrated as age 0+ smolts (ADF&G 1982a).

The peak outmigration of age 0+ sockeye at RM 103 occurred during early July in 1982 and 1983 (ADF&G 1983b, Schmidt et al. 1984) (Figure 24). The outmigration was monitored from mid-June to mid-October in 1982 and from mid-May to the end of August in 1983 (ADF&G 1983b, Schmidt et al. 1984). Catches of age 0+ sockeye occurred throughout the sampling season. The



CHUM SALMON FRY DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 20, 1983. (SOURCE: SCHMIDT et al. 1984)



SOCKEYE SALMON FRY DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 30, 1983. (SOURCE: SCHMIDT et al. 1984)

FIGURE 24

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outmigration of age 1+ sockeye occurred primarily during May and June and was over by the end of July in 1982 and the end of June in 1983.

Analyses were done to compare 1983 juvenile sockeye outmigration catch rates at RM 103 with mainstem discharge (Schmidt et al. 1984). The coefficient of determination (r^2) between mainstem discharge and outmigration rate was 0.12 for age 0+ fish and 0.06 for age 1+ fish.

(v) Size

The average size of outmigrating age 0+ sockeye in 1982 at RM 103 was 42 mm in late June and increased to 72 mm by early October (ADF&G 1983b). Age 1+ sockeye in 1982 averaged 77 mm in early June and 87 mm in late July. In 1983 age 0+ and 1+ fish were separated by length analysis. In early May age 0+ sockeye were less than 56 mm, while age 1+ fish were 56 mm or greater. In late June age 0+ sockeye were less than 71 mm, while age 1+ fish were 71 mm or greater (Schmidt et al. 1984).

(vi) Population Estimates

In 1983 the population size of age 0+ sockeye was estimated in the Talkeetna-to-Devil Canyon reach (RM 98.6-152). Fry were fin clipped and tagged with half-length coded wire tags at sloughs 8A, 11 and 21 and recaptured in downstream outmigrant traps at RM 103. The population size was an estimated 560,000 fish using the Peterson mark/recapture estimator and 575,000 fish using the Schaefer estimator (Schmidt et al. 1984).

In 1983 survival estimates for egg to fry were calculated by dividing the fry population estimate by the total potential egg deposition. Survival from egg to fry was about 40.9 percent using the Peterson estimate of population size and 42.0 percent using the Schaefer estimate of population size (Schmidt et al. 1984).

The high survival rate (41-42 percent) for egg to outmigrant for juvenile sockeye in the Talkeetna-to-Devil Canyon reach is not comparable to survival estimates for egg to fry in other studies (Schmidt et al. 1984). The study in the Susitna River covered a shorter period of time (egg to age 0+ sockeye), while other studies (Russell 1972 and Meehan 1966, cited in Schmidt et al. 1984) reported survival estimates of 0.6 to 8.5 percent from egg to age 1+ or age 2+ sockeye smolts.

4.3.2 Chum Salmon

(i) Emergence

Chum salmon emergence in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) occurred during 1982 in late February and March (ADF&G 1983b,c). By late April most juvenile chum were 35 mm in length. Thus, it appears that chum salmon emergence occurs in this reach of the Susitna River from February through April.

(ii) Seasonal Movements

After emergence chum salmon may outmigrate to the estuary in a single night if they are in systems close to the ocean (Scott and Crossman 1973). However, in other situations the chum outmigration may last for days or weeks (Morrow 1980).

Most juvenile chum in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) emerge by late April, while the peak outmigration (at RM 103) does not occur until early June or early July (ADF&G 1983b,c; Schmidt et al. 1984). This indicates that juvenile chum from this reach of the Susitna River may spend one to three months rearing in freshwater. All juvenile chum in the Susitna River outmigrate as age 0+ fish (ADF&G 1981a,b; 1982a; 1983b; Barrett et al. 1984; Schmidt et al. 1984).

Almost all juvenile chum (over 90 percent) were distributed in side slough and tributary habitats in the Talkeetna-to-Devil Canyon reach during 1983 (Figure 25). These side sloughs and tributaries were the same areas of adult chum spawning in 1982 (ADF&G 1982a). Slough 21 supported the highest density of juveniles in side sloughs in 1983 while Indian River had the highest density of juveniles in tributaries (Schmidt et al. 1984).

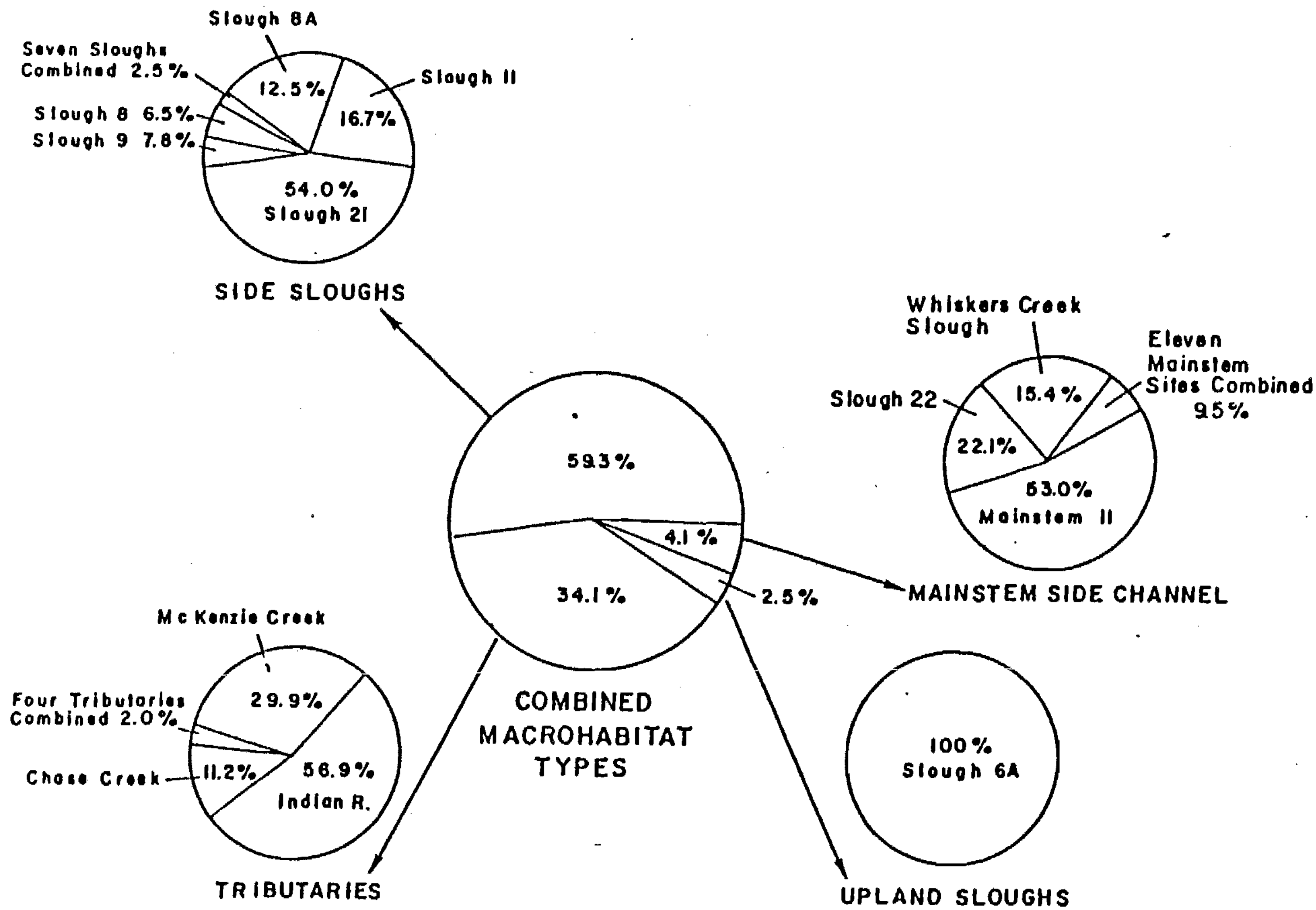
In early June 1983 juvenile chum densities dropped in side slough and tributary habitats and increased at side channels, upland sloughs and the downstream outmigrant traps at RM 103 (Schmidt et al. 1984). Most juvenile chum salmon leave the Talkeetna-to-Devil Canyon reach by mid-July (Figure 24).

(iii) Food Habits

The food habits of juvenile chum have not been examined in the Susitna River. However, juvenile chum spend one to three months rearing in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) before outmigrating and can gain up to 27 mm in length during this period (ADF&G 1983b). Morrow (1980) reports that they may feed on chironomids and cladocerans. Food habitat studies of juvenile chinook, coho and sockeye in the Talkeetna-to-Devil Canyon sub-basin indicate that chironomids comprised a significant portion of the diet for these three species (ADF&G 1983b). It is expected that juvenile chum also feed on chironomids in this reach of river. Other food items may be important.

(vi) Outmigration Timing

All juvenile chum salmon in the Susitna River outmigrate to the ocean in their first year of life. The outmigration from the Talkeetna-to-Devil Canyon sub-basin was monitored by the downstream outmigrant traps (RM 103) from mid-June to



DISTRIBUTION OF JUVENILE CHUM SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH OCTOBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL. (SOURCE: SCHMIDT et al. 1984)

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FIGURE 25

mid-October in 1982 and mid-May to the end of August in 1983 (ADF&G 1983b, Schmidt et al. 1984). In 1982, the peak outmigration occurred on June 21, just three days after the trap began fishing. Therefore, it is possible that the peak outmigration occurred before June 18 in 1982. By mid-July 1982 almost 90 percent of the outmigrants (754 chum) had been caught. No juvenile chum were caught at the trap after mid-August in 1982 (ADF&G 1983b). In 1983 the outmigration peaked between early June and early July. By mid-August all juvenile chum had left the Talkeetna-to-Devil Canyon reach (RM 98.6-152) (Figure 24).

Analyses were done to compare 1983 juvenile chum outmigration catch rates with mainstem discharge (Schmidt et al. 1984). During mid-May to mid-July (this period accounted for over 98 percent of the catch at the downstream migrant traps) almost 80 percent of the variation in catch rates was accounted for by mainstem discharge. The coefficient of determination (r^2) between mainstem discharge and juvenile chum outmigration rates was 0.79; r = 0.89 (Schmidt et al. 1984).

