SUSITNA HYDROELECTRIC PROJECT

FISH RESOURCES AND HABITATS OF THE SUSITNA BASIN

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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 reflects 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 Su Hydro Aquatic Study Team, R&M Consultants, and E. Woody Trihey and Associates. 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 of the Susitna Basin. This report, prepared by Woodward-Clyde Consultants, consolidates information on the fish resources and habitats in the Talkeetna-to-Devil Canyon reach of the Susitna basin available through June 1984 that is currently dispersed throughout numerous reports.

Technical Report No. 2. Physical Processes Report. This report, prepared by R&M Consultants, describes naturally occurring physical processes within the Talkeetna-to-Devil Canyon river reach pertinent to evaluating project effects on riverine fish habitat.

Technical Report No. 3. Water Quality/Limnology Report. This report, 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. This report is based principally on data and information that is available through June 1984.

Technical Report No. 4. Reservoir and Instream Temperature. This report, prepared by AEIDC, consists of three principal components: (1) reservoir and instream temperature modeling; (2) selection 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.

Technical Report No. 5. Aquatic Habitat Report. This report, prepared by E. Woody Trihey and Associates, describes the availability of various types of aquatic habitat in the Talkeetna-to-Devil Canyon river reach as a function of mainstem discharge.

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1.0 INTRODUCTION

This report summarizes the available information on the fishery resources and habitats of the Susitna River. 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 the important information relative to the decisionmaking process, this report is focused on habitats and species most likely to be affected by the proposed project. Most of the report emphasizes the Talkeetna-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).

The proposed project is expected to have the greatest downstream effects on habitats within this reach. Downstream from Talkeetna, the inflow from the Talkeetna and Chulitna rivers is expected to reduce the magnitude of change in physical processes under with-project conditions. Additionally, this report emphasizes salmon species and their habitat utilization because of their importance in commercial, sport and subsistence fisheries and high social value. The available project information reflects the heavy emphasis given salmon species.

Section 2.0 contains a brief description of the project and project area and a synopsis of the studies that have been conducted to date on fish resources of the Susitna River. 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 five Pacific salmon found in the Susitna River. Habitat utilization and relationships are discussed in Section 5.0. Based on studies to date, the significance of habitat types for a species life stage is presented. Section 6.0 summarizes some factors that affect fish production in freshwater and discusses their possible significance in 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 its mouth in Cook Inlet (Figure 1). The study area for the Susitna hydroelectric project fish studies includes the Susitna River mainstem, side channels, sloughs, and mouths of major tributaries. A diagram and description of major 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: Devil Canyon Dam (RM 152) and Watana Dam (RM 184). The project would reduce streamflows during the summer and increase them during the winter. Suspended sediment, 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 are presented by Acres (1983a,b).

Fish and aquatic habitat investigations have been conducted on the Susitna River for about ten years to evaluate the proposed hydroelectric project. Beginning in 1974, studies were conducted to describe and quantify fish resources, habitat utilization and aquatic habitats of the Susitna River. In 1980 the Susitna Hydroelectric Aquatic Studies Program was initiated. Baseline data collection on fish and aquatic habitat resources was divided into three groups: Adult Anadromous Fish Studies (AA), Resident and Juvenile Anadromous Fish Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH).

The objectives of the three sections 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 and the relationship between the availability of these habitat conditions and the mainstem discharge of the Susitna River.

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

Adult Anadromous

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 above RM 98.6.

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

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

Resident and Juvenile Anadromous

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

b. Identified important spawning locations for 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.

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

f. Defined outmigration timing and rates 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 access and 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 sport fishing for residents of Anchorage and the surrounding area. Anadromous species that form the base of commercial and non-commercial fisheries include five species of Pacific salmon: chinook, coho, chum, sockeye, and pink. Other anadromous species include eulachon and Bering cisco.

The Susitna River is a migrational corridor, spawning area, and juvenile rearing area for five species of salmon from its point of discharge into Cook Inlet [river mile (RM) 0] to Devil Canyon (RM 152), where salmon are usually prevented from moving upstream by the water velocity at high discharge. 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 (ADF&G 1984a,b).

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 identified from 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 upper Cook Inlet salmon production originates in the Susitna Basin (ADF&G 1984a). The long-term average annual catch of 3.0 million fish is worth approximately $17.9 million to the commercial fishery (K. Florey, ADF&G, personal communication, 1984). In 1982 and 1983 fishermen landed record numbers of salmon in the upper Cook Inlet fishery (Figure 3); over 6.2 million salmon were caught in 1982 and over 6.7 million fish were landed in 1983. The Susitna River is considered the most important salmon-producing system in upper Cook

Inlet; 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 migration timing of mixed stocks and species in Cook Inlet harvest areas.

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

3.2.1 Sockeye Salmon

The commercial sockeye harvest has averaged 1.31 million fish annually in upper Cook Inlet over the last 30 years (Table 2). The estimated contribution of Susitna River sockeye to the upper Cook Inlet fishery is between 10 to 30 percent (ADF&G 1984a). This represents an estimated annual Susitna River sockeye harvest of between 131,000 to 393,000 fish in the commercial harvest over the last 30 years. In 1983 the upper Cook Inlet sockeye catch was the highest in the 30 years of record (Figure 4) and Susitna River sockeye contributed approximately 500,000 fish to the total catch of 5 million (Table 3).

3.3.2 Chum Salmon

The upper Cook Inlet chum salmon catch has averaged 658,000 fish annually since 1954 (Table 2). The contribution of Susitna River chum to the upper Cook Inlet fishery is about 85 percent (ADF&G 1984a). This contribution represents an estimated average annual chum harvest of 559,000 Susitna River fish in the commercial harvest over the last 30 years. The Susitna harvest of chum in 1982 was about 1.22 million fish (Table 3) when a record 1.43 million chum were caught in the upper Cook Inlet fishery (Figure 5).

3.2.3 Coho Salmon

Since 1954, the upper Cook Inlet coho salmon commercial catch has averaged 258,000 fish annually (Table 2). Approximately 50 percent of the commercial coho harvest in upper Cook Inlet is Susitna River coho (ADF&G 1984a). This contribution represents an average annual Susitna River coho harvest of 129,000 fish in the commercial harvest over the last 30 years. In 1982 the estimated Susitna coho harvest was 388,500 fish (Table 3) when a record 777,000 coho were harvested in the upper Cook Inlet fishery (Figure 6).

3.2.4 Pink Salmon

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, while the average, annual, even-year harvest is approximately 1.64 million pink with a range of 484,000 to 3.23 million fish (Table 2; Figure 7). The estimated contribution of Susitna River pink salmon to the upper Cook Inlet pink fishery is 85 percent (ADF&G 1984a). This represents an average annual Susitna River contribution of 102,000 odd-year pink and 1.39 million even-year pink to the upper Cook Inlet fishery over the last 30 years.

3.2.5 Chinook Salmon

The commercial chinook harvest has averaged 19,600 fish annually in the upper Cook Inlet fishery over the last 30 years (Table 2). Since 1964, the opening date of the commercial fishery has been June 25, and the Susitna River chinook salmon run begins in late May and peaks in mid-June. Thus, the majority of chinook have already passed through the area subject to commercial fishing. Commercial catches for

1964-1983 have been lower than catches before 1964 (Figure 8) because of the change in the opening date. Catches have averaged 11,600 chinook annually for the 20 year period of 1964-1983. Approximately 10 percent of the total chinook harvest in upper Cook Inlet is Susitna River stock (ADF&G 1984a). 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.

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, especially 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 easily accessible from Anchorage and other Cook Inlet communities. Since 1978, the Susitna River and its primary tributaries have accounted for an average of 127,100 angler days of sport fishing effort, 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, 1984). The estimates represent the sport fishing harvests throughout the Susitna Basin and includes an area that is larger than that which could be affected by the proposed project (see Figures 9 and 10 for locations of 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). This represents a Susitna Basin contribution of about 30 percent to the Southcentral Arctic grayling sport harvest for the six year period. The largest sport harvest of Arctic grayling on record in the Susitna Basin occurred in 1980 when an estimated 22,100 fish were caught, which represents about 32 percent of the total Southcentral grayling harvest for that year (Mills 1981).

3.3.2 Rainbow Trout

The Susitna Basin and Southcentral Alaska rainbow trout sport harvests have averaged 16,000 and 132,900 annually since 1978 (Table 5). Approximately 12 percent of the annual Southcentral Alaska rainbow trout sport harvest was caught in the Susitna Basin over the last six years. In 1979, about 18,350 rainbow trout were harvested by anglers in the Susitna Basin, which represents approximately 14 percent of the 1979 Southcentral region grayling sport catch (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). This represents a Susitna Basin harvest of about 32 percent of the annual, even-year pink sport catch in Southcentral Alaska since 1978. 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). Approximately 15 percent of the odd-year Southcentral pink harvest was caught in the Susitna Basin since 1979. The largest sport harvest on record of pink salmon 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 coho salmon sport harvests have averaged 13,200 and 103,800 fish annually

(Table 5). This represents a Susitna Basin sport harvest of 13 percent of the Southcentral Alaska coho sport harvest for the six year period. In 1982 about 16,664 coho were landed by anglers in the Susitna Basin (Mills 1983), which is the largest annual catch on record. The annual sport harvest of coho in the Susitna Basin is significant when compared with the estimated total escapement of coho in the basin. In 1983, almost one out 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 chum salmon sport harvests have averaged 6,800 and 12,150 fish annually since 1978 (Table 5). This represents an annual Susitna Basin contribution of 56 percent to the Southcentral chum sport harvest for the six year period. 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). This represents an annual Susitna Basin contribution of less than 2 percent of the Southcentral sockeye sport harvest for the six year period. 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

Subsistence harvests within the Susitna Basin are unquantified even though salmon provide an important resource for many Susitna Basin residents. The village of Tyonek, approximately 30 miles (50 km) southwest of the Susitna River mouth, is supported primarily by subsistence fishing on Susitna River chinook stocks (ADF&G 1984d). The Tyonek subsistence fishery was reopened in 1980 after being closed for sixteen years. The annual Tyonek subsistence harvest has averaged 2,000 chinook, 250 sockeye and 80 coho for the years 1980 through 1983 (ADF&G 1984c).

4.0 SPECIES BIOLOGY

4.1 ADULT MIGRATION

4.1.1 Sockeye Salmon

(i) Timing of Runs

Sockeye salmon enter the Susitna River in two distinct runs. The first run of fish enters the river in late May to early June and peaks at Sunshine Station (RM 80) between the first and third weeks of June (ADF&G 1984a). The escapement of first-run sockeye at Sunshine Station was about 5,800 fish in 1982 and 3,300 fish in 1983. First run sockeye spawned exclusively in Papa Bear Lake and inlet stream in the Talkeetna River drainage (RM 97.1) in 1982 and 1983 (ADF&G 1982a, 1984a). Peak spawning activity for first run sockeye in Papa Bear Lake was between the second and fourth weeks of July in 1983 and between the third week of July and the first week of August in 1982.

Second-run sockeye enter the Susitna River about the last of June and in 1981, 1982 and 1983 passed Sunshine Station between the third week of July and the second week of August (ADF&G 1984a). Second-run sockeye are abundant in the Talkeetna-Devil Canyon reach (RM 98.6-152) from about the third week of July to the fourth week of August. A summary of second-run sockeye migration timing in the Susitna River basin for 1981, 1982, and 1983 is presented in Figure 11.

Second-run sockeye salmon migration timing may be influenced by river discharge. In 1982 a discharge spike above 80,000 cfs at Sunshine Station coincided with reduced ADF&G fishwheel catches at Sunshine Station (Figure 12). In 1983 river discharge was below 80,000 cfs during most of the second-run sockeye migration at Sunshine Station and the migration passed Sunshine Station in one major peak (Figure 12). In 1981 river discharge was declining from over 150,000 cfs at Sunshine Station when most of the second-run sockeye passed Sunshine Station (Figure 12). Based on this analysis, it appears that spikes in discharge over 80,000 cfs at Sunshine Station can delay sockeye salmon migration timing.

(ii) Escapement

The total annual escapement of second-run sockeye salmon in the Susitna River has averaged 250,000 fish for 1981, 1982 and 1983 (Table 6). Total escapement is derived by the summation of population estimates at Yentna Station [RM 28, tributary river mile (TRM) 04] and Sunshine Station (RM 80) plus an additional five percent to correct for fish that may spawn in other portions of the basin (Barrett 1984). The majority (94 percent) of second-run sockeye in the Susitna River enter the Yentna sub-basin (RM 28) and the Talkeetna-Chulitna sub-basin (RM 80-98.6), with an estimated annual escapement to these sub-basins of 235,000 fish (Table 6).

For 1981, 1982, and 1983, second-run sockeye escapements have averaged 2,800 fish annually in the Talkeetna-Devil Canyon sub-basin (Table 6), with a range of 2,170 to 3,360. The escapements are based on population estimates at Talkeetna Station (RM 103), corrected for the estimated 30 percent of the fish that return downstream below Talkeetna Station and spawn elsewhere (Barrett 1984). The annual second-run sockeye escapement to the Talkeetna-Devil Canyon sub-basin for 1981 through 1983 represents about 1 percent of the total annual sockeye escapement to the Susitna Basin for 1981-1983 (Table 6, Figure 13).

Scale patterns of sockeye returning to the Chulitna River (RM 98.6) and Talkeetna River (RM 97.1) spawning areas and of sockeye spawning in sloughs upstream of Talkeetna Station were examined as part of the ADF&G stock separation program. The analysis indicated that the sockeye spawning in sloughs upstream of Talkeetna Station in 1982 could not be separated from Talkeetna and Chulitna stocks on the basis of scale patterns (ADF&G 1982b). The sockeye spawning upstream of Talkeetna Station may be strays from Chulitna River and Talkeetna

River stocks, or could be a stock that originated from strays of the Talkeetna or Chulitna stocks.

(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 1.8 miles per day (mpd) in 1981, 2.4 mpd in 1983 and 2.7 mpd in 1982 (ADF&G 1984a). The average rate of travel increased for tagged, second-run sockeye between Sunshine Station and Curry Station (RM 120): 2.7 mpd in 1981, 3.4 mpd in 1982 and 3.7 mpd in 1983 (ADF&G 1984a). It appears that sockeye migration rates increase and/or milling decreases as sockeye approach spawning areas.

Do you mean Talkeetna

4.1.2 Chum Salmon

(i) Timing of Runs

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 (ADF&G 1984a). The chum migration lasts about one month in the lower river, with most fish passing Yentna Station by the third week of August (ADF&G 1984a). The chum migration passes Sunshine Station (RM 80) from the end of July to early September. In the Talkeetna-Devil Canyon reach (RM 98.6-152), the chum 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.

Chum salmon migration timing may be influenced by river discharge, commercial catches in upper Cook Inlet and stock differences (ADF&G 1984a). During chum migrations in 1981 and 1983, peak river discharge levels greater than 80,000 cfs at Sunshine Station coincided with reduced fishwheel catches at Sunshine Station and appeared to delay the chum migrations (Figure 15). In contrast, during the 1982 chum migration, river discharge levels at Sunshine Station did not exceed

80,000 cfs during the chum migration and the migration passed Sunshine Station in one major peak (Figure 15). The 1982 chum migration at Sunshine Station was approximately two weeks shorter in duration than the 1981 and 1983 migrations, presumably because the 1982 migration was undelayed by high river discharge. In 1982, the chum salmon average migration rate (see Sec. 4.1.2, iii) from Sunshine Station to Talkeetna Station (RM 103) was faster than in 1981 and 1983 (ADF&G 1984a) and indicates that the 1982 chum migration was undelayed by high river discharge at Sunshine Station.

Commercial catch data from the upper Cook Inlet fishery for 1981, 1982 and 1983 were compared with 1981, 1982 and 1983 ADF&G fishwheel catches at Sunshine Station. A 20 day adjustment was made to allow for migration timing between the fishery and Sunshine Station (ADF&G 1984a). Reduced fishwheel catches in 1981 and 1983 corresponded with peak commercial catches greater than 100,000 fish. However, the 1982 peak fishwheel catch and the second peak fishwheel catch in 1983 at Sunshine Station coincided with peak commercial catches greater than 100,000 fish in upper Cook Inlet. In some years differential commercial fishing may take place on Susitna River chum stocks, while in other years commercial harvests in upper Cook Inlet do not appear to influence the migration timing of chum in the Susitna River. The effect of commercial catches on chum migration timing may be masked by run strength and river discharge.

Preliminary observations by ADF&G personnel suggest that the chum migration in the Susitna River is not segregated by spawning habitat types (ADF&G 1984a). Slough spawning and stream spawning chum salmon were numerous in both habitats in late July 1983.

Does this indicate no stock differences or coincidal stock movement?

(ii) Escapement

For the last three years, the annual chum salmon total escapement in the Susitna River has averaged 356,200 fish (Table 6). Chum total escapement is derived by the summation of population estimates at Yentna Station (RM 28, TRM 04) and Sunshine Station (RM 80) plus an additional five percent estimated to spawn in other portions of the basin (Barrett 1984). The majority (83 percent) of Susitna River chum salmon enter the Talkeetna-Chulitna sub-basin (RM 80-98.6), which has a three-year average escapement of 295,600 fish (Table 6).

In the Talkeetna-Devil Canyon reach, the chum salmon escapement has averaged 24,100 fish for 1981, 1982 and 1983 (Table 6), with a range of 12,500 fish to 30,200 fish. The escapements are derived from population estimates at Talkeetna Station (RM 103), less 40 percent for those fish that return downstream below Talkeetna Station and spawn elsewhere (Barrett 1984). The Talkeetna-Devil Canyon sub-basin chum salmon escapements for 1981 through 1983 represent about seven percent of the total Susitna River basin escapements for those years (Table 6, Figure 16).

(iii) <u>Migration Rate</u>

Tagged chum salmon migrated between Sunshine Station (RM 80) and Talkeetna Station (RM 103) at an average rate of travel of 3.8 miles per day (mpd) in 1983, 4.1 mpd in 1981 and 4.9 mpd in 1982. Chum salmon migrated at faster rates between Talkeetna Station and Curry Station (RM 120): 4.5 mpd in 1981, 6.3 mpd in 1983, and 7.7 mpd in 1982. Migration rates appear to increase as chum salmon approach spawning areas.

4.1.3 Coho Salmon

(i) <u>Timing of Runs</u>

Coho salmon enter the Susitna River in 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 (ADF&G 1984a). The majority of the coho migration passes Sunshine Station (RM 80) between the end of July and the end of August. Coho salmon are numerous in the Talkeetna-Devil Canyon reach (RM 98.6-152) from the last week of July to the first week of September. A summary of coho migration timing in the Susitna River for 1981, 1982, and 1983 is presented in Figure 17.

Coho salmon migration timing may be influenced by river discharge, commercial catches in upper Cook Inlet and stock differences (ADF&G 1984a). During coho migrations in 1981 and 1983 river discharge levels greater than 80,000 cfs at Sunshine Station coincided with reduced ADF&G fishwheel catches at Sunshine Station and appeared to delay the migrations (Figure 18). In 1982 river discharge did not exceed 80,000 cfs at Sunshine Station during the coho migration and the migration passed Sunshine Station in one main peak (Figure 18). The 1982 coho migration was approximately two weeks shorter in duration than the 1981 and 1983 migrations, presumably because it was undelayed by high river discharge levels. The average migration rate of coho salmon in 1982 (see Sec 4.1.3, iii) between Sunshine Station and Talkeetna Station (RM 103) was faster than in 1981 and 1983 (ADF&G 1984a). The faster migration rate in 1982 adds support to the suggestion that coho salmon were undelayed by high river discharge in 1982.

Commercial catch data from upper Cook Inlet in 1981, 1982 and 1983 were compared with 1981, 1982, and 1983 ADF&G fishwheel catches at Sunshine Station (RM 80). A 24 day adjustment was made to allow for coho migration timing between Cook Inlet and Sunshine Station. Peak commercial catches coincided with peak fishwheel catches in all three years suggesting that migration timing of Susitna River coho is not influenced by differential commercial fishing on Susitna River stocks in Cook Inlet. However, high catches in the commercial fishery apparently reduced the strength of the coho escapement into the Susitna River in 1983 (Table 3).

It appears that the coho migration in the Susitna River is not segregated by spawning habitat type (ADF&G 1984a).

(ii) Escapement

The annual coho salmon total escapement in the Susitna River basin has averaged 86,800 fish for 1981, 1982 and 1983 (Table 6). Total escapement estimates of coho salmon are obtained by summation of population estimates at Yentna Station (RM 28, TRM 04) and Sunshine Station (RM 80) plus an additional 85 percent estimated to spawn in other portions of the basin (Barrett 1984). Most coho salmon (97 percent) enter the lower Susitna sub-basin (below RM 80), the Yentna sub-basin (RM 28) and the Talkeetna-Chulitna sub-basin (RM 80-98.6) (Table 6).

The annual coho escapement in the Talkeetna-Devil Canyon reach (RM 98.6-152) has averaged 2,200 fish for the last three years (Table 6) with a range of 1,400 fish to 3,100 fish. The estimates are based on population estimates at Talkeetna Station (RM 103), less 40 percent for those fish that return downstream below Talkeetna Station and spawn elsewhere (Barrett 1984). During 1981 through 1983, the Talkeetna-Devil Canyon sub-basin coho escapement contributed less than three percent to the total Susitna River basin coho escapement for those years (Table 6, Figure 19).

(iii) Migration Rate

For the last three years, tagged coho salmon traveled from Sunshine Station (RM 80) to Talkeetna Station (RM 103) at average rates of 1.4 miles per day (mpd) in 1983, 4.0 mpd in 1981 and 5.3 mpd in 1982 (ADF&G 1984a). Coho salmon migrated at faster rates between Talkeetna Station and Curry Station (RM 120): 5.7 mpd in 1983, 10.0 mpd in 1982 and 11.3 mpd in 1981 (ADF&G 1984a). Coho migration rates appear to increase and/or milling decreases the further upstream they migrate.

4.1.4 Pink Salmon

(i) Timing of Runs

Pink 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) from the second week of July to the third week of August (ADF&G 1984a). The majority of the pink migration passes Sunshine Station (RM 80) between the third week of July and the second week of August. In the Talkeetna-Devil Canyon sub-basin (RM 98.6-152) the pink salmon migration lasts about 4 weeks from the fourth week of July to the third week of August. A summary of pink migration timing in the Susitna River for 1981, 1982 and 1983 is presented in Figure 20.

The pink salmon migration at Sunshine Station in 1982 was about 2 weeks shorter in duration than the 1981 and 1983 migrations at Sunshine Station (Figure 20). During pink migrations in 1981 and 1983 river discharge levels greater than 80,000 cfs at Sunshine Station coincided with reduced fishwheel catches at Sunshine Station and apparently delayed the migrations (Figure 21). In 1982 river discharge did not exceed 80,000 cfs at Sunshine Station during the pink salmon migration and the migration passed Sunshine Station in one main peak (Figure 21). The average migration rate of pink salmon in 1982 (see Sec. 4.1.4, iii) between Sunshine Station and Talkeetna Station (RM 103) was faster than in 1981 and 1983 (ADF&G 1984a). The faster migration rate in 1982 adds support to the suggestion that pink salmon were undelayed by high river discharge in 1982. Peak discharge levels apparently delay upstream movements of pink salmon.

(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 (ADF&G 1984a). The annual odd-year pink salmon total escapement in the Susitna River has averaged 138,200 fish for 1981 and 1983, while the even-year pink salmon total escapement in the Susitna River was approximately 1,317,900 fish in 1982 (Table 6). Pink salmon total escapement is derived by the summation of population estimates at Yentna Station (RM 28, TRM 04) and Sunshine Station (RM 80) plus an additional 48 percent estimated to spawn in other portions of the basin (Barrett 1984). Most pink salmon (96 percent of the even-year run, 97 percent of the odd-year run) are distributed in the lower Susitna sub-basin, the Yentna sub-basin, and the Talkeetna-Chulitna sub-basin (Table 6).

For the years 1981 and 1983, odd-year pink salmon escapements have averaged 4,400 fish annually in the Talkeetna-Devil Canyon sub-basin (Table 6), with a range of 1,700 fish to 7,100 fish. In 1982, the even-year pink salmon escapement in the Talkeetna-Devil Canyon sub-basin was approximately 54,800 fish (Table 6). The escapement estimates are derived from population estimates at Talkeetna Station (RM 103), less 25 percent for those fish that return downstream below Talkeetna Station and spawn elsewhere (Barrett 1984). The odd-year average escapement for 1981 and 1983 in the Talkeetna-Devil Canyon sub-basin represents about 3 percent of the total odd-year Susitna Basin pink escapement, while the even-year escapement in 1982 represents about 4 percent of the total even-year Susitna Basin escapement (Table 6, Figure 22).

(iii) Migration Rate

During 1981 through 1983, 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, 5.9 mpd in 1983 and 7.4 mpd in 1982 (ADF&G 1984a). The average rates of travel for pink salmon increased between Talkeetna Station and Curry Station (RM 120): 6.0 mpd in 1981, 7.1 mpd in 1983 and 10.0 mpd in 1982 (ADF&G 1984a). Pink salmon migration rates appear to increase and/or milling decreases the further upstream they migrate (ADF&G 1984a).

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). Chinook salmon are abundant at Sunshine Station (RM 80) for about one month between mid-June and mid-July (ADF&G 1984a). In the Talkeetna-Devil Canyon reach (RM 98.6-152), the chinook migration lasts for about one month from the third week in June to the third week in July. A summary of chinook migration timing in the Susitna River for the years 1981, 1982, and 1983 is presented in Figure 23.

Chinook migration timing may be influenced by river discharge (ADF&G 1982a). During the 1981 chinook migration and in the early part of the 1982 chinook migration, river discharge peaked near 80,000 cfs at Sunshine Station (RM 80). These discharge peaks coincided with reduced fishwheel catches at Sunshine Station (Figure 24). However, in 1983 reduced fishwheel catches during the chinook migration did not coincide with the peak river discharges near or above 80,000 cfs (Figure 24). The correlation of high river discharge (above 80,000 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 total escapement of chinook salmon in the Susitna River basin for 1983 was approximately 125,600 fish (Table 6). The estimate is based on 1983 chinook stream count surveys (ADF&G 1984a) and the relationship that a peak chinook survey count represents at most 52 percent of the total escapement (Neilsen and Geen 1981). The escapement estimates derived by this method should be viewed as preliminary minimum escapements because: (1) in 1983 the surveys did not include all known chinook spawning streams in the Susitna Basin (ADF&G 1984a); (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.

The 1983 estimate of chinook escapement by the stream count method in the Talkeetna-Devil Canyon reach (RM 98.6-152) was about 8,500 chinook (ADF&G 1984a) compared to 10,800 chinook approximated by the mark/recapture method in 1983. The mark/recapture estimate has a correction factor of 25 percent applied to the ADF&G population estimate of 14,400 fish, which accounts for the estimated number of fish that move downstream of Talkeetna Station (RM 103) and spawn elsewhere (Barrett 1984). Figure 25 shows the chinook escapements to the Talkeetna-Devil Canyon sub-basin and the Talkeetna-Chulitna sub-basins based on 1983 and 1984 ADF&G population estimates.

All known and suspected chinook spawning streams in the Talkeetna-Devil Canyon sub-basin were surveyed twice in 1983, whereas elsewhere in the Susitna Basin stream surveys were not conducted in all of the known and suspected chinook spawning streams and most streams were surveyed once (ADF&G 1984a). Due to the increased sampling effort, the chinook escapement estimated by the stream count method in the Talkeetna-Devil Canyon sub-basin in 1983 is probably more accurate than other sub-basin chinook escapements approximated by the stream count method in 1983.

While chinook stream survey counts and escapements derived by the stream count method may not accurately estimate chinook total escapement numbers, they do provide an index of the relative importance of chinook spawning streams in the Susitna Basin. Chinook salmon peak spawning counts have been conducted by ADF&G in selected Susitna Basin chinook spawning streams since 1976 (Table 7). The 1983 survey included most of the major chinook spawning streams in the Susitna Basin and was completed under good to excellent survey conditions (ADF&G 1984a). The 1983 chinook salmon count in the Susitna drainage index streams was approximately six percent higher than the 1976-1982 average (ADF&G 1984a). In 1983, approximately 80 percent of chinook salmon counted in the survey were observed below RM 80 in the Yentna sub-basin and the lower Susitna sub-basin (Table 7). In the Talkeetna-Devil Canyon reach, the chinook stream count in 1983 of 4,432 was the highest recorded for 1976-1983 and represents approximately seven percent of the 1983 total Susitna Basin chinook stream count (Table 7).

(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 and 1.8 mpd in 1983 (ADF&G 1984a). The average rate of travel for tagged chinook salmon between Talkeetna Station and Curry Station (RM 120) was 2.2 mpd in 1982 and 2.7 mpd in 1983 (ADF&G 1984a). It appears that chinook salmon spend less time milling and/or migration rates increase the further upstream they travel (ADF&G 1984a).

4.2 SPAWNING

4.2.1 Sockeye Salmon

(i) Spawning Locations

Nearly all of the ~~The majority of~~ second-run sockeye salmon in the Talkeetna-Devil Canyon reach (RM 98.6-152) spawn in slough habitat. Approximately 99 percent of the 2420 second-run sockeye counted during peak spawner counts were observed in sloughs (ADF&G 1984a). The remaining second-run sockeye salmon were in mainstem and tributary stream habitats. One main channel second-run sockeye spawning site was identified during the 1981-1983 surveys (ADF&G 1981a, 1982a, 1984a). The site (RM 138.6 - 138.9) was used by eleven spawning second-run sockeye on September 15, 1983. Six second-run sockeye were observed in streams during the 1981-1983 surveys, however all six were considering milling fish that did not spawn in streams (ADF&G 1981a, 1982a, 1984a). During slough spawning surveys in 1981-1983, second-run sockeye were observed in seventeen sloughs above RM 98.6 (Table 8). Only three of the seventeen sloughs contained significant numbers of spawning second-run sockeye in all three years. Sloughs 8A, 11 and 21 accounted for 89 percent of the total slough peak counts in 1981, 95 percent in 1982 and 92 percent in 1983 (Table 8).

The peak of spawning occurred between the last week of August and the end of September in all three years (ADF&G 1981a, 1982a, 1984a). A portion (24-43 percent) of the second-run sockeye salmon monitored in three sloughs in 1983 did not spawn in the slough of first recorded entry (ADF&G 1984a). These fish suffered mortality from either bear predation or stranding, or departed the slough and presumably spawned elsewhere.

Peak survey counts are indices of fish abundance. To estimate the total slough escapement of second-run sockeye above RM 98.6, the total fish days in slough habitat for sockeye salmon was divided by the average slough life of sockeye salmon (11.8 days in 1983) (ADF&G 1984a). The 1983 total slough escapement of second-run sockeye salmon in sloughs above RM 98.6 was an estimated 1,060 fish (Table 9). This estimate is about 56 percent of the 1983 Curry Station (RM 120) second-run sockeye escapement of 1,900 fish and approximately 25 percent of the 1983 Talkeetna Station (RM 103) second-run sockeye escapement of 4,200 fish. Second-run sockeye were observed spawning almost exclusively in slough habitat above RM 98.6, therefore the differences between the total slough escapement and the Curry Station and Talkeetna Station population estimates are probably attributable to: (1) milling fish that return downstream below Talkeetna Station and spawn elsewhere; (2) the error associated with estimating the slough escapement; and (3) the error associated with approximating the population estimates at Talkeetna and Curry Stations (ADF&G 1984a). It was assumed that in 1981 and 1982 second-run sockeye salmon averaged the same slough life of 11.8 days that was estimated for 1983 second-run sockeye (ADF&G 1984a). The estimated total fish days for second-run sockeye in sloughs in 1981 and 1982 was divided by the 1983 estimated slough life to estimate total slough escapement of second-run sockeye in 1981 and 1982. The total slough escapement above RM 98.6 was about 2,200 second-run sockeye in 1981 and approximately 1,500 second-run sockeye in 1982 (Table 9). The 1981 total slough escapement of 2,200 fish is 79 percent of the 1981 Curry Station estimate of 2,800 second-run sockeye and 46 percent of the 1981 Talkeetna Station population estimate of 4,800 second-run sockeye. The 1982 total slough escapement of 1,500 fish is 115 percent of the 1982 Curry Station population estimate of 1,300 second-run sockeye and 48 percent of the 1982 Talkeetna Station population estimate of 3,100 second-run sockeye. Differences between total slough escapements and the population estimates at Talkeetna and Curry stations are probably due to the same factors outlined above for the differences in 1983.

Second-run sockeye generally spawn in the upper habitat zones of sloughs, while chum salmon spawn in the lower habitat zones of sloughs (Table 10). Although some overlap exists, it appears that spawning chum salmon and second-run sockeye salmon in sloughs above RM 98.6, are segregated within the slough habitat (ADF&G 1984a).

I disagree with this conclusion, Significant overlap occurs so that you cannot state segregation occurs!

(ii) Access

The access and upstream passage of sockeye salmon into sloughs and side channels are dependent primarily on water depth and length of the passage reaches that are restrictive to the upstream movement of salmon (ADF&G 1984d). Hydraulic velocity barriers do not exist at sloughs in the Talkeetna-Devil Canyon reach (RM 98.6-152). The mainstem discharge level directly influences access and passage into sloughs because of its influence on backwater at the mouth of sloughs and breaching at the upstream (head) end of sloughs. Under low mainstem discharge levels (unbreached conditions), the backwater at the mouth 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 critical passage 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, until breaching occurs, at which point depths become adequate for passage at all passage reaches in most sloughs and side channels (ADF&G 1984d).

reference needed!

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) (ADF&G 1984d). Because of the diversity in the morphology of individual sloughs, the access and passage into sloughs varies considerably at a mainstem discharge level. Breaching of sloughs at most sites in the Talkeetna-Devil Canyon reach (RM 98.6-152) occurs at relatively high mainstem discharges (19,000 to 42,000 cfs) (ADF&G 1984d). During the peak spawning period (20 August to 20 September) mainstem discharge at Gold Creek equals or exceeds 15,000 cfs only 50 percent of the time (ADF&G 1984d). Therefore, access and passage into sloughs and side channels is more often controlled by the backwater at the slough mouth and the local flow from groundwater and runoff sources. Local flow from groundwater appears to be correlated with mainstem discharge (APA 1984). Therefore, as mainstem discharge decreases, local flow from groundwater may also decrease.

based on the 33 year flow record?

