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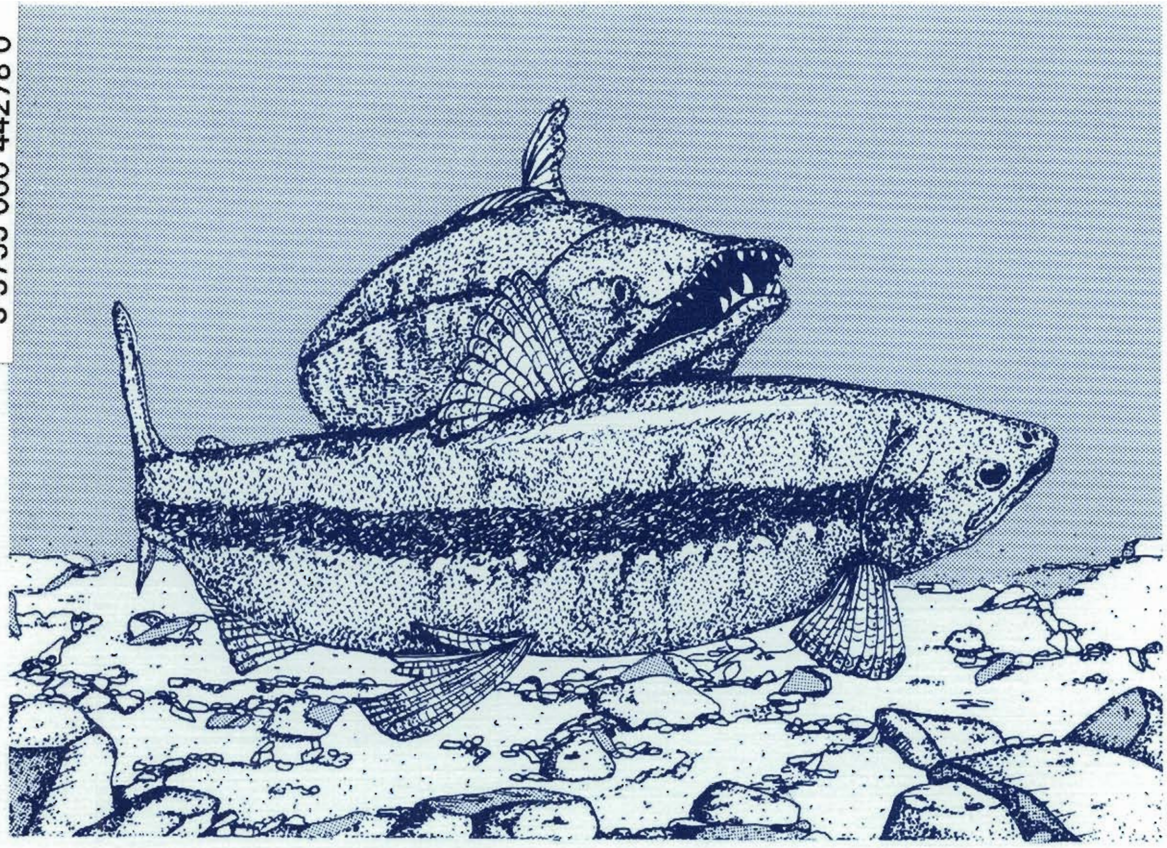

SUSITNA HYDRO AQUATIC STUDIES
PHASE II REPORT

Synopsis of the 1982
Aquatic Studies and Analysis of
Fish and Habitat Relationships

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Synopsis of the 1982 Aquatic Studies and Analysis of Fish and Habitat Relationships

by

ALASKA DEPARTMENT OF FISH AND GAME
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503
1983

PREFACE

This report is a synopsis of the fisheries, aquatic habitat, and instream flow data collected by the Alaska Department of Fish and Game (ADF&G) Susitna Hydroelectric (Su Hydro) Feasibility Aquatic Studies Program during the 1981-82 (October-May) ice-covered and 1982 (May-October) open water seasons. It is one of a series of reports prepared for the Alaska Power Authority (APA) by the ADF&G and other contractors to evaluate the feasibility of the proposed Susitna Hydroelectric Project.

In addition to the synopsis, this report also includes the analysis of the pre-project fish and habitat relationships derived from Volumes Two through Five (ADF&G 1983a, 1983b, 1983c, 1983d) and related reports prepared by other study participants. The topics discussed in Volumes Two through Five are illustrated in Figure A.