(v) <u>Size</u>

Most juveniles had reached a length of 35 mm by late April 1982 (ADF&G 1983b). The mean size of juvenile chum in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) was 42 mm (length range 29-55 mm) during the first two weeks of July 1982 (ADF&G 1983b).

(vi) <u>Population Estimates</u>

The population size of juvenile chum was estimated in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) in 1983. Fry were fin clipped and tagged with half-length coded wire tags at sloughs 8A, 9, 11 and 21 and at Indian River. Outmigrating fry were captured at downstream outmigrant traps at RM 103 and examined for marks. The population size was an estimated 3,322,000 fish using the Peterson mark/recapture estimator and 3,037,000 fish using the Schaefer estimator (Schmidt et al. 1984).

Survival estimates for egg to fry were calculated by dividing the population estimate by the total potential egg deposition. Survival from egg to fry was 14.1 percent using the Peterson estimate of population size and 12.9 percent using the Schaefer estimate of population size (Schmidt et al. 1984). The survival rate (13-14 percent) for egg to fry for chum salmon in the Talkeetna-to-Devil Canyon reach is within the range (0.4-35.4 percent) of those reported from other studies (Schmidt et al. 1984).

Daily outmigration rates, population size and recruitment rates of juvenile chum were estimated at Slough 11 in 1983 (Schmidt et al. 1984). Fish were tagged with half-length coded wire tags and marked with Bismark Brown dye so that fish marked over a three day period could be separated upon recapture by the particular day they were marked. On day two of the experiment, the juvenile chum population size in Slough 11 was an estimated 2,068 fish, the daily emigration rate was 32.7 percent of the population, and the daily recruitment (emergence) rate was 1.84 percent of the population (Schmidt et al. 1984).

A comparison of data from the east bank outmigrant trap at RM 103 for 1982 and 1983 indicates that in 1983 juvenile chum catch rates were 2.3 times higher than 1982 catch rates (Schmidt et al. 1984). This relative abundance of juvenile chum corresponds with the parent spawner relative abundance. The 1982 chum escapement (29,400 fish) at Curry Station (RM 120) was 2.2 times higher than the 1981 escapement (13,100 fish) (Barrett et al. 1984).

4.3.3 Coho Salmon

(i) Emergence

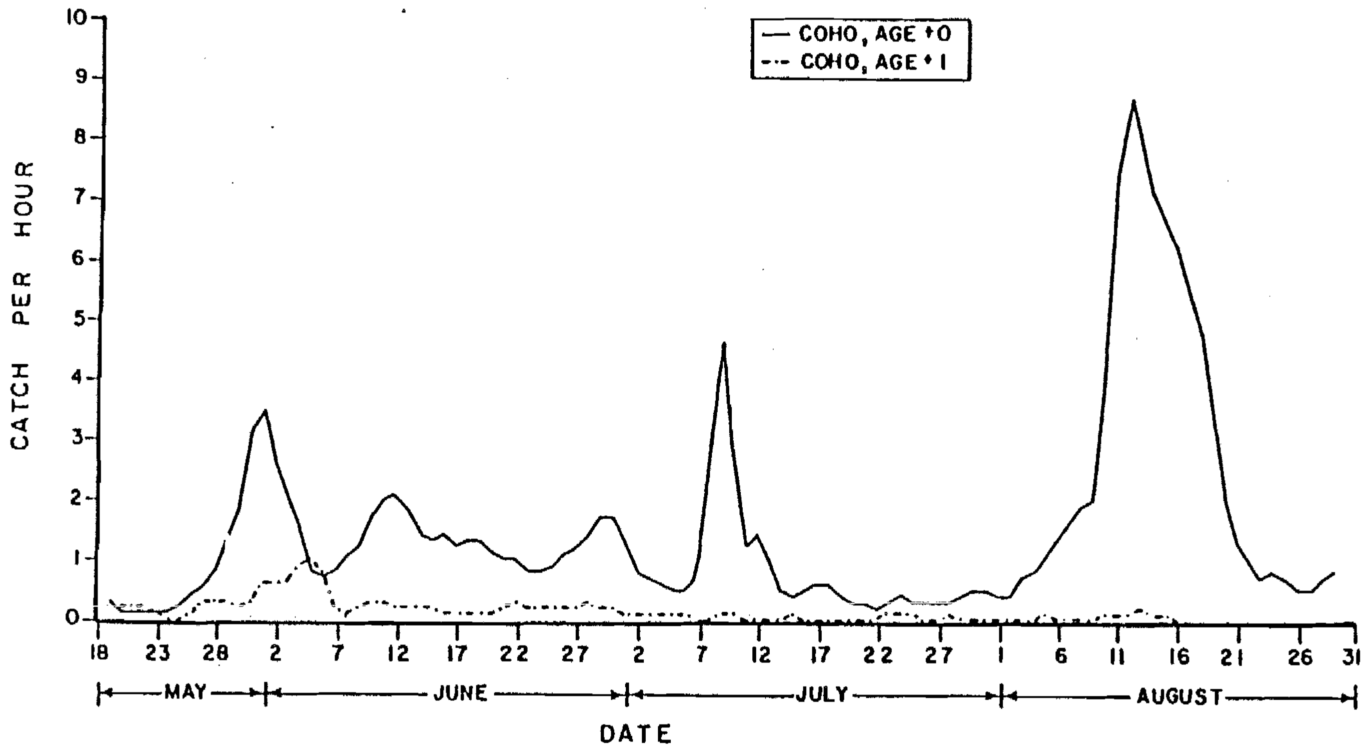
Coho emergence likely occurs before May in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) as the downstream outmigrant traps (RM 103) began catching age 0+ juvenile coho in mid-May 1983 (Schmidt et al. 1984). However, the emergence likely extends over a considerable time period, based upon the shorter lengths of fish observed in June and July 1981, 1982 and 1983 (ADF&G 1981b, 1983b; Schmidt et al. 1984). Scott and Crossman (1973) also report that coho emergence can occur from early March to late July, depending upon time of spawning and incubating water temperatures.

(ii) Seasonal Movements

There is a pattern of downstream movement of juvenile coho throughout the summer in the Talkeetna-to-Devil Canyon river reach (RM 98.6-152) (Figure 26). Some juvenile coho of all age groups (age 0+, 1+, 2+) leave the Talkeetna-to-Devil Canyon sub-basin (ADF&G 1983b, Schmidt et al. 1984).

Most juvenile coho (96 percent) were distributed in tributary, upland slough and side slough habitats in the Talkeetna-to-Devil Canyon sub-basin during 1983 (Figure 27). Important tributaries for juvenile rearing in 1983 were spawning areas for adult coho in 1982 (ADF&G 1982a). Whiskers Creek, Chase Creek and Indian River had the highest juvenile coho densities, based upon mean catch per cell, of the tributaries in 1983 (Schmidt et al. 1984).

Sloughs 6A and 5 were important upland sloughs for juvenile coho rearing, while Whiskers Creek Slough and Slough 8 were important side sloughs in 1983 (Schmidt et al. 1984). The



COHO SALMON AGE 0^{+} AND AGE 1^{+} OR OLDER DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 30, 1983. (SOURCE: SCHMIDT et al. 1984)

FIGURE 26

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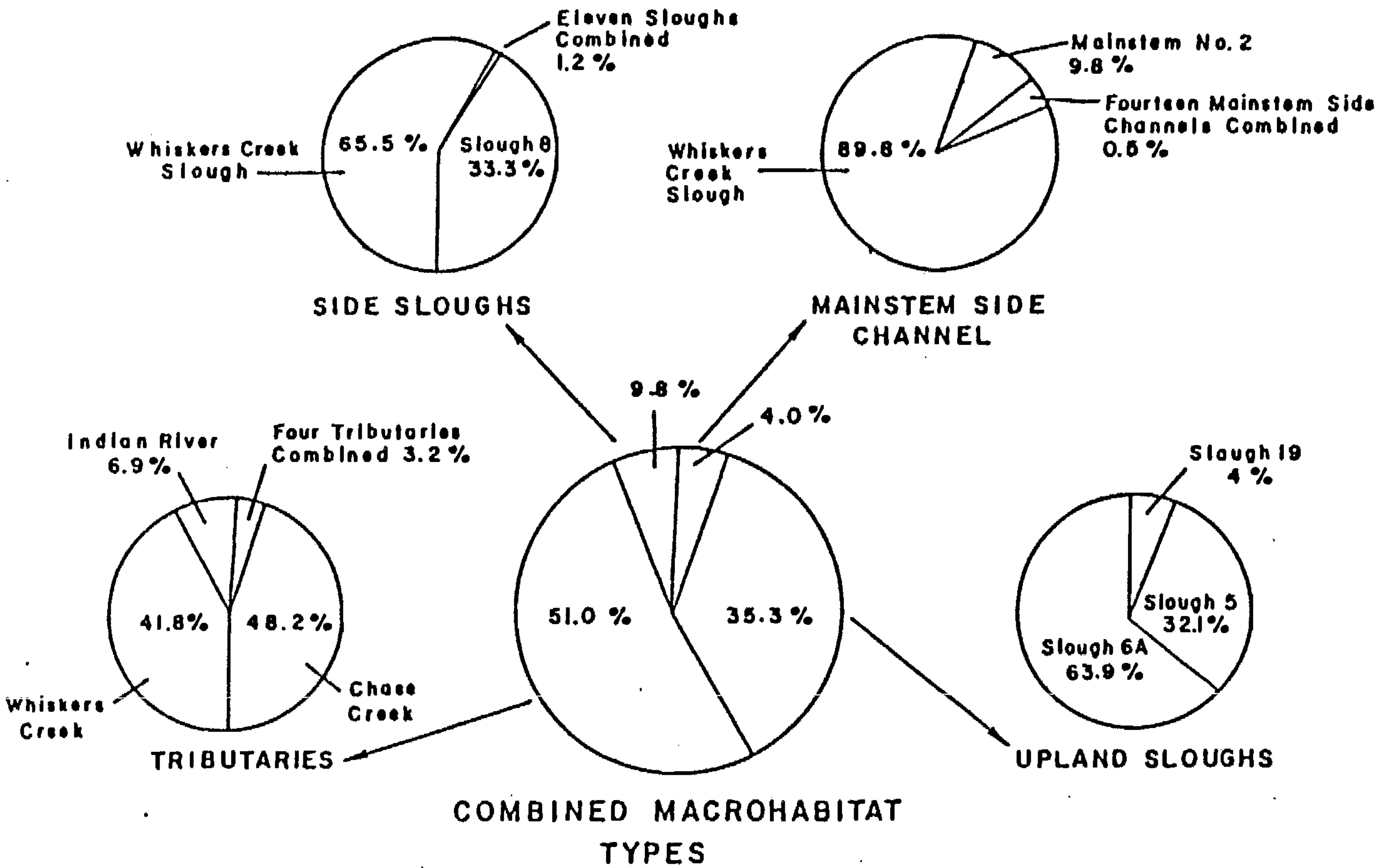

DISTRIBUTION OF JUVENILE COHO SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH NOVEMBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL. (SOURCE: SCHMIDT et al. 1984)

FIGURE 27

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presence of juveniles in these sloughs coupled with the infrequent catches in side channel habitat suggests that juvenile coho are found primarily in low-velocity, clear water areas. Upland and side sloughs may also attract juvenile coho due to higher water temperatures (Schmidt et al. 1984).