Sloughs 8A, 11 and 21 have accounted for over 90 percent of the sockeye salmon total peak counts in slough habitat (Table 8). The most serious passage restrictions for mainstem discharges below breaching discharge for these three sloughs occur in Slough 21 (ADF&G 1984d).

serious problems in 8A and 11 also. Need to expand this ¶.

(iii) Fecundity and Sex Ratio

The fecundity of second-run sockeye salmon was estimated from a sample of 25 females collected at Sunshine Station (RM 80) in 1983 (ADF&G 1984a). The mean number of eggs per female, based on this sample, was 3,543 eggs (range: 2,950 to 4,800 eggs). This is similar to the range of sockeye fecundity (2,500 to 4,300 eggs) reported by Morrow (1980). Regression analyses of the number of eggs per female as a function of length and/or weight were used to predict Susitna River second-run sockeye fecundities. The details of the analyses are reported by ADF&G (1984a). The mean fecundity for Susitna River second-run sockeye is 3,350 eggs per female (ADF&G 1984a). 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.

The egg retention of second-run sockeye salmon was estimated in 1983 from sampling 56 female sockeye carcasses from four sloughs between river miles 98.6 and 161 (ADF&G 1984a). The average egg retention was about 250 eggs per female. 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.

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 1981 and 1.3:1 in 1983 (ADF&G 1981a, 1982a, 1984a). Sex ratios of sockeye salmon at specific sampling locations varied considerably between some locations and years (Table 11). Sex ratios of sockeye salmon by age are reported by ADF&G (1981a, 1982a, 1984a). Some males matured at an earlier age than females. Most returning adult sockeye were four and five year fish that had gone to sea after one winter in freshwater.

4.2.2 Chum Salmon

(i) Spawning Locations

Most chum salmon above RM 98.6 spawn in either slough or tributary stream habitats. About 93 percent of the 10,570 chum salmon counted during peak index surveys were observed in stream or slough habitats; the remaining 7 percent were observed at mainstem spawning sites (Table 12). In 1983 chum salmon peak index counts in stream and slough habitats were about equal, while in 1982 and 1981 counts were higher in slough habitats (Table 12).

Chum salmon peak index counts in sloughs above RM 98.6 were: 2,596 fish in 1981, 2,244 fish in 1982 and 1,467 fish in 1983 (Table 13). Eleven of the 33 sloughs surveyed in all three years were occupied by spawning chum salmon in each year (Table 13).

Four of the eleven, sloughs 21, 11, 8A and 9, averaged more than 200 fish for 1981, 1982 and 1983 and accounted for about two-thirds of the total chum salmon counted in slough habitats (Table 13).

Total slough escapements of chum salmon in sloughs above RM 98.6 was estimated by dividing the total fish days in slough habitat by the average slough life of chum (ADF&G 1984a). The total slough escapement was about 2,950 chum salmon in 1983, 5,100 chum salmon in 1982 and 4,500 chum salmon in 1981 (Table 14).

In 1983, some chum salmon monitored for slough life were not confirmed spawners in the slough of first recorded entry. The percent of non-spawning chum salmon ranged from 0 to 85.7 in the five sloughs monitored (ADF&G 1984a). Some of the non-spawners were milling fish that later spawned elsewhere.

Chum salmon generally spawn in the lower habitat zones of sloughs, while second-run sockeye spawn in the upper habitat zones of sloughs (Table 10). Although some overlap exists, spawning chum and sockeye salmon are apparently segregated within slough habitat above RM 98.6 (ADF&G 1984a).

Chum salmon peak index counts in streams above RM 98.6 were: 241 fish in 1981, 1,737 fish in 1982, and 1,500 fish in 1983 (Table 15). In 1982 and 1983 over 95 percent of the chum salmon counted during peak spawner surveys were observed in three streams: Indian River, Fourth of July Creek and Portage Creek (Table 15). In 1981, Indian River, Fourth of July Creek and Lane Creek were occupied by about 85 percent of the 241 chum salmon counted during peak surveys (Table 15).

Chum salmon peak counts at mainstem spawning sites were: 16 fish in 1981, 550 fish in 1982 and 219 fish in 1983 (Table 12). Eighteen chum salmon mainstem spawning sites were identified during 1981-1983 surveys; seven sites were used in two or more of the three years (Table 16).

The peak of chum salmon spawning occurred during the last week of August in streams, the first week of September in sloughs, the first two weeks of September at mainstem spawning sites in 1981, 1982 and 1983 (ADF&G 1981a, 1982a, 1984a).

(ii) <u>Access</u>

Chum salmon spawn primarily in tributary or slough habitat in the Talkeetna-Devil Canyon reach (RM 98.6-152) (Table 12). Access and passage into selected sloughs has received preliminary investigations by ADF&G (1983d). Trihey (1983) and R&M Consultants (1982) have examined passage conditions and streambed stability in selected tributaries.

Small deltas are formed at the mouth of most tributaries. As the stage in the mainstem decreases, the tributaries become perched above the river, that is, the tributaries flow across steep deltas. If the steep deltas were to remain under low mainstem conditions, the access and upstream passage of fish would be inhibited or eliminated. Based on the analyses by Trihey (1983) and R&M Consultants (1982), most tributaries in the Talkeetna-Devil Canyon sub-basin have sufficient energy to downcut the perched deltas to establish a channel at a new gradient. Tributaries that support chum spawning that may remain perched under low mainstem flows are Jack Long Creek, Sherman Creek, Fifth of July Creek (RM 123.9), and Little Portage Creek (R&M Consultants 1982). None of these streams appear to support significant numbers of spawning chum salmon (Table 15). Tributaries that have not been evaluated are Chase Creek and Lower McKenzie Creek; however, neither of these streams appear to be important chum spawning tributaries (Table 15).

The access and upstream passage of chum salmon into sloughs and side channels are dependent primarily on water depth and length of the passage reaches that are restrictive to the upstream movement of salmon (ADF&G 1984d). Hydraulic velocity barriers do not exist at sloughs in the Talkeetna-Devil Canyon reach (RM 98.6-152).

The mainstem discharge level directly influences access and passage into sloughs because of its influence on backwater at the mouth of sloughs and breaching at the upstream (head) end of sloughs. Under low mainstem discharge levels (unbreached conditions), the backwater at the mouth 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 critical passage 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, until controlling discharge levels occur, at which point depths become adequate for passage at all passage reaches in most sloughs and side channels (ADF&G 1984d).

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) (ADF&G 1984d). Because of the diversity in the morphology of individual sloughs, the access and passage into sloughs varies considerably at a mainstem discharge level. Breaching of sloughs at most sites in the Talkeetna-Devil Canyon reach occurs at relatively high mainstem discharges (19,000 to 42,000 cfs) (ADF&G 1984d). During the peak spawning period (20 August to 20 September) mainstem discharge at Gold Creek equals or exceeds 15,000 cfs 50 percent of the time (ADF&G 1984d). Therefore, access and passage into sloughs and side channels are more often controlled by the backwater at the slough mouth and the local flow from groundwater and runoff sources. Local flow from groundwater appears to be correlated with mainstem discharge (APA 1984). Therefore, as mainstem discharge decreases, local flow from groundwater may also decrease.

Sloughs 8A, 9, 11 and 21 have accounted for about two-thirds of the total peak counts of chum salmon in slough habitats during 1981, 1982 and 1983 (Table 13). The most serious passage restrictions for

Needs expansion

mainstem discharges below breaching discharge for these four sloughs occur in Sloughs 9 and 21 (ADF&G 1984d).

(iii) Fecundity and Sex Ratio

The fecundity of chum salmon was estimated from a sample of 27 females collected at Sunshine Station (RM 80) in 1983 (ADF&G 1984a). The mean number of eggs per female, based on this sample, was 3,189 eggs with a range of 2,478 to 4,076 eggs (ADF&G 1984a). This is similar to the range of chum fecundity (2,400 to 4,000 eggs) reported by Scott and Crossman (1973). Regression analyses of the number of eggs per female as a function of length and/or weight were used to estimate Susitna River chum salmon fecundities. The details of the analyses are reported by ADF&G (1984a). The mean fecundity for Susitna River chum salmon is 2,850 eggs per female. This estimated fecundity is derived from the regression analysis of fecundity as a function of length and from the mean length of chum salmon females sampled at Sunshine Station.

The egg retention of chum salmon was estimated in 1983 from sampling 229 female chum salmon carcasses in 12 sloughs and one main channel spawning site between river miles 98.6 and 161 (ADF&G 1984a). The average egg retention was about 114 eggs per female. 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.

The sex ratio (male to female) of chum salmon in the Susitna River was 1.0:1 in 1981, 1.1:1 in 1982 and 1.3:1 in 1983 (ADF&G 1981a, 1982a, 1984a). Sex ratios of chum salmon at specific sampling location varied between locations and years (Table 17). Sex ratios of chum salmon by age are reported by ADF&G (1981a, 1982a, 1984a). Most returning adult chum were four and five year old fish that had gone to sea during their first summer of life.

4.2.3 Coho Salmon

(i) Spawning Locations

Most coho salmon in the Talkeetna-Devil Canyon reach (RM 98.6-152) spawn in tributary stream habitat. During spawning ground peak surveys in 1981-1983, over 99 percent of the 1,336 coho salmon counted were observed in streams (ADF&G 1984a). Only five coho salmon were observed spawning in mainstem and slough habitats. In 1981, one coho salmon was captured in the mainstem at RM 129.2, while in 1983 two coho salmon were observed spawning in the mainstem at RM 131.1 (ADF&G 1981a, 1984a). The only documented slough habitat that coho salmon utilized for spawning during 1981 through 1983 was at Slough 8A (RM 125.1), where two coho salmon were observed spawning on October 2, 1982 (ADF&G 1982a).

Coho salmon peak index counts in tributary streams above RM 98.6 were: 458 fish in 1981, 633 fish in 1982 and 240 fish in 1983 (ADF&G 1984a). Twelve tributary streams above RM 98.6 were found to contain coho salmon during index surveys in 1981-1983 (Table 18). Peak index counts greater than 10 fish in all three years were recorded in: Whiskers Creek, Chase Creek, Gash Creek, Lower McKenzie Creek, Indian River and Portage Creek. 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 and Whiskers Creek and Indian River in 1983 (Table 18).

Coho spawning activity in tributary streams above RM 98.6 peaked between the last week of August and the first week of October in 1981, 1982 and 1983 (ADF&G 1981a, 1982a, 1984a).

(ii) Access

Coho salmon spawn almost exclusively in tributaries in the Talkeetna-Devil Canyon reach (RM 98.6-152). Small deltas are formed at the mouth of most tributaries. As the stage in the mainstem decreases, the tributaries become perched above the river, that is, the tributaries flow across the steep deltas. If the steep deltas were to remain under low mainstem conditions, the access and upstream passage of fish would be inhibited or eliminated.

Trihey (1983) examined the hydraulic conditions supporting fish passage into Indian River and Portage Creek, while R&M Consultants (1982) evaluated the streambed stability of numerous tributary mouths between the confluence of the Susitna and Chulitna rivers (RM 98.6) and Devil Canyon (RM 152). Based on the analyses in these studies, most tributaries in this reach of river have sufficient energy to downcut the perched deltas to establish a channel at a new gradient. One tributary that supports coho spawning that may remain perched under low mainstem flows is Jack Long Creek. Tributaries that have not been evaluated include the following coho spawning streams: Chase Creek, Slash Creek and Lower McKenzie Creek. Of the three, Chase Creek and Lower McKenzie Creek support higher numbers of coho salmon than Slash Creek and are among the five most important coho spawning tributaries in this reach of river based on three year index count averages (Table 18).

(iii) Fecundity and Sex Ratio

Fecundity has not been estimated for coho salmon in the Susitna River, but is expected to be approximately 2,500 to 3,000 eggs, as reported by Morrow (1980).

The sex ratio (male to female) of coho salmon in the Susitna River was 0.9:1 in 1981, 1.4:1 in 1982 and 1.3:1 in 1983 (ADF&G 1981a, 1982a, 1984a). The sex ratios of coho salmon at specific sampling locations varied between years and sites (Table 19). Sex ratios of coho salmon by age are reported by ADF&G (1981a, 1982a, 1984a). Most returning adult coho were three and four year old fish that had gone to sea after one or two winters in freshwater.

4.2.4 Pink Salmon

(i) Spawning Locations

The majority of pink salmon in the Talkeetna-Devil Canyon reach (RM 98.6-152) spawned in tributary stream habitat. Peak index counts for streams above RM 98.6 were 378 fish in 1981, 2,855 fish in 1982 and 1,329 fish in 1983 (Table 20). In 1981 Lane Creek, Chase Creek and Fourth of July Creek had peak counts of 358 pink salmon; which accounted for almost 95 percent of the total peak counts of 378 fish for that year. In 1982, when pink salmon escapement in the Susitna River was at an even-year high, eight streams had peak index counts of over 100 pink salmon each and accounted for almost 93 percent of the total count of 2,855 fish for that year (Table 20). 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 which contributed about 94 percent of the total stream peak count of 1,329 fish. The peak of pink salmon spawning in streams above RM 98.6 occurred during the second and third weeks of August in all three years (ADF&G 1981a, 1982a, 1984a).

Pink salmon were observed spawning in slough habitat in 1981 and 1982. Total slough escapement for pink salmon above RM 98.6 in 1981 was 38 fish in Slough 8 (Table 21). In 1982, total slough escapement above RM 98.6 was about 297 fish in seven sloughs (Table 21). Two of the seven sloughs, 11 and 20, accounted for over 80 percent of the pink salmon total escapement in sloughs in 1982. No pink salmon were observed spawning in sloughs in 1983; fish counted in slough habitat during spawning surveys in 1983 were considered milling fish (ADF&G 1984a). In 1981 the peak of pink salmon spawning in Slough 8 occurred about the last week of August, while in 1982 the peak of pink salmon spawning in sloughs occurred during the first three weeks of August (ADF&G 1981a, 1982a).

No pink salmon were observed spawning in the mainstem of the Susitna River above RM 98.6 in 1981-1983 (ADF&G 1984a).

(ii) Access

Pink salmon spawn primarily in tributaries in the Talkeetna-Devil Canyon reach (RM 98.6-152); sloughs are used by spawning pink salmon to a lesser extent. The highest use in both habitats occurs during even years (Tables 20, 24).

Small deltas are formed at the mouth of most tributaries. As the stage in the mainstem decreases, the tributaries become perched above the river, that is, the tributaries flow across steep deltas. If the steep deltas were to remain under low mainstem conditions, the access and upstream passage of fish would be inhibited or eliminated.

Trihey (1983) examined the hydraulic conditions supporting fish passage into Indian River and Portage Creek, while R&M Consultants (1982) evaluated the streambed stability of numerous tributary mouths between confluence of the Susitna and Chulitna rivers (RM 98.6) and Devil Canyon (RM 152). Based on the analyses in these studies, most tributaries in this reach of river have sufficient energy to downcut the perched deltas to establish a channel at a new gradient.

Tributaries that support pink salmon spawning that may remain perched under low mainstem flows are Little Portage Creek, Fifth of July Creek (RM 123.9), Sherman Creek and Jack Long Creek (R&M Consultants (1982). Chase Creek and Lower McKenzie Creek are pink spawning tributaries that have not been evaluated for streambed stability or salmon passage. These streams appear to be of moderate to low importance for pink salmon spawning (Table 20).

The access and upstream passage of pink salmon into sloughs and side channels are dependent primarily on water depth and length of the passage reaches that are restrictive to the upstream movement of salmon (ADF&G 1984d). Hydraulic velocity barriers apparently do not exist at sloughs in the Talkeetna-Devil Canyon reach.

The mainstem discharge level directly influences access and passage into sloughs because of its influence on backwater at the mouth of sloughs and breaching at the upstream (head) end of sloughs. Under low mainstem discharge levels (unbreached conditions), the backwater at the mouth 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 critical passage 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, until controlling discharge levels occur, at which point depths become adequate for passage at all passage reaches in most sloughs and side channels (ADF&G 1984d).

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) (ADF&G 1984d). Because of the diversity in the morphology of individual sloughs, the access and passage into sloughs varies considerably at a mainstem discharge level. Breaching of sloughs at most sites in the Talkeetna-Devil Canyon reach occurs at relatively high mainstem discharges (19,000 to 42,000 cfs) (ADF&G 1984d). During the peak spawning period (20 August to 20 September) mainstem discharge at Gold Creek equals or exceeds 15,000 cfs 50 percent of the time (ADF&G 1984d). Therefore, access and passage into sloughs and side channels is more often controlled by the backwater at the slough mouth and the local flow from groundwater and runoff sources. Local flow from groundwater appears to be correlated with mainstem discharge (APA 1984). Therefore, as mainstem discharge decreases, local flow from groundwater may also decrease.

Sloughs 11 and 20 accounted for over 80 percent of the total pink salmon escapement in sloughs in 1982 (Table 21). Based on analyses by ADF&G (1984d) it appears that Slough 11 will have passage restrictions at low mainstem discharge levels, while access and passage into Slough 20 will be maintained for most passage reaches by the local flow of Waterfall Creek.

Are main spawning areas in Slough 20 above or below Waterfall creek? This is significant!

(iii) Fecundity and Sex Ratio

Pink salmon fecundity was estimated from a sample of 22 females at Sunshine Station (RM 80) in 1983 (ADF&G 1984a). The mean number of eggs per female was 1,475 eggs with samples ranging from 1,125 to 1,975 eggs. This is similar to the range reported for pink salmon (800 to 2,000) by Morrow (1980). Regression analyses of fecundity as a function of fish length and/or weight were used to predict Susitna River pink salmon fecundities. The details of the analyses are reported by ADF&G (1984a). The predicted fecundity for Susitna River pink salmon is about 1,350 eggs per female, which is based on the regression analysis of fecundity as a function of length and the mean length of the all female pink salmon measured at Sunshine Station.

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 and 0.9:1 in 1983 (ADF&G 1981a, 1982a, 1984a). A summary of pink salmon sex ratios at sampling locations in the Susitna River for 1981 through 1983 is presented in Table 22. All pink salmon returning to the Susitna River are two year old fish that went to sea in their first summer of life.

4.2.5 Chinook Salmon

Chinook salmon spawn exclusively in tributary stream habitat in the Talkeetna-Devil Canyon reach (RM 98.6-152). No chinook spawning was observed in any mainstem, side channel or slough habitats. Peak index counts of chinook salmon in streams above RM 98.6 were: 1,121 fish in 1981, 2,474 fish in 1982 and 4,432 fish in 1983 (Table 23).

The total chinook salmon escapement to streams above 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, chinook total escapement to streams above RM 98.6 was about 2,150 fish in 1981, 4,750 fish in 1982 and 8,500 fish in 1983. These estimates of chinook total stream escapement should be viewed as preliminary estimates because: (1) in 1981 not all chinook salmon spawning streams were surveyed above RM 98.6; and (2) most 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.

The 1982 total stream escapement of 4,750 chinook salmon is about 44 percent of the 1982 Talkeetna Station (RM 103) chinook escapement of 10,900 fish and approximately 42 percent of the 1982 Curry Station (RM 120) chinook escapement of 11,300 fish. Differences between the total stream escapement and the Talkeetna Station and Curry Station population estimates are probably due to: (1) milling fish that return downstream below Talkeetna Station and spawn elsewhere; (2) the error associated with estimating total stream escapement; and (3) the error associated with estimating the population size at Talkeetna and Curry Stations (ADF&G 1984a).

The 1983 total stream escapement of 8,500 chinook salmon is about 60 percent of the 1983 Talkeetna Station (RM 103) chinook escapement of 14,400 fish and 90 percent of the 1983 Curry Station (RM 120) chinook escapement of 9,600 fish. Differences in 1983 between total stream escapement and the Talkeetna Station and Curry Station population estimates are attributable to the reasons outlined above for 1982. In 1981, chinook salmon escapement was not estimated at Talkeetna and Curry stations, therefore comparisons of the total stream escapement in 1981 to escapement estimates at Talkeetna and Curry Stations were not possible.

Portage Creek and Indian River are the two most important tributary streams for chinook salmon spawning in this reach of river. The two streams accounted for over 90 percent of the chinook peak index counts above RM 98.6 in 1981 through 1983 (Table 23).

Chinook spawning activity in tributary streams above RM 98.6 peaked between the last week of July and the first week of August in 1981, 1982 and 1983 (ADF&G 1981a, 1982a, 1984a).

(ii) Access

Salmon are usually prevented from migrating upstream of Devil Canyon (RM 152) because of the high water velocity at high discharge. However, in 1982 and 1983 chinook salmon were observed in tributary mouths and tributaries in upper Devil Canyon. In 1982, 21 chinook salmon were observed in two tributaries in upper Devil Canyon; 34 chinook salmon were observed in three tributaries in upper Devil Canyon in 1983 (Table 23).

Chinook salmon spawn exclusively in tributaries in the Talkeetna-Devil Canyon reach (RM 98.6-152). Small deltas are formed at the mouth of most tributaries. As the tributary enters the mainstem river, the change in gradient and subsequent change in flow velocity cause the tributary to drop transported materials if the velocity in the mainstem is not sufficient to carry the material downstream. As the stage in the mainstem river decreases, the tributaries become perched above the river, that is, the tributaries flow across the steep deltas. If the steep deltas were to remain under low mainstem flow conditions, the access and upstream passage of fish would be inhibited or eliminated.

Trihey (1983) examined the hydraulic conditions supporting fish passage into the mouths of two tributaries, Indian River and Portage Creek, in the Talkeetna-Devil Canyon sub-basin. Portage Creek and Indian River are the two most important tributaries in this river reach for chinook spawning (Table 23). The influence of mainstem discharge on passage of salmon into these tributaries was evaluated at mainstem discharges ranging from 8,000 to 34,500 cfs. Trihey's analysis indicated that passage of salmon into these two tributaries is not likely to be impeded at low mainstem discharge. It is expected that tributary flows would provide sufficient energy to downcut the perched tributary mouths to establish a channel at a new gradient. If Indian River or Portage Creek does not downcut to a new streambed, adequate tributary streamflow is expected to provide sufficient depths for passage at the tributary mouths.

R&M Consultants (1982) examined the streambed stability at numerous tributary mouths between the confluence of the Susitna and Chulitna rivers (RM 98.6) and Devil Canyon (RM 152). Based on this study, it is expected that most tributaries in this river reach will downcut perched deltas at low mainstem flows and establish a channel at a new gradient. Tributaries with chinook spawning that may have restricted access (perched deltas) under low mainstem flows are Jack Long Creek and Sherman Creek. Both of these creeks support low numbers of spawning chinook salmon (Table 23).

(iii) Fecundity and Sex Ratio

Fecundity has not been estimated for chinook salmon in the Susitna River, but is expected to be approximately 4,200 to 13,600 eggs, 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 and 1.5:1 in 1983 (ADF&G 1981a, 1982a, 1984a). A summary of chinook salmon sex ratios at sampling locations in the Susitna River for 1981 through 1983 is presented in Table 24. Sex ratios of chinook salmon by age are reported by ADF&G (1981a, 1982a, 1984a). Most returning adult chinook were five and six year old fish that had gone to sea after one winter in freshwater.

4.3 INCUBATION

Salmon embryo incubation (defined as the period between fertilization and complete yolk absorption) in the Susitna River begins in July with chinook spawning. This is followed by pink salmon in mid- to late August and chum and sockeye in late August to early September. In the middle Susitna River, chum incubation begins slightly earlier in the tributaries than in the sloughs. Incubation of sockeye in the middle river sloughs begins about the same time as chum. The last species to spawn are the coho salmon, which spawn almost exclusively in tributaries in September.

Successful incubation and emergence is dependent on numerous biological, chemical, and physical factors. These factors include dissolved oxygen, water temperature, biochemical oxygen demand (BOD), water depth, surface water discharge, and velocity, permeability, porosity, and intragravel flow (Reiser and Bjornn 1979). Also, droughts, floods, freezing temperatures, superimposition of redds, and predators can affect successful incubation (McNeil 1969). The following section discusses these factors. The information is derived from studies on the Susitna River system and from studies at other locations.

4.3.1 Dissolved Oxygen

Dissolved oxygen is needed during egg incubation to facilitate metabolic reactions. Reiser and Bjornn (1979), following extensive literature review, found that:

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

(2) Reduced oxygen concentrations lead to smaller newly hatched fry and a lengthened incubation period;

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

(4) Low oxygen concentration during the latter stages of development may stimulate premature hatching.

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

In studies on four sloughs (8A, 9, 11, and 21) on the middle Susitna 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 concentrations occurred in Slough 8A and the highest in Slough 11. The low concentrations in Slough 8A may have caused some delay in chum and sockeye development although diversion of cold mainstem water through this slough as a result of an ice jam may also have contributed or been directly responsible. 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, while Reiser and Bjornn (1979) recommended concentrations at or near saturation with temporary reductions to 5.0 mg/l. In general, for the Susitna sloughs studied thus far, this recommendation is usually met. The exception is the lower values found in Slough 8A and some concentrations in Slough 9 (ADF&G 1983).

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. what about Susitna sloughs?

4.3.2 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 to 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). This relationship appears to be consistent for all Pacific salmon species except coho. In certain instances, this species is apparently able to tolerate near 0°C initial temperatures (Och, ADF&G, personal communication, 1984).

The relationship between temperature and embryo development is frequently measured in temperature units (TU's). 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.

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 the time to complete yolk absorption for Susitna chum and sockeye eggs varied between 30 to 60 days, with lower temperatures resulting in longer periods of development. There are some compensatory mechanisms that tend to counteract these differences, otherwise salmon would not be able to adjust to natural variations in temperatures. 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. This, however, does not decrease the total number of days for incubation. For example, Wangaard and Burger (1983) found that chum and sockeye from the Susitna River do not have the ability to regulate their development rates to result in a similar number of days to complete yolk absorption when average incubation temperatures vary from 2.1 to 4.0°C. This was evident from the 30 to 60 day delay in complete yolk absorption in their tests. Wangaard and Burger also found, however, that temperature compensation is noted for growth as a function of accumulated temperature units (particularly below 1°C). The authors did not find a less efficient development in cold water at hatching. Instead, they found that alevins in colder water temperatures had hatched earlier relative to length development.

In summary, it appears that although metabolic efficiency is similar at temperatures less than 4.0°C and that it takes more temperature units at higher incubation temperatures to reach complete yolk absorption, the ultimate result is that higher temperatures (in the range 0 to 4°C) results in increased growth. This increased growth overshadows the compensation that takes place with growth rates as a function of accumulated temperature units (Wangaard and Burger 1983).

For most species on the Susitna River, the timing of egg deposition is sufficiently early in the season to avoid initial temperatures near 0°C. If an embryo has accumulated approximately 140 TU's (the approximate level needed to achieve closing of the blastopore), then it probably has passed the sensitive stage. The peak spawning for most salmon in the Talkeetna-Devil Canyon reach (RM 98.6-152) occurs prior to September 1. This is the case for chinook and pink salmon (ADF&G 1984a). Chum and sockeye salmon overlap this period, however, they utilize areas of upwelling in the mainstem and sloughs that have temperatures throughout the winter that vary between about 2 to 4°C, thus potentially avoiding the initial critical stage. Coho salmon spawn late in the season and, if they do not spawn in upwelling areas (this is not known at the present time), embryos theoretically do not accumulate sufficient temperature units to get them past this critical stage. However, because coho salmon have been successfully spawned and initially incubated at 0°C, (Och, ADF&G, personal communication, 1984), perhaps this species does not have these initial temperature requirements for successful incubation.

Of interest on temperature/time of emergence relationships are the findings by Graybill et al. (1979) on the Skagit River in Washington. This river has been affected by hydropower development for at least 60 years. Present water temperature conditions year round are generally warmer by several degrees than pre-project temperatures (no actual pre-project temperatures have been recorded, however modeling has established a possible 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 been advanced by about one month. Pink salmon emergence has been advanced by about 4 to 11 weeks and chums from 0 to 5 weeks. The implications of this advancement in the Skagit River are not clear. Numerous authors have speculated that such 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.

One long term example of potential effects of an altered thermal regime on salmon populations is provided by Environocon Ltd. (1981) as quoted by Shepard (1984). In 1954, a hydroelectric project was completed on the Kemano River in British Columbia, Canada. The project diverted water from a lake into the Kemano River which resulted in a tripling of the mean annual flow in the lower Kemano and warmer winter temperatures. Based on emergence projections for pink and chum salmon, advancement of emergence over pre-project conditions may be five weeks. Correspondingly, pink and chum salmon stocks in the Kemano have increased from 1951 through 1980 whereas other streams nearby have not exhibited this general trend. It is unclear if temperature is an important factor in this example because wetted habitat has also increased and flows have become more stable. However, Shepard (1984) concludes that premature emigration of up to five weeks would appear to have either nil or beneficial impact on the Kemano runs.

Wangaard and Burger's (1983) findings of a 30 to 60 delay in chum 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 (the parr-smolt transformation is the salmonid life phase where they undergo a physiological change so that they can adapt to a saltwater environment) and therefore, they would not be viable. Wangaard and Burger state that the effect on the sockeye (that they incubated) was unclear because they 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. This is useful for examining and for estimating potential changes in the Susitna incubation periods from pre-project to with-project conditions.

4.3.3 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 fines which could cut off the flow or prevent emergence of fry. Based on a literature review, 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 utilize large rocks or solid substrate. Instead they require intermediate sized gravels. The substrate size 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 ADF&G (1984e), chum salmon in sloughs generally 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 that spawn in the tributaries must often utilize rubble (3-5 in. diameter) and cobble (5-10 in.). Based on literature review and extrapolation from the other river systems, ADF&G (1984e) indicates that pink salmon utilize substrates between approximately small gravel (1/8-1 in. in diameter) to rubble

(3-5 in.) with large gravel (1-3 in.) being near the point of most utilization. Using a similar method of analysis, ADF&G (1984e) found that coho would mainly use small gravel (1/8 to 1 in.) with sizes up through large gravel (1-3 in.) potentially suitable.

4.3.4 Streamflow

(i) <u>High Streamflow</u>

During periods of high streamflow, McNeil (1969) found that disappearance of embryos 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. In another example, Wilson, et al., (1981) found losses for pink salmon eggs incubating in the mainstem Terror River on Kodiak Island, Alaska as a result of storm flows. In addition, 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 intergravel and surface waters and improving the oxygen supply to embryos (Reiser and Bjornn 1979). In general, velocities should be less than those that displace spawning bed materials (Reiser and Bjornn 1979).

In the Susitna River and tributaries, high streamflows and scour predominantly occur during the open water season either due to rain events or ice/snow melting. Increases in streamflow to specific habitats can also occur during the ice covered period. For example, ice jams and staging can cause overflows from the mainstem into habitats such as sloughs (Wangaard and Burger 1983). No quantitative information is available on scouring effects in the Susitna River. However, it is reasonable to assume that at high flows, the potential for scouring increases along with the potential for increased adverse impact if incubating embryos are present.

(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 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) up to 24 hrs per day in several substrate types resulted in a high prehatching survival for all species and 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 be valid for the severe conditions (particularly cold) that occur on the Susitna River. The Skagit River studies do point out, however, that the alevins have some ability to avoid severe conditions by moving through the gravel.

4.3.5 Biochemical Oxygen Demand (BOD)

Reiser and Bjornn (1979) state that excessive amounts of organic material to a stream may result in reduced oxygen and detrimental impacts on embryos. Based on this, it was recommended that BOD should not diminish or deplete the dissolved oxygen content below stated levels.

BOD levels have not been measured in the Susitna. 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. This may not be apparent in habitats adjacent to the mainstem due to high organic content of waters (e.g. upland sloughs), concentrations of dead post-spawned salmon (e.g., side sloughs) or movement of water through the groundwater system.

4.3.6 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.

4.3.7 Predators

Numerous species of predators can consume eggs. McNeil (1969) suggests that sculpins (Cottus sp.) and possibly other fish predators may be involved. Apparently sculpins are capable of digging into coarse gravel substrates and consuming embryos and alevins. Sculpins (Cottus sp.) and other potential predators on eggs are present in the Susitna River, but no information is available on the effects of predation by this species.

Excellent discussion of incubation life phase effects. Impacts to the Susitna River habitats are lacking - this we can fill in [illegible] part with our winter report!

4.4 REARING

4.4.1 Sockeye Salmon

(i) Emergence

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

(ii) Seasonal Movements

After emergence sockeye usually spend one to two years in lakes and other freshwater rearing areas before going to sea (Morrow 1980, Scott and Crossman 1973). However, in the Talkeetna-Devil Canyon reach, sockeye rearing lakes are not interconnected to the river. Most juvenile sockeye leave the Talkeetna-Devil Canyon reach during their first year of life (age 0+ fish); age 1+ sockeye have accounted for only one percent of the catch in the downstream migrant traps (ADF&G 1983b,c). It is unknown if the age 0+ sockeye leaving the sub-basin go directly out to sea as smolts or move to rearing habitats in other sub-basins of the Susitna River.

After emergence, there is a pattern of downstream movement throughout the summer (ADF&G 1983b,c and 1984b). The peak of this downstream movement for age 0+ sockeye is in late June to early July. During 1983 in the Talkeetna-Devil Canyon reach catches of juvenile sockeye were the highest in side slough and upland slough habitats. Over 90 percent of the 1,010 juvenile sockeye collected by seining and electrofishing were captured in these two habitats. In 1982 the high utilization of side and upland sloughs was similar to 1983 utilization; over 90 percent of the 1325 juvenile sockeye collected primarily by seining in 1982 were caught in upland and side-slough habitat (ADF&G 1984b).

In 1983 juvenile sockeye were about equally distributed between upland slough habitat and side slough habitat (Figure 26). The most important upland slough for sockeye rearing in 1983 was Slough 6A. Slough 11 was the most important side-slough habitat for juvenile sockeye in 1983. In comparison to upland and side-slough habitats, tributaries and side channels were relatively unimportant to rearing sockeye in 1983.