These and other ADF&G reports (1974, 1976, 1977, 1978, 1979, 1981a, b, c, d, e, f, 1982) and information reported by others will be summarized and analyzed by the Arctic Environmental Information and Data Center (AEIDC) to evaluate post-project conditions within the overall study area of the proposed project (Figure B). Woodward Clyde Consultants will, in turn, use this information to support the preparation of the Federal Energy Regulatory Commission License Application.

The five year (Acres 1980) ADF&G Su Hydro Aquatic Studies program was initiated in November 1980. It is subdivided into three study sections:

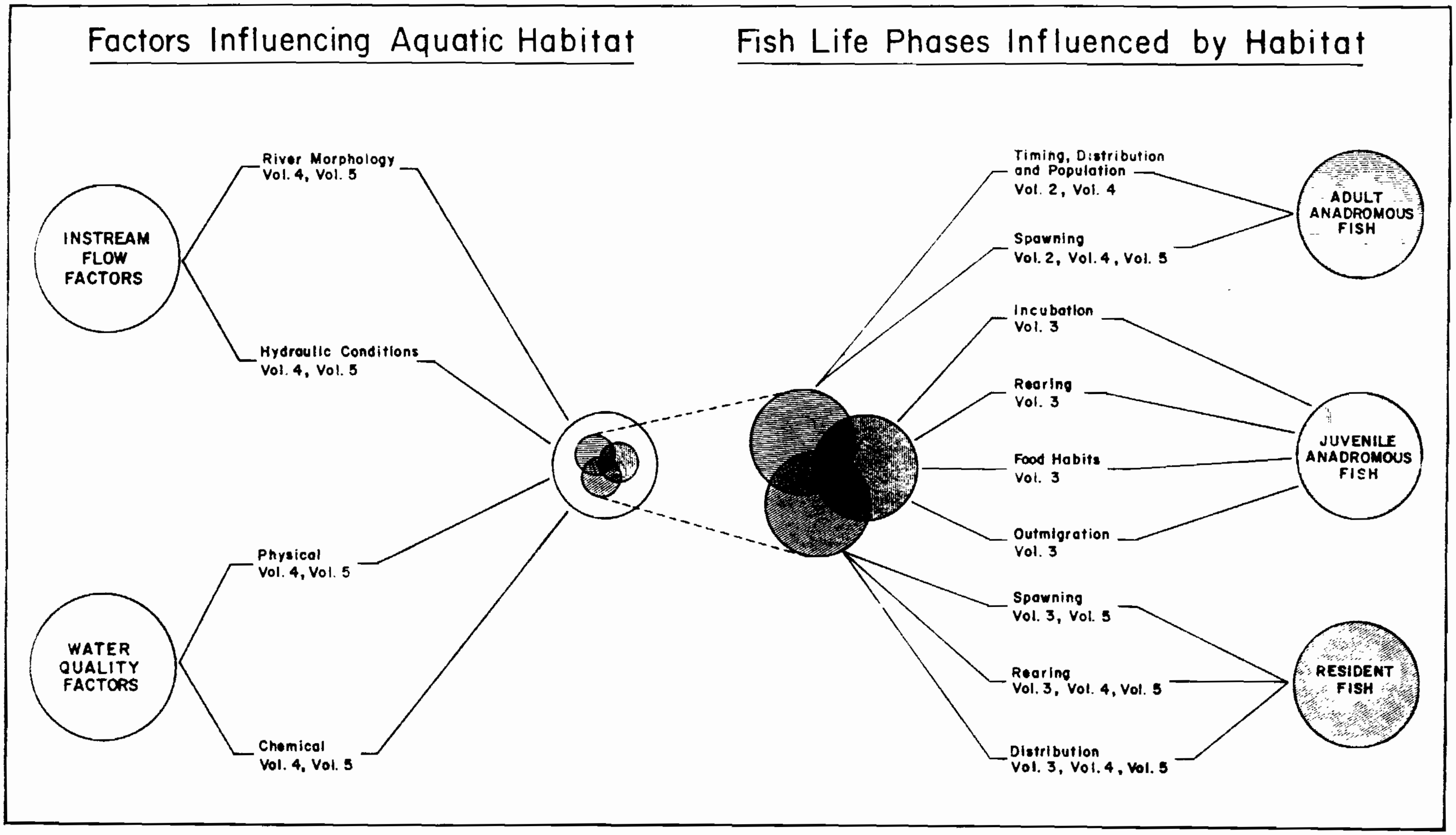

Figure A. Intregration of and relationships among program elements presented in Volumes II through IV.