Significant overwintering of juvenile coho in the Talkeetna-to-Devil Canyon reach occurs in side sloughs and upland sloughs (Schmidt et al. 1984). In 1981 through 1983, Whiskers Creek Slough (side slough) and Slough 6A (upland slough) were used for overwintering by age 1+ and 2+ coho. Some coho may also use the mainstem, side channels and tributaries for overwintering.

(iii) Food Habits

Food habits were examined in August and September 1982 in the Talkeetna-to-Devil Canyon reach (RM 98.6-152). Chironomids were the dominant food item numerically in samples collected. Since chironomids are small, their volumetric contribution is probably less than their numeric contribution. Electivity indices suggested a positive selection for chironomid larvae. Other dipterans, and mayfly and stonefly nymphs were occasionally eaten. Riis and Friese (ADF&G 1978) found that juvenile coho in the Susitna River fed on drifting aquatic insect larvae in the spring, while the adult stage of aquatic insects were major food items during the summer and fall.

Scott and Crossman (1983) report that juvenile pink, chum and sockeye can be important food items for age 1+ and older coho. These food items are more likely to occur in coho diets between May and August, when juvenile pink, chum and sockeye are more numerous in the Talkeetna-to-Devil Canyon sub-basin.

(iv) Outmigration Timing

The outmigration of juvenile coho from the Talkeetna-to-Devil Canyon reach (RM 98.6-152) was monitored by downstream migrant traps (RM 103) during 1982 and 1983 (ADF&G 1983b, Schmidt et al. 1984). There was a downstream movement of juvenile coho throughout the summer (Figure 26). Age 0+ fish accounted for over 90 percent of the trap catch of 5,646 coho, while age 1+ and 2+ fish comprised the remaining portion (Schmidt et al. 1984).

From November 1980 to May 1981 age 2+ coho were captured in the Talkeetna-to-Devil Canyon reach (ADF&G 1981b). After May in this reach of river and mid-June in the Cook Inlet to Talkeetna reach no age 2+ coho were caught. Catches of age 2+ coho were low at the outmigrant traps at RM 103, however it appears that catches peaked in early June in 1982 and 1983 (ADF&G 1983b, Schmidt et al. 1984). Analyses of scales in 1982 and 1983 from returning adult coho salmon at Curry Station (RM 120) indicate that most coho outmigrate from the Susitna River as age 1+ or 2+ smolts (ADF&G 1981a, 1982a, Barrett et al. 1984).

Analyses were done to compare juvenile coho outmigration catch rates at RM 103 with mainstem discharge (Schmidt et al. 1984). The coefficient of determination (r^2) between mainstem discharge and outmigration rates was 0.17 for age 0+ fish and 0.22 for age 1+ fish.

(v) Size

The average size of age 0+ coho in the Talkeetna-to-Devil Canyon sub-basin (RM 98.6-152) was 56 mm in late June 1981 and 41 mm in late June 1982. The size increased to 63 mm in late September in 1981 and 65 mm in late September 1982 (ADF&G 1981b, 1983b). In 1983, age 0+ coho were separated from age 1+ and older coho by length frequency and scale analyses; age 0+

coho were less than 46 mm in early May, less than 66 mm in late June, and less than 96 mm in late September (Schmidt et al. 1984).

Length frequency and scale analyses of coho salmon cannot be used to separate age 1+ and 2+ coho because of overlapping lengths (ADF&G 1983b). Therefore, age 1+ and 2+ fish were combined as age 1+ and older in most analyses (Schmidt et al. 1984).

(vi) Population Estimates

Population size and survival estimates of juvenile coho have not been done in the Susitna River. Catches of juvenile coho in 1982 suggest that the river reach downstream of RM 98.6 is used more for coho rearing than the reach upstream of RM 98.6. About 80 percent of the 1,857 juvenile coho caught in 1982 were captured downstream of RM 98.6 (ADF&G 1983b).

A comparison of data from the east bank outmigrant trap at RM 103 for 1982 and 1983 indicates that in 1983 juvenile coho catch rates were 2.8 times higher than the 1982 catch rates (Schmidt et al. 1984). This relative abundance of juvenile coho corresponds with the parent spawner relative abundance. The 1982 coho escapement (2,400 fish) at Curry Station (RM 120) was 2.2 times higher than the 1981 escapement (1,100 fish) (Barrett et al. 1984).

4.3.4 Pink Salmon

(i) Emergence

The emergence of pink salmon probably occurs in March and April in the Talkeetna-to-Devil Canyon reach (RM 98.6-152). Limited information obtained in 1981 indicated that fry appeared in Slough 11 and Indian River on April 11 (ADF&G 1981b).

(ii) Seasonal Movements

After emergence juvenile pink salmon move almost immediately downstream to the ocean (ADF&G 1981b, 1983b; Schmidt et al. 1984). All juveniles in the Susitna River outmigrate in their first summer (age 0+ fish) and little if any freshwater rearing occurs.

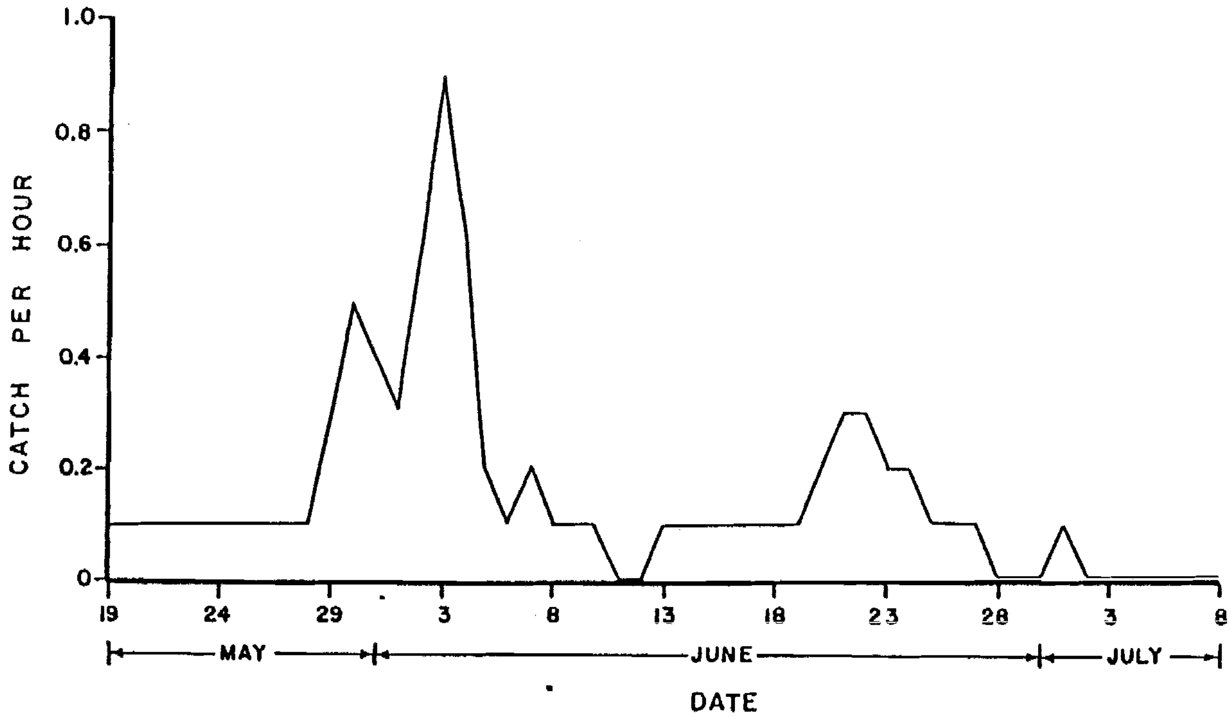
Most juvenile pink salmon were captured in the downstream outmigrant traps (RM 103) in May and June (Figure 28). In 1982, the downstream outmigrant trap caught only seven juvenile pink during early July (ADF&G 1983b). In 1983 the downstream outmigrant traps caught few juvenile pink after July (Schmidt et al. 1984).

(iii) Food Habits

It is uncertain if juvenile pink salmon feed in the Susitna River. They apparently spend little time in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) after emergence (Schmidt et al. 1984). Scott and Crossman (1973) indicate that juvenile pink salmon remain in freshwater for such a short time that many do not feed at all. However, those that migrate longer distances to the estuary may eat nymphal and larval insects. It is likely that juvenile pink salmon in the Talkeetna-to-Devil Canyon sub-basin may feed occasionally on chironomid larvae and other aquatic insects during their outmigration.

(iv) Outmigration Timing

After emergence in April and May, juvenile pink move almost immediately downstream to the estuary. In 1983 juvenile pink catches were highest at the outmigrant traps (RM 103) during late May and early June (Figure 28).



PINK SALMON FRY DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH JULY 8, 1983. (SOURCE: SCHMIDT et al. 1984)

FIGURE 28

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Analyses were done to compare 1983 juvenile pink outmigration catch rates at RM 103 with mainstem discharge (Schmidt et al. 1984). During mid-May to mid-July about 30 percent of the variation in catch rates was accounted for by mainstem discharge. The coefficient of determination (r^2) between mainstem discharge and outmigration rates was 0.30; r = 0.55 (Schmidt et al. 1984).