The percent distribution of juvenile sockeye in macrohabitat type presented in Figure 26 has been derived by dividing the total catch in a habitat type by the number of cells sampled in that habitat type.

This value is then expressed as the percent of the total catch in all habitats divided by the number of cells sampled in all habitats (ADF&G 1984b). This method weights the catches in each habitat type equally; because catches are divided by the amount of sampling intensity (i.e. the number of cells sampled) in each habitat type.

Changes in juvenile sampling techniques in 1981, 1982 and 1983 and gear biases may make direct comparisons of abundance and distribution data between years inappropriate (ADF&G 1984b). In 1981 minnow traps were the primary gear, in 1982 seining was principally used and in 1983 seining and electrofishing were the primary methods (ADF&G 1984b). While catch comparisons and percent distribution differences among years may be invalid, the trends of habitat utilization in 1981-1983 are probably valid. Most juvenile sockeye were found in side-slough and upland slough habitat in all three years (ADF&G 1981b, 1983b, 1984b).

The high catches in 1983 of juvenile sockeye in Slough 11 (75 percent of the side slough distribution) were probably due to two factors. First, Slough 11 is an important side slough for sockeye spawning; in 1982 456 sockeye were counted in Slough 11 during peak counts and the total slough escapement to Slough 11 was an estimated 1,199 sockeye (ADF&G 1984a). These numbers represent over 75 percent of the peak counts and total slough escapement for sockeye salmon in 1982. Because Slough 11 was such an important sockeye spawning area in 1982, it is expected that in 1983 Slough 11 would be an important sockeye natal slough. Secondly, Slough 11 is breached only at high discharges (over 42,000 cfs) that occur about 1 percent of the time (ADF&G 1984d) while the other two important side sloughs for sockeye spawning (sloughs 8A and 21) breach at lower discharge levels (25,000 to 33,000 cfs) (ADF&G 1984d). There has been decreased catches in natal side sloughs associated with breaching that transforms the side-slough to side-channel habitat (ADF&G 1984b). Juvenile sockeye may leave breached side sloughs in search of more favorable rearing habitat. Unbreached side sloughs provide habitats with lower water velocities and deeper pools, which juvenile sockeye apparently utilize more than the swifter velocities of the mainstem and tributaries (ADF&G 1984b).

During July to August 1983 there was a redistribution of juvenile sockeye from natal side slough habitat to upland slough habitat (ADF&G 1984b). This may have resulted from breaching discharges in early June at sloughs 8A and 21. Slough 6A was the most important upland slough for juvenile sockeye in 1983 and 1982 (ADF&G 1983b, 1984b). Slough 6A has low water velocity, clear water, adequate depth and abundant cover and is quite different from the majority of sloughs in the Talkeetna-Devil Canyon sub-basin (ADF&G 1984b).

Some overwintering of juvenile sockeye occurs in the Talkeetna-Devil Canyon sub-basin. This has been documented by winter sampling and the downstream outmigrant trap catches of age 1+ fish. However, catches of age 1+ sockeye have been low (less than 1 percent of the outmigrant trap catches) and it appears that this reach of the river is not used extensively for overwintering by juvenile sockeye. Age 1+ sockeye have been observed in sloughs 9, 11 and 6A (ADF&G 1984b).

(iii) <u>Food Habits</u>

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 is based on numbers not biomass or volume. Since chironomids are small, their contribution may be overemphasized by the numerical method. Electivity indices suggested a positive selection for chironomid larvae. Cladocerans and copepods were an important food source for juvenile sockeye in slough 11 during August. A variety of aquatic and terrestrial insects were also consumed.

Riis and Friese (ADF&G 1978) also found that Susitna River juvenile sockeye fed primarily on zooplankton and diptera larvae. Sockeye juvenile in lakes feed principally on plankton crustaceans, chironomid pupae and occasionally terrestrial insects (Scott and Crossman 1973).

4.4.2 Chum Salmon

(i) Emergence

Chum salmon emergence in the Talkeetna-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 had reached 35 mm in length and completely absorbed their yolk sacs. Morrow (1980) reports that chum eggs hatch from December to February and that fry emerge from the gravel in about 60 to 90 days after hatching.

(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 situations where the chum outmigration lasts for days or weeks, juvenile chum will feed actively in freshwater and grow considerably before reaching the estuary (Morrow 1980).

Most juvenile chum in the Talkeetna-Devil Canyon reach (RM 98.6-152) emerge and absorb their yolk sacs by late April, however peak outmigration (at RM 103) does not occur until early June and early July in 1983 (ADF&G 1983b,c; 1984b). This indicates that juvenile chum from this reach of the Susitna River can spend one to three months rearing in freshwater. All juvenile chum outmigrate as age 0+ fish.

Most juvenile chum (over 90 percent) were distributed in side slough and tributary habitats in the Talkeetna-Devil Canyon reach during 1983 (Figure 27). These side sloughs and tributaries were primarily areas of adult chum spawning in 1982. Slough 21, which had the highest juvenile chum density in side sloughs in 1983, had the highest peak count in sloughs of adult spawners in 1982 (ADF&G 1984a,b). Similarly, Indian River had the highest density of juvenile chum in tributaries in 1983 and the highest peak count of adult spawners in tributary habitat in 1982 (ADF&G 1984a,b).

In early June during 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 (ADF&G 1984b). Most juvenile chum had left the sub-basin by mid-July (Figure 28).

(iii) Food Habits

The food habits of juvenile chum have not been examined in the Talkeetna-Devil Canyon reach (RM 98.6-152). Juvenile chum can spend one to three months rearing in this reach of river before outmigrating and can gain up to 27 mm in length during this period (ADF&G 1983b). Morrow (1980) reports that juvenile chum may feed on chironomids and cladocerans. Food habit studies of juvenile chinook, coho and sockeye in the Talkeetna-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.

4.4.3 Coho Salmon

(i) Emergence

Coho emergence probably occurs before May in the Talkeetna-Devil Canyon reach (RM 98.6-152) as age 0+ juvenile coho were caught in the downstream outmigrant traps (RM 103) in mid May 1983 (ADF&G 1984b). However, the emergence timing for coho appears to extend over a considerable time period, based upon the lower lengths observed in June and July 1981, 1982 and 1983 (ADF&G 1981b, 1983b, 1984b). Scott and Crossman (1973) report that coho emergence can occur from early March to late July, depending upon time of spawning and incubating water temperatures.

(ii) Seasonal Movements

Juvenile coho usually spend one to two years rearing in freshwater (age 1+ and 2+ smolts), although some coho outmigrate at the end of their first summer (age 0+ fish) and some coho remain in freshwater three or four years (Scott and Crossman 1973). Juvenile coho apparently prefer pool habitat for rearing over riffle habitat, where they establish territories and become aggressive toward other juvenile coho and other salmonids (Morrow 1980).

There is a pattern of downstream movement of juvenile coho throughout the summer in the Talkeetna-Devil Canyon river reach (RM 103-152) (Figure 29). The low catches of juvenile coho at the downstream outmigrant traps (RM 103) indicate that some juvenile coho of all age groups (age 0+, 1+, 2+) leave the Talkeetna-Devil Canyon sub-basin (ADF&G 1984b, 1983b). Some fish (age 0+, 1+ may move to other sub-basins and continue their freshwater residence, while others (age 1+, 2+ fish) probably outmigrate to the sea as smolts.

Most juvenile coho (96 percent) were distributed in tributary, upland slough and side slough habitats in the Talkeetna-Devil Canyon sub-basin during 1983 (Figure 30). This percent distribution is based upon mean catch per cell in the different habitats; catches are weighted equally among the macrohabitats because total catch in a habitat type is divided by the number of cells sampled in that habitat type (ADF&G 1984b).

Important tributaries for juvenile coho rearing in 1983 (Figure 30) were spawning areas for adult coho in 1982 (ADF&G 1982a). Whiskers Creek, Chase Creek and Indian River had the highest coho densities, based upon mean catch per cell, of the tributaries in the Talkeetna-Devil Canyon reach (RM 98.6-152) in 1983.

Sloughs 6A and 5 were important upland sloughs for juvenile coho rearing, while Whiskers Creek Slough and Slough 8 were important side sloughs for juvenile coho rearing in 1983 (ADF&G 1984b). The presence of juvenile coho 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 sloughs and side sloughs may attract juvenile coho additionally because water temperatures tend to be warmer than side channels and tributaries (ADF&G 1984b). Due to low catches of juvenile coho, seasonal movements of juvenile coho between macrohabitat types are not clearly defined.

Changes in juvenile sampling techniques in 1981, 1982 and 1983, and gear biases may make direct comparisons between years of abundance and distribution data inappropriate (ADF&G 1984b). In 1981 minnow traps were the primary year, in 1982 seining was principally used and in 1983 seining and electrofishing were the primary methods (ADF&G 1984b). While catch comparisons and percent distribution differences among years may be invalid, the trends of habitat utilization in 1981-1983 are probably valid. Sampling in 1981 and 1982 indicated that Slough 6A, Whiskers Creek Slough, Slough 8, Fourth of July Creek, Lane Creek and Indian River were important juvenile coho rearing areas (ADF&G 1981b, 1983b).

Significant overwintering of juvenile coho in the Talkeetna-Devil Canyon reach occurs in side sloughs and upland sloughs (ADF&G 1984b). In 1981 through 1983 Whiskers Creek Slough (side slough) and Slough 6A (upland slough) were important overwintering areas for age 1+ and 2+ coho. Juvenile coho also use mainstem and side-channel habitats for overwintering (ADF&G 1981b).

(iii) <u>Food Habits</u>

Juvenile coho food habits were examined in August and September 1982 in the Talkeetna-Devil Canyon reach (RM 98.6-152). Juvenile coho were caught at Indian River, Fourth of July Creek, Slough 8A, Slough 11 and Slough 21 (ADF&G 1983b). Chironomids were the dominant food item numerically in samples collected during August and September. Since chironomids are small, their volumetric contribution is probably less than their numeric contribution. Electivity indices suggested a positive selection for chironomid larvae by juvenile coho. Other dipterans, and mayfly and stonefly nymphs were occasionally eaten. 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-Devil Canyon sub-basin. Riis and Friese (ADF&G 1978) found that juvenile coho in the Susitna River fed on drifting aquatic insect larvae in the spring; the adult stage of aquatic insects were major food items during the summer and fall.

4.4.4 Pink Salmon

(i) Emergence

The emergence of pink salmon probably occurs in March and April in the Talkeetna-Devil Canyon reach (RM 98.6-152). Limited information obtained in 1981 indicated that pink salmon fry appeared in Slough 11 and Indian River on March 23 and yolk sac absorption for pink fry was about 50 percent on April 11 (ADF&G 1981b). Scott and Crossman (1973) report that pink salmon emerge in April or May.

(ii) Seasonal Movements

After emergence juvenile pink move almost immediately downstream to the sea (Morrow 1980, Scott and Crossman 1973). All juvenile pink salmon outmigrate in their first summer (age 0+ fish) and little if any freshwater rearing occurs.

It appears that most juvenile pink salmon leave the Talkeetna-Devil Canyon reach (RM 98.6-152) in May and June. In 1983 the downstream outmigrant traps (RM 103) caught few juvenile pink after July; the highest catches at the outmigrant traps were recorded in late May and early June (ADF&G 1984b). In 1982, the downstream outmigrant trap caught only seven juvenile pink during early July; this further suggests that most juvenile pink move downstream before July (ADF&G 1983b).

(iii) Food Habits

It is uncertain if juvenile pink feed in the Susitna River. It appears that juvenile pink spend little time in the Talkeetna-Devil Canyon reach (RM 98.6-152) after emergence. Scott and Crossman (1973) report that juvenile pink salmon remain in freshwater for such a short time that many do not feed at all. However, juvenile pink that migrate longer distances to the estuary, probably eat nymphal and larval insects. Thus, it may be reasonable to expect that juvenile pink in the Talkeetna-Devil Canyon sub-basin may feed occasionally on chironomid larvae and other aquatic insects during their outmigration.

4.4.5 Chinook Salmon

(i) Emergence

Most chinook salmon emerge from the gravel in tributaries of the Talkeetna-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). Post-emergent chinook in Indian River ranged in length from 31-41 mm in April and May 1981 (mean length was 34 mm) (ADF&G 1981b).

(ii) Seasonal Movements

After emergence juvenile chinook school at first, but as they grow and become mobile they become territorial and aggressive (Scott and Crossman 1973). Most juvenile chinook spend one year in freshwater residence before outmigrating to the ocean (as age 1+ smolts), however in some cases juvenile chinook outmigrate in their first summer (as age 0+ smolts) or spend two years in freshwater and outmigrate as age 2+ smolts (Scott and Crossman 1973, Morrow 1980). Most juvenile chinook in the Talkeetna-Devil Canyon sub-basin (RM 98.6-152) spend one winter in freshwater before going to sea as age 1+ smolts (ADF&G 1981a,b; 1982a; 1984a,b).

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, 1984b). 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 age 0+ juvenile chinook move downstream and leave the Talkeetna-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 (ADF&G 1984b). These age 0+ chinook were probably redistributing to rearing and overwintering sites below RM 103 and don't represent outmigrating age 0+ smolts.

The distribution of juvenile chinook in the Talkeetna-Devil Canyon reach in 1983 reflects the importance of natal, rearing and overwintering macrohabitat types (Figure 31). Tributaries are the only natal areas of juvenile chinook in the Talkeetna-Devil Canyon sub-basin. Indian River and Portage Creek accounted for over 90 percent of the adult spawner peak counts in tributaries during 1981-1983 (ADF&G 1981a, 1982a, 1984a). Thus, it is expected that tributaries are important juvenile chinook habitats (61 percent of the juvenile chinook distribution for all macrohabitats in 1983) and that Indian River and Portage Creek are the two most important tributaries for juvenile chinook rearing (90 percent of the juvenile chinook distribution in tributary habitat in 1983) (Figure 31). Tributaries had the highest densities of juvenile chinook in spring and early summer, while mainstem side-channel habitat increased in importance in July and late summer (ADF&G 1984b).

Important summer rearing macrohabitats for juvenile chinook are side sloughs, side channels, upland sloughs and tributary mouths (ADF&G 1981b, 1983b, 1984b). In 1983 juvenile chinook were widely distributed in the Talkeetna-Devil Canyon sub-basin at numerous side channels, side sloughs and upland sloughs after chinook moved downstream from natal tributaries (Figure 31). Apparently juvenile chinook prefer areas of moderate water velocity and depth, and utilize turbidity for cover (ADF&G 1984b). These conditions are often present at side-channel habitats; consequently, densities of juvenile chinook were higher in side channels than in side slough or upland slough habitats (Figure 31).

Side sloughs, tributaries, mainstem, and side channels are used by juvenile fish for overwintering areas (ADF&G 1981b, 1983b, 1984b). However, tributaries apparently become less important after November as low winter flows and icing occurs (ADF&G 1981d). Side sloughs may attract overwintering juvenile chinook because of warmer water temperatures associated with groundwater upwelling (ADF&G 1984b).

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) and may be due to higher spawner utilization (Table 7) in the areas below the Talkeetna-Devil Canyon reach and/or an abundance and quality of juvenile rearing habitat.

Changes in juvenile sampling techniques in 1981, 1982 and 1983 and gear biases may make direct comparisons of abundance and distribution data between years inappropriate (ADF&G 1984b). While catch comparisons and percent distribution differences between years may be invalid, the trends of habitat utilization in 1981 through 1983 are probably valid. It is apparent from catch data that in 1982 juvenile chinook abundance in the Talkeetna-Devil Canyon sub-basin was lower than in 1981 and 1983 (ADF&G 1984b).

(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 was based on numbers and not biomass or volume. Since chironomids are small, their 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 by juvenile chinook (ADF&G 1983b).

Riis and Friese (ADF&G 1978) found that terrestrial insects were more important than aquatic insects in the diet of Susitna River juvenile chinook. Apparently, Riis and Friese (ADF&G 1978) lumped adult stages of some aquatic insects with insects that have entire life cycles on land. Therefore, their conclusion that terrestrial insects comprised a major portion of the diet of juvenile chinook may be inaccurate. They also concluded that juvenile chinook and coho had similar food habits. However, the results of food habit studies done in 1982 indicated that juvenile chinook and coho diets were usually significantly different ($P<0.05$) (ADF&G 1983b).

Need to state significant question existing as to whether active feeding occurs in turbid water mainstem affected habitats.

4.5 OUTMIGRATION

4.5.1 Sockeye Salmon

(i) Timing

Most juvenile sockeye salmon leave the Talkeetna-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+ (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, 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 occurred during early July in both 1983 (Figure 28) and 1982 (ADF&G 1984b, 1983b). 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 1984b, 1983b). Catches of age 0+ sockeye occurred throughout the sampling season. The outmigration of age 1+ sockeye was over by the end of June in 1983 and the end of July in 1982.

During 1983 juvenile sockeye outmigration rates in the mainstem at RM 103 were weakly correlated with mainstem discharge (ADF&G 1984b). The coefficient of determination (r^2) between mainstem discharge and juvenile sockeye outmigration rate was 0.12 for age 0+ fish and 0.06 for age 1+ fish, thus only 12 and 6 percent of the variation in the outmigration rates was accounted for by correlating outmigration rates with mainstem discharge.

Juvenile sockeye apparently outmigrate close to the river banks. A high outmigrant trap selectivity for juvenile sockeye was observed in 1983 (ADF&G 1984b).

(ii) Size

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

Morrow (1980) reports that sockeye smoltification is mainly controlled by fish size rather than age. The size at which fish smolt seems to be determined by the genetics of the stock.

(iii) Population Estimates

In 1983 the outmigrant population of age 0+ sockeye was estimated from the Talkeetna-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 outmigrant population of age 0+ sockeye was an estimated 560,000 fish using the Peterson mark/recapture estimator and 575,000 fish using the Schaefer estimator (ADF&G 1984b).

Survival estimates for egg to outmigrant were calculated by dividing the outmigrant population estimate by the total potential egg deposition. Survival from egg to outmigrant was about 40.9 percent using the Peterson estimate of population size and 42.0 percent using the Schaefer estimate of population size (ADF&G 1984b).

The high survival rate (41-42 percent) for egg to outmigrant for juvenile sockeye in the Talkeetna-Devil Canyon reach is not comparable to survival estimates for egg to outmigrant in other studies (ADF&G 1984b). The study in the Susitna River covered a shorter period of time (egg to outmigrating age 0+ sockeye at RM 103), while other studies (Russell 1972 and Meehan 1966, cited in ADF&G 1984b) reported survival estimates of 0.6 to 8.5 percent from egg to outmigration of age 1+ or age 2+ sockeye smolts.

The high survival rate for egg to outmigrant in the Talkeetna-Devil Canyon river reach may be due to the productivity of sockeye spawning areas (ADF&G 1984b). The three major sockeye spawning areas, sloughs 8A, 11 and 21, are side sloughs associated with the mainstem Susitna River. These side sloughs may provide a more stable incubating and rearing habitat than tributaries (ADF&G 1984b). However, the dewatering of eggs deposited under high water conditions along the slough margins, may be a case when side sloughs would not provide stable incubating habitat for all incubating embryos.

A comparison of data from the east bank outmigrant trap at RM 103 for 1982 and 1983 indicated that 1983 juvenile sockeye catch rates were 1.4 times higher than 1982 catch rates (ADF&G 1984b). This relative abundance of age 0+ sockeye in 1983 and 1982 did not correspond to the parent spawner relative abundance in 1982 and 1981. The total slough escapement of sockeye salmon above RM 98.6 in 1982 was only 68 percent of the 1981 total slough escapement and the 1982 Curry Station (RM 120) sockeye escapement was only 50 percent of the 1981 Curry Station escapement. The possible explanations for lower than expected juvenile catches in 1982 are: (1) parent spawner density was high enough in 1981 to result in superimposition of redds, which would lead to poor egg survival; and (2) eggs in 1981 were spawned under high water conditions, which later could have led to dewatering of many redds and subsequent egg mortality (ADF&G 1984b).

4.5.2 Chum Salmon

(i) Timing

All juvenile chum salmon in the Susitna River outmigrate to the ocean in their first year of life. The outmigration was monitored by the downstream outmigrant traps from mid May to the end of August in 1983 and from mid June to mid October in 1982 (ADF&G 1983b, 1984b). In 1982, the peak outmigration of juvenile chum 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 total downstream migrant trap catch (754 total chum) had been caught; no juvenile chum were caught at the downstream migrant trap after mid August in 1982 (ADF&G 1983b). In 1983 the chum outmigration at the downstream migrant traps (RM 103) peaked in early June and early July; by mid August all fish had left the Talkeetna-Devil Canyon reach (RM 98.6-152) (Figure 28).

In 1983 juvenile chum outmigration rates were strongly correlated with mainstem discharge (ADF&G 1984b). 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 chum catch rates was accounted for by correlating outmigration rates with mainstem discharge. The coefficient of determination (r^2) between mainstem discharge and juvenile chum outmigration rates was 0.79; r = 0.89 (ADF&G 1984b). Thus, chum outmigration timing is strongly influenced by increases in mainstem discharge.

Juvenile chum apparently outmigrate primarily near mid river. A low outmigrant trap selectivity for juvenile chum was observed in 1983 (ADF&G 1984b).

(ii) Size

The average size of juvenile chum in the Talkeetna-Devil Canyon reach (RM 98.6-152) was about 42 mm (length range 29-55 mm) during the first two weeks of July 1982 (ADF&G 1983b). By this time most juvenile chum (almost 90 percent of the outmigrant trap catch) had left this reach of the river. Most juvenile chum had reached a length of 35 mm after emergence by late April 1982 (ADF&G 1983b). Thus, some chum grow considerably after emergence before outmigrating while others exhibit little growth. This could be due to differences in timing of emergence and outmigration for juvenile chum in this reach of river, or perhaps some juvenile chum feed less actively than others.

(iii) Population Estimates

In 1983 the outmigrant population of juvenile chum was estimated from the Talkeetna-Devil Canyon reach (RM 98.6-152). 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 outmigrant population of juvenile chum was an estimated 3,322,000 fish using the Peterson mark/recapture estimator and 3,037,000 fish using the Schaefer estimator (ADF&G 1984b).

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

The survival rate for chum salmon egg to outmigrant may be lower than the survival rate (41-42 percent) for egg to outmigrant for sockeye salmon because of macrohabitat differences (ADF&G 1984b). Sockeye spawn exclusively in side slough habitat while chum spawn in side slough and tributary habitats. Thus chum salmon embryos are exposed to a wider range of habitat conditions and it can be inferred that slough spawning and incubation may result in higher survival rates than tributary spawning and incubation.

Daily outmigration rates, population size and recruitment rates of juvenile chum were estimated at Slough 11 in 1983 (ADF&G 1984b). 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. This technique made it possible to estimate population size for a given day, daily emigration rates and daily recruitment rates. On day two of the experiment, population size of juvenile chum 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 (ADF&G 1984b). Thus, the population size was increasing over the three day period because the emergence rate exceeded the emigration rate.

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 (ADF&G 1984b). This relative abundance of juvenile chum in 1983 and 1982 corresponded 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 chum escapement (13,100 fish) (ADF&G 1984a). Thus, downstream outmigrant trap catch rates can provide a comparative index of annual differences in the relative abundance of chum outmigrants (ADF&G 1984b).

4.5.3 Coho Salmon

(i) Timing

The outmigration of juvenile coho from the Talkeetna-Devil Canyon reach (RM 98.6-152) was monitored by downstream migrant traps (RM 103) during 1982 and 1983 (ADF&G 1983b, 1984b). There was a pattern of downstream movement of juvenile coho throughout the summer (Figure 29). Age 0+ coho accounted for over 90 percent of the total trap catches of 5,646 fish; age 1+ and 2+ coho comprised the remaining portion of the catch (ADF&G 1984b). The low catches of juvenile coho at the downstream outmigrant traps (RM 103) indicate that some juvenile coho of all age groups (age 0+, 1+, 2+) leave the Talkeetna-Devil Canyon reach (ADF&G 1984b, 1983b). Some fish (age 0+, 1+) may move to other sub-basins and continue their freshwater residence, while others (age 1+, 2+ fish) probably outmigrate to the sea as smolts.

From November 1980 to May 1981 age 2+ coho were captured in the Talkeetna-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. It appears that age 2+ smolts leave the Talkeetna-Devil Canyon sub-basin by June 1 and the lower Susitna River by June 15. Catches of age 2+ coho have been low at the outmigrant traps at RM 103, however it appears that age 2+ coho catches peaked in early June 1982 and 1983 (ADF&G 1983b, 1984b).

There is evidence that age 1+ and older fish may not have the same catchability as age 0+ fish at the outmigrant traps (ADF&G 1984b). The outmigrant traps may be more effective in catching the younger and smaller fish, thus the relative abundance of older fish outmigrating from the sub-basin may be underestimated.

Analyses of scales in 1981 through 1983 from returning adult coho salmon at Curry Station (RM 120) indicated that most coho outmigrate from the Susitna River as age 1+ or 2+ smolts; in 1981 one coho adult was sampled at Curry Station that had outmigrated in its first summer (age 0+) (ADF&G 1984b, 1983b, 1981b). Thus, if the age 0+ coho caught at the downstream migrant traps (RM 103) are outmigrating to the sea as smolts, their survival is low. In 1981 about two-thirds of the returning coho adults sampled at Curry Station had outmigrated as age 2+ smolts, in 1982 46 percent were age 2+ smolts and in 1983 53 percent were age 2+ smolts.

During 1983 juvenile coho outmigration rates in the mainstem at RM 103 were moderately correlated with mainstem discharge (ADF&G 1984b). The coefficient of determination (r^2) between mainstem discharge and juvenile coho outmigration rates was 0.17 for age 0+ fish and 0.22 for age 1+ fish, thus 17 and 22 percent of the variation in the outmigration rates was accounted for by correlating outmigration rates with mainstem discharge.

The increased catch of age 0+ coho in August 1983 at the downstream outmigrant traps (Figure 29) may be a result of: (1) high discharge levels (about 32,000 cfs at Gold Creek on August 10) that breached mainstem rearing areas and displaced juvenile coho downstream; and (2) increased discharge in tributaries allowed trapped juvenile coho in side channels and pools of Indian River and Portage Creek to outmigrate from these tributaries (ADF&G 1984b).

(ii) Size

The average size of age 0+ coho in the Talkeetna-Devil Canyon sub-basin (RM 98.6-152) was 41 mm in late June 1982 and 56 mm in late

June 1981; age 0+ coho increased in size over the summer to 65 mm in late September 1982 and 63 mm in late September 1981 (ADF&G 1983b, 1981b). 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 (ADF&G 1984b).

Length frequency and scale analyses did not provide a separation length between age 1+ and 2+ coho because of length overlaps (ADF&G 1983b). Therefore, age 1+ and 2+ fish were combined as age 1+ and older in most analyses. During February to May 1982 from Cook Inlet to Devil Canyon, age 1+ coho ranged in length from 63-116 mm, while age 2+ coho ranged in length from 89-158 mm. During early June 1982 from Cook Inlet to Devil Canyon, age 1+ fish ranged in length from 85-129 mm, while age 2+ fish ranged in length from 117-202 mm (ADF&G 1983b). Most age 2+ coho in the Deshka River (RM 40.6) ranged between 120-140 mm in 1980 and had outmigrated by late July (Delaney et al. 1981).

(iii) Population Estimates

No population estimate or survival estimate for juvenile coho has been done in the Susitna River. Catches of juvenile coho in 1982 suggest that the river reach below RM 98.6 is more important to coho rearing than above RM 98.6. About 80 percent of the juvenile coho caught in 1982 were captured below 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 (ADF&G 1984b). This relative abundance of juvenile coho in 1983 and 1982 corresponded with parent spawner relative abundance. The 1982 coho escapement (2,400 fish) at Curry Station (RM 120) was 2.2 times higher than the 1981 coho escapement (1,100 fish) (ADF&G 1984a). Thus, the downstream outmigrant trap catch rates can provide a comparative index of annual differences in the relative abundance of juvenile coho outmigrants (ADF&G 1984b).

4.5.4 Pink Salmon

(i) Timing

All juvenile pink salmon in the Susitna River outmigrate to the ocean in their first year of life (age 0+ fish). 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; few (eight) juvenile pink were caught after June (Figure 32).

In 1983 juvenile pink outmigration rates were moderately correlated with mainstem discharge (ADF&G 1984b). During mid May to mid July about 30 percent of the variation in pink catch rates was accounted for by correlating outmigration rates with mainstem discharge. The coefficient of determination (r^2) between mainstem discharge and juvenile pink outmigration rates was 0.30; r = 0.55 (ADF&G 1984b). It appears that pink outmigration timing is influenced by increases in mainstem discharge.

(ii) Size

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

(iii) Population Estimates

No estimate of population size of juvenile pink in the Talkeetna-Devil Canyon reach (RM 98.6-152) has been done. Catches of juvenile pink have been low; in 1983 245 fish were caught in the downstream outmigrant traps (RM 103), while in 1982 only six juvenile pink were captured in the outmigrant trap.

Juvenile pink abundance is undoubtedly greater in odd years than in even years. Adult runs of pink salmon are numerically dominant in even years in the Susitna River; even year escapement of pink salmon is about 10 times greater than odd year escapement. Thus, the progeny of even year pink salmon emerge and outmigrate in the following odd year.

4.5.5 Chinook Salmon

(i) Timing

Most juvenile chinook spend one year in freshwater before outmigrating to the ocean (as age 1+ smolts), however in some cases juvenile chinook outmigrate in their first summer (as age 0+ smolts) or spend two years in freshwater and outmigrate as age 2+ smolts (Scott and Crossman 1973, Morrow 1980). Most juvenile chinook in the Talkeetna-Devil Canyon reach (RM 98.6-152) spend one winter in freshwater before going to sea as age 1+ smolts (ADF&G 1981a,b; 1982a; 1984a,b).

The downstream outmigrant traps (RM 103) in 1983 captured age 0+ chinook throughout the season (mid May to the end of August) with a major peak occurring in August (Figure 33). These age 0+ chinook were probably redistributing to rearing and overwintering areas below RM 103 and don't represent outmigrating age 0+ smolts.

The majority of the outmigration of age 1+ chinook smolts from the Talkeetna-Devil Canyon sub-basin occurred in May and June in 1981 and 1982 (ADF&G 1983b). In 1983, the outmigration of age 1+ chinook at the downstream outmigrant traps (RM 103) was over by mid July (Figure 33). Age 1+ chinook had outmigrated downstream of Goose Creek

(RM 73) by the end of July in 1982 (ADF&G 1983b). Most age 1+ chinook apparently leave the Susitna River by September as no age 1+ chinook were captured between Cook Inlet and Talkeetna Station (RM 103) after the end of August (ADF&G 1981b).

During 1983 juvenile chinook outmigration rates were moderately correlated with mainstem discharge (ADF&G 1984b). The coefficient of determination (r^2) between mainstem discharge and juvenile chinook 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 correlating outmigration rates with mainstem discharge.

The outmigration peak of age 0+ chinook in mid August 1983 was probably influenced by the discharge peak of 32,000 cfs at Gold Creek on August 10 (ADF&G 1984b). The discharge peak may have breached chinook mainstem rearing areas and caused a downstream displacement of juvenile chinook. In addition, tributary discharges increased during this time period and could have allowed juvenile chinook that were trapped in side channels and pools of tributaries to outmigrate from tributaries.

(ii) Size

Age 1+ juvenile chinook averaged 90 mm in length during May and June in 1981 and 1982 (ADF&G 1983b). This is when most age 1+ chinook are outmigrating from the Talkeetna-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 (ADF&G 1984b). In early May age 0+ chinook above RM 103 are less than 56 mm, in early June age 0+ chinook are less than 71 mm, and in early July age 0+ chinook are less than 81 mm. After August 1 all chinook above RM 103 are considered age 0+ fish (ADF&G 1984b).

Below 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 below RM 103 are considered age 0+ fish (ADF&G 1981b).

(iii) Population Estimates

No estimation of population size for juvenile chinook has been done in the Susitna River. Moderate numbers of juvenile chinook have been caught in the Talkeetna-Devil Canyon reach (RM 98.6-152). Analysis of catch data for 1981 through 1983 indicates that in 1982 juvenile chinook abundance in the Talkeetna-Devil Canyon sub-basin was lower than in 1981 and 1983 (ADF&G 1984b). Catch comparisons of 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. The downstream outmigrant traps (RM 103) apparently provide an index of relative abundance of juvenile salmon between years (ADF&G 1984b).

In 1983 only 434 age 1+ chinook were caught in downstream outmigrant traps at RM 103, while 5,768 age 0+ chinook were caught (ADF&G 1984b). Correlation analysis between age 1+ chinook catches and trap velocities indicates that the relative abundance of age 1+ fish may be underestimated because of trap avoidance (ADF&G 1984b).

5.0 HABITAT UTILIZATION AND RELATIONSHIPS

5.1 MAINSTEM AND SIDE CHANNEL HABITAT

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. Groundwater and tributary inflow appear to be inconsequential contributors to the overall characteristics of mainstem habitat. The mainstem 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 and lasts until April or May (ADF&G 1983e, Trihey 1982).

not during winter!

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 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 channels are characterized by shallower depths, lower velocities and smaller streambed materials than the adjacent habitat of the mainstem river (ADF&G 1983e, Trihey 1982).

5.1.1 Adult Salmon

Five species of Pacific salmon utilize the mainstem and side channels of the Susitna River above the Chulitna confluence (RM 98.6) primarily as a migrational corridor and to a lesser extent as spawning habitat from late spring into the fall (ADF&G 1981a, 1982a, 1984a). Use periods for adults of each species are:

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

seperate according to migrational times and spawner times

Relative abundance estimates based upon 1981, 1982 and 1983 escapement data indicate that the mainstem and side channels of the Talkeetna-Devil Canyon reach (RM 98.6-152) serves as a migrational corridor for less than 10 percent of the total Susitna River salmon escapement (Table 6). During migration periods, various behavioral and distribution patterns are associated with certain characteristics of mainstem habitat, including water depth, velocity, channel configuration, and location or absence of obstructions (ADF&G 1981c).