(v) Size

The average size of juvenile pink, between RM 79 and 136, was 36 mm (length range 29-43 mm) during late May to late July 1982 (ADF&G 1983b). No increase in size was observed between fish measured in May compared to those measured in July. However, the sample size was small (28 fish). It appears that juvenile pink grow little, if any, during their freshwater residence.

(vi) Population Estimates

No estimation of the population size of juvenile pink salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) has been done. Catches have been low for this species. In 1982, only six fish were caught in the downstream migrant trap (RM 103), while in 1983, 245 juveniles were captured (ADF&G 1983b, Schmidt et al. 1984).

Adult runs of pink salmon are numerically dominant in even years in the Susitna River, with even-year escapements about 10 times greater than odd-year escapements (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). The progeny of even-year pink salmon emerge and outmigrate in the following odd year. Therefore, the abundance of juvenile pink salmon is likely greater in odd years than in even years.

4.3.5 Chinook Salmon

(i) Emergence

Most chinook salmon emerge from the gravel in tributaries of the Talkeetna-to-Devil Canyon reach (RM 98.6-152) in March or April (ADF&G 1983d). Juvenile chinook had emerged prior to mid-April in Indian River in 1981 (ADF&G 1983c).

(ii) Seasonal Movements

In other river systems juvenile chinook usually spend one or two years in freshwater residence before outmigrating to the ocean (as age 1+ or 2+ smolts) (Scott and Crossman 1973, Morrow 1980). Most juveniles in the Talkeetna-to-Devil Canyon sub-basin (RM 98.6-152) spend one year in freshwater before going to sea as age 1+ smolts (ADF&G 1981a,b; 1982a, Barrett et al. 1984; Schmidt et al. 1984).

One to two months after emergence there is a downstream movement of some juvenile chinook (age 0+) from areas of high post-emergent densities (natal tributaries) to rearing and overwintering areas (mainstem, side channels, side sloughs, upland sloughs and tributary mouths) (ADF&G 1981b, 1983b; Schmidt et al. 1984). The downstream redistribution of age 0+ juvenile chinook has been observed in the Deshka River (RM 40.6) by Delaney et al. (1981), in Montana Creek (RM 77) by Riis and Friese (ADF&G 1978) and in the Little Susitna River (eight miles east of the Susitna River mouth) by Delaney and Wadman (ADF&G 1979). Some juveniles move downstream and leave the Talkeetna-to-Devil Canyon reach. The downstream outmigrant traps (RM 103) in 1983 captured age 0+ juvenile chinook throughout the season with a major peak catch occurring in August (Schmidt et al. 1984).

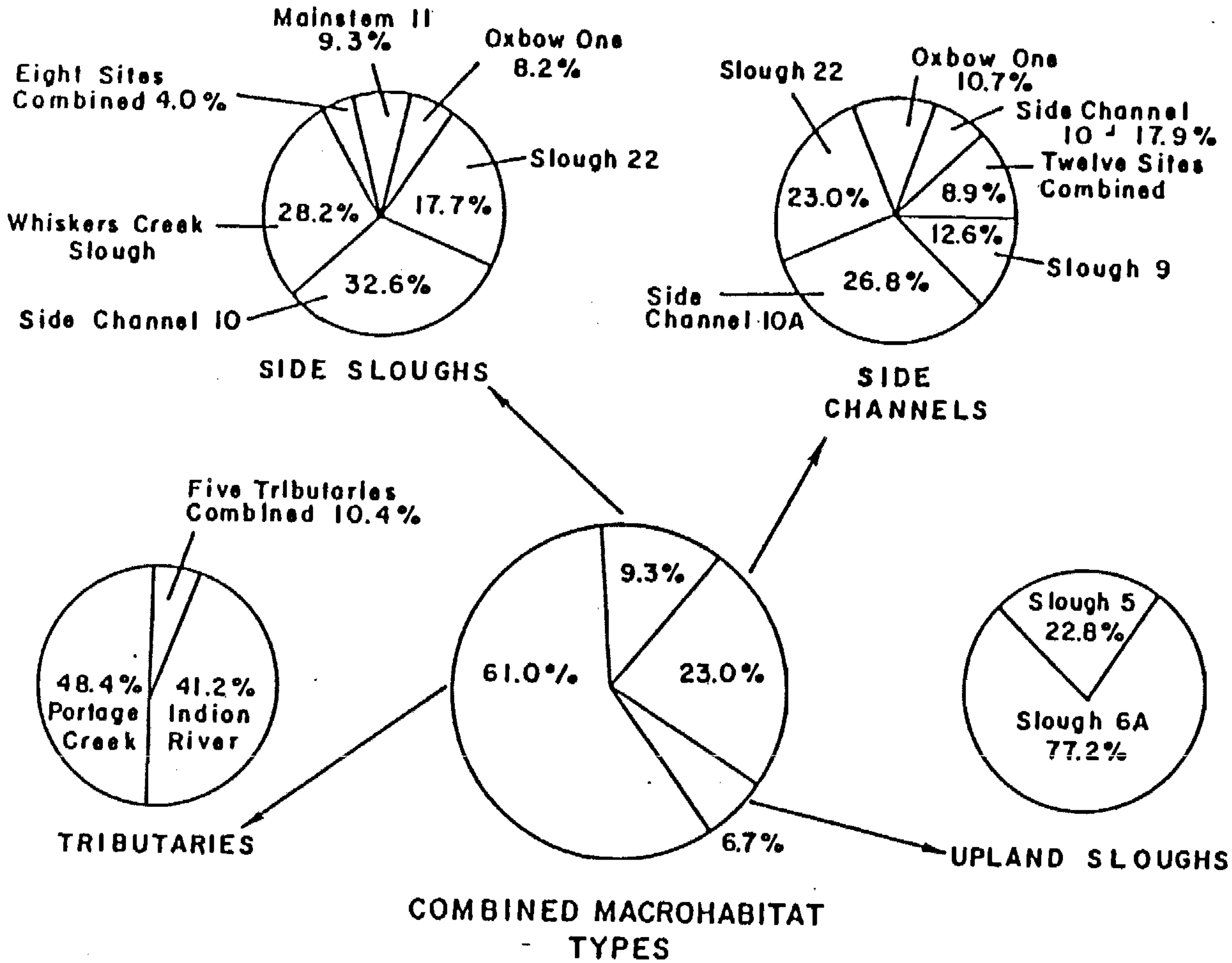
Important rearing habitats for juvenile chinook are side sloughs, side channels, upland sloughs and tributary mouths (ADF&G 1981b, 1983b; Schmidt et al. 1984). Apparently juveniles prefer areas of moderate water velocity and depth, and utilize turbidity for cover (Schmidt et al. 1984). These conditions are often present in side channels. Consequently, densities of juvenile chinook were higher in side channels than in side or upland slough habitats (Figure 29).

Side sloughs, tributaries, the mainstem, and side channels are used by juvenile chinook for overwintering areas (ADF&G 1981b, 1983b; Schmidt et al. 1984). Side sloughs may attract overwintering juvenile chinook because of the warmer water temperatures that are associated with groundwater upwelling in sloughs (Schmidt et al. 1984).

In 1981 juvenile chinook were captured throughout the Susitna River from Alexander Creek (RM 10.1) upstream to Portage Creek (RM 148.8) (ADF&G 1981b); in 1982 fish were collected between Goose Creek (RM 73.1) and Portage Creek (RM 148.8) (ADF&G 1983b). In both years juvenile chinook abundance was higher downstream of the Chulitna River (RM 98.6).

(iii) Food Habits

Juvenile chinook food habits were examined in August and September 1982 at sloughs 8A, 11, 20, 21 and at Indian River and Fourth of July Creek (ADF&G 1983b). Fish were found to be feeding primarily on chironomid larvae, pupae and adults. However, dominance of food items was based on numbers and not biomass or volume. Since chironomids are small, their volumetric importance may be overemphasized by the numerical method. Electivity indices indicated that juvenile chinook had a positive selection for chironomid larvae. Terrestrial and other aquatic insects were also eaten (ADF&G 1983b).



DISTRIBUTION OF JUVENILE CHINOOK SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH NOVEMBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL. (SOURCE: SCHMIDT et al. 1984)

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants and ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 29

(iv) Outmigration Timing

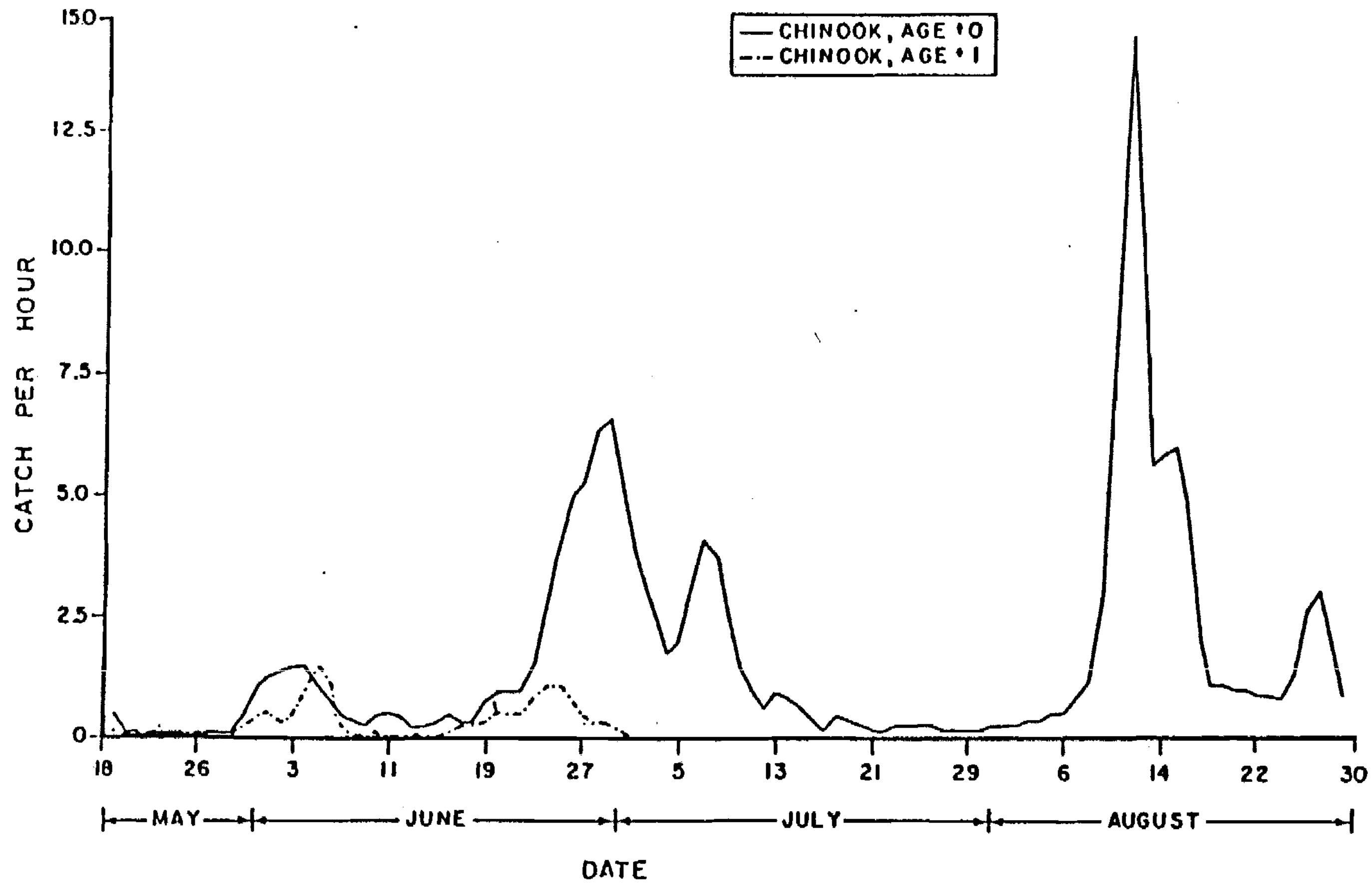
There is a downstream movement of age 0+ chinook throughout the summer (mid-May through August) with a major peak occurring in August (Figure 30). These age 0+ chinook likely redistribute to rearing and overwintering areas downstream of RM 103.