? Don't understand sentence

Generally, passage of adult salmon during migration corresponds with the summer high-flow season. However, peak river discharge events above 80,000 cfs at Sunshine Station (RM 80) apparently cause upstream movements of salmon to decrease and increases milling behavior until flows subside following major flow events (Figures 12, 15, 18, 21, 24). This relationship of slowed upstream migration caused by high river discharge was observed in the Talkeetna-Devil Canyon reach at flows above 40,000 cfs at the USGS gaging station Gold Creek (RM 136.8) (ADF&G 1984d).

Mainstem and side channel spawning above RM 98.6 has been observed for sockeye, chum and coho salmon (ADF&G 1981a, 1982a, 1984a). Chum salmon apparently utilize the mainstem margins and side channels for spawning more than coho or sockeye. Counts of chum salmon spawning in mainstem and side-channel habitat were: 16 fish in 1981, 550 fish in 1982 and 219 fish in 1983 (Table 12). Only three coho and eleven sockeye were observed spawning in mainstem and side-channel habitat during 1981-1983. Mainstem spawning is apparently restricted by the — also velocity lack of suitable spawning substrate and groundwater upwelling (ADF&G 1981c).

5.1.2 Juvenile Salmon

Juvenile salmon of all five species present in the Susitna River utilize the mainstem and side channels above RM 98.6 primarily as a migrational corridor. Mainstem and side channels are important overwintering and rearing areas for some species. Periods of juvenile salmon mainstem and side channel use and relative abundance in the Talkeetna-Devil Canyon reach (RM 98.6-152) are outlined below.

Sockeye - During 1982 and 1983 juvenile sockeye moved out of the Talkeetna-Devil Canyon reach primarily during June and July (ADF&G 1983b, 1984b) (Figure 28). In 1983, juvenile sockeye used mainstem and side-channel habitat in low densities for rearing (Figure 26).

Chum - During 1982 and 1983 juvenile chum had migrated downstream of RM 103 by mid-July (ADF&G 1983b, 1984b) (Figure 28). Juvenile chum used mainstem and side channels for rearing in low densities (ADF&G 1984b) (Figure 27).

Coho - Outmigration of juvenile coho peaked during June, July and August during 1983 and during June in 1982 (ADF&G 1983b, 1984b) (Figure 29). Coho juveniles used mainstem and side-channel habitats for overwintering in 1981 (ADF&G 1981b). Relatively few juvenile coho utilized mainstem and side-channel habitat for rearing in 1983 (Figure 30).

Pink - Most juvenile pink moved downstream of RM 103 during May and June in 1983 (Figure 32). Minimal freshwater rearing and growth occurs for juvenile pink salmon because of their short (one month) residence time. Mainstem and side channel use by juvenile pink for rearing is probably low.

Chinook - The majority of age 1+ chinook moved downstream below RM 103 in May and June in 1981, 1982, and 1983 (ADF&G 1981b, 1983b, 1984b) (Figure 33). Age 0+ chinook moved downstream throughout the open water season in 1983. Mainstem and side channels are important rearing and overwintering habitat for juvenile chinook (ADF&G 1981b, 1983b, 1984b).

During 1983 juvenile salmon outmigration rates were positively correlated with mainstem discharge (ADF&G 1984b). 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 increased 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. Peak flow events may displace some juvenile salmon (e.g. chinook) from mainstem and side-channel rearing areas (ADF&G 1984b).

5.2 SIDE AND UPLAND SLOUGH HABITAT

The clear water in sloughs originates from local surface runoff and ground water upwelling. Ground water upwells in the slough channels throughout the year, thus keeping these areas relatively ice free in the winter. Observations indicate the Susitna River is the primary source of the water in many of the sloughs. Local runoff is an important water source 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 and turbid water. The mainstem water creates a turbid plug at the mouth of the slough that backs up the clear water in the slough. As the stage in the mainstem drops, the size and character of the backwater changes. At fall flows of approximately 8,000 to 10,000 cfs at Gold Creek (RM 136.7), the backwater recedes. This reduces the depth of water at the entrance to

how does it change?

the sloughs. In some cases, the slough mouth and the mainstem become separated by a gravel bar.

When high mainstem flows overtop the upstream (head) end of the sloughs, the flows flush 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 end of the slough, discharge through the slough drops and the water in the slough begins to clear.

Because there is much diversity in the morphology of individual sloughs, the flows at which they overtopped vary considerably. In general, most side sloughs are overtopped at flows between 20,000 to 30,000 cfs, although some sloughs (e.g. Slough 11) are only overtopped at high discharge levels (42,000 cfs).

In general slough water temperatures are warmer than mainstem water temperatures in the winter. why? expand

Upland sloughs differ from side sloughs in that the upstream (head) end of the slough is not interconnected with the surface waters of the mainstem Susitna River or its side channels (Figure 2). except during extremely high MS Q's Upland 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.

The access and upstream passage of salmon into sloughs and side channels are dependent primarily on water depth and length of the passage reaches that are restrictive to the upstream movement of salmon (ADF&G 1984d). Hydraulic velocity barriers apparently do not exist at sloughs in the Talkeetna-Devil Canyon reach (RM 98.6-152). The mainstem discharge level directly influences access and passage into sloughs because of its influence on backwater at the mouth of sloughs and breaching at the upstream (head) of sloughs. Under low mainstem discharge levels (unbreached conditions), the backwater at the mouth 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 critical passage 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, until the slough is breached, at which point depths become adequate for passage at all passage reaches in most sloughs and side channels (ADF&G 1984d).

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) (ADF&G 1984d). Because of the diversity in the morphology of individual sloughs, the access and passage into sloughs varies considerably at a mainstem discharge level. Breaching of important spawning sloughs in the Talkeetna-Devil Canyon reach occurs at relatively high mainstem discharges (19,000 to 42,000 cfs) (ADF&G 1984d). During the peak spawning period (20 August to 20 September) mainstem discharge at Gold Creek equals or exceeds 15,000 cfs 50 percent of the time (ADF&G 1984d). Therefore, access and passage into sloughs and side channels are more often controlled by the backwater at the slough mouth and the local flow from groundwater and runoff sources. Local flow from groundwater appears to be correlated with mainstem discharges (APA 1984). Therefore, as mainstem discharge decreases, local flow from groundwater may also decrease. The most serious passage restrictions for mainstem discharges below breaching discharge in important spawning sloughs occurs in Sloughs 9 and 21 (ADF&G 1984d).

Oversimplified! Needs expansion

5.2.1 Adult Salmon

Adults of four salmon species have been observed spawning in slough habitat in the Talkeetna-Devil reach (RM 98.6-152); only chinook salmon have not been observed using slough habitats for spawning

(ADF&G 1981a, 1982a, 1984a). Results of escapement and spawning surveys in 1981 through 1983 indicated that chum and sockeye were the most numerous salmon in sloughs during peak spawning periods, pink and coho were less abundant (see Sec. 4.2.1-4.2.5,iii).

Total slough escapements in sloughs above RM 98.6 were:

Chum - 4,501 fish in 1981; 5,057 fish in 1982, 2,944 fish in 1983
Sockeye - 2,178 fish in 1981; 1,488 fish in 1982; 1,060 fish in 1983
Pink - 38 fish in 1981; 297 fish in 1982; 0 fish in 1983

give average escapements

Two coho salmon were observed spawning in Slough 8A on October 2, 1982.

Sloughs 8A, 9, 11 and 21 have accounted for about two-thirds of the total peak counts of chum salmon in slough habitats during 1981, 1982 and 1983 (Table 13). Sloughs 8A, 11 and 21 have accounted for over 90 percent of the sockeye salmon total peak counts in slough habitat (Table 8).

Use periods for salmon spawning in sloughs above RM 98.6 were August and September in 1981, 1982 and 1983. The peak of pink salmon spawning occurred during the first three weeks of August, the peak of chum spawning was the first week of September and sockeye peak spawning activity was from the last week of August to the end of September (ADF&G 1981a, 1982a, 1984a).

Does sockeye peak last for 5 weeks as inferred?

Sockeye salmon above RM 98.6 spawn almost exclusively (over 99 percent of the peak spawner counts of 2,420 for 1981-1983) in slough habitat. Sloughs are also important spawning habitats for chum salmon as 60 percent of the peak spawner counts of 10,570 for 1981 through 1983 was observed in slough habitat. Factors contributing to salmon spawning in sloughs in this river reach are: (1) clear water base flows originating from ground water upwelling, local surface runoff or interstitial inflow insure maintenance flows; and (2) the presence of ground water upwelling in sloughs oxygenates spawning substrate, keeps silt from compacting the spawning gravels, and provides a stable

why does it matter if the base flow is clear to insure maintenance flow? Cannot turbid water also do this?

temperature regime that maintains incubating embryos through the winter.

5.2.2 Juvenile Salmon

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

Sockeye - Most sockeye natal areas are side sloughs. Three important sockeye natal areas are Sloughs 8A, 11 and 21 (Table 8). Some sockeye move to upland slough habitat for rearing. Overwintering sockeye have been found in slough habitat (ADF&G 1984b).

Chum - Many sloughs above RM 98.6 are natal areas for juvenile chum (Table 13). These natal sloughs provide rearing habitat for about one to three months until juvenile chum move downstream as smolts.

Coho - Some juvenile coho move from natal tributaries to upland and side sloughs for rearing. Juvenile coho apparently prefer clear water and lower velocities found in upland sloughs. Upland sloughs were second in importance in 1983 for coho rearing after natal tributaries (ADF&G 1984b). Some juvenile coho use sloughs for overwintering.

Pink - The extent of slough utilization by juvenile pink is uncertain because juvenile pink spend little time in freshwater. Use of slough habitat by juvenile pink appears to be limited to natal sloughs.

Chinook - Juvenile chinook used side sloughs and upland sloughs for rearing in relatively low densities in 1983 (Figure 31).

Sloughs appear to be important overwintering habitat for juvenile chinook.

Also important feeding areas for salmon during spawning period

The importance of sloughs as juvenile overwintering and rearing habitats may be related to: (1) the ice-free, clear-water conditions during winter compared to lowered flow and icing in coho and chinook natal tributaries; and (2) during summer mainstem flow, the high stage of the mainstem acts as a hydraulic control at the slough outlet, increasing the depth of water in the lower end of the slough. These clear water areas promote benthic production, which improves the quality of the rearing habitat for juvenile salmon.

whole system is clear-water so what does this matter

5.3 TRIBUTARY AND TRIBUTARY MOUTH HABITAT

reference needed

The depth of water in the mouths of tributaries in the Talkeetna-Devil Canyon reach (RM 98.6-152) is sensitive to changes in mainstem flow. At high flows, the mainstem creates a backwater at the tributary mouth, thus increasing the water depth. The lineal extent of the backwater in the tributary depends on the stage in the mainstem and the gradient of the tributary. At low mainstem stages, the backwater is eliminated, resulting in increased flow velocities at the mouth.

Small deltas form at the mouth of most of the tributaries. As the tributary enters the mainstem river, the change in gradient and subsequent change in flow velocity cause the tributary to drop transported materials if the velocity in the mainstem is not sufficient to carry the material downstream. As the stage in the mainstem river decreases, the tributaries may become perched above the river, that is, the tributaries flow across steep deltas. If the steep deltas were to remain under low mainstem flow conditions, upstream passage of adult salmon and resident fish would be inhibited or eliminated. However, based on studies by R&M Consultants (1982), the tributary flows are sufficient to cut through the deltas to establish a channel at a new gradient. In 1982, tributaries were observed to cut through perched deltas during low August flows; most

This is a vast oversimplification. The type of response that occurs at a particular tributary mouth depends on the type of confluence the trib. has (i.e., mainstem or slough/side channel) see chapter 8 Report No. 3

of the tributaries had sufficient energy to move the delta material (R&M Consultants 1982).

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

Tributary mouth habitat extends from the uppermost point 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 sloughs (ADF&G 1981c). The tributary plume is clearwater which extends downstream in the main channel before mixing with the more turbid mainstem water. This area has a mixture of characteristics associated with both mainstem and tributary. The extent of the plume is influenced by mainstem and tributary flow. At higher flows, the plume is restricted. Depths and velocities in the plume are a function of channel morphology and mainstem stage. Water temperature and water quality are those of the tributary.

5.3.1 Adult Salmon

Except for sockeye salmon, salmon species present in the Susitna River were observed spawning in tributaries in the Talkeetna-Devil Canyon reach (RM 98.6-152) during 1981, 1982 and 1983 (ADF&G 1981a, 1982a, 1984a). Peak spawner counts in tributaries above RM 98.6 for chum, coho, pink and chinook salmon are given in Tables 15, 18, 20, 23. Tributaries serve as the primary spawning habitat for chinook, coho and pink salmon. Based on peak spawner counts in all habitats, tributaries are about equal in importance with slough habitat for chum salmon.

Important salmon spawning tributaries include: Indian River (chinook, pink, coho and chum), Portage Creek (chinook, coho, pink and chum), Fourth of July Creek (pink and chum), Lane Creek (chinook and pink)

What about trib mouths

Cash Creek (coho), Whiskers Creek (coho) and Lower McKenzie Creek (coho) (Tables 15, 18, 20, 23).

5.3.2 Juvenile Salmon

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

Sockeye - Juvenile sockeye apparently utilize tributary habitat incidentally; in 1983 few juvenile sockeye were captured in tributary habitat (Figure 26). It is probable that juvenile sockeye do not overwinter in tributary habitat. No tributaries are known sockeye natal areas.

Chum - Some tributaries above RM 98.6 are natal areas for juvenile chum (Table 15). These natal tributaries may provide rearing habitat for about one to three months until juvenile chum move downstream as smolts.

Coho - Some juvenile coho use tributaries for rearing throughout the summer (ADF&G 1984b). Some coho redistribute downstream from areas of emergence in tributaries to more favorable rearing habitat, including tributary mouths. This redistribution occurs throughout the summer as fish become more mobile. Tributary mouths apparently provide important milling and rearing areas for age 0+ coho (ADF&G 1981b, 1983b). It appears that mainstem side channels, side sloughs and upland sloughs are more important overwintering habitat for juvenile coho than tributaries.

Pink - Some tributaries above RM 98.6 are natal areas for juvenile pink (Table 20). The extent of tributary utilization by juvenile pink is uncertain because juvenile pink spend little time in freshwater.

Chinook - Tributaries had the highest densities of juvenile chinook in spring and early summer in 1983 (ADF&G 1984b). Redistribution of juveniles from areas of emergence in tributaries to more favorable rearing habitat, including tributary mouths, occurs throughout the summer as fish become more mobile. Tributary mouths apparently provide important milling and rearing areas for juvenile chinook. Tributaries may be utilized by juvenile chinook for overwintering, however most fish apparently leave tributaries after November when low winter flows and icing occurs (ADF&G 1981b).

Need to further substantiate how each factor is related to the Susitna basin study area. also only state implications for some factors not others.

6.0 SUMMARY DESCRIPTION

6.1 FACTORS AFFECTING PRODUCTION

Each life stage of salmon has factors that may limit production. Some of these factors are complex and the mechanisms are not easily understood such as the relationships among food availability, growth, and survival. In contrast, other factors are readily defined, like freezing of redds which cause direct mortality. Although biological organisms do 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 only 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 on laboratory conditions) that exclude many of the limiting factors. Following is a summary of the major limiting factors that 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 as factors in other similar river systems and therefore it is assumed that similar factors may be important in the Susitna River.

6.1.1 Adult Migration

A discussion on limiting factors in salt water is not included in this discussion, however, factors such as predation, environmental conditions (e.g. water quality), predator-prey relationships and commercial and sport fishing must be considered in relation to production. Once adult salmon enter the Susitna River, several potential situations can exclude or prevent them from successful spawning. These are briefly listed and described as follows:

a. Sport Fishing - sportfish harvests remove fish from the system. The primary effort in the Susitna River is the taking of chinook salmon followed by coho. The effect of sport fishing on Susitna

River salmon is most evident on coho salmon (Table 3). In 1983, almost one of every five coho entering the Susitna River was caught by an angler. The extent of harvest is governed by regulation, fishing and water conditions, access by people to sites, etc.

b. Predation - in areas where salmon are available, predators such as bears and seals can remove adults prior to spawning. ADF&G personnel (1984a) have noted predation by bears, as well as 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.

c. Access - barriers to upstream migration such as impassable reaches in sloughs under low flow can prevent fish from reaching spawning areas. Whether or not this precludes successful spawning elsewhere is unknown, but exposure to bear predation and lack of success in passing these reaches can result in mortality. Salmon strandings in passage reaches of sloughs have been noted (ADF&G 1984a). ?

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 in 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 (ADF&G 1984a) (Figures 12, 15, 18, 21, 24), but movement does resume following these events and fish do successfully move to their spawning sites. Therefore, the fish are not removed from production and mortality associated with high flow events is not a significant factor.

6.1.2 Spawning and Incubation

Each species within the Susitna Basin tends to utilize specific areas for spawning (see Section 4.2). In this regard, the lack of a specific type of area can limit production for a specific species. Spawning and incubation habitat may be limited in the Talkeetna-Devil Canyon reach (RM 98.6-152).

Specific factors which would limit the availability of spawning are:

a. Water Velocity - Although velocity requirements vary amongst species, areas with high velocities (in excess of sustained swimming speeds) will preclude spawning activity. High velocity may limit utilization of mainstem and side-channel habitats in the Susitna River. pre & post project

b. Water Depth - Theoretically, depth is only a factor when it is too shallow. However, salmon tend to prefer certain depths which can vary from species to species and stock to stock. Depth may be limiting in some side-slough habitats in the Susitna River.

c. Substrate - Lack of useable substrate within the range utilized by a specific species limits the amount of area available for spawning and incubation. Substrate such as sand or silt is unusable as are extremely large substrate and bedrock. Additionally, even though the correct range of gravel may be present, the substrate may be cemented together by silts and therefore fish are unable to effectively dig a redd. This may be one of the reasons for the small use of mainstem and side channel habitats by salmon for spawning in the Susitna River. what about substrate effects on spawning?

d. Water Temperature - Various species seek areas and spawning periods that have favorable water temperatures for spawning and incubation. If these temperatures are not within tolerance range, mortality can result. Low temperatures can delay spawning activity. Temperature also affects development rate. Cold water temperatures may limit use of mainstem and side-channel habitats. based on what

reference needed

reference needed

what about temp affects on incubation

e. Upwelling - Certain species, particularly chum salmon, seek areas of groundwater upwelling for spawning and incubation (ADF&G 1984e). These areas offer potential temperature and flow benefits. Because these areas often support major spawning, it is assumed that the lack of such areas is potentially limiting to spawning and incubation for chum and sockeye salmon in the Talkeetna-Devil Canyon reach (RM 98.6-152).

f. Predation - Sculpins and other fish species have been implicated as taking significant numbers of salmon eggs. Hunter (1959) found that, with pink and chum fry, the mortality could range from 23 to 86 percent.

— Egg predation?
— What about Susitna?

g. Low Streamflow - Extremely 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 (ADF&G 1984b). The dependence on upwelling may limit mortalities associated with flow fluctuations in the Susitna River.

h. High Streamflow - Extremely high flows can scour redds and destroy eggs and alevins. High scouring flows (greater than 30,000 cfs at Gold Creek) are uncommon in fall and winter in the Susitna River. Thus, scouring is probably not an important limiting factor.

i. Freezing - If redds are frozen, the eggs will be destroyed and lost. 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 yearly in the Susitna River. The reduction in production due to frozen redds is unquantified in the Susitna River, however, dependence on upwelling by spawners may reduce losses due to freezing.

j. Sedimentation - An influx of fine sediments can shut off the water flow through substrate and result in unsuitable spawning areas. Sedimentation of spawning areas in sloughs and side channels by high mainstem discharge and ice processes occurs in the Susitna River. In spring 1982, Slough 9 suffered a heavy influx of silts and sands reducing the amount of usable spawning habitat.

also by local flows

Need to state how high flow flush sediments out

k. Intraspecific Competition - The number of eggs and resulting fry can increase proportionally up to a certain point. However, beyond this point, competition for redd sites and superimposition of redds on previous redds results in lower survival. Based on egg [illegible] studies, ADFYG (1984a) concluded that spawner den[illegible] too high for chum salmon in 1983 in slough ha[illegible]

l. [illegible]ition - Spawners from two or more species may [illegible]ific redd sites (e.g. chum and sockeye may [illegible] spawning habitats in middle river sloughs). This [illegible]roblems similar to those for intraspecific compe[illegible]

m. 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, flow, and substrate permeability may be sufficient. However, at higher egg densities, this level might be totally insufficient and therefore would limit production by causing 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.

and source of water and substrate composition

n. Ice Processes - In certain instances, staging resulting from ice cover can raise the stage of the river diverting cold winter mainstem water (0°C) into sloughs that are predominantly supplied by warmer upwelling water (e.g. Slough 8A in 1983; ADF&G 1983a). Cold mainstem water can reduce intragravel temperatures causing mortalities or delays in emergence that affect production.

6.1.3 Rearing

Factors that limit the rearing phase of salmonids are complex and vary with species, size, and time of year. They 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:

a. Primary and secondary production - The amount of food available at specific times of the year can be critical to assuring that production continues. In the Susitna River the highly turbid water in the ice-free season prevents significant light penetration and primary production; winter primary ~~and secondary~~ production may be severely restricted by the ice cover and low levels of light. These, in turn, can severely reduce secondary production and potential fish food sources from within the system (autochthonous food 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 understand primary productivity relationships. Nutrients that support primary production may not be limiting in the Susitna River because extensive blooms of algae have been noted during brief clear-water periods that occur prior to freeze-up.

not in all aquatic habitat types
may, but not
and what about
secondary production

eliminate

and secondary

b. 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 (ADF&G 1984b).

c. Water Depth - Small fish appear to utilize shallower areas with greater frequency. Unless too shallow to allow free movement, depth is not thought to limit fish production in the Susitna River.

d. 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 reduces their utility to rearing juveniles.

e. 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 within 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. However, temperatures do not reach this level in the Susitna).

f. Cover - Juvenile salmonids require microhabitats that provide protection or escape opportunities from predators. Cover can include turbid water, vegetation, substrate and depth. Large substrate and turbidity commonly provide cover in mainstem and side-channel habitats. Vegetation and organic debris provide cover in upland and side-slough habitats.

6.2 RELATIONSHIPS AMONG LIMITING FACTORS

Limiting factors prevent all organisms from unrestricted expansion. Each factor has a certain degree of importance, but existing populations are the result of exposure to the composite of these factors. In the Susitna River, a precise definition of the exact level of importance of each of the factors described for each species and life stage is nearly impossible.

Factors that cause direct mortality are most easily defined (e.g, if flood flows scour out redds, the eggs are most likely lost from production). Factors such as primary and secondary productivity are not as easy to define because fish will attempt to find alternate habitats or food sources if one particular combination of these is not available. For impact prediction, the best analysis possible is to determine whether or not a factor will change significantly and cause or habitat an increase or decrease in production under with-project conditions. For example, large annual variations in streamflow can affect spawning, incubation, and rearing. A more stable flow regime may, in fact, have a very ~~this~~ positive impact on production (Canada Fisheries ← typo and Oceans 1980). The actual degree of positive impact may be difficult to quantify, but at least the change may be in a positive direction rather than negative. Thus, production could be predicted to be maintained or increased. What about negative impacts?

A general statement regarding the relative importance of limiting factors affecting various life stages can be made. Spawning habitat for all species of salmon appears to be limited in this reach of the Susitna River. reference or further substantiation The lack of suitable substrates and upwelling areas are the predominant factors in low utilization of mainstem and side-channel areas. Low winter water temperatures may be a significant factor affecting incubation. These can be caused by dewatering and freezing or ice processes in the Susitna River. Survival of embryos in slough habitats appear to be quite high.

Rearing habitat is probably not an important limiting factor for chum, chinook, pink or coho production in the Talkeetna-Devil Canyon reach

(RM 98.6-152). Rearing habitat for sockeye salmon is limited in this reach. Sockeye rear in a few sloughs which support plankton production. Physical characteristics of other sloughs and other habitat types are not conducive to sockeye rearing.

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. If the project is built, with-project monitoring will be used to determine if the composite of factors resulting from project operation has increased or decreased production.

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Table 1. Common and scientific names of fish species recorded from 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	
Catostomus catostomus	longnose sucker
Gadidae	
Lota lota	burbot
Gasterosteidae	
Gasterosteus aculeatus	threespine stickleback
Cottidae	
Cottus sp.	sculpin

Table 2. Commercial catch of upper Cook Inlet salmon in numbers of fish by species, 1954 - 1983.

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 (1)	20,396	5,003,070	520,831	73,555	1,124,421	6,742,273
Average	19,595	1,314,917	257,811	even-1,640,222 odd - 120,416	658,363	3,031,382

(1) ADF&G Preliminary Data

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

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

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[2]
+ 48% for pink[2]
+ 5% for chum[2]
+ 85% for coho[2]

4 Mills 1982, 1983, 1984 preliminary data
5 Preliminary data

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

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	115	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

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	4,566	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 1984 (Preliminary data)

Source: Mills (1979-1983)

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

Year	Arctic Grayling		Rainbow Trout		Pink Salmon		Coho Salmon		Chinook Salmon		Chum Salmon		Sockeye Salmon	
	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	7,389	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[1]	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	134,413 (even) 58,264 (odd)	42,954 (even) 8,611 (odd)	103,774	13,157	37,294	7,943	12,149	6,797	112,869	2,128

[1] Mills 1984, Preliminary Data

Source: Mills (1979-1983)

Table 6. Susitna River annual salmon escapement by sub-basin and species.

Sub-basin	Sockeye[1]	Chum[2]	Coho[2]	Pink[3]	Chinook[4]		Total
Lower Susitna River (RM 0 to 80) excluding Yentna River (RM 28)[5]	11,900	17,000	39,900	Even 427,400 Odd 44,800	56,300		Even 552,500 Odd 169,900
Yentna River (RM 28)[6]	119,200	19,500	20,000	Even 447,300 Odd 48,400	44,700		Even 650,700 Odd 251,800
Talkeetna (RM 97.1) and Chulitna (RM 98.6) rivers including Susitna River from RM 80 to 98.6[7]	116,000	295,600	24,700	Even 388,400 Odd 40,600	16,100	(62,000)	Even 840,800 Odd 493,000
Talkeetna Station to Devil Canyon (RM 98.6 to 152)[8]	2,800	24,100	2,200	Even 54,800 Odd 4,400	8,500	(9,500)	Even 92,400 Odd 42,000
Total Susitna basin[9]	249,900	356,200	86,800	Even 1,317,900 Odd 138,200	125,600		Even 2,136,400 Odd 956,700

1 1981-83 average of ADF&G second-run sockeye escapements

2 1981-83 average of ADF&G escapement estimates

3 Even year 1982 only; odd year 1981 and 1983 average; from ADF&G escapement estimates

4 Minimum estimates of escapement from ADF&G 1983 survey counts and conversion factor of 52% (Nielson and Geen 1981); numbers in parenthesis are 1982-83 average of ADF&G escapement estimates

5 Lower Susitna sub-basin equals total Susitna basin escapement minus Yentna and Sunshine escapements

6 Yentna sub-basin escapement from ADF&G estimates at Yentna Station (TRM 04)

7 Talkeetna-Chulitna sub-basin escapement equals Sunshine Station (RM 80) escapement minus Talkeetna-Devil Canyon sub-basin escapement

8 Talkeetna Station-Devil Canyon sub-basin escapement equals Talkeetna Station (RM 103) escapement minus milling fish that return downstream. Milling rates: sockeye 30%, chum 40%, pink 25%, chinook 25%, coho 40% (Barrett 1984)

9 Total Susitna basin escapement equals Yentna Station (TRM 04) escapement plus Sunshine Station (RM 80) escapement plus: 5% for sockeye, 48% for pink, 5% for chum, 85% for coho (Barrett 1984)

Table 7. Chinook salmon peak survey escapement counts of Susitna River streams by sub-basin from 1976 to 1983.

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

Table 7. (Continued)

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

[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

Source: ADF&G 1984a

Table 8. Second-run sockeye salmon peak survey counts in sloughs above RM 98.6, 1981-1983.

Slough	River Mile	1981	1982	1983	3-Year Average
3B	101.4	1	0	5	2
3A	101.9	7	0	0	2
6A	112.3	1	0	0	0
8C	121.9	0	2	0	1
8B	122.2	0	5	0	2
Moose	123.5	0	8	22	10
8A	125.1	177	68	66	104
B	126.3	0	8	2	3
9	128.3	10	5	2	6
9B	129.2	81	1	0	27
9A	133.8	2	1	1	1
10	133.8	0	0	1	0
11	135.3	893	456	248	532
17	138.9	6	0	6	4
19	139.7	23	0	5	9
20	140.1	2	0	0	1
21	141.1	38	53	197	96
Total		1,241	607	555	801[1]

Source: ADF&G 1981a, 1982a, 1984a

[1] Three-year average of totals

Table 9. Second-run sockeye salmon total slough escapement above RM 98.6, 1981-1983.

Slough	River Mile	1981	1982	1983	3-Year Average
3B	101.4	0	0	10	3
3A	101.9	13	0	0	4
8C	121.9	0	5	0	2
8B	122.2	0	13	0	4
Moose	123.5	0	20	31	17
8A	125.1	195	131	130	152
B	126.3	0	20	10	10
9	128.3	18	13	0	10
9B	129.2	212	0	0	71
9A	133.8	4	0	0	1
11	135.3	1,620	1,199	564	1,128
17	138.9	11	0	11	7
19	139.7	42	0	10	17
21	141.1	63	87	294	148
Total		2,178	1,488	1,060	1,575[1]

Source: ADF&G 1984a

1 Three-year average of totals

Table 10. Percentages of fish spawning by habitat zone in 1983 for sloughs Moose, 8A and 11.

Slough/ RM[1]	Species	n	Spawning Location by Habitat Zones[2] 1	2	3	4	5	6	7	Percent Non-Spawning[3]
Moose	Sockeye	7	50.0	50.0	---	---	---	---	---	42.9
RM 123.5	Chum	7	100.0	0.0	---	---	---	---	---	85.7
8A	Sockeye	16	8.3	0.0	91.7	---	---	---	---	25.0
RM 125.1	Chum	5	20.0	80.0	0.0	---	---	---	---	0.0
11	Sockeye	55	7.1	7.1	0.0	45.3	0.0	28.6	11.9	23.6
RM 135.3	Chum	29	39.1	52.2	0.0	8.7	0.0	0.0	0.0	20.7

Source: ADF&G 1984a

1 RM = River Mile
2 Habitat Zones are defined in ADF&G 1984a
3 Includes milling fish, bear killed fish and other non-spawning mortalities

Table 11. Sex ratios of second-run sockeye at Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1983.

Location	Sex ratio (M:F)[1] 1981	1982	1983
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
Sunshine Station Rm 80	1.0:1	0.9:1	0.9:1
Talkeetna Station RM 103	0.6:1	1.3:1	1.6:1
Curry Station RM 120	0.8:1	2.1:1	1.6:1

Source: ADF&G 1981a, 1982a, 1984a

1 Includes all aged and non-aged fish

Table 12. Chum salmon peak index counts by habitat type above RM 98.6, 1981-1983.

Habitat Type	1981	1982	1983	3-Year Total
Mainstem[1]	16	550	219	785
Streams	241	1,737	1,500	3,478
Sloughs[2]	2,596	2,244	1,467	6,307
Total	2,853	4,531	3,186	10,570

Source: ADF&G 1981a, 1982a, 1984a

1 Includes main channel and side channel habitats

2 Includes upland slough and side slough habitats

Table 13. Chum salmon peak index counts in sloughs above RM 98.6, 1981-83.

Slough	River Mile	1981	1982	1983	3-Year Average
1	99.6	6	0	0	2
2	100.2	27	0	49	25
3B	101.4	0	0	3	1
3A	101.9	0	0	0	0
4	105.2	0	0	0	0
5	107.6	0	2	1	1
6	108.2	0	0	0	0
6A	112.3	11	2	6	6
7	113.2	0	0	0	0
8	113.7	302	0	0	101
8D	121.8	0	23	1	8
8C	121.9	0	48	4	17
8B	122.2	1	80	104	62
Moose	123.5	167	23	68	86
A'	124.6	140	0	77	72
A	124.7	34	0	2	12
8A	125.1	620	336	37	331
B	126.3	--	58	7	--
9	128.3	260	300	169	243
9B	129.2	90	5	0	32
9A	133.8	182	118	105	135
10	133.8	0	2	1	1
11	135.3	411	459	238	369
12	135.4	0	0	0	0
13	135.9	4	0	4	3
14	135.9	0	0	0	0
15	137.2	1	1	2	1
16	137.3	3	0	0	1
17	138.9	38	21	90	50
18	139.1	0	0	0	0
19	139.7	3	0	3	2
20	140.0	14	30	63	36
21	141.1	274	736	319	443
22	144.5	--	--	114	---
21A	144.3	8	0	0	3
Total		2,596	2,244	1,467	2,102[1]

Source: ADF&G 1981a, 1982a, 1984a

[1] Three-year average of totals

Table 14. Chum salmon total slough escapement above RM 98.6, 1981-1983.

Slough	River Mile	1981	1982	1983	3-Year Average
1	99.6	10	0	0	3
2	100.2	43	0	96	46
6A	112.3	19	5	0	8
8	113.7	695	0	0	232
8D	121.8	0	53	0	18
8C	121.9	0	108	8	39
8B	122.2	0	99	261	120
Moose	123.5	222	59	86	122
A'	124.6	200	0	155	118
A	124.7	81	0	4	28
8A	125.1	480	1,062	112	551
B	126.3	0	104	14	39
9	128.3	368	603	430	467
9B	129.2	277	12	0	96
9A	133.8	140	86	231	152
11	135.3	1,119	1,078	674	957
13	135.9	7	0	8	5
15	137.2	0	0	4	1
16	137.3	5	0	0	2
17	138.9	135	23	166	108
19	139.7	5	0	6	4
20	140.0	24	28	103	52
21	141.1	657	1,737	481	958
21A	144.3	14	0	0	5
22	144.5	0	0	105	35
Total		4,501	5,057	2,944	4,167[1]

Source: ADF&G 1984a

[1] Three-year average of totals

Table 15. Chum salmon peak index counts in streams above RM 98.6, 1981-83.

Stream	River Mile	1981	1982	1983	3-Year Average
Whiskers Creek	101.4	1	0	0	0
Chase Creek	106.9	1	0	0	0
Lane Creek	113.6	76	11	6	31
Lower McKenzie Creek	116.2	14	0	1	5
Little Portage Creek	117.7	0	31	0	10
Fifth of July Creek	123.7	0	1	6	2
Skull Creek	124.7	10	1	0	4
Sherman Creek	130.8	9	0	0	3
Fourth of July Creek	131.1	90	191	148	143
Indian River	138.6	40	1,346	811	732
Jack Long Creek	144.5	0	3	2	2
Portage Creek	148.9	0	153	526	226
Total		241	1,737	1,500	1,159[1]

Source: ADF&G 1981a, 1982a, 1984a

[1] Three-year average of totals

Table 16. Chum salmon peak spawner counts and spawning observations in mainstem habitats above RM 98.6, 1981-1983.

River Mile 1/	1981	1982	1983	Spawning Observation Dates
100.5	2/	---	---	
114.6	---	10	3/	9/2/82
115.1	---	---	20	9/12/83
118.9	---	---	17	9/19/83
128.6	---	10	---	9/5/82 9/7/82
129.2	2	---	---	9/8/81
129.8	3/	5	---	9/12/82
130.5	3	---	---	9/8/81
131.0	---	3/	3/	
131.1	3	3/	---	9/7/81
131.3	---	12	4	9/4/82 10/1/83
136.1	6	50	110	9/6/81 9/4/82 9/9/83
136.8	---	---	12	9/9/83
137.4	---	25	---	8/19/82 9/5/82
138.3	---	2/	---	
139.0	---	16	56	9/4/82 9/15/83
143.3	---	22	---	9/4/82
148.2	---	400	---	8/18/82
Total	16	550	219	

1/ River miles of spawning locations from ADF&G were standardized by EWT&A to R&M blue line maps.

2/ No spawning observed. Redds observed and/or live eggs sampled.

3/ Spawning areas designated by spawning maps in ADF&G appendices.

Source: ADF&G 1984a

Table 17. Sex ratios of chum salmon at Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1983.

Location/ River Mile	Sex Ratio (M:F)[1]		
	1981	1982	1983
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
Sunshine Station RM 80	0.8:1	1.0:1	1.0:1
Talkeetna Station RM 103	1.3:1	1.9:1	1.5:1
Curry Station RM 120	1.1:1	1.1:1	1.9:1

Source: ADF&G 1981a, 1982a, 1984a

1 Includes all aged and non-aged fish

Table 18. Coho salmon peak index counts[1] in streams above RM 98.6, 1981-1983.

Stream	River Mile	1981	1982	1983	3-Year Average
Whiskers Creek	101.4	70	176	115	120
Chase Creek	106.9	80	36	12	43
Slash Creek	111.2	0	6	2	3
Gash Creek	111.6	141	74	19	78
Lane Creek	113.6	3	5	2	3
Lower McKenzie Creek	116.2	56	133	18	69
Little Portage Creek	117.7	0	8	0	3
Fourth of July Creek	131.1	1	4	3	3
Gold Creek	136.7	0	1	0	0
Indian River	138.6	85	101	53	80
Jack Long Creek	144.5	0	1	1	1
Portage Creek	148.9	22	88	15	42
Total		458	633	240	444[2]

Source: ADF&G 1981a, 1982a, 1984a

1 Counts done by helicopter and/or foot surveys

2 Three-year average of totals

Table 19. Sex ratios of coho salmon at Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1983.

Location/ River Mile	Sex Ratio (M:F)[1]		
	1981	1982	1983
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
Sunshine Station RM 80	0.7:1	1.4:1	1.2:1
Talkeetna Station RM 103	1.5:1	1.5:1	1.7:1
Curry Station RM 120	2.0:1	1.3:1	2.0:1

Source: ADF&G 1981a, 1982a, 1984a

1 Includes all aged and non-aged fish

Table 20. Pink salmon peak index counts in streams above RM 98.6, 1981-1983.

Stream	River Mile	1981	1982	1983	3-Year Average
Whiskers Creek	101.4	1	138	0	46
Chase Creek	106.9	38	107	6	50
Lane Creek	113.6	291	640	28	320
Lower McKenzie Creek	116.2	0	23	17	13
McKenzie Creek	116.7	0	17	0	6
Little Portage Creek	117.7	0	140	7	49
Fifth of July Creek	123.7	2	113	9	41
Skull Creek	124.7	8	12	1	7
Sherman Creek	130.8	6	24	0	10
Fourth of July Creek	131.1	29	702	78	270
Gold Creek	136.7	0	11	7	6
Indian River	138.6	2	738	886	542
Jack Long Creek	144.5	1	21	5	9
Portage Creek	148.9	0	169	285	151
Total		378	2,855	1,329	1,521[1]

Source: ADF&G 1984a

[1] Three-year average of totals

Table 21. Pink salmon total slough escapement above RM 98.6, 1981-1983.

Slough	River Mile	1981	1982	1983	3-Year Average
8	113.7	38	0	0	13
Moose	123.5	0	2	0	1
8A	125.1	0	5	0	2
B	126.3	0	18	0	6
9	128.3	0	18	0	6
11	135.3	0	170	0	57
20	140.0	0	75	0	25
21	141.1	0	9	0	3
Total		38	297	0	112[1]

Source: ADF&G 1984a

[1] Three-year average of totals

Table 22. Sex ratios of pink salmon at Susitna, Yentna, Sunshine, Talkeetna and Curry stations, 1981-1983.

Location/ River Mile	Sex Ratio (M:F) 1981	1982	1983
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
Sunshine Station RM 80	0.8:1	1.8:1	1.0:1
Talkeetna Station RM 103	1.2:1	1.6:1	0.8:1
Curry Station RM 120	0.8:1	1.5:1	1.0:1

Source: ADF&G 1984a

Table 23. Chinook salmon peak index counts in streams above RM 98.6, 1981-1983.

Stream	River Mile	1981	1982	1983	3-Year Average
Whiskers Creek	101.4	---	0	3	---
Chase Creek	106.9	---	15	15	---
Lane Creek	113.6	40	47	12	33
Fifth of July Creek	123.7	---	3	-	---
Sherman Creek	130.8	---	3	0	---
Fourth of July Creek	131.0	---	56	6	---
Gold Creek	136.7	---	21	23	---
Indian River	138.6	422	1,053	1,193	889
Jack Long Creek	144.5	---	2	6	---
Portage Creek	148.9	659	1,253	3,140	1,684
Cheechako Creek	152.5	---	16	25	---
Chinook Creek	156.8	---	5	8	---
Devil Creek	161.0	---	0	1	---
Total		1,121	2,474	4,432	2,676[1]

Source: ADF&G 1981a, 1982a, 1984a

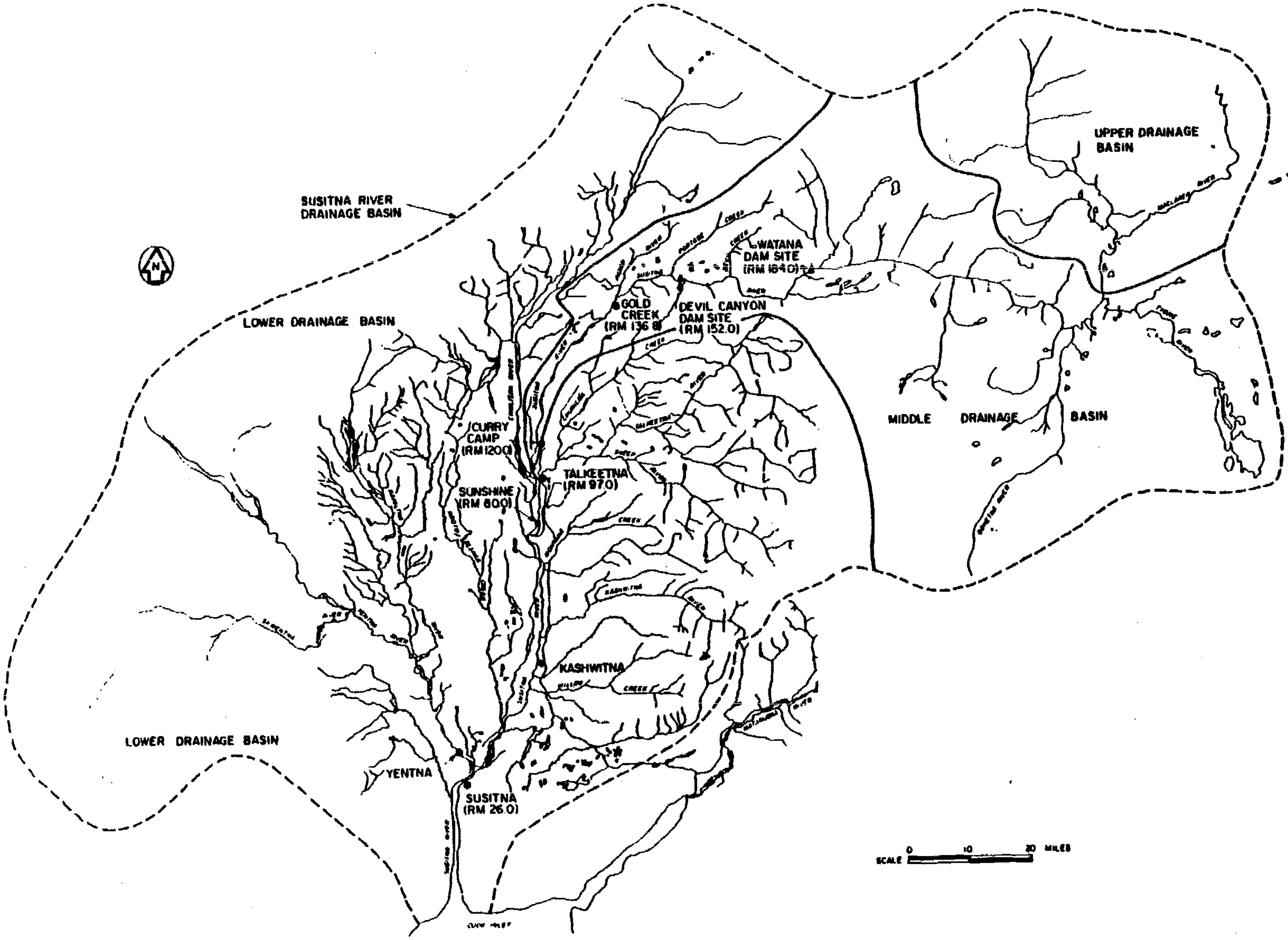
[1] Three-year average of totals

Table 24. Sex ratios of chinook salmon at Yentna, Sunshine, Talkeetna and Curry stations, 1981-1983.

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

Source: ADF&G 1984a

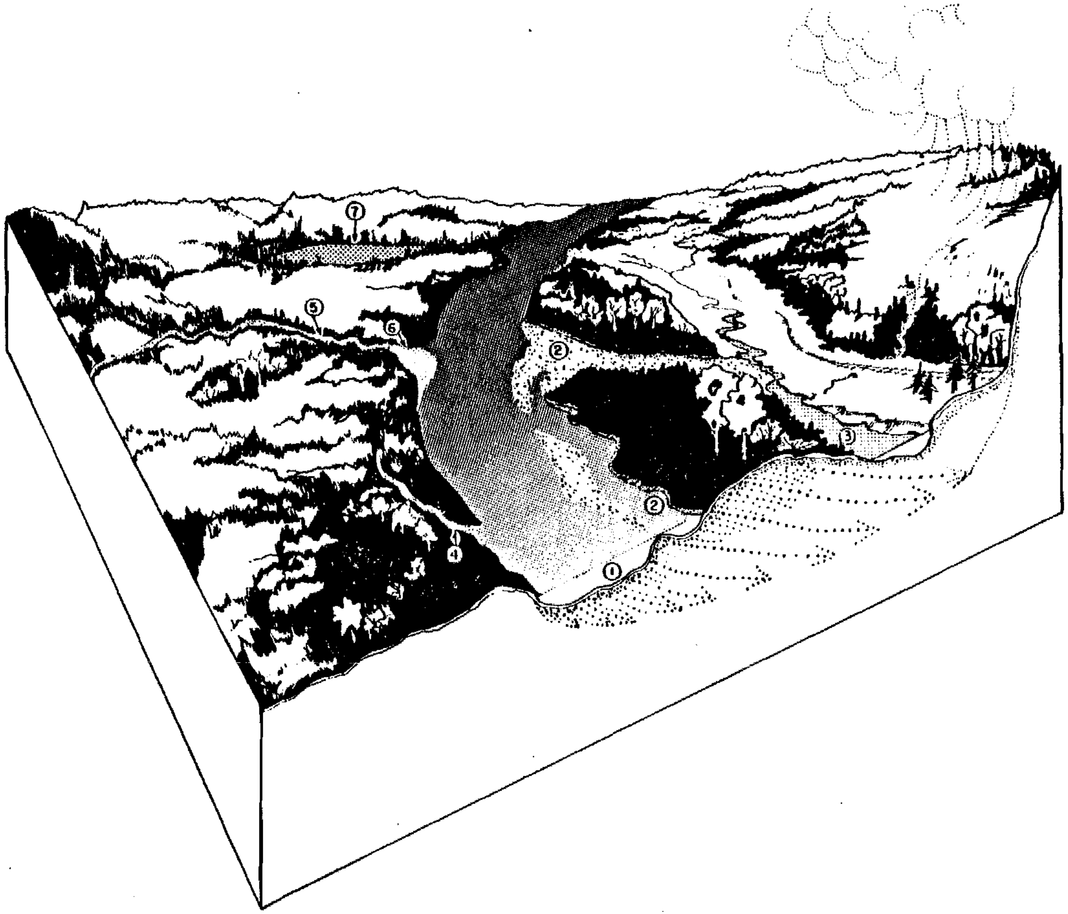
[1] Includes all aged and non-aged fish



SUSITNA RIVER DRAINAGE BASIN

FIGURE 1

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



GENERAL HABITAT CATEGORIES OF THE SUSITNA RIVER

1) Mainstem Habitat consists of those portions of the Susitna River that normally convey streamflow throughout 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.

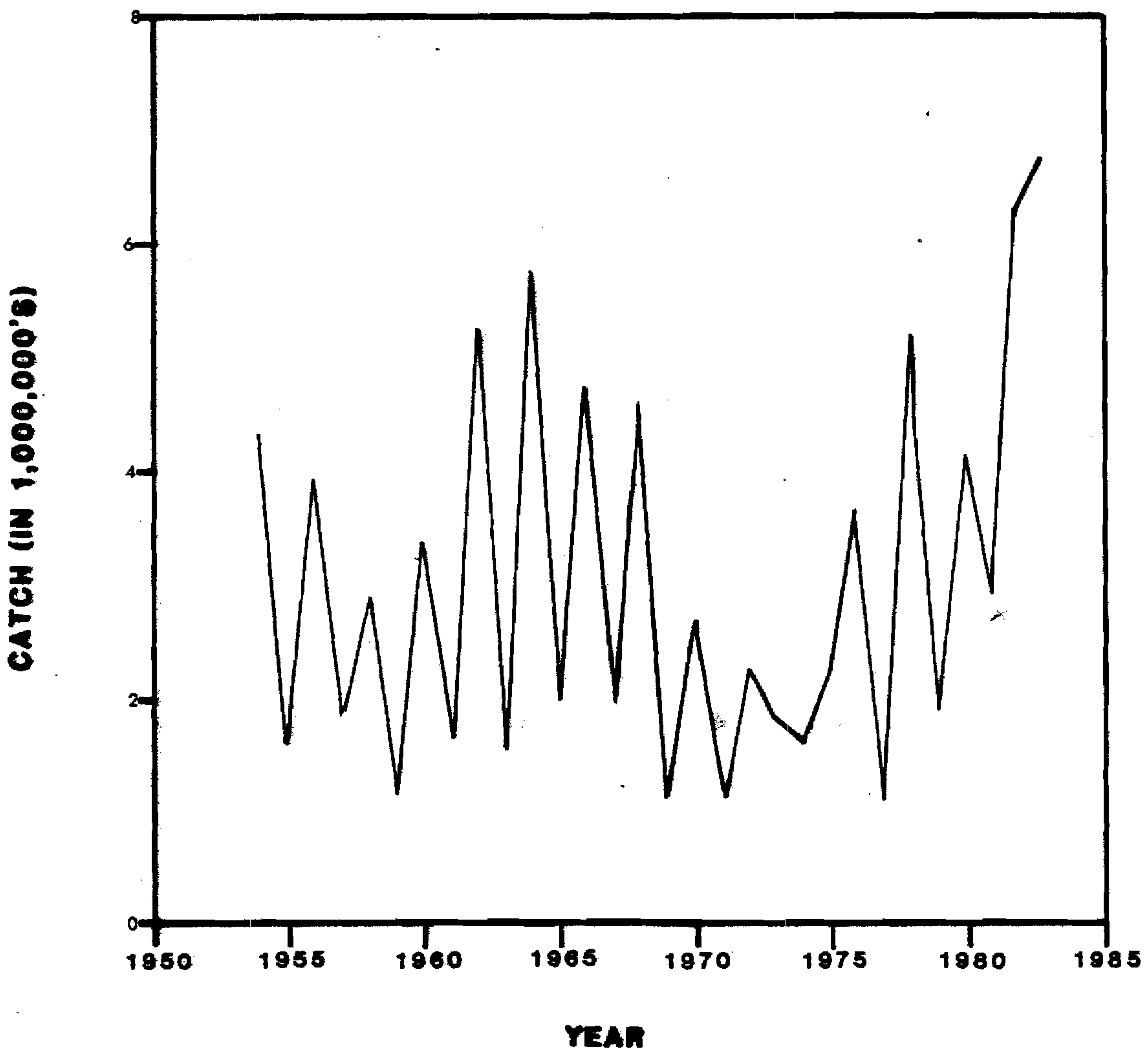
GENERAL HABITAT CATEGORIES OF THE SUSITNA RIVER - A CONCEPTUAL DIAGRAM (SOURCE: ADF&G 1982 e).

FIGURE 2

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

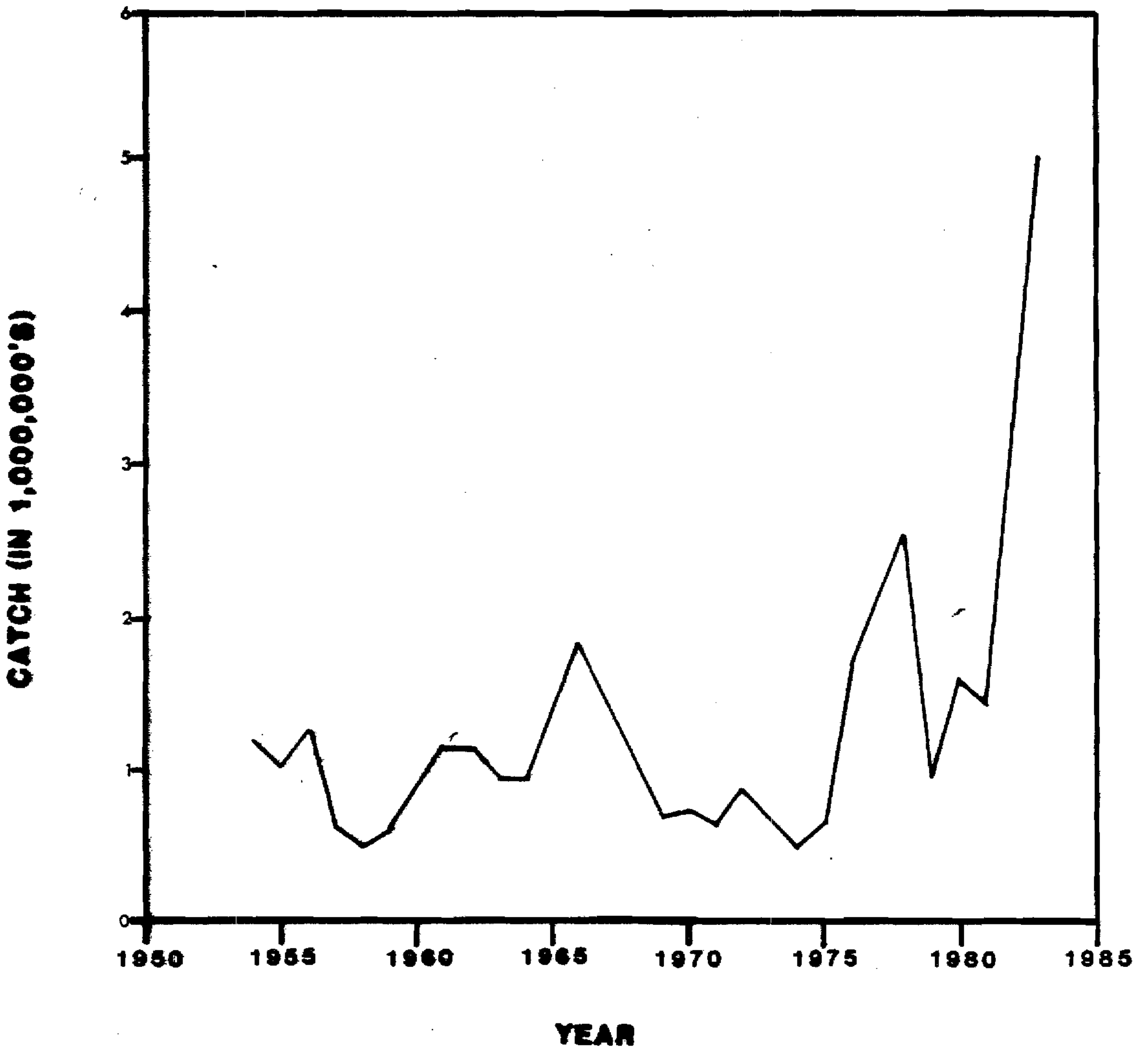
HARZA-EBASCO
SUSITNA JOINT VENTURE



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

FIGURE 3

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



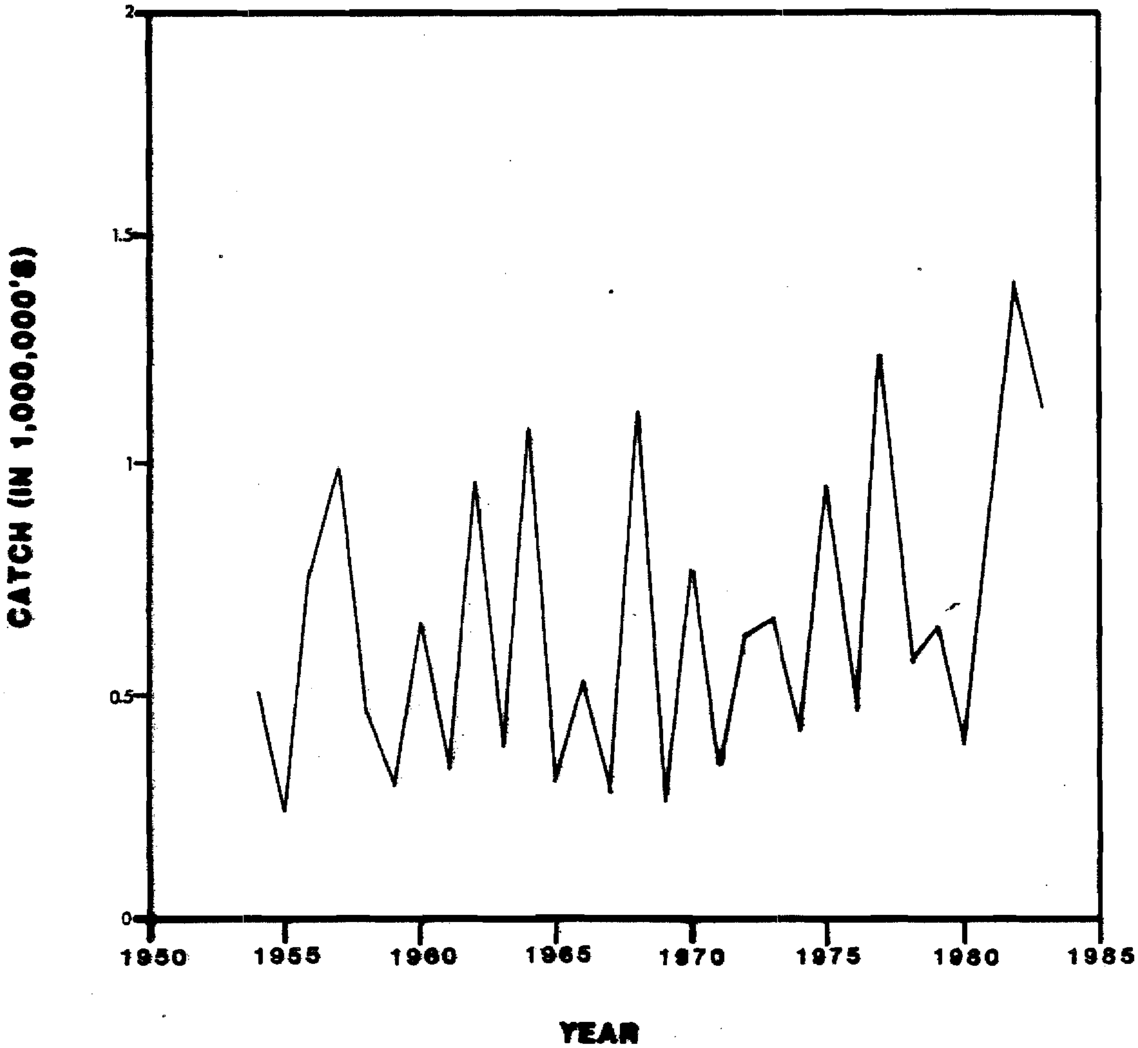
COMMERCIAL CATCH OF UPPER COOK INLET SOCKEYE, 1954-1983.

FIGURE 4

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



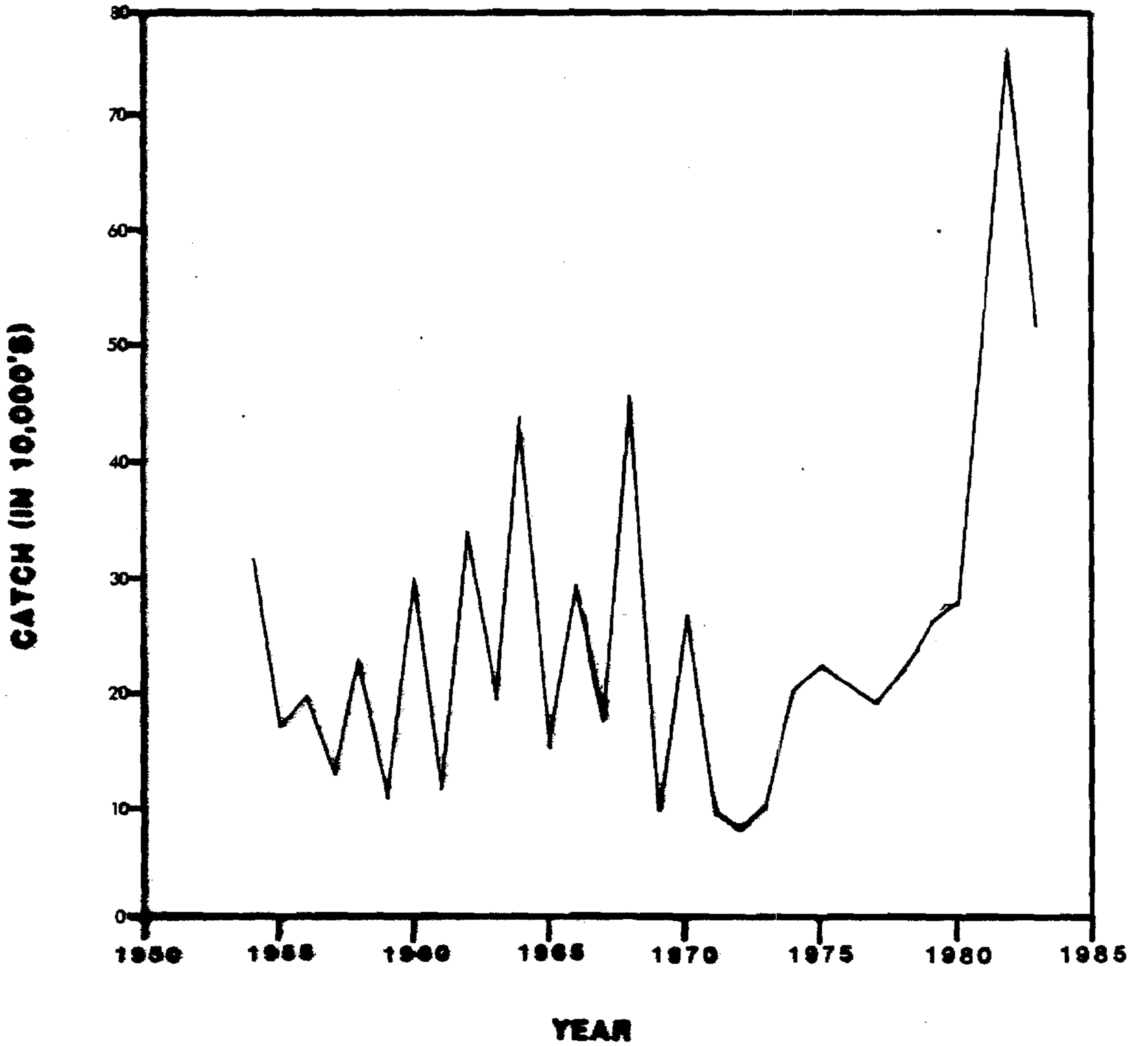
COMMERCIAL CATCH OF UPPER COOK INLET CHUM, 1954-1983.

FIGURE 5

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



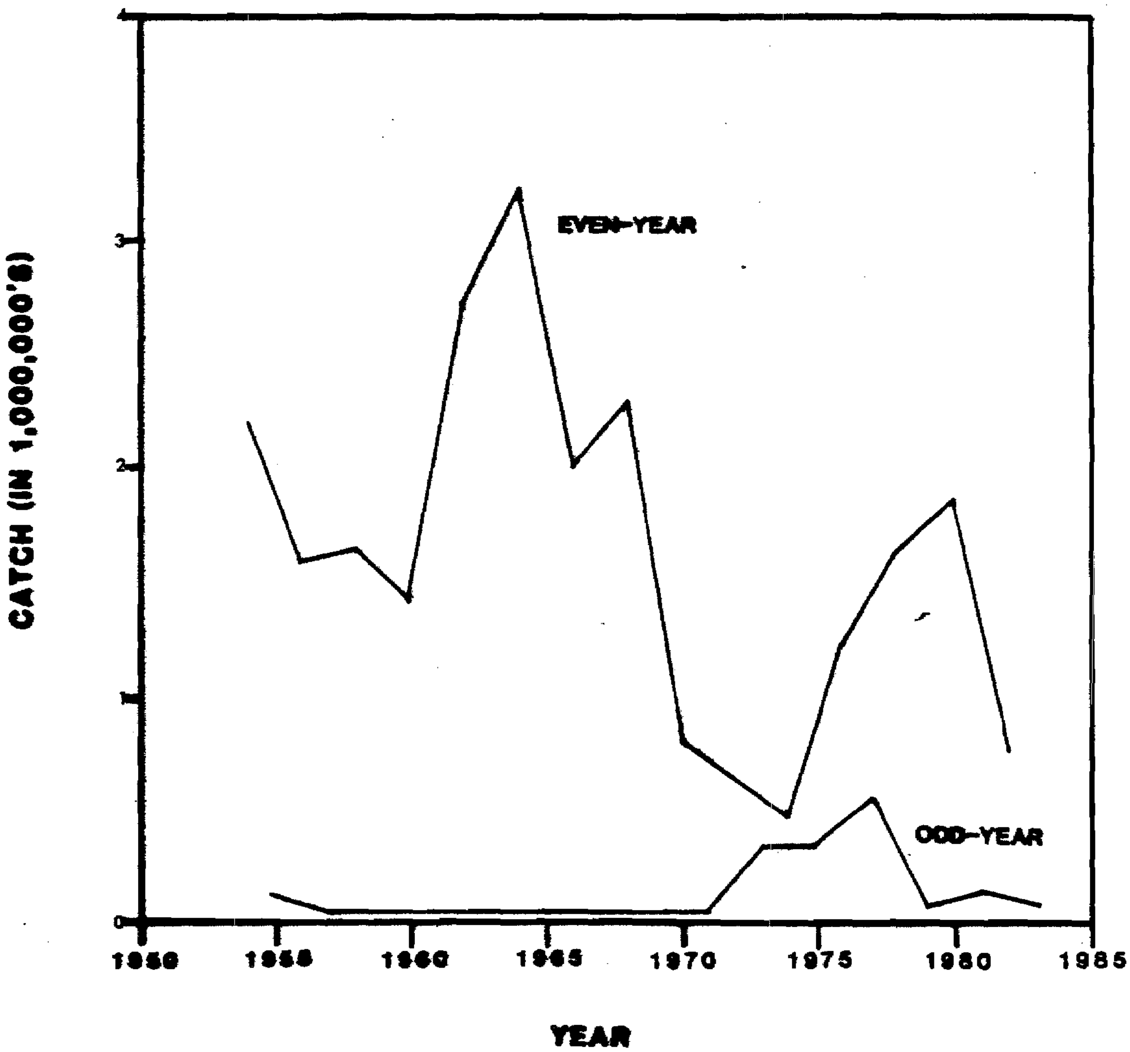
COMMERCIAL CATCH OF UPPER COOK INLET COHO, 1954-1983.