Age 1+ chinook leave the Talkeetna-to-Devil Canyon sub-basin primarily in May and June (ADF&G 1983b). In 1983, the outmigration of age 1+ chinook at RM 103 was over by mid-July (Figure 30). Age 1+ chinook apparently leave the Susitna River by September as no age 1+ juveniles were captured between Cook Inlet and Talkeetna Station (RM 103) after the end of August (1981b).

Analyses were done to compare 1983 juvenile chinook outmigration catch rates at RM 103 with mainstem discharge (Schmidt et al. 1984). The coefficient of determination (r^2) between mainstem discharge and outmigration rates was 0.25 (r = 0.50) for age 1+ fish and 0.19 (r = 0.44) for age 0+ fish. Thus 25 and 19 percent of the variation in outmigration rates was accounted for by mainstem discharge.

(v) Size

Age 1+ chinook averaged 90 mm in length during May and June in 1981 and 1982 (ADF&G 1983b). This is when most age 1+ chinook leave the Talkeetna-to-Devil Canyon sub-basin (RM 98.6-152). In this reach of the Susitna River, age 0+ and age 1+ chinook can be separated by length frequency analysis (Schmidt et al. 1984). In early May age 0+ chinook upstream of RM 103 are less than 56 mm, in early June they are less than 71 mm, and in early July they are less than 81 mm. After August 1 all chinook upstream of RM 103 are considered age 0+ fish (Schmidt et al. 1984).



CHINOOK SALMON AGE 0^+ AND AGE 1^+ DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 30, 1983. (SOURCE: SCHMIDT et al. 1984)

FIGURE 30

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants and ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Downstream of Talkeetna Station (RM 103), it is not possible to separate age 0+ and age 1+ chinook from length frequency data alone because of overlapping lengths of the two age groups. After September 1 all juvenile chinook downstream of RM 103 are considered to be age 0+ fish (ADF&G 1981b).

(vi) Population Estimates

No estimate of population size for juvenile chinook has been done in the Susitna River. In 1982 juvenile chinook abundance in the Talkeetna-to-Devil Canyon sub-basin was lower than in 1981 and 1983 (Schmidt et al. 1984). Comparisons of the catches at the east bank downstream migrant trap (RM 103) between 1982 and 1983 indicate that juvenile chinook abundance was over four times greater in 1983 than for the same time period in 1982 (Schmidt et al. 1984).

4.4 RESIDENT SPECIES

4.4.1 Rainbow Trout

Rainbow trout occur throughout the Susitna Basin below Devil Canyon (ADF&G 1983b). Upstream from Talkeetna, they mainly use tributaries for spawning and rearing, while overwintering occurs primarily in the mainstem (Schmidt et al. 1984).

Upstream of the Chulitna River confluence (RM 98.6), rainbow trout move into tributaries to spawn in late May and early June (Schmidt et al. 1984). Whiskers Creek (RM 104.4), Lane Creek (RM 113.6) and Fourth of July Creek (RM 131.1) are the major spawning areas in this river reach, whereas the larger tributaries (Indian River and Portage Creek) are of lesser importance (Schmidt et al. 1984). Both sexes mature by age 5+ (Schmidt et al. 1984).

There is a post-spawning movement from spawning areas to feeding areas (Schmidt et al. 1984). These feeding areas may be located in the same tributaries in which spawning occurred, or in other tributaries and at tributary mouths (ADF&G 1983b, Schmidt et al. 1984). During August and September rainbow trout can be found in sloughs and at tributary mouths that are occupied by adult salmon (ADF&G 1983b, Schmidt et al. 1984). It is suspected that rainbow trout feed on salmon eggs at these sites (Schmidt et al. 1984).

Juvenile rainbow trout rear mainly in tributaries (ADF&G 1983b, Schmidt et al. 1984). Some juveniles also rear in the mainstem and sloughs, but the use of these habitats appears to be limited (ADF&G 1983b, Schmidt et al. 1984). Fourth of July Creek (RM 131.1) is an important rearing area for juvenile rainbow trout (Schmidt et al. 1984).

In the fall, rainbow trout move out of tributaries into the mainstem to overwinter (ADF&G 1983b, Schmidt et al. 1984). By early December in 1983, most radio-tagged rainbow trout were located in mainstem areas that were not influenced by tributary inflow (Schmidt et al. 1984).

Based on recaptures from three years of tagging (1981-1983), the population size of rainbow trout in the Talkeetna-to-Devil Canyon reach was estimated to be about 4,000 fish (greater than 150 mm in length) (Schmidt et al. 1984). This estimate should be viewed as an approximation because it does not account for annual recruitment, mortality or emigration (Schmidt et al. 1984).

4.4.2 Arctic Grayling

Arctic grayling are found throughout the Susitna Basin (ADF&G 1983b). In the Talkeetna-to-Devil Canyon reach, Arctic grayling primarily use mainstem habitats for overwintering and tributaries for spawning and rearing (ADF&G 1983b, Schmidt et al. 1984).

Upstream of Talkeetna, Arctic grayling move into tributaries to spawn in May and early June (ADF&G 1983b, Schmidt et al. 1984). High catches occurred in Whiskers Creek Slough (RM 101.2), Lane Creek (RM 113.6), Fourth of July Creek (RM 131.1), Indian River (RM 138.6), Jack Long Creek (RM 144.5) and Portage Creek (RM 148.8) in 1982 and 1983 (Schmidt et al. 1984). Although these tributaries have not been identified as spawning areas, they are likely candidates. Spawning may also occur in the mainstem. In 1983, it was suspected that spawning occurred at or near RM 150.1 (Schmidt et al. 1984).

After spawning, most adults and juveniles remain in tributaries or move to tributary and slough mouths until early September (ADF&G 1983b, Schmidt et al. 1984). Some juvenile fish rear in mainstem areas (ADF&G 1983b, Schmidt et al. 1984). These juveniles may be displaced from tributary habitat by the territorial behavior of older, larger fish (ADF&G 1983b, Schmidt et al. 1984).

During September, Arctic grayling move into the mainstem from tributaries (ADF&G 1983b, Schmidt et al. 1984). It is suspected that this movement to the mainstem is for overwintering, however specific areas have not been identified (Schmidt et al. 1984). Some fish may use the larger, deeper pools in Portage Creek for overwintering (Schmidt et al. 1984).

4.4.3 Burbot

Burbot occur throughout the Susitna River basin (ADF&G 1981d, 1983b). Burbot appear to be more abundant downstream from the Chulitna River confluence (RM 98.6) (Schmidt et al. 1984).

Burbot are associated almost exclusively with the mainstem and mainstem-influenced areas.

Burbot apparently move to spawning areas in the winter and then disperse to feeding areas after spawning is completed (ADF&G 1983b, Schmidt et al. 1984). Other than these migrations, burbot are generally sedentary (ADF&G 1983b). Burbot spawning takes place from mid-January to early February in mainstem-influenced areas (ADF&G 1983a, Schmidt et al. 1984). Tributary and slough mouths are thought to be important areas of spawning, as are mainstem areas with groundwater upwelling (ADF&G 1983a, Schmidt et al. 1984). Spawning areas have not been located in the Talkeetna-to-Devil Canyon reach (Schmidt et al. 1984). Downstream of Talkeetna, the mouth of the Deshka River (RM 40.5) is a known spawning area (ADF&G 1983a).

Due to the limited catch data, juvenile rearing areas are unknown. It is suspected that juvenile burbot rear in the mainstem, tributary and slough mouths, and clearwater sloughs (ADF&G 1981d, 1983b).

In 1983, 15 burbot were estimated to occur between RM 138.9 and 140.1 (Schmidt et al. 1984). This population estimate should be viewed as an approximation because few fish were caught during this study (Schmidt et al. 1984). However, it appears that the burbot population size in the middle Susitna River is low.

4.5 OTHER SPECIES

4.5.1 Round Whitefish

Round whitefish occur throughout the Susitna River drainage (ADF&G 1981d). Downstream from Devil Canyon, they appear to be more abundant in the middle river reach (ADF&G 1983b). Within this reach, round whitefish are most numerous between RM 132.6 and 150.1 (Schmidt et al. 1984).

Round whitefish were found in tributaries and sloughs more often than mainstem areas in 1982 and 1983 (Schmidt et al. 1984). The mainstem is used for some spawning and juvenile rearing, and as a migrational corridor.

During September, there is an upstream migration of round whitefish that is thought to be associated with spawning (ADF&G 1983b). This species spawns in the mainstem and at tributary mouths in October (ADF&G 1983b, Schmidt et al. 1984). During 1981 through 1983, nine spawning areas were identified upstream of Talkeetna. Mainstem sites were: RM 100.8, 102.0, 102.6, 114.0, 142.0 and 147.0 (Schmidt et al. 1984). Round whitefish may also spawn in tributaries, such as Indian River and Portage Creek (Schmidt et al. 1984).