FIGURE 6

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



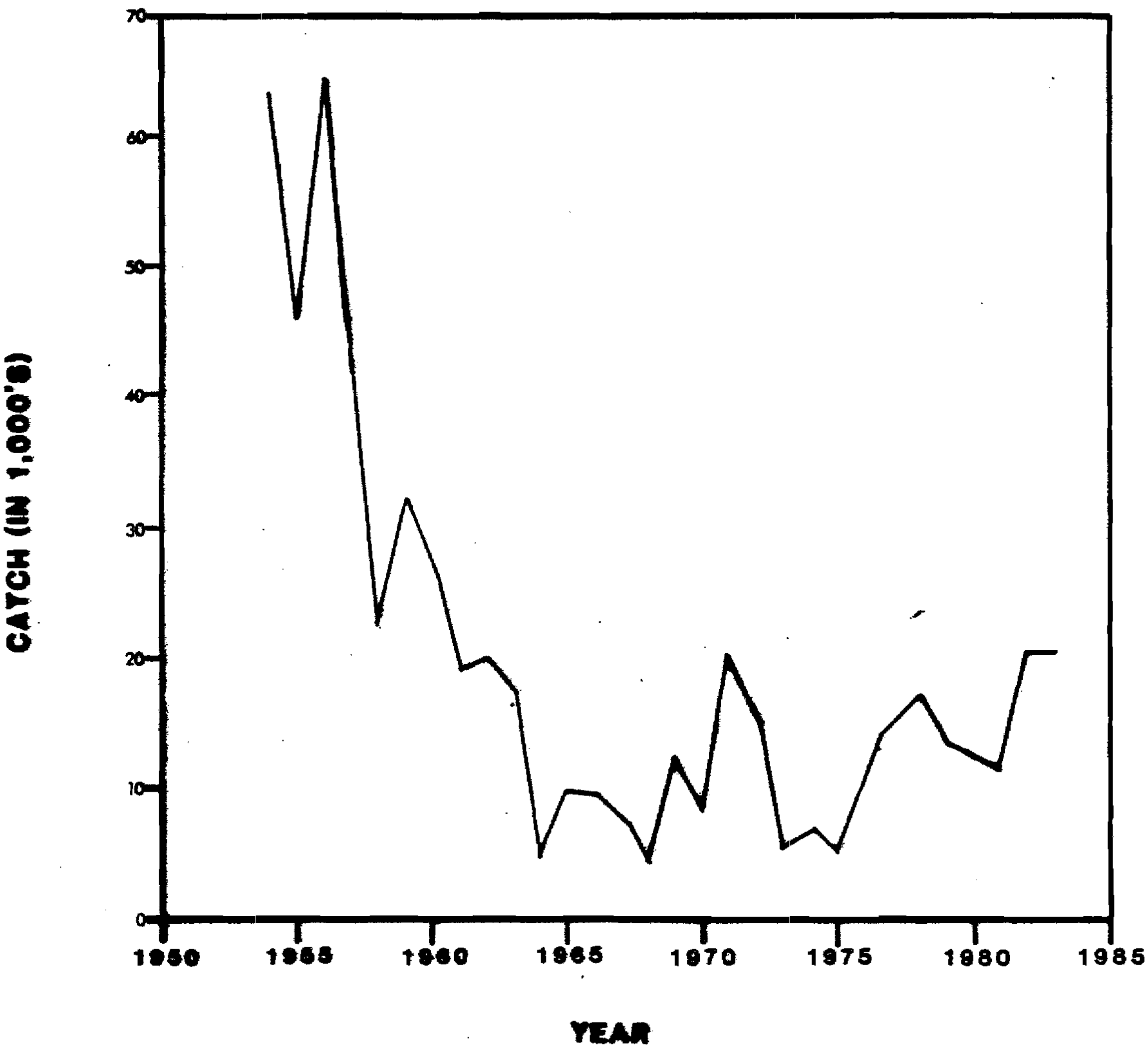
COMMERCIAL CATCH OF UPPER COOK INLET PINK, 1954-1983.

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE

FIGURE 7



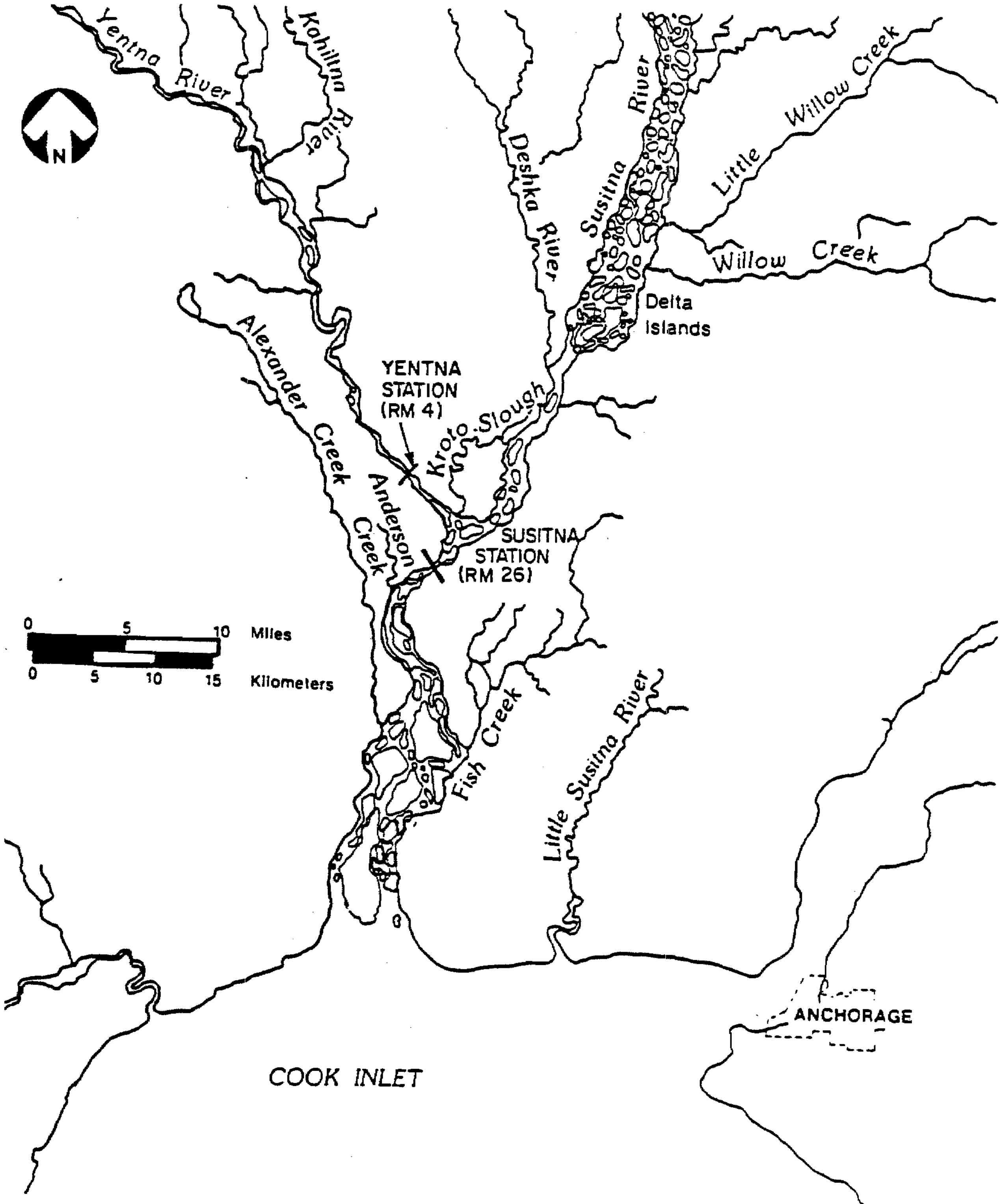
COMMERCIAL CATCH OF UPPER COOK INLET CHINOOK, 1954-1983.

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE

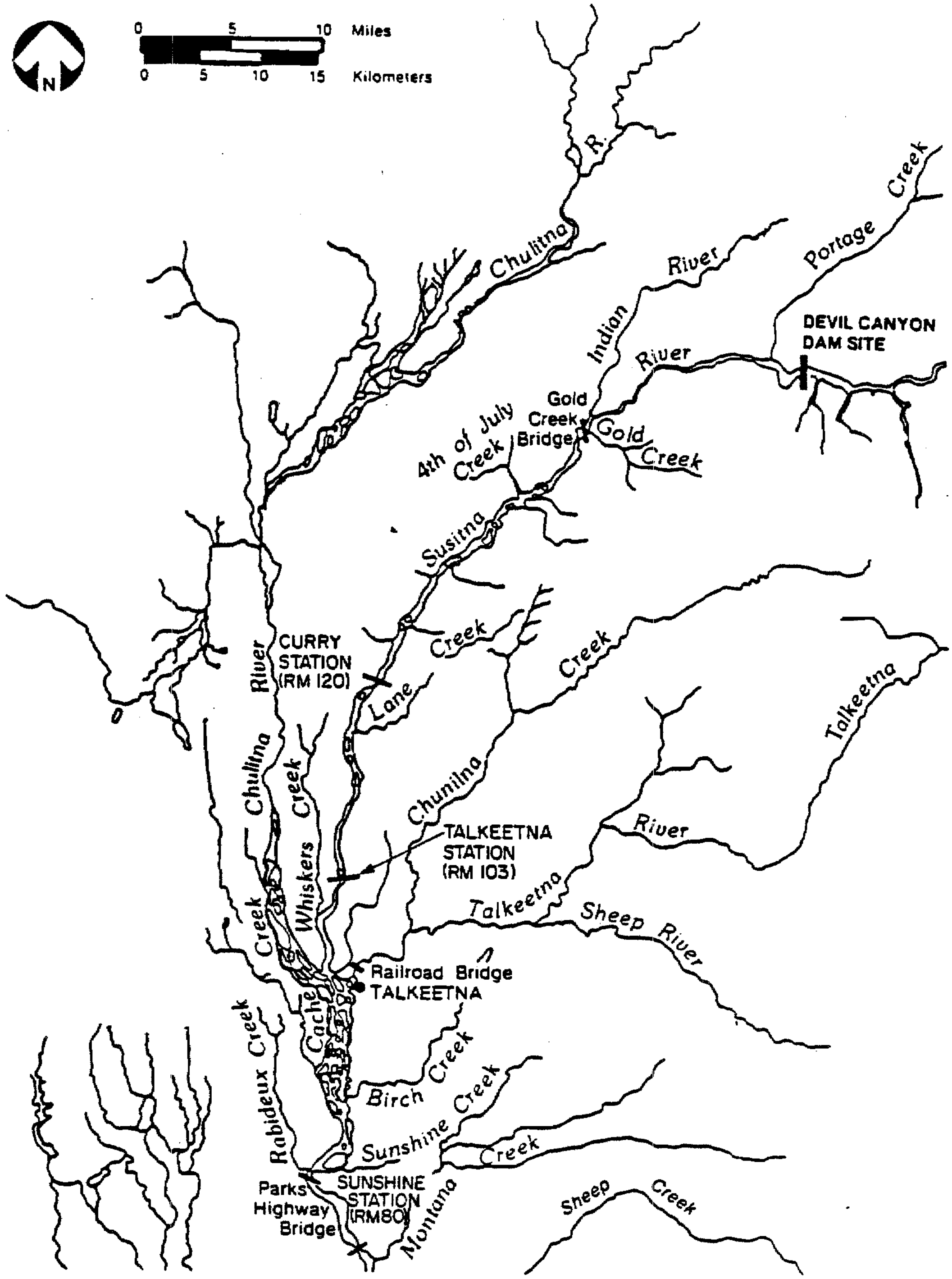
FIGURE 8



SUSITNA RIVER AND MAJOR TRIBUTARIES FROM MOUTH TO LITTLE WILLOW CREEK

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 9



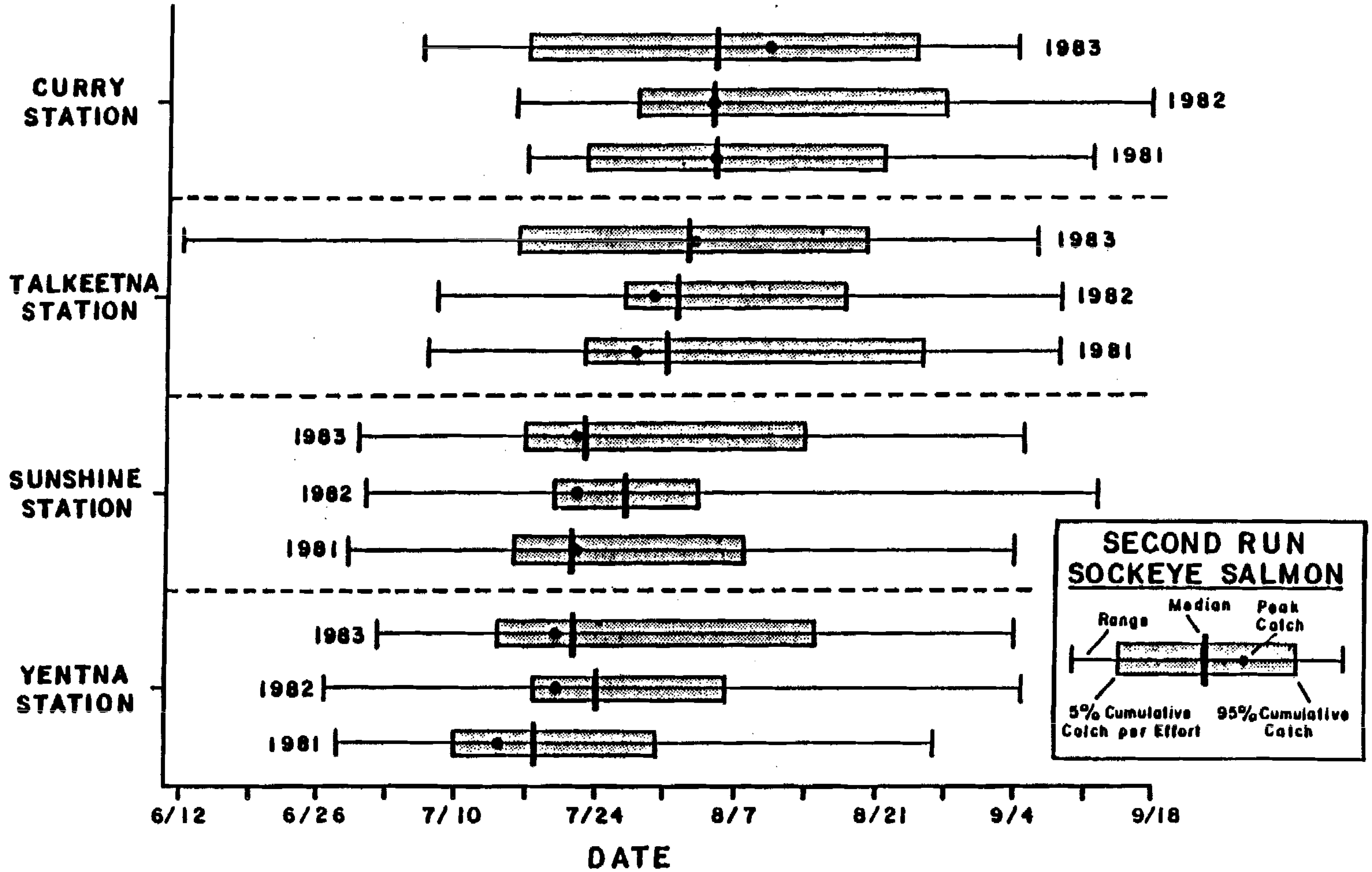
SUSITNA RIVER AND MAJOR TRIBUTARIES
FROM MONTANA CREEK TO DEVIL CAYON

FIGURE 10

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



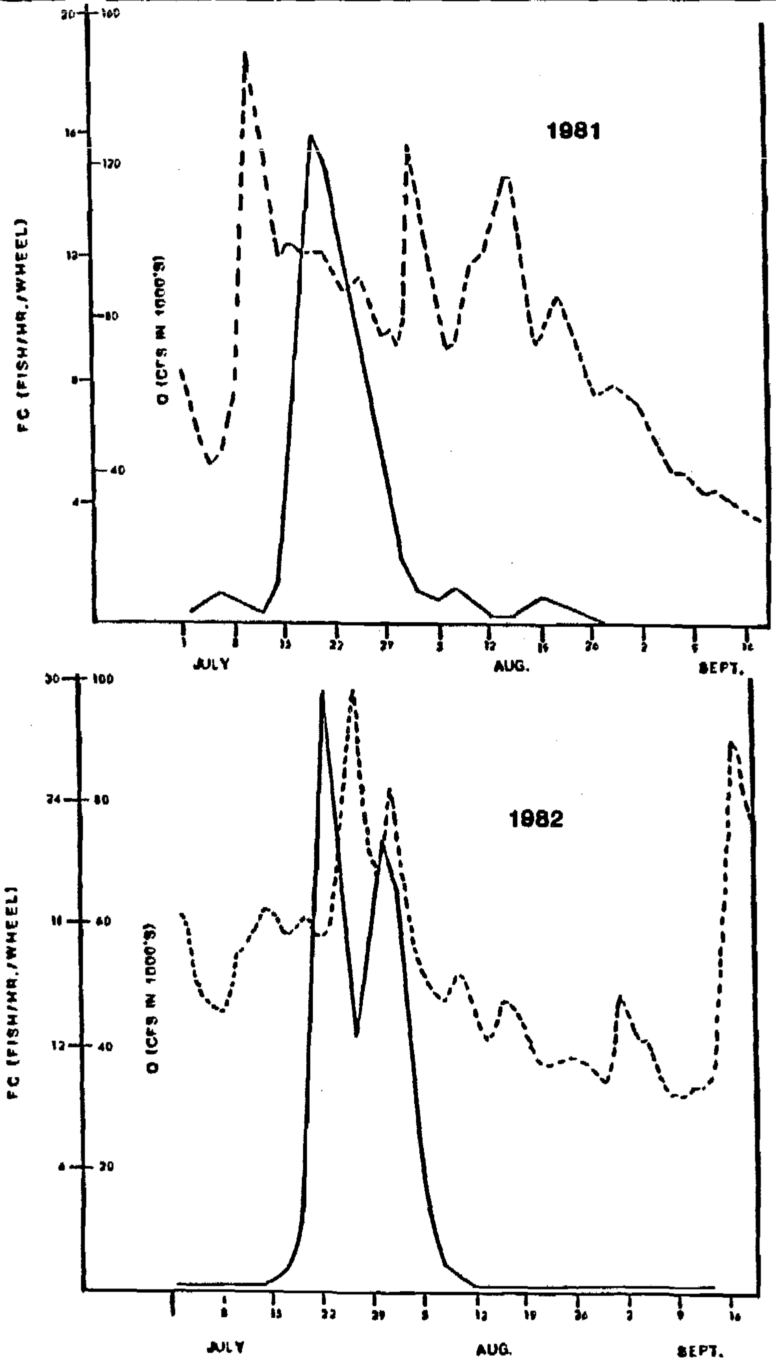
MIGRATIONAL TIMING OF SECOND-RUN SOCKEYE SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: ADF&G 1984 a).

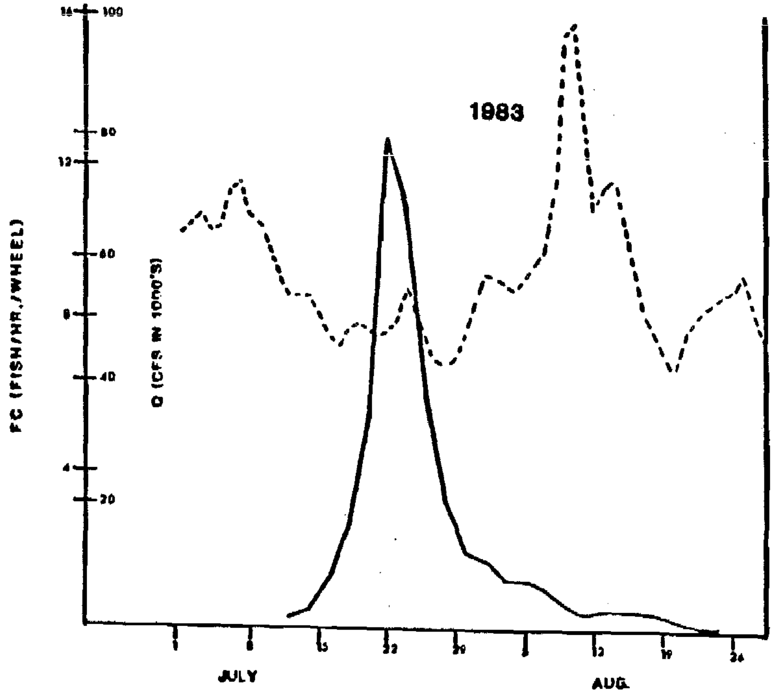
FIGURE 11

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE





FISHWHEEL CATCH (FC) ————

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

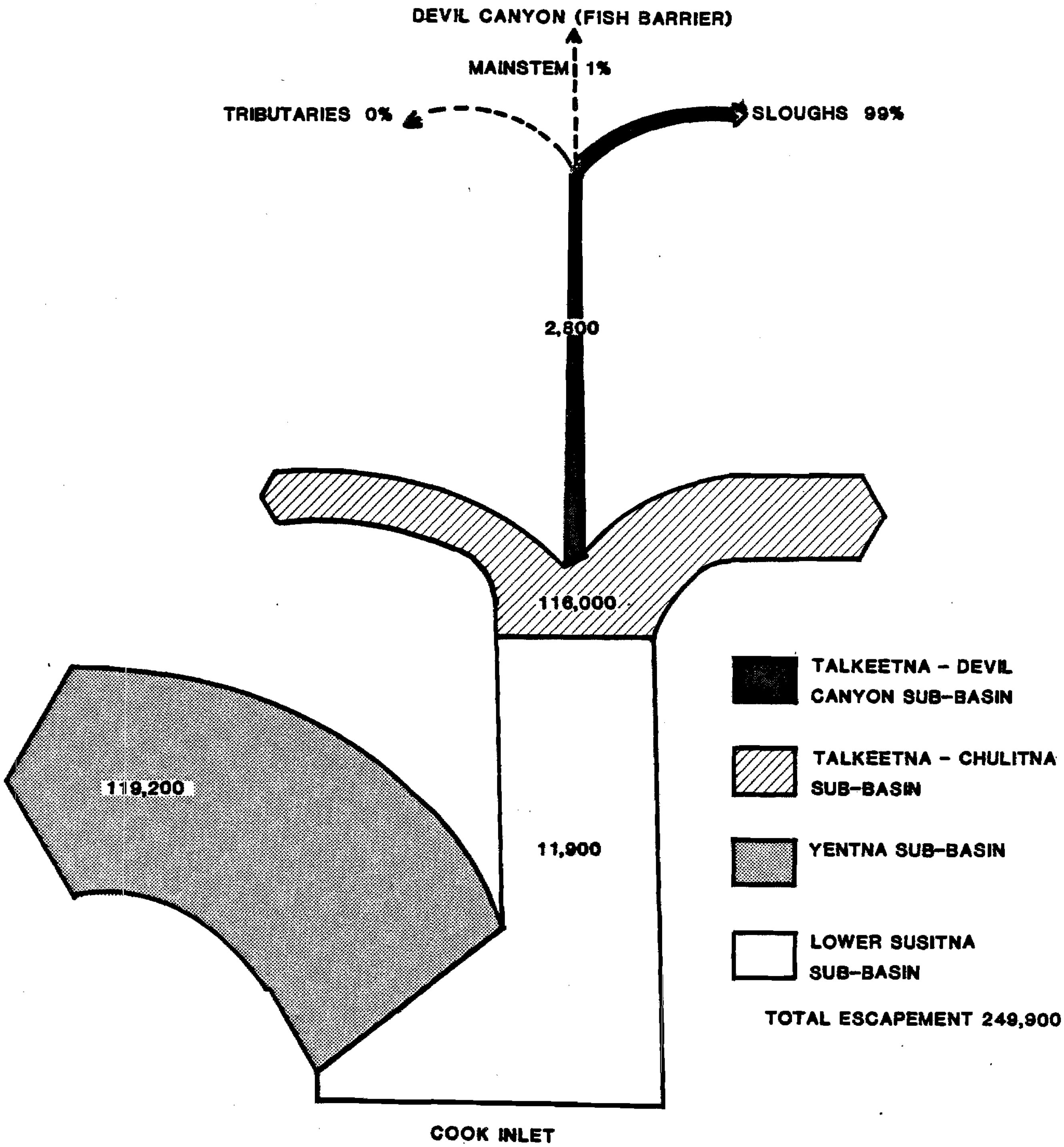
COMPARISON OF SECOND-RUN SOCKEYE FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION, 1981-1983.

FIGURE 12

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

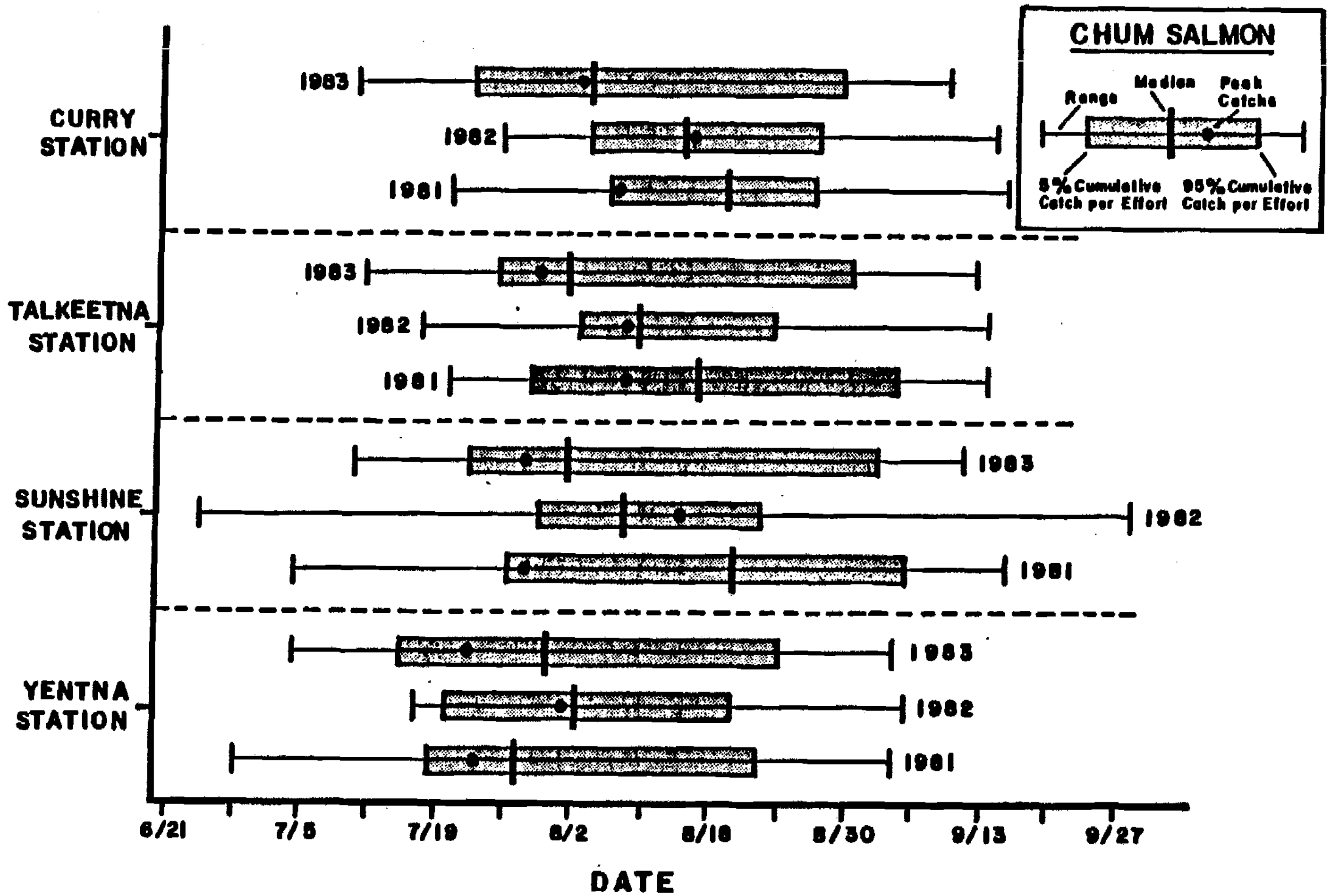
HARZA-EBASCO
SUSITNA JOINT VENTURE



1981 - 1983 SUSITNA SOCKEYE ESCAPEMENT AND RELATIVE UTILIZATION

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 13



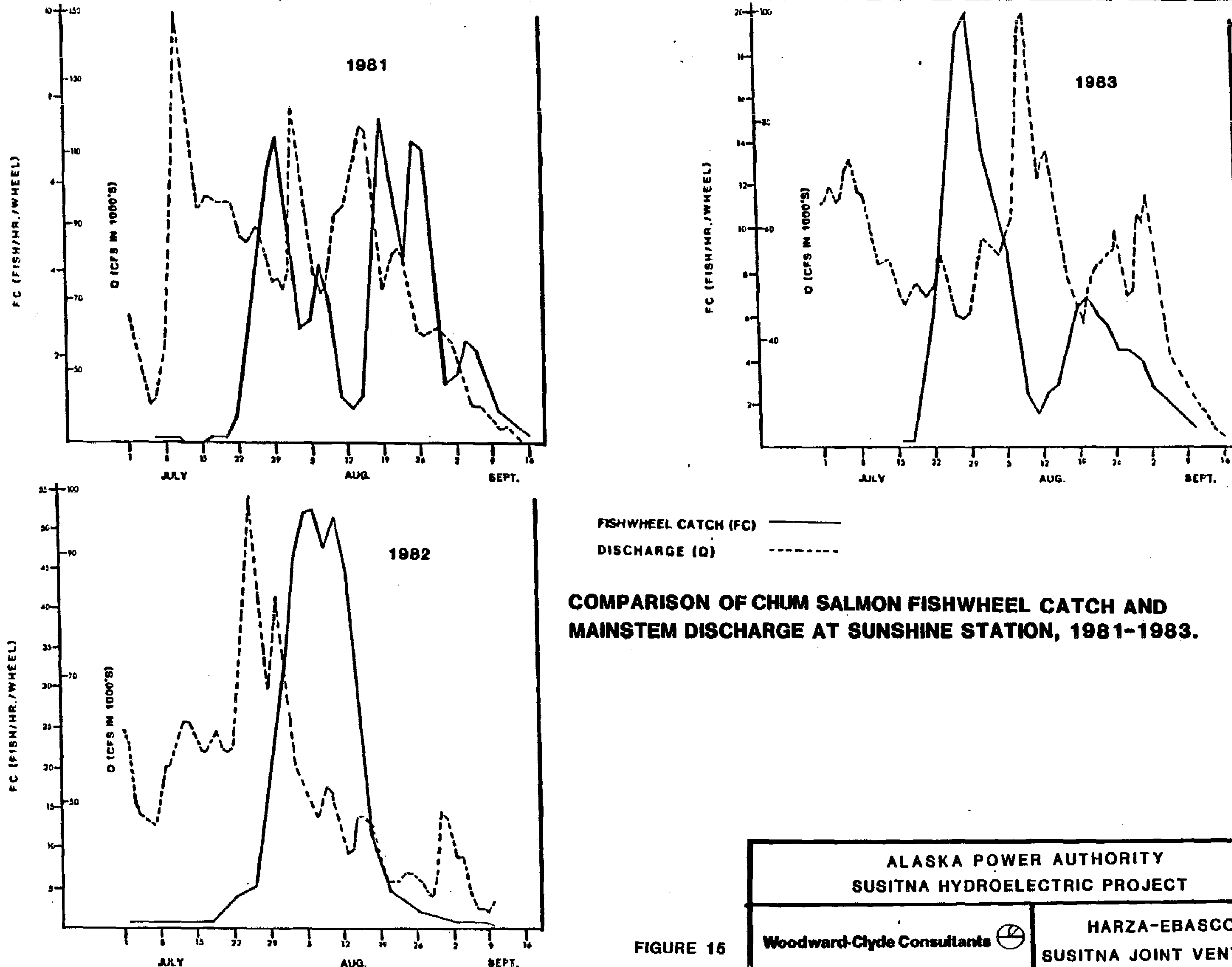
MIGRATIONAL TIMING OF CHUM SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: ADF&G 1984 a)

FIGURE 14

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



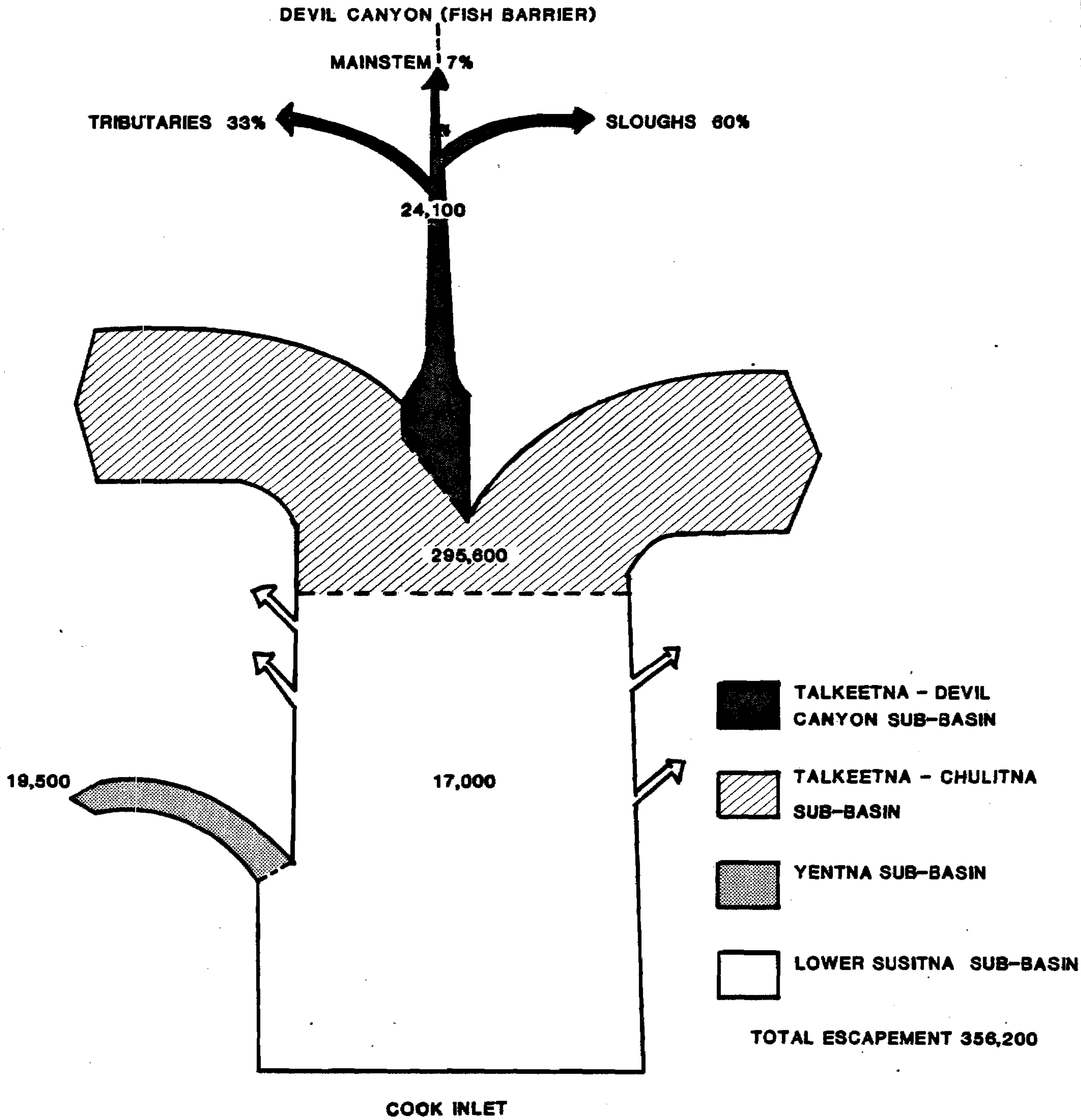
COMPARISON OF CHUM SALMON FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION, 1981-1983.