Juvenile round whitefish rear mainly in the mainstem and sloughs (ADF&G 1983b, Schmidt et al. 1984). Slow velocities and turbid water are apparently preferred (Schmidt et al. 1984). Overwintering areas of round whitefish have not been identified (ADF&G 1983b).

4.5.2 Longnose Sucker

Longnose suckers occur throughout the Susitna Basin (Schmidt et al. 1984, Sautner and Stratton 1984). They appear to be more abundant downstream of the Chulitna River confluence (RM 98.6) (Schmidt et al. 1984). In the Talkeetna-to-Devil Canyon reach (RM 98.6-152), longnose suckers are primarily associated with tributary and slough mouths, although the mainstem is also used throughout the open-water season (ADF&G 1983b, Schmidt et al. 1984). The major overwintering and juvenile rearing areas of this species are unknown (ADF&G 1983b). The mouths of Trapper

Creek (RM 91.5) and Sunshine Creek and side channel (RM 85.7) are known spawning areas (ADF&G 1983b).

4.5.3 Humpback Whitefish

Humpback whitefish are found downstream of Devil Canyon between RM 10.1 and 150.1 (Schmidt et al. 1984). They appear to be more abundant downstream from the Chulitna River confluence (RM 98.6) (Schmidt et al. 1984). In the Talkeetna-to-Devil Canyon reach, tributary and slough mouths are used by adults most frequently, with the mainstem serving mainly as a migrational corridor (ADF&G 1983b, Schmidt et al. 1984). Due to low catches of humpback whitefish, little is known of their overwintering, spawning and juvenile rearing areas (ADF&G 1983b, Schmidt et al. 1984). It is suspected that they spawn in tributaries during October (Schmidt et al. 1984).

4.5.4 Dolly Varden

Dolly Varden occur throughout the Susitna Basin (Schmidt et al. 1984). In the Talkeetna-to-Devil Canyon reach, Dolly Varden are found primarily in the upper reaches of tributaries and at tributary mouths (ADF&G 1983b, Schmidt et al. 1984). They apparently use the mainstem for overwintering (Schmidt et al. 1984). Spawning and juvenile rearing areas are suspected to be in tributaries (ADF&G 1983b). The population size of Dolly Varden in the Talkeetna-to-Devil Canyon reach appears tc be low and they are apparently more abundant downstream from the Chulitna River confluence (RM 98.6) (Schmidt et al. 1984).

4.5 5 Arctic Lamprey

Arctic lamprey have been found in the Susitna River as far upstream as Gash Creek (RM 111.5), however they are more abundant downstream of RM 50.5 (ADF&G 1983b, Schmidt et al.

1984). Most fish have been found in tributaries and tributary mouths (ADF&G 1983b, Schmidt et al. 1984).

4.5.6 Threespine Stickleback

Threespine stickleback have been caught in the Susitna River as far upstream as RM 146.9, but they are more abundant downstream of the Chulitna River confluence (RM 98.6) (ADF&G 1983b, Schmidt et al. 1984). Spawning and juvenile rearing apparently occur in tributary and slough mouths (ADF&G 1983b). Over-wintering areas of this species are unknown (ADF&G 1983b).

4.5.7 Bering Cisco

Bering cisco occur mainly downstream of the Chulitna River confluence (RM 98.6) in the Susitna River (Barrett et al. 1984). In 1981 and 1982, the major spawning areas for this species were in the mainstem between RM 75 and 85 (Barrett et al. 1984). In 1982, most spawning fish were age 5 that had gone to the ocean for rearing in their first summer (ADF&G 1982a).

4.5.8 Eulachon

Eulachon occur in the Susitna River as far upstream as RM 50.5, but are more abundant downstream of RM 29 (Barrett et al. 1984). Because eulachon are not found in the middle reach of the Susitna River, they are not discussed in great detail. Information on preferred habitat and life history information can be found in reports by Barrett et al. (1984) and Vincent-Lang and Queral (1984). Eulachon enter the Susitna River in two runs (Barrett et al. 1984). The first run enters the river during the last two weeks of May, while the second run follows during the first two weeks of June (Barrett et al. 1984). Fish from both runs spawn in the mainstem (Barrett et al. 1984). The first-run population size is likely several hundred thousand fish, while the second run is probably several million fish (Barrett et al. 1984). In 1982, most returning adults were age 3 that had gone to the ocean for rearing in their first summer (ADF&G 1982a).

4.5.9 Sculpin

Slimy sculpin occur throughout the Susitna River drainage (ADF&G 1981e, 1983b). They are most abundant in tributaries and tributary mouths, although the mainstem is also used (ADF&G 1983b). Sculpin in the Susitna River are sedentary with spawning, juvenile rearing and adult movements confined to a limited area (ADF&G 1983b). In addition to slimy sculpin, other species of sculpin may occur in the lower Susitna River (ADF&G 1981d).

4.5.10 Lake Trout

Lake trout occur throughout the Susitna Basin, primarily in larger, deeper lakes. Occasionally they can be found in the inlet or outlet streams of these lakes. Lake trout have not been captured in the mainstem-influenced areas of the Susitna River below Devil Canyon (ADF&G 1981b, 1983b; Schmidt et al. 1984).

4.5.11 Northern Pike

Northern pike were apparently illegally transplanted into several lakes in the Yentna River drainage (RM 28) during the 1950's (ADF&G 1981d). During 1981 one northern pike was captured in the Susitna River at Kroto Slough (RM 30.1) (ADF&G 1981d).

4.5.12 Ninespine Stickleback

Ninespine stickleback are apparently rare in the Susitna River. This species has been captured in the vicinity of the Deshka River (RM 40.5) (ADF&G Su Hydro, unpublished data).

5.0 SUMMARY OF HABITAT UTILIZATION

5.1 MAINSTEM AND SIDE CHANNEL HABITATS

Mainstem habitat is comprised of those portions of the Susitna River that normally convey streamflow throughout the year (Figure 2). Both single and multiple channels are included in this habitat category. The mainstem is typically characterized by high water velocities and armored streambeds. Substrates generally consist of gravel and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and sands. Suspended sediment concentrations and turbidity are high during summer due to the influence of glacial melt-water. Streamflows recede in early fall and the mainstem clears appreciably in October. An ice cover forms on the river in late November or December and lasts until late April or May (Trihey 1982, ADF&G 1983e).

Side channel habitat consists of those portions of the Susitna River that normally convey streamflow during the open-water season but become appreciably dewatered during periods of low flow (Figure 2). Side channel habitat may exist either in well-defined overflow channels, or in poorly defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem river. Side channels are characterized by shallower depths, lower velocities and smaller streambed materials than the adjacent habitat of the mainstem river (Trihey 1982, ADF&G 1983e).

5.1.1 Adult Salmon

Five species of Pacific salmon utilize the mainstem and side channels upstream of the Chulitna confluence (RM 98.6), primarily as a migrational corridor (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Migrational periods for adults of each species are:

Sockeye - July through mid-September;
Chum - mid-July through mid-September;
Coho - mid-July through mid-September;
Pink - mid-July through August; and
Chinook - June through July.

Escapement estimates based on 1981 through 1984 data indicate that the mainstem and side channels of the Talkeetna-to-Devil Canyon reach (RM 98.6-152) serve as a migrational corridor for less than 5 percent of the total Susitna River salmon escapement (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

Generally, the upstream migration of adult salmon corresponds with the summer high-flow season. However, peak river discharge events apparently cause slowed upstream movements of salmon until high flows subside (Figures 13, 15, 17, 19, 21). Slowed upstream migration was observed in the Talkeetna-to-Devil Canyon reach at flows above 40,000 cfs at Gold Creek (RM 136.8) (Sautner et al. 1984).

Mainstem and side channel spawning upstream of RM 98.6 has been observed for sockeye, chum and coho salmon (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Chum salmon apparently utilize the mainstem margins and side channels for spawning more than coho or sockeye do. Peak counts of chum salmon spawning in mainstem and side channel habitats were: 14 fish in 1981, 550 fish in 1982, 219 fish in 1982 and 1,266 fish in 1984 (Table 14). Only five coho and 44 sockeye were observed spawning in mainstem and side channel habitats during 1981-1984. Most mainstem spawning has been observed in late August to mid-September. The armored streambed material, high water velocities and infrequent upwelling sites apparently limit spawning in mainstem habitat. In 1984, about 5 percent of the 68,750 salmon spawning upstream of RM 98.6 used the mainstem for spawning (Barrett et al. 1985).

5.1.2 Juvenile Salmon

Juvenile salmon of all five species utilize the mainstem and side channels upstream of RM 98.6 as a migrational corridor. Additionally, mainstem and side channels are important overwintering areas for chinook and coho, and summer rearing areas for chinook salmon. Periods of juvenile salmon mainstem and side channel use in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) are outlined below.

Sockeye - Juvenile sockeye use the mainstem and side channels mainly for movements and outmigration. During 1982 and 1983 most juvenile sockeye moved out of the Talkeetna-to-Devil Canyon reach during June and July (ADF&G 1983b, Schmidt et al. 1984) (Figure 24). Mainstem and side channel habitats are relatively unimportant rearing habitats for this species (Figure 23).

Chum - Juvenile chum leave natal tributaries and sloughs in June and move into side channels and the mainstem (Schmidt et al. 1984). During 1982 and 1983 most juveniles had migrated downstream of RM 103 by mid-July (ADF&G 1983b, Schmidt et al. 1984) (Figure 24). Juvenile chum use mainstem and side channels for rearing in low densities (Schmidt et al. 1984) (Figure 25).

Coho - Relatively few juvenile coho utilized mainstem and side channel habitats for rearing in 1983 (Figure 27). They use these habitats primarily as a migrational corridor and for overwintering. Outmigration of juvenile coho peaked during June in 1982 and in June, July and August during 1983 (ADF&G 1983b, Schmidt et al. 1984) (Figure 26).

Pink - Juvenile pink salmon use the mainstem and side channels mostly as migrational corridors. Most fish moved downstream of RM 103 during May and June in 1983 (Figure 28). Minimal freshwater rearing and growth occurs for juvenile pink salmon because of their short residence time (Schmidt et al. 1984).