FIGURE 15

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



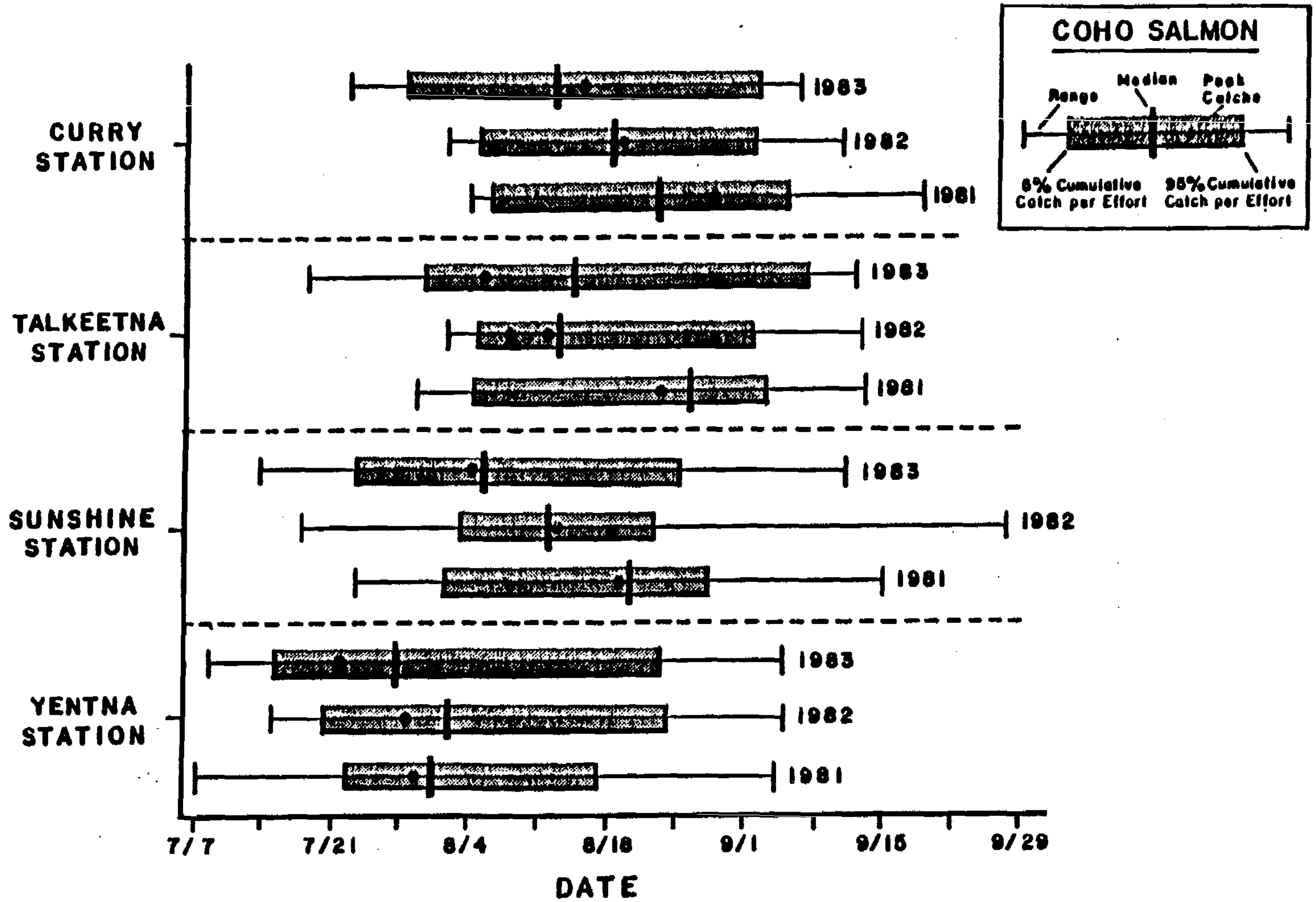
1981 - 1983 SUSITNA CHUM ESCAPEMENT AND RELATIVE UTILIZATION

FIGURE 16

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

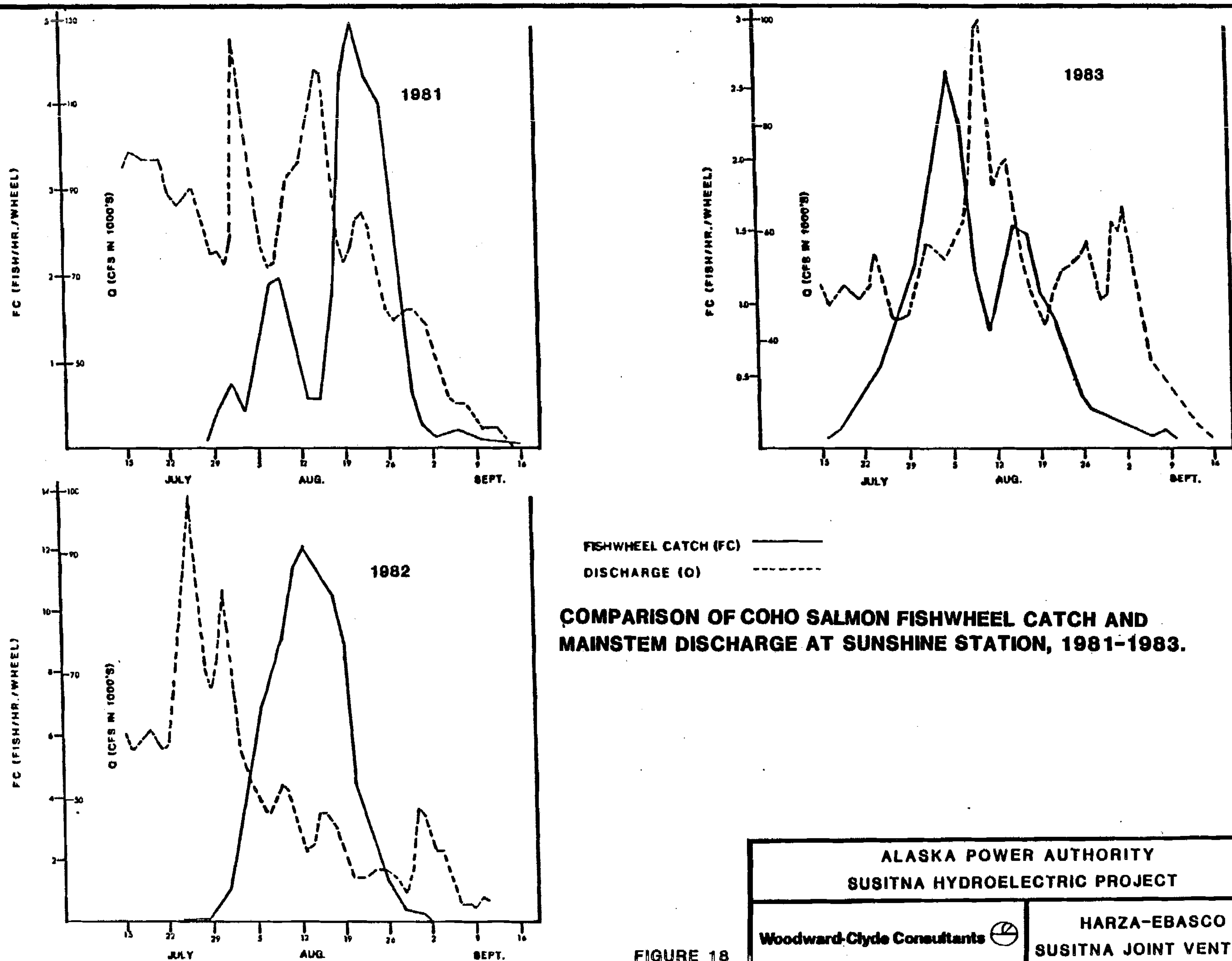
HARZA-EBASCO
SUSITNA JOINT VENTURE



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: ADF&G 1984 a).

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE

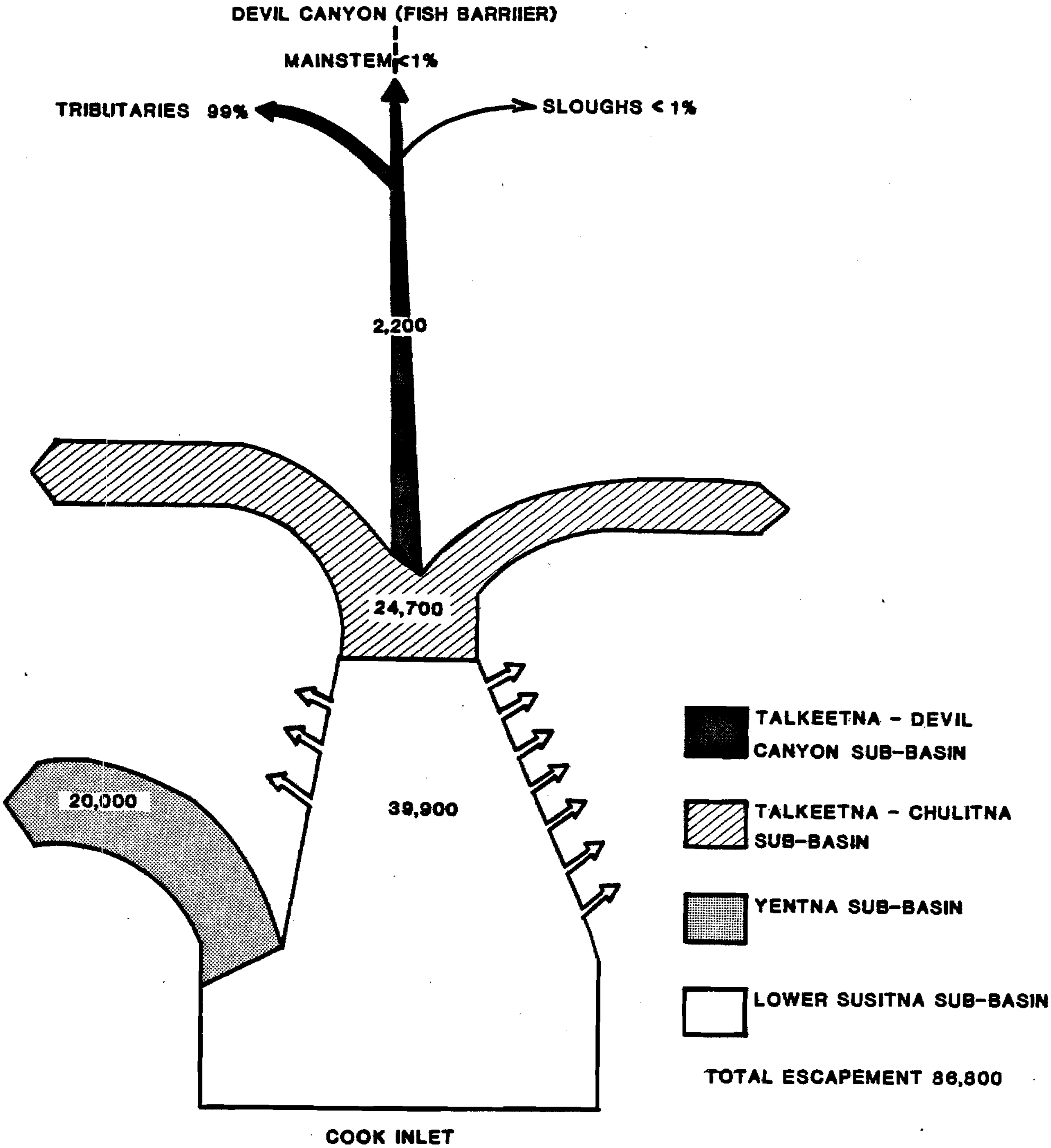
FIGURE 17



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

FIGURE 18

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



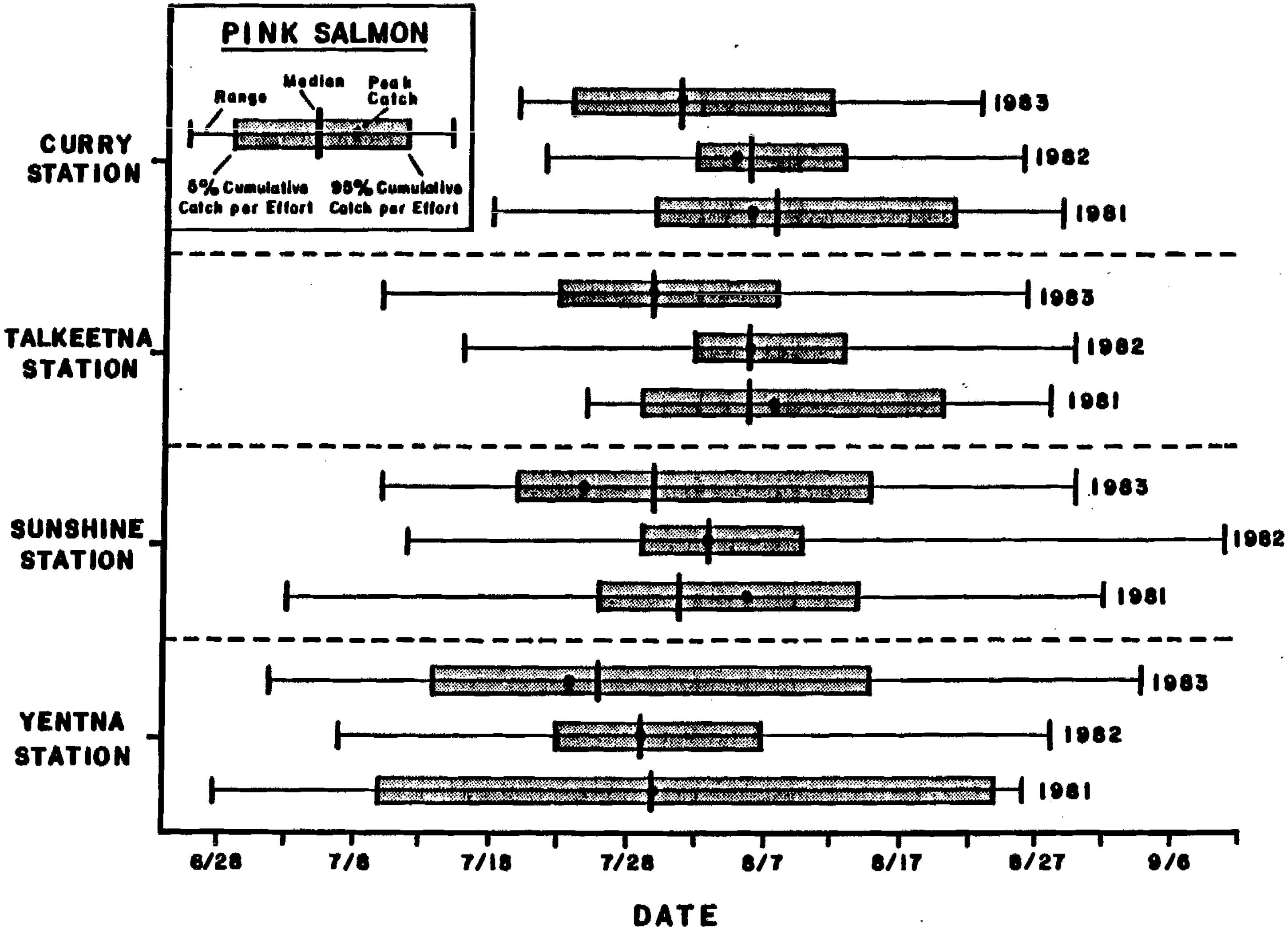
1981 - 1983 SUSITNA COHO ESCAPEMENT AND RELATIVE UTILIZATION

FIGURE 19

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



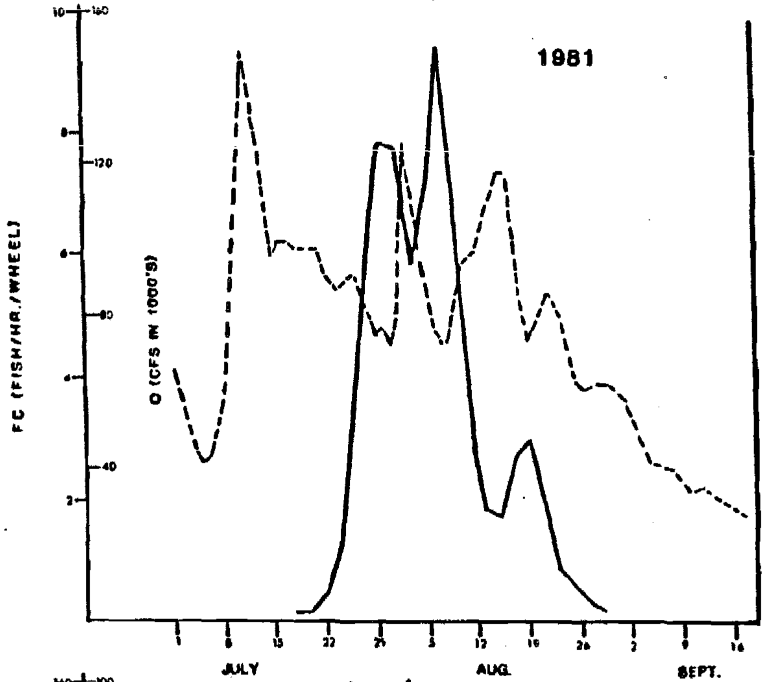
MIGRATIONAL TIMING OF PINK SALMON BASED ON FISHWHEEL CATCH PER UNIT EFFORT AT SELECTED LOCATIONS ON THE SUSITNA RIVER IN 1981, 1982 AND 1983. (SOURCE: ADF&G 1984 a).

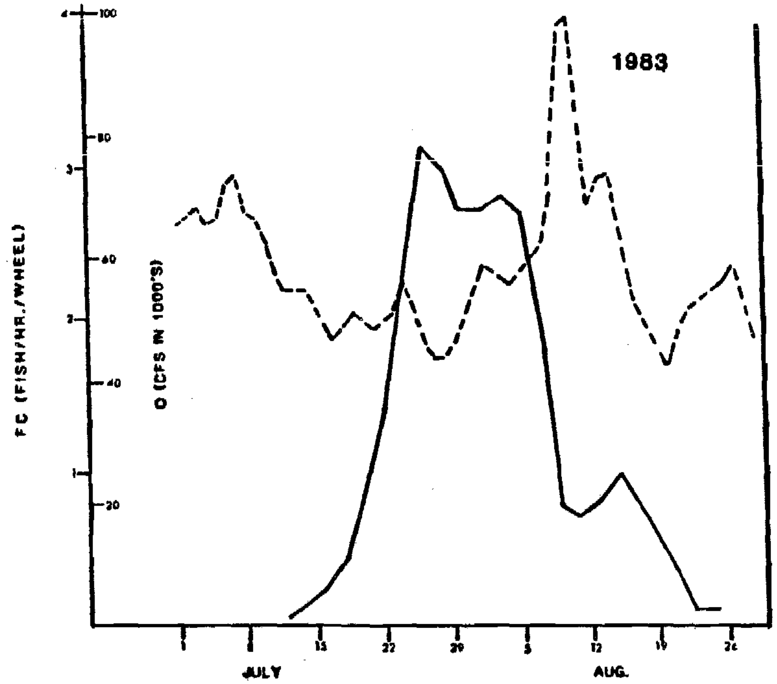
FIGURE 20

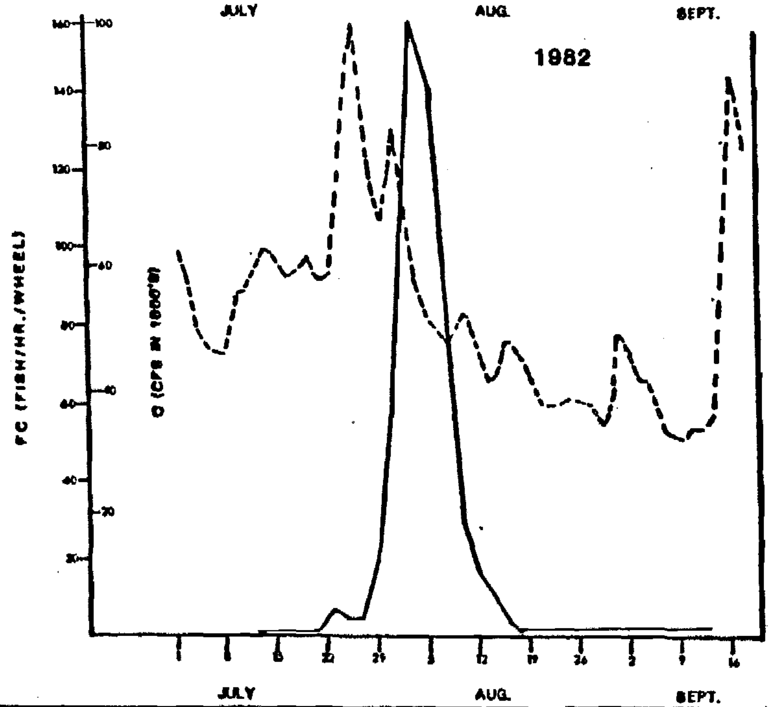
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE







FISHWHEEL CATCH (FC) ———

DISCHARGE (Q) - - - - - -

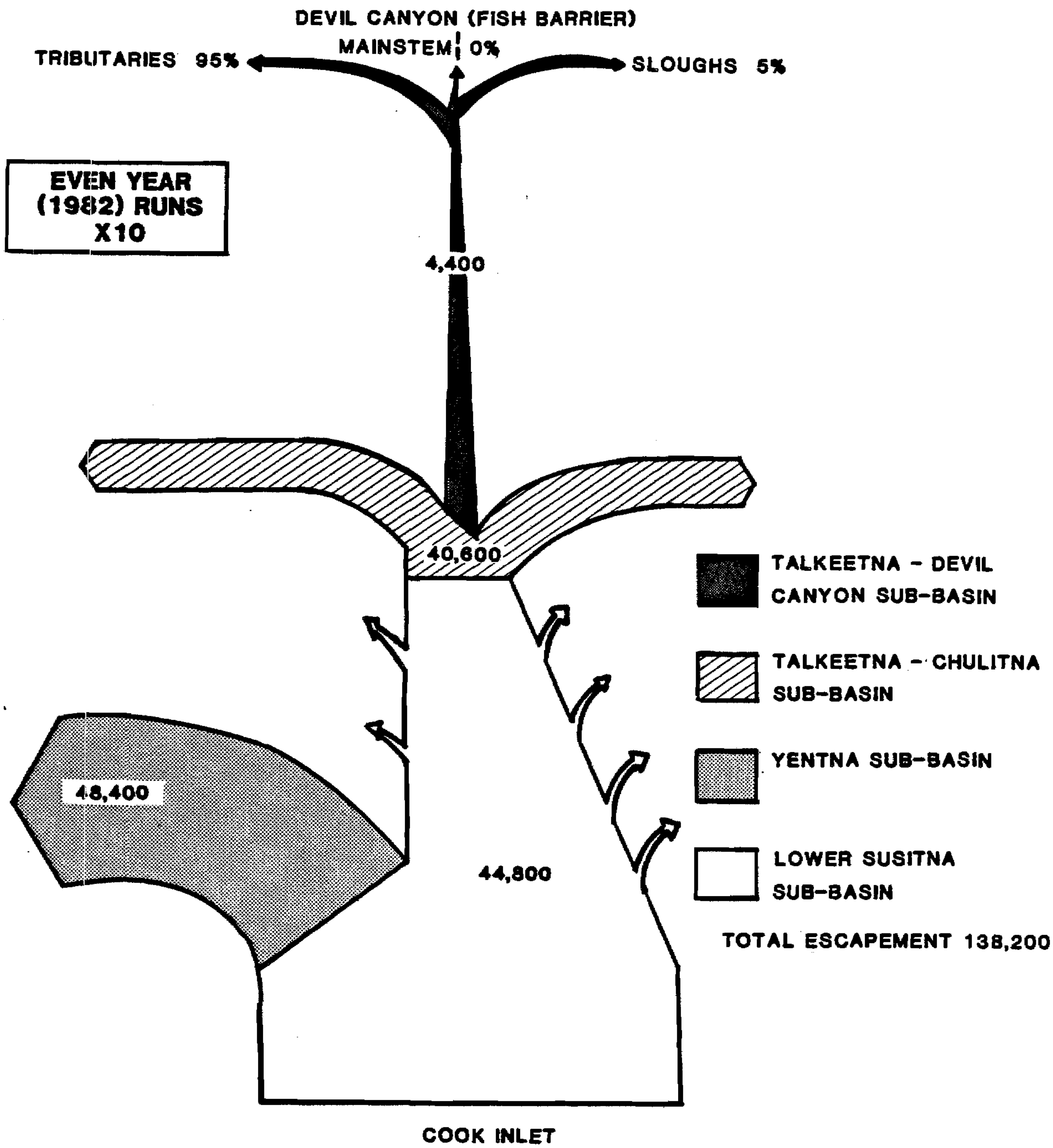
COMPARISON OF PINK SALMON FISHWHEEL CATCH AND MAINSTEM DISCHARGE AT SUNSHINE STATION, 1981-1983.

FIGURE 21

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



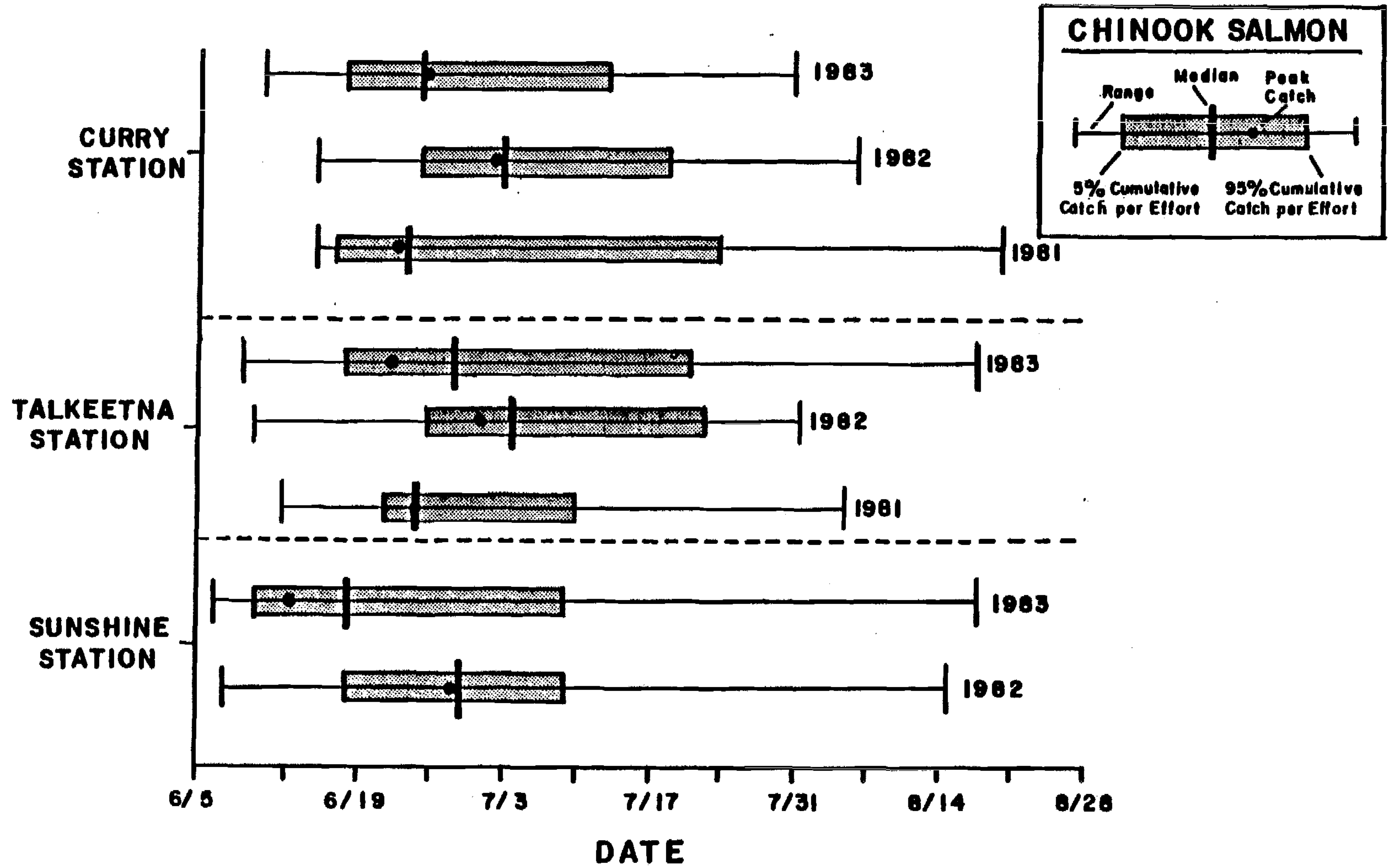
ODD-YEAR (1981 & 1983) SUSITNA PINK ESCAPEMENT AND RELATIVE UTILIZATION

FIGURE 22

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

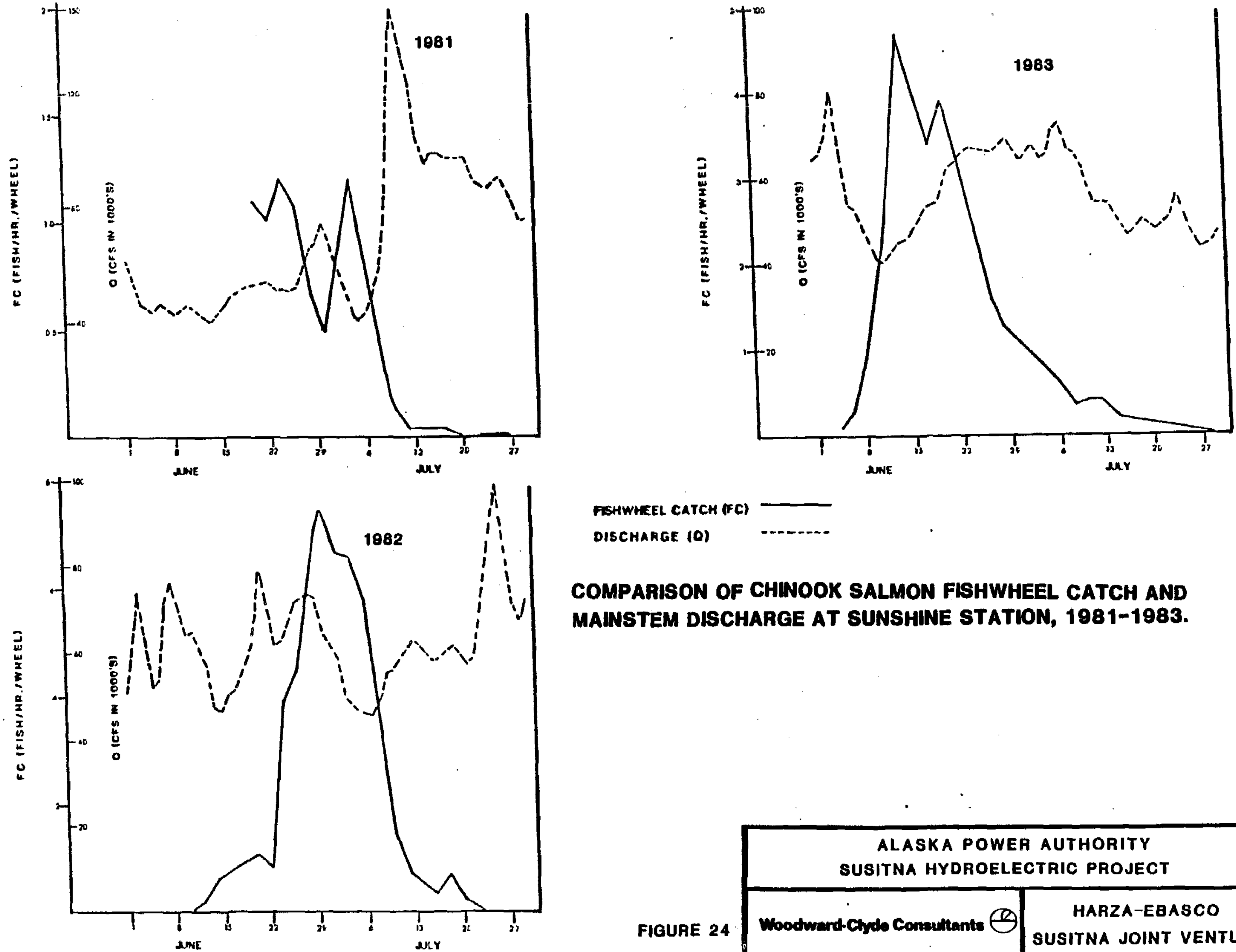
HARZA-EBASCO
SUSITNA JOINT VENTURE



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: ADF&G 1984 a).