Chinook - Mainstem and side channels are important summer rearing and overwintering habitats for juvenile chinook (ADF&G 1981b, 1983b; Schmidt et al. 1984) (Figure 29). Additionally, these habitats are used as migrational corridors. Most age 1+ chinook moved downstream of RM 103 in May and June in 1981 through 1983 (ADF&G 1981b, 1983b; Schmidt et al. 1984), while age 0+ chinook moved downstream throughout the open water season (Figure 30).

Analyses were done to compare 1983 juvenile salmon outmigration rates with mainstem discharge (Schmidt et al. 1984). The correlation coefficient was highest for juvenile chum ($r = 0.89$; $r^2 = 0.79$), indicating that outmigration rates for juvenile chum may be influenced by river discharge levels. Correlation coefficients were moderate to low for the remaining juvenile salmon and ranged from $r = 0.55$ ($r^2 = 0.30$) for juvenile pink to $r = 0.24$ ($r^2 = 0.06$) for age 1+ sockeye.

5.1.3 Resident Species

Most resident species use the mainstem and side channels as migrational corridors. Some species, such as burbot and round whitefish, also spawn in these habitats (ADF&G 1983a, Schmidt et al. 1984).

The mainstem appears to be an important overwintering area for many resident fish. Rainbow trout, Arctic grayling and burbot apparently use the mainstem extensively during the winter (Schmidt et al. 1984). Other species, such as Dolly Varden, whitefish, and suckers, likely overwinter in the mainstem. However, overwintering areas have not been identified for these species.

Juvenile burbot, round whitefish and longnose suckers rear primarily in mainstem and side channel habitats (ADF&G 1983b, Schmidt et al. 1984). Some Arctic grayling and rainbow trout juveniles also use these habitats (Schmidt et al. 1984).

5.2 SIDE SLOUGH AND UPLAND SLOUGH HABITATS

The clear water in sloughs originates from local surface runoff and groundwater upwelling. Groundwater of 2-4^{o}C upwells in some slough channels throughout the year, thus keeping these areas relatively ice free in the winter. The shallow infiltration from the Susitna River is the primary source of the groundwater in many of the sloughs (APA 1984). Local runoff can be an important source of water for some sloughs in the summer.

The stage in the mainstem controls the water surface elevation of the lower portion of the sloughs by forming a backwater that can extend some distance upstream into the slough. This backwater is divided into two parts--clear water from the slough and turbid water from the mainstem. At high mainstem discharges, the water level in the mouth of the slough raises and backs up the clear water in the slough. As the stage in the mainstem drops, the size and character of the backwater changes, reducing the depth of water at the entrance to most sloughs.

When high mainstem flows overtop the upstream (head) end of the sloughs, the flows flush out fine sediments that accumulate in the lower portion of the sloughs. As peak flows in the mainstem subside and the stage in the mainstem drops below the head of the slough, discharge through the slough drops and the water begins to clear, with sand in suspension settling out.

Because of the diversity in the morphology of individual sloughs, the flows at which they are overtopped by the mainstem vary considerably. Most side sloughs are overtopped at flows between 15,000 to 25,000 cfs, although some sloughs are only overtopped at high discharge levels (e.g. Slough 11 at 42,000 cfs).

In general, slough water temperatures are warmer than mainstem water temperatures in the winter, due to the strong influence of groundwater upwelling in the sloughs. This may attract overwintering juvenile anadromous and resident fish to these areas (Schmidt et al. 1984).

Upland sloughs differ from side sloughs in that the upstream (head) end of the slough is rarely connected with the mainstem Susitna River or its side channels (Figure 2). Upland sloughs are characterized by near zero velocities and an accumulation of silt covering the substrate resulting from the absence of mainstem scouring flows. Beaver activity is common in upland sloughs, and large backwater areas of the Susitna River.

5.2.1 Adult Salmon

Sockeye, coho, pink and chum salmon have been observed spawning in slough habitat in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Results of escapements and spawning surveys in 1981 through 1984 indicate that chum and sockeye are the most numerous salmon in sloughs while pink and coho are less abundant.

Total slough escapements upstream of RM 98.6 for 1981 through 1984 are summarized below:

Species	1981	1982	1983	1984	Average
Sockeye	2,178	1,488	1,060	2,203	1,732
Chum	4,501	5,057	2,944	14,634	6,784
Coho	0	2	0	0	1
Pink	38	297	0	647	Odd-years 19
					Even-years 472

In 1984, about 25 percent of all spawning salmon (68,742 fish) upstream of RM 98.6 spawned in slough habitat (Barrett et al. 1985).

Most slough-spawning salmon upstream of RM 98.6 spawn in August and September (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). During 1981 through 1984, spawning activity occurred mainly during the first three weeks of August for pink salmon, the first week of September for chum salmon, and the first two weeks of September for sockeye (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

5.2.2 Juvenile Salmon

Sloughs are important habitats for juvenile salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) because they serve as rearing and overwintering areas. The use of slough habitat by juvenile salmon is discussed below.

Sockeye - Most sockeye rear in sloughs (Figure 23). Natal sloughs (8A, 11 and 21) and upland sloughs are used most frequently. Some sockeye also overwinter in slough habitat (Schmidt et al. 1984).

Chum - Sloughs provide important rearing habitat for juvenile chum salmon (Figure 25). Chum salmon rear for one to three months before they move downstream as smolts.

Most juvenile chum leave the Talkeetna-to-Devil Canyon reach by mid-July (Schmidt et al. 1984).

Pink - The extent of slough utilization by juvenile pink is limited because they spend little time in freshwater (ADF&G 1983b, Schmidt et al. 1984). Pink salmon natal sloughs are listed in Table 18.

Coho - Some juvenile coho move from natal tributaries to upland and side sloughs for rearing (Figure 27). Juvenile coho apparently prefer clear water and lower velocities (Schmidt et al. 1984). These conditions usually occur in upland sloughs more frequently than in side sloughs. Some juvenile coho use sloughs for overwintering.

Chinook - Juvenile chinook used side sloughs and upland sloughs for rearing in relatively low densities in 1983 (Figure 29). However, sloughs apparently provide important feeding areas for juvenile chinook during the fall, salmon-spawning period. During the period, juvenile chinook move into sloughs to feed on salmon eggs (Schmidt et al. 1984). Sloughs may be important overwintering habitat for juvenile chinook.

5.2.3 Resident Species

Sloughs are rearing areas for some resident fish. Rainbow trout, Arctic grayling and round whitefish use sloughs and slough mouths for rearing, while some burbot rear in slough mouths (Schmidt et al. 1984). These fish apparently feed on salmon eggs in sloughs during the salmon-spawning period. Spawning in sloughs by resident fish appears to be limited. Burbot and longnose sucker may spawn in slough mouths (ADF&G 1981a, 1984b). The extent of overwintering in sloughs by resident fish is unknown.

5.3 TRIBUTARY AND TRIBUTARY MOUTH HABITATS

Tributary streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology, and climate of the tributary drainage (Figure 2). Hence, the physical attributes of tributary habitats are not dependent on mainstem conditions.

Tributary mouth habitat extends from the uppermost point that the tributary is influenced by either the mainstem or the slough backwater to the downstream extent of the tributary plume (ADF&G 1981c). The tributary plume is clearwater which extends downstream in the mainstem, side channel or slough before mixing with the more turbid water. The extent of the plume is influenced by both mainstem and tributary flows. At higher mainstem flows, the plume is usually restricted. Depths and velocities in the plume are a function of channel morphology and mainstem stage. Physical characteristics and fish utilization of tributary mouths are also influenced by the type of confluences: tributary/slough, tributary/side channel or tributary/mainstem (Sandone et al. 1984). Water temperature and water quality are those of the tributary.

5.3.1 Adult Salmon

Tributaries serve as the primary spawning habitat for chinook, coho and pink salmon (Barrett et al. 1984, 1985). About one-third of the chum salmon escapement upstream of Talkeetna spawned in tributaries during 1984 (Barrett et al. 1985). Tributaries are rarely used by adult sockeye salmon (Barrett et al. 1984, 1985).

The peak counts in tributaries upstream of RM 98.6 for 1981 through 1984 are summarized below:

Species	1981	1982	1983	1984	Average
Chinook	1,121	2,474	4,432	7,180	3,802
Chum	241	1,737	1,500	3,814	1,823
Pink	378	2,855	1,329	17,505	Odd-year 854
					Even-year 10,180
Coho	458	633	240	1,434	691
Sockeye	1	4	1	13	5

In 1984, about 70 percent of all spawning salmon upstream of RM 98.6 (68,742 fish) spawned in tributaries (Barrett et al. 1985).

All five salmon species spawned in tributary mouth habitat in 1984 (Barrett et al. 1985). Sockeye salmon spawning is limited in this habitat type (Barrett et al. 1985). In contrast, chinook, pink, chum and coho salmon frequently spawned in tributary mouths in 1984 (Barrett et al. 1985). Index counts of spawning salmon in tributary mouth habitats are unavailable, as counts are included in tributary counts. It appears that more spawning occurs in tributaries than in tributary mouths (Barrett et al. 1985). Water depth and velocity may limit spawning in tributary mouths (Sandone et al. 1984).

5.3.2 Juvenile Salmon

The significance of tributary and tributary mouth habitats for juvenile salmon in the Talkeetna-to-Devil Canyon reach (RM 98.6-152) is discussed below.

Sockeye - Juvenile sockeye utilize tributary habitat incidentally (Schmidt et al. 1984). In 1983, few juvenile sockeye were captured in tributary habitat (Figure 23).

Chum - Tributaries likely provide rearing habitat for chum salmon for about one to three months (Schmidt et al.

1984). Tributaries upstream of RM 98.6 that are natal areas for juvenile chum are listed in Table 13.

Coho - Tributaries serve as the primary coho natal areas upstream of RM 98.6. Some juvenile coho use tributaries for rearing throughout the summer, while others redistribute downstream from areas of emergence to other rearing habitats, including tributary mouths (Schmidt et al. 1984). This redistribution occurs throughout the summer as fish become more mobile. Tributary mouths apparently provide important rearing areas for age 0+ coho (ADF&G 1981b, 1983b). Some of the larger tributaries, such as Indian River and Portage Creek, likely provide overwintering habitat for juvenile coho.

Pink - Tributaries upstream of RM 98.6 are the primary natal areas for pink salmon (Barrett et al. 1984, 1985). However, the extent of tributary utilization by juvenile pink is limited because they move downstream to the ocean shortly after emergence (Schmidt et al. 1984).

Chinook - Tributaries are important rearing areas for chinook in the spring and early summer (Schmidt et al. 1984). The redistribution of some juveniles from tributaries to other rearing habitat, including the mainstem, sloughs and tributary mouths, occurs throughout the summer (Schmidt et al. 1984). Tributary mouths apparently are important rearing areas for juvenile chinook. Tributaries, such as Indian River and Portage Creek, are likely utilized by juvenile chinook for overwintering.

5.3.3 Resident Species

In the Talkeetna-to-Devil Canyon reach, tributaries are the primary spawning and rearing areas for rainbow trout and Arctic grayling (Schmidt et al. 1984). The larger tributaries in this reach, such as Portage Creek, may provide overwintering habitat for some rainbow trout and Arctic grayling (Schmidt et al. 1984). However, it appears that overwintering in tributaries is limited (Schmidt et al. 1984).

Round whitefish, humpback whitefish, Dolly Varden and longnose suckers likely spawn in tributary or tributary mouth habitats (ADF&G 1983b, Schmidt et al. 1984). Juvenile Dolly Varden are thought to rear in the upper reaches of tributaries (Schmidt et al. 1984). Tributary mouths are important rearing and feeding areas for many resident species, such as rainbow trout, Arctic grayling and whitefish (ADF&G 1981d, 1983b; Schmidt et al. 1984).

6.0 FACTORS AFFECTING PRODUCTION

Each life stage of fish has factors that may limit production. Some of these factors are complex and the mechanisms are not easily understood (e.g., the relationships among food availability, growth, and survival). In contrast, other factors are readily defined, such as freezing of redds causing direct mortality. Although biological organisms have the ability to adjust and adapt to various environmental conditions, overall they may not be highly successful. For example, survival of salmon eggs from deposition to fry emergence may be 5 percent or less under natural conditions. In contrast, survival rates of 95 percent or greater occur frequently under artificially controlled conditions (e.g. hatchery or laboratory conditions) that exclude many of the limiting factors. Following is a summary of the major limiting factors that may affect the freshwater phases of anadromous salmonids in the Susitna River. Although specific studies may not have identified some of these as factors in the Susitna River, they have been described in other similar river systems.

6.1 ADULT SALMON

When adult salmon enter the Susitna River, several potential situations can prevent them from successfully spawning. These include:

(i) Sport Fishing - sportfish harvests remove fish from the system. The primary fishing effort in the Susitna River is for chinook and coho salmon. The effect of sport fishing is most evident on the coho salmon run. In 1983, almost one of every five coho entering the Susitna River was caught by an angler (Table 3). The extent of harvest is governed by regulations, water conditions, access to fishing sites, etc.

(ii) Predation - in areas where salmon are available, predators can remove adults prior to spawning. Alaska Department of Fish and Game personnel (1984a) have noted predation by bears, otter, weasels and eagles in the Susitna River, but this removal of fish is unquantified. Predation by animals is probably less significant than the effects of sport fishing.

(iii) Access - barriers to upstream migration such as Devil Canyon, impassable reaches in sloughs during low flow conditions and beaver dams can prevent fish from reaching spawning areas. It is unknown if this precludes successful spawning. Salmon strandings in passage reaches of sloughs, which can result in mortality, have been noted (Barrett et al. 1984).

Additional factors such as high or low temperature extremes, low dissolved oxygen, and turbid waters have been implicated as potential factors limiting upstream migration (Reiser and Bjornn 1979). However, these have not been shown to prevent successful migration in the Susitna River, probably because the adults are exposed to ranges of these factors that are within their range of tolerance. Other factors such as high flows have been shown to result in cessation of upstream movement (Barrett et al. 1984, 1985) (Figures 13, 15, 17, 19, 21), but movement does resume following these events and fish do successfully move to their spawning sites. Therefore, mortality associated with high flow events is likely not a significant factor.

6.2 SPAWNING AND INCUBATION

Each species within the Susitna Basin characteristically tends to utilize specific areas for spawning (see Section 4.1). The lack of a particular type of area can limit production for a specific species.

(v) Upwelling - Certain species, particularly chum salmon, seek areas of groundwater upwelling for spawning and incubation (Vincent-Lang et al. 1984, Barrett et al. 1985). These areas offer potential temperature and flow benefits. Because upwelling areas often support major spawning, it is assumed that areas lacking upwelling would likely limit the spawning and incubation success of species like chum salmon.

(vi) Predation - Sculpins and other fish species such as Dolly Varden and rainbow trout have been implicated as taking significant numbers of salmon eggs. For example, Hunter (1959) found that, with pink and chum fry, the mortality from predation could range from 23 to 86 percent. Predation on salmon eggs and embryos in the Susitna River has not been quantified.

(vii) Low Streamflow - Low water can dewater spawning areas and expose incubating eggs and alevins (McNeil 1969). Reduced winter flows may cause significant mortality, if adult fish spawned under high water conditions and redds were located along the margins. This may have occurred during 1982 spawning and 1982-1983 incubation periods (Schmidt et al. 1984). The occurrence of groundwater upwelling may reduce mortalities in areas of upwelling when natural flows in the Susitna River are lower during the winter.

(viii) High Streamflow - Extremely high flows can scour redds and destroy eggs and alevins. High scouring flows are uncommon in fall and winter in the Susitna River. Thus, scouring is probably not an important limiting factor.

(ix) Freezing - If redds are frozen, mortalities will occur. Alevins may be able to move through the gravel to avoid adverse conditions. Freezing of redds is associated with low streamflows and sub-freezing temperatures; these conditions occur annually in the Susitna River. However, mortality due to frozen redds is unquantified in the Susitna River. Dependence on upwelling areas by adult salmon may reduce embryo losses due to freezing.

(x) Sedimentation - An influx of fine sediments can shut off the water flow through the substrate and result in increased mortality. Sedimentation of spawning areas in sloughs and side channels by high mainstem discharge, ice processes and local flows occur in the Susitna River. During spring breakup in 1982, Slough 9 suffered a heavy influx of silts and sands, reducing the amount of usable spawning habitat (ADF&G 1983a).

(xi) Intraspecific Competition - Adult salmon of the same species may compete for specific spawning areas if the density of spawning adults is high. Competition for redd sites can lead to superimposition of redds (the excavation of existing redds). Based on egg retention studies, Barrett et al. (1984) concluded that the adult salmon density was not excessive for chum salmon in slough habitats in 1983.

(xii) Interspecific Competition - Adult salmon of two or more species may compete for specific redd sites (e.g. chum and sockeye may utilize similar spawning habitats in sloughs). This can cause problems similar to those for intraspecific competition.

(xiii) Dissolved Oxygen - If sufficient dissolved oxygen is not present, growth of embryos can be retarded and mortality may occur. Dissolved oxygen is strongly tied to permeability of gravels and intragravel flow. Density of salmon eggs can also be a significant factor. If only a few eggs are present, a given level of dissolved oxygen, intragravel flow, and substrate permeability may be sufficient. At higher egg densities, this level might be insufficient and would cause poorly developed fry or, in severe cases, mortality. Studies by ADF&G (1983a) have indicated that dissolved oxygen levels in the Susitna River are generally not a problem for incubating embryos.

(xiv) Ice Processes - In certain instances, staging due to ice cover can raise the level of the river diverting cold mainstem water ($0^{\circ}C$) into sloughs that are predominantly supplied by warmer upwelling water (e.g. Slough 8A in 1982-1983; ADF&G 1983a). This can lead to reduced intragravel water temperatures, which can delay embryo development or cause mortality.

6.3 REARING

Factors that limit the rearing phase of salmonids are complex and vary with species, size, and time of year. These factors may affect species for only a short period of time (e.g., pink salmon fry may only be in freshwater for a few days before they outmigrate) or for more than a year (e.g. chinook, coho or sockeye juveniles). Following is a brief summary of the major factors that affect rearing fish:

(i) Primary and secondary production - the amount of available food at specific times of the year can be critical to assuring the growth and survival of rearing fish. In the Susitna River, the highly turbid water in the ice-free season reduces light penetration and primary production; primary and secondary production in the winter may be severely restricted by the ice cover and low levels of light. These, in turn, can severely reduce secondary production and potential sources of fish food from within the system (autochthonous production). The extent of either autochthonous or allochthonous (food sources from outside the system such as insects that fall into the water) food production in the Susitna River is presently unknown, although a study is currently underway to determine primary productivity relationships. Nutrients that support primary production may not be limiting in the Susitna River: extensive blooms of benthic algae have been noted during brief clear-water periods that occur prior to freeze-up.

(ii) Water Velocity - This factor is important both for allowing production of food organisms and for optimization of energy expenditures by fish. For example, fish will seek areas in which they do not have to needlessly expend energy. Low to moderate stream gradients and water velocities generally are considered productive juvenile rearing habitat (Canada Fisheries and Oceans 1980). Peak flow events that affect mainstem rearing areas may cause a downstream displacement of juvenile chinook (Schmidt et al. 1984).

(iii) Water Depth - Small fish appear to utilize shallower areas with greater frequency. Unless too shallow to allow free movement, depth does not usually cause mortality in the Susitna River. Juvenile fish utilize water depth for cover in some situations.

(iv) Substrate - The number of benthic invertebrates generally decreases in the progression of rubble to bedrock to gravel to sand (Reiser and Bjornn 1979). This affects fish food production. Substrate also provides cover for juveniles and areas of decreased velocity. Cementing of interstitial spaces in mainstem and side channel substrates likely reduces their utility to rearing juveniles.

(v) Water Quality - Temperature, dissolved oxygen, turbidity, pH and other water quality parameters can all limit production if they are not within a specific range. Even with this range, an optimum may not be available under natural conditions (e.g. an optimum temperature for growth of salmonids may be around 15°C, but temperatures do not reach this level in the Susitna).

(vi) Cover - Juvenile salmonids require cover that provides protection from predators. Cover can include turbid water, vegetation, substrate and depth. Large substrates and turbidity commonly provide cover in mainstem and side channel habitats. Vegetation and organic debris provide cover in upland and side slough habitats.

The end result of exposure to limiting factors in any system is the number of fish that are able to survive and reproduce. The on-going studies to document the fish resources and habitats of the Susitna River are designed to establish these numbers.

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