FIGURE 23

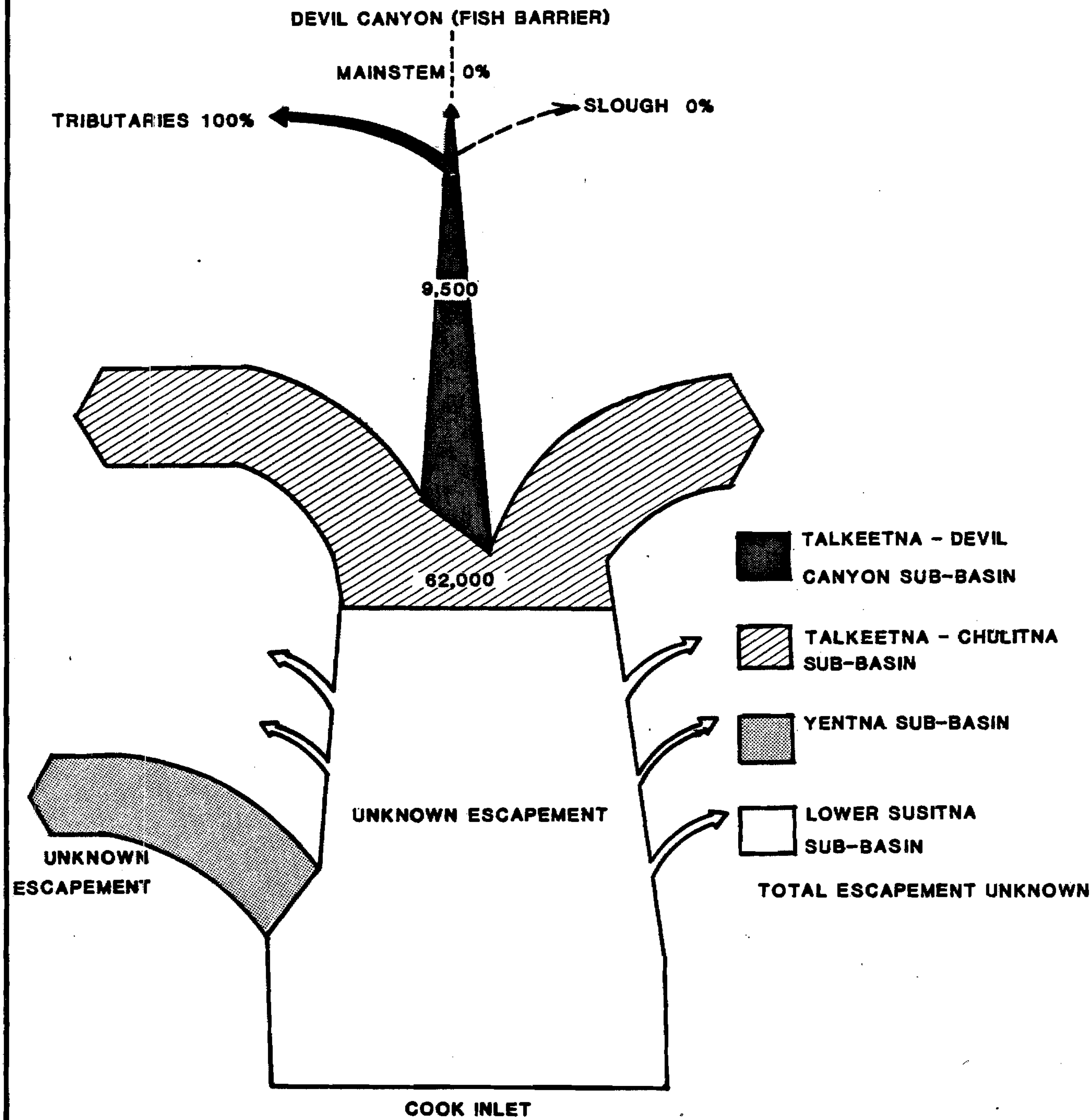
ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



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

FIGURE 24

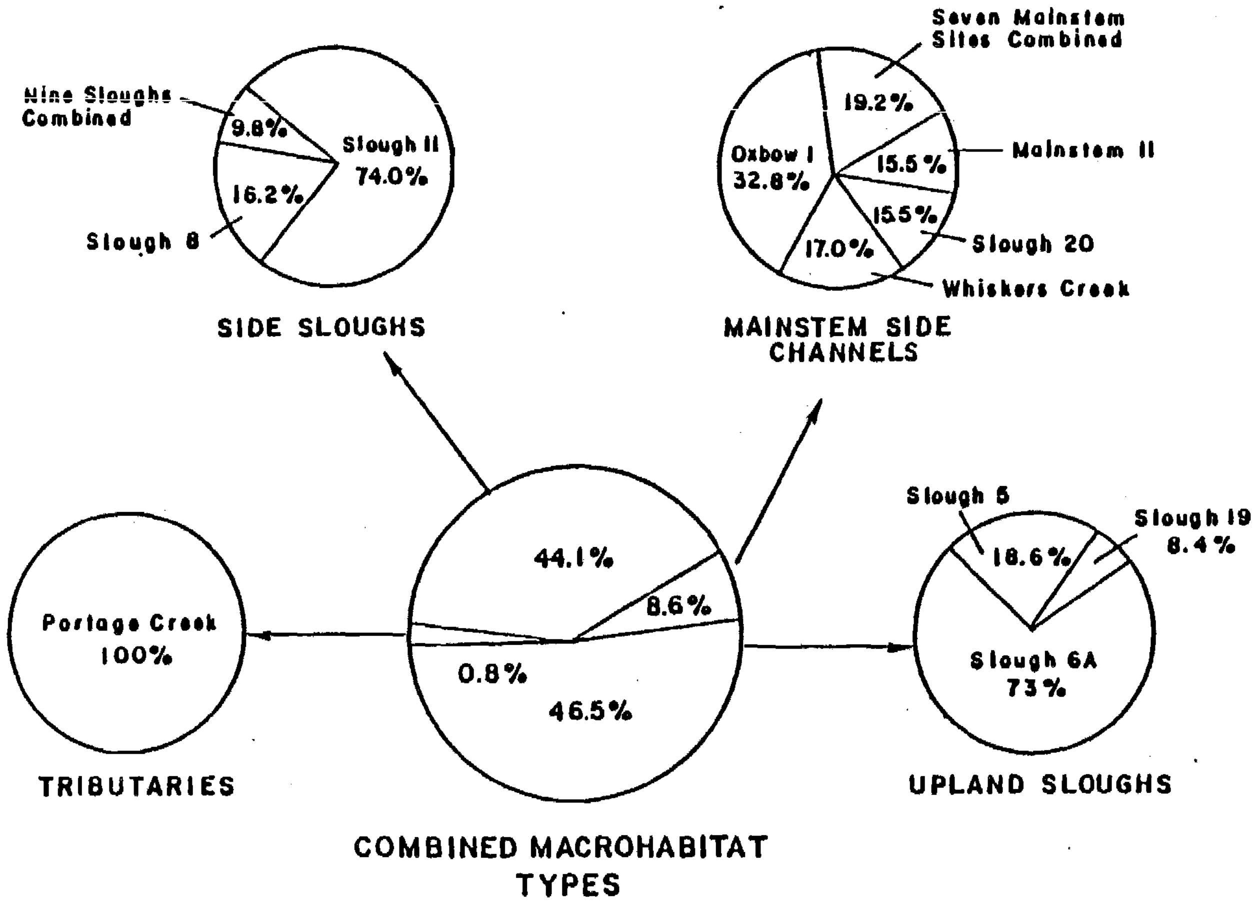
ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



1982 - 1983 SUSITNA CHINOOK ESCAPEMENT AND RELATIVE UTILIZATION

FIGURE 25

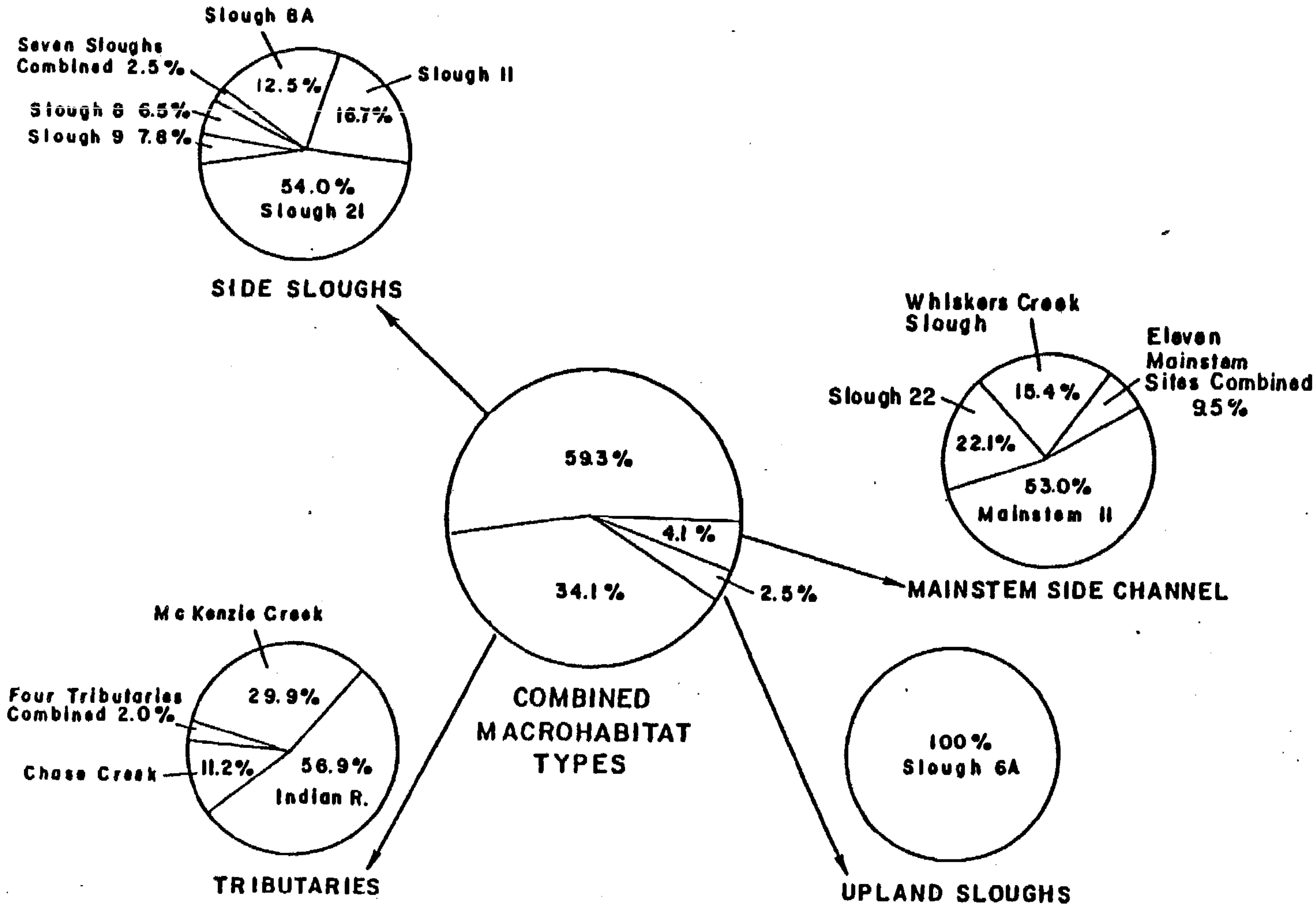
ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



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: ADF&G 1984 b).

FIGURE 26

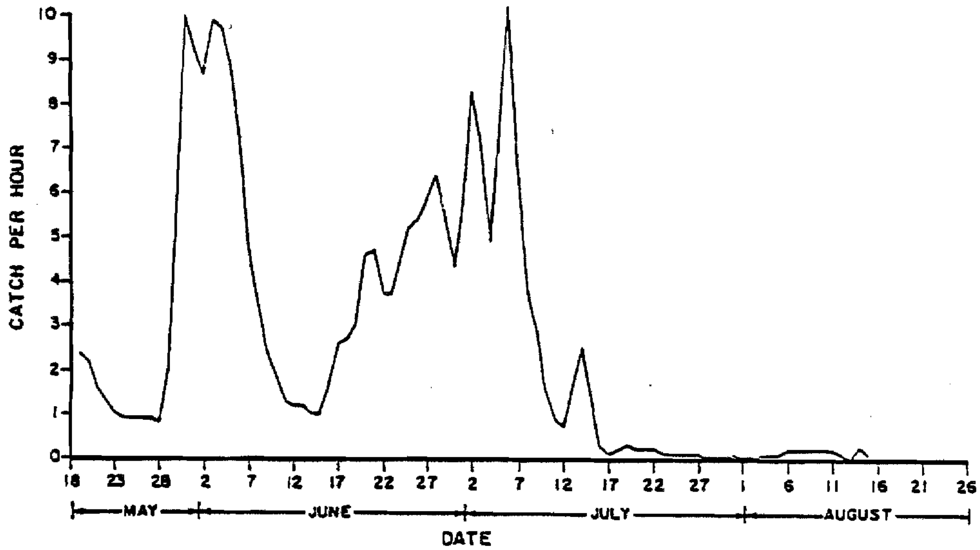
ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



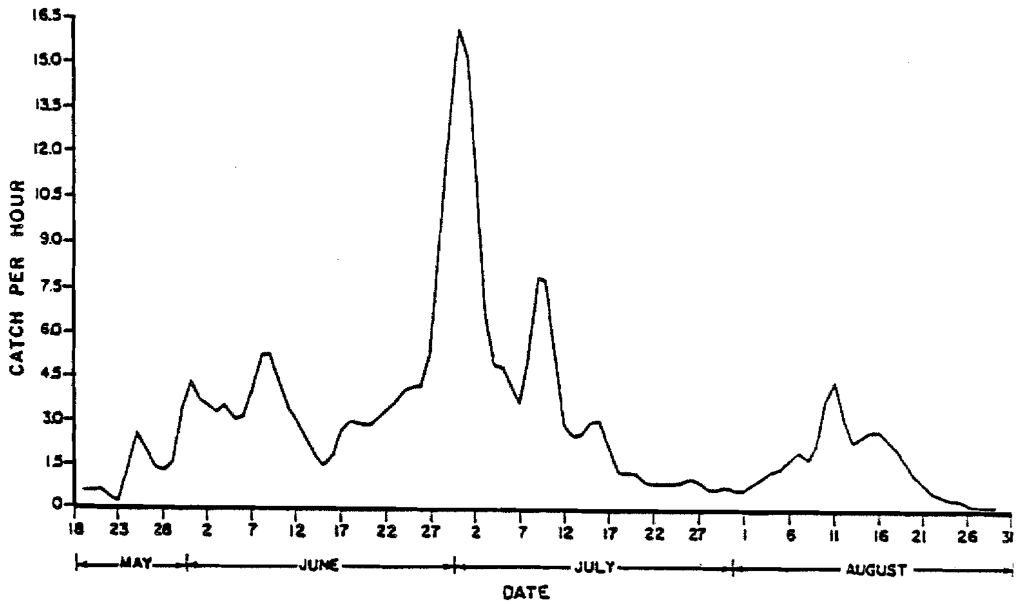
DISTRIBUTION OF JUVENILE CHUM SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH OCTOBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL. (SOURCE: ADF&G 1984 b).

FIGURE 27

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE



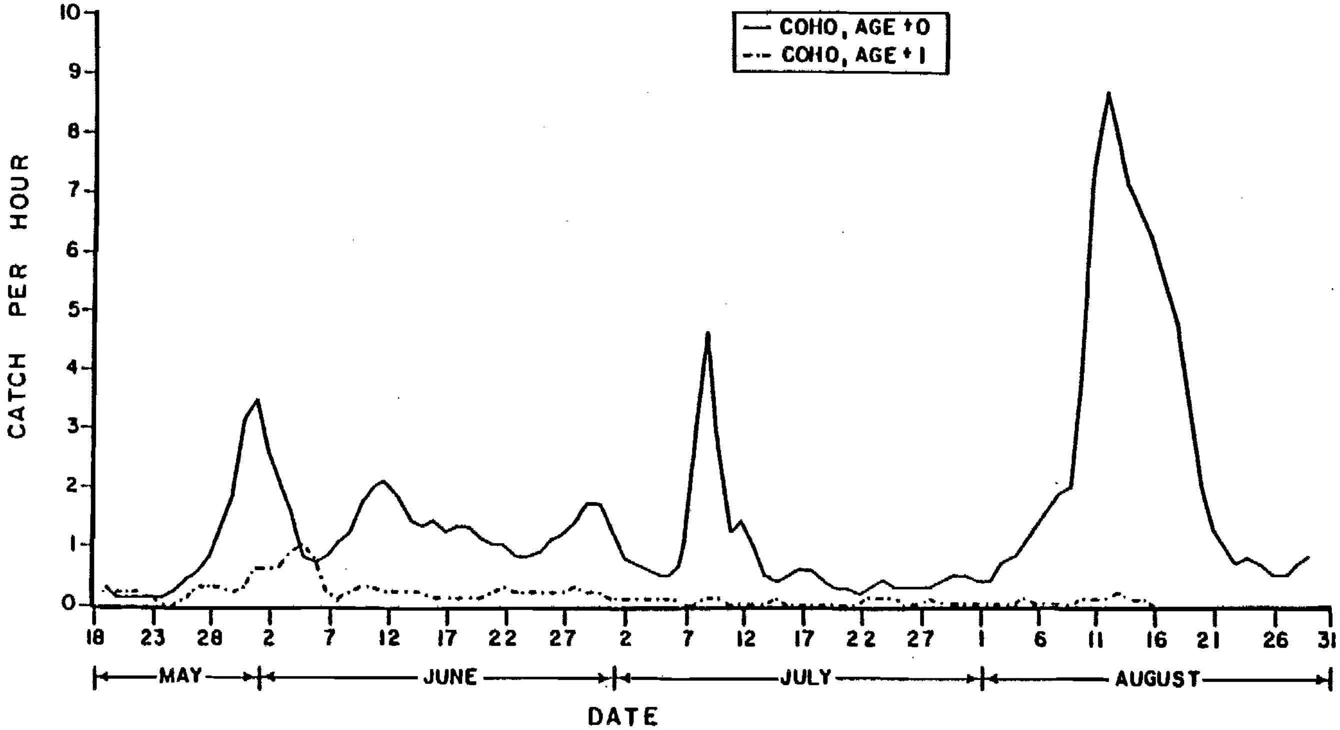
CHUM SALMON FRY DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 20, 1983. (SOURCE: ADF&G 1984 b).



SOCKEYE SALMON FRY DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 30, 1983. (SOURCE: ADF&G 1984 b).

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 28



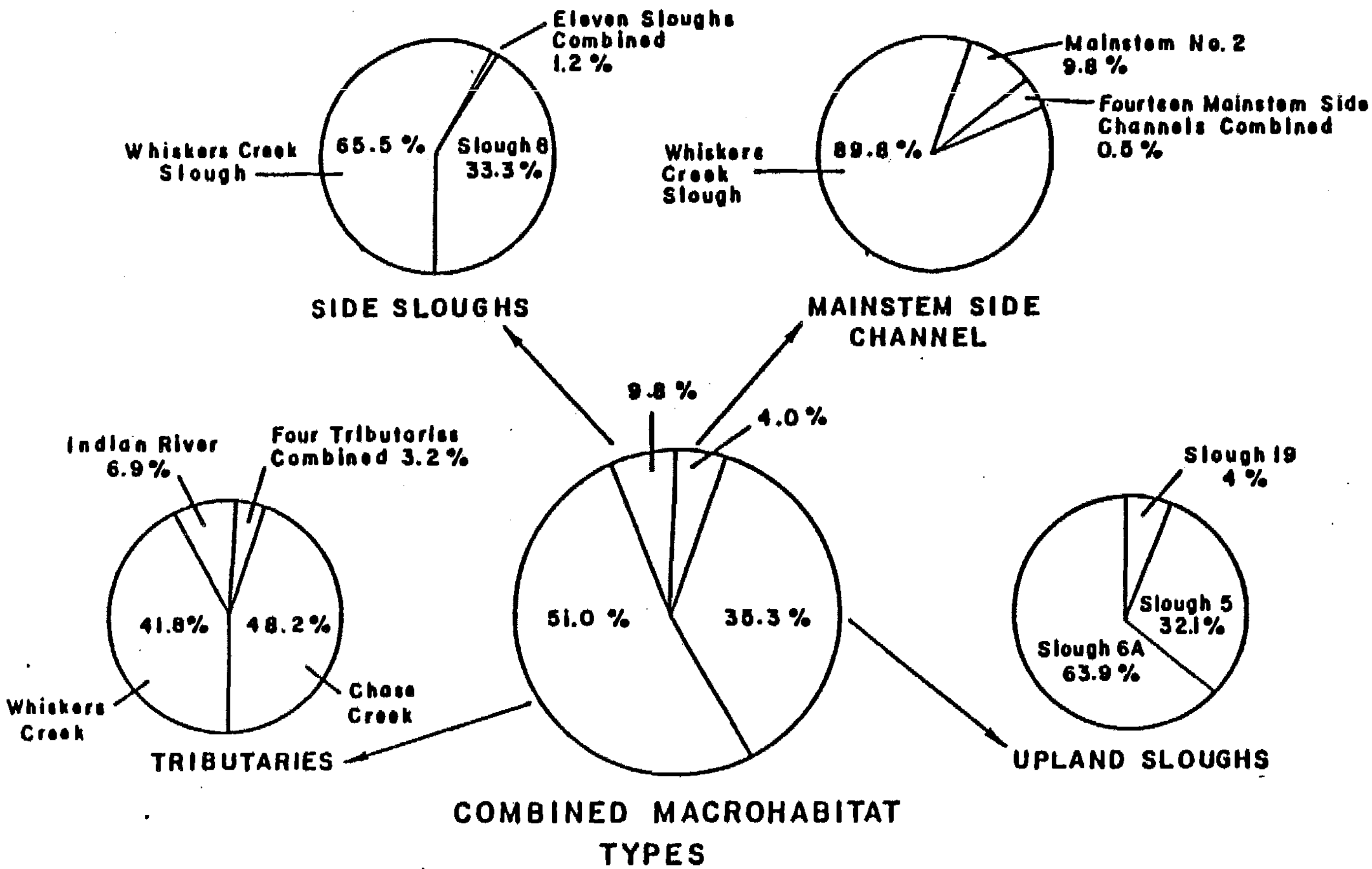
COHO SALMON AGE 0+ AND AGE 1+ OR OLDER DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 30, 1983. (SOURCE: ADF&G 1984 b).

FIGURE 29

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



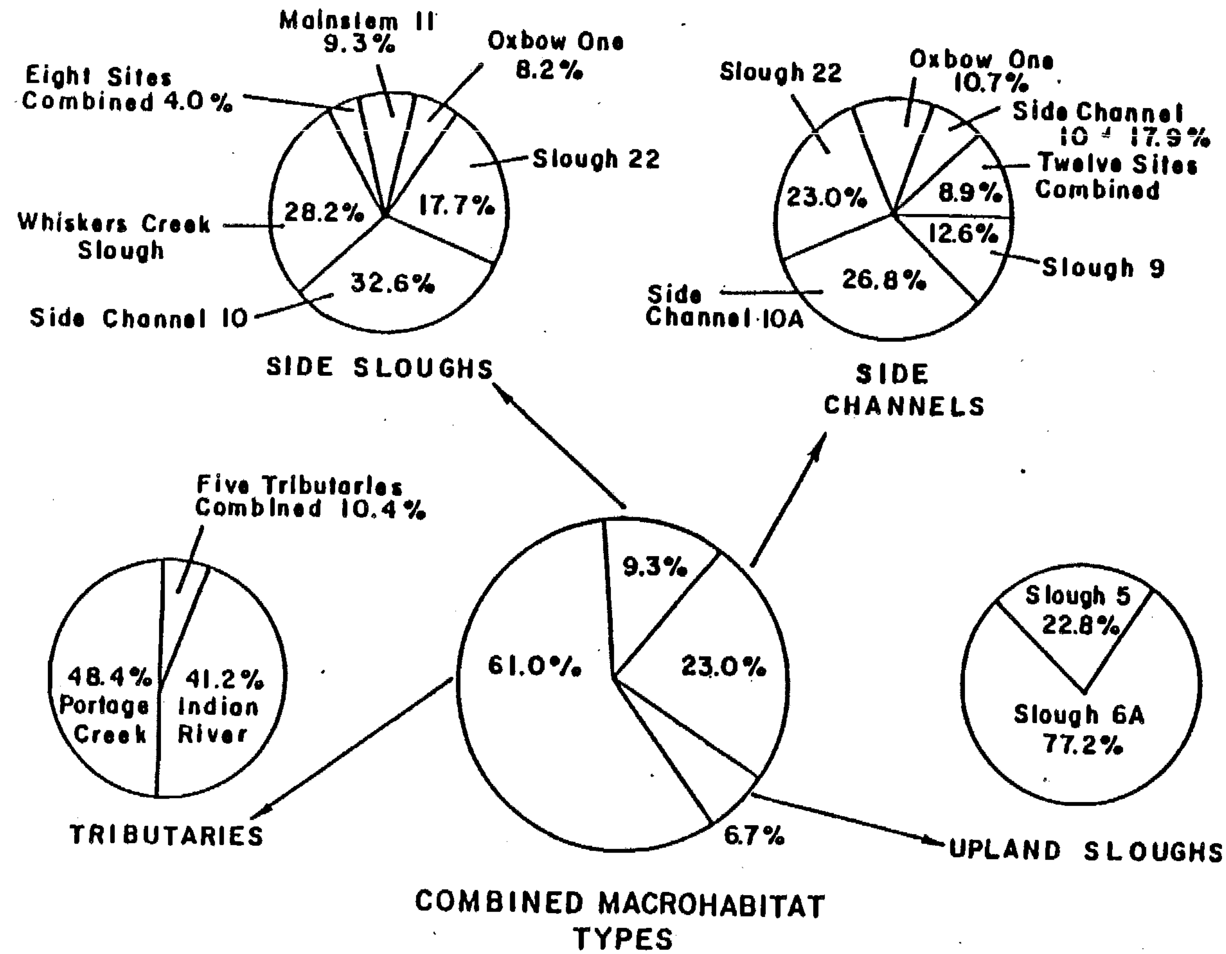
DISTRIBUTION OF JUVENILE COHO SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH NOVEMBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL. (SOURCE: ADF&G 1984 b).

FIGURE 30

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

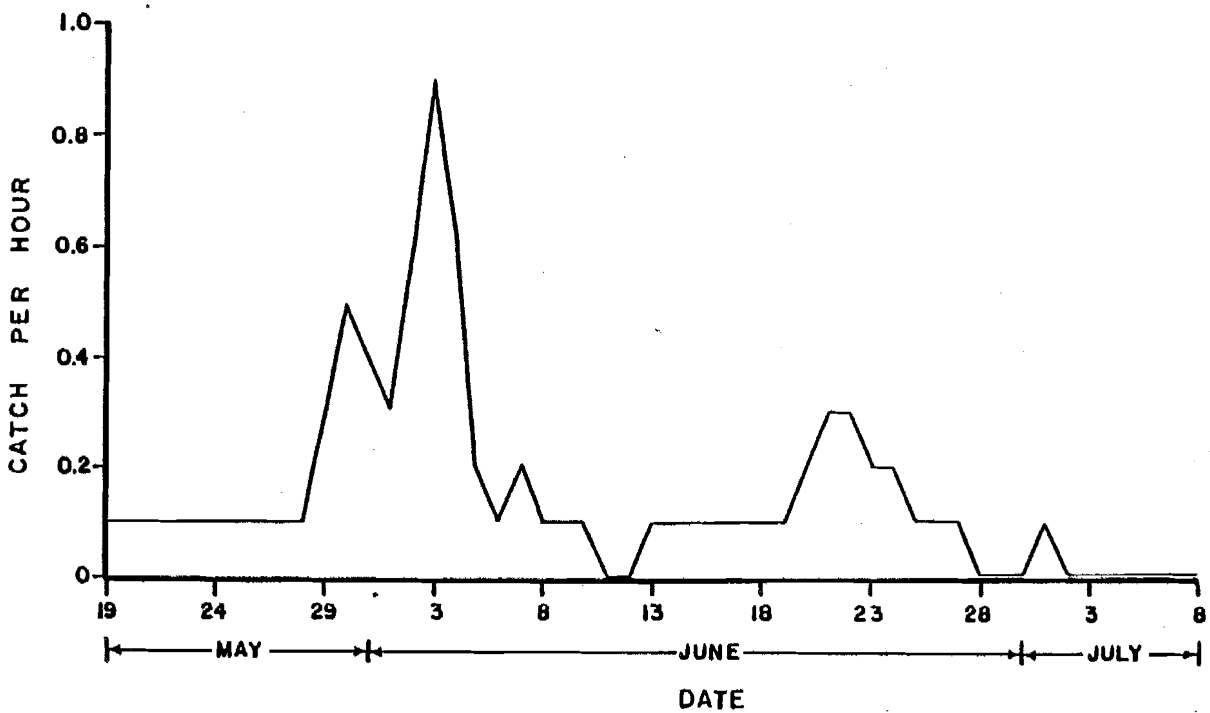
HARZA-EBASCO
SUSITNA JOINT VENTURE



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: ADF&G 1984 b).

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 31



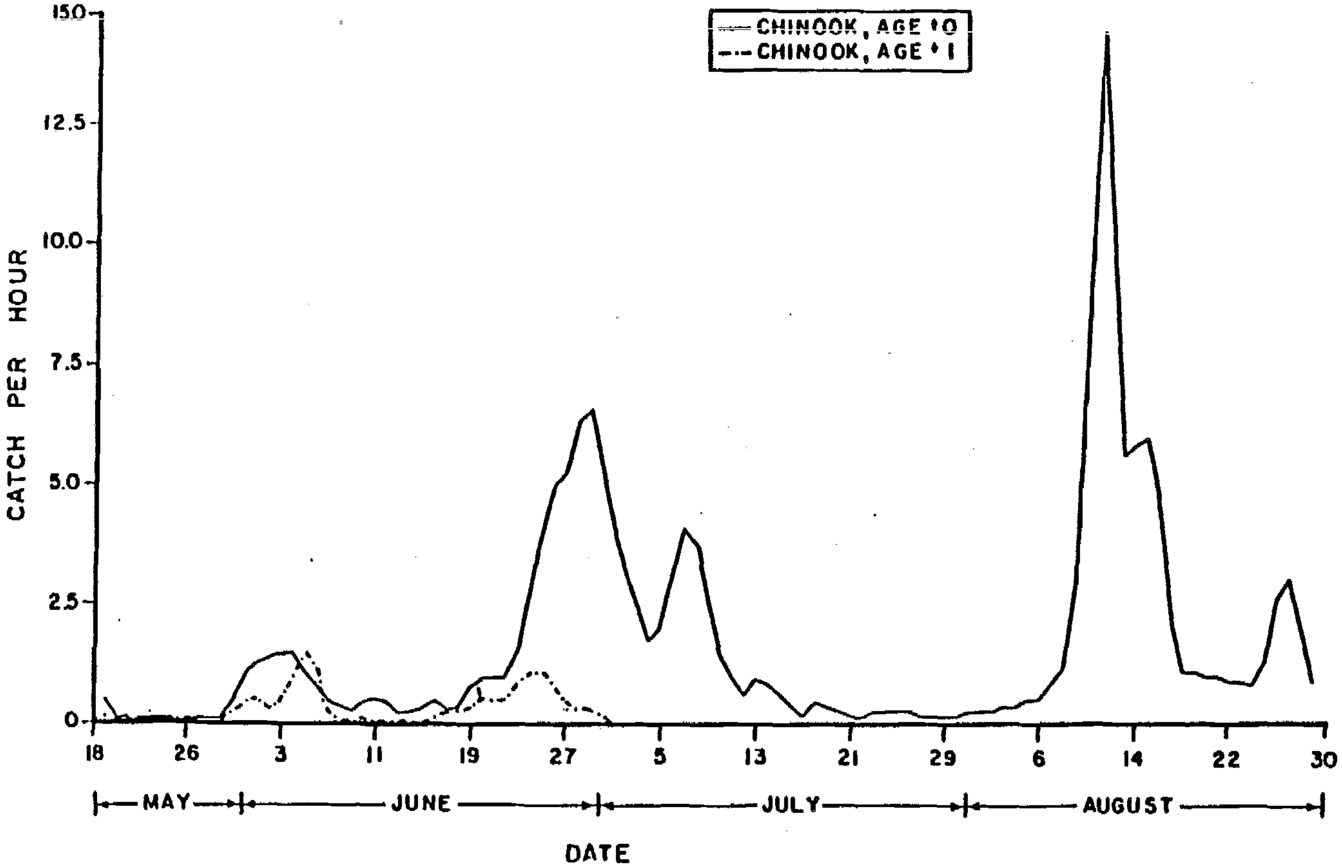
PINK SALMON FRY DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH JULY 8, 1983. (SOURCE: ADF&G 1984 b).

FIGURE 32

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE



CHINOOK SALMON AGE 0+ AND AGE 1+ DAILY CATCH PER HOUR RECORDED AT THE DOWNSTREAM MIGRANT TRAPS, MAY 18 THROUGH AUGUST 30, 1983. (SOURCE: ADF&G 1984 b).

FIGURE 33

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE

APPENDICES

APPENDIX A - ADF&G Susitna Specific Reference List

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