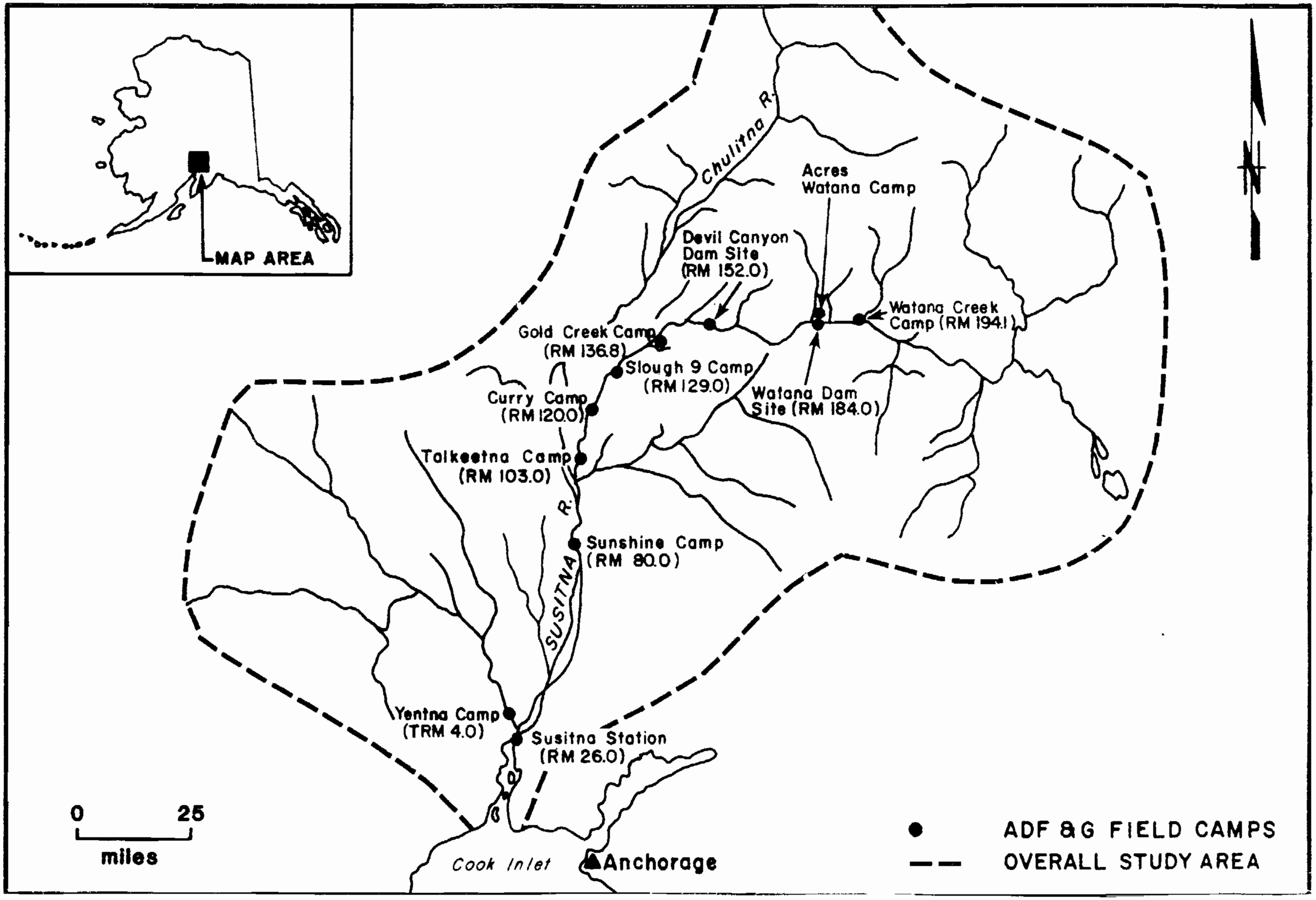

Figure B. Overall study area of the Susitna Hydroelectric Feasibility Study Program.

Adult Anadromous Fish Studies (AA), Resident and Juvenile Anadromous Fish Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH).

Specific objectives of the three sections are:

1. AA - determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the study area (Figure B);

2. RJ - determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area; and

3. AH - characterize the seasonal habitat requirements of selected anadromous and resident fish species within the study area and the relationship between the availability of these habitat conditions and the mainstem discharge of the Susitna River.

The 1981-82 ice-covered and 1982 open-water ADF&G study areas (Figures C and D) were limited to the mainstem Susitna River, associated sloughs and side channels, and the mouths of major tributaries. Portions of tributaries which will be inundated by the proposed Watana and Devil Canyon reservoirs were also evaluated. Descriptions of study sites are presented in each of these volumes including the ADF&G reports (ADF&G 1981a, b, c, d, e, f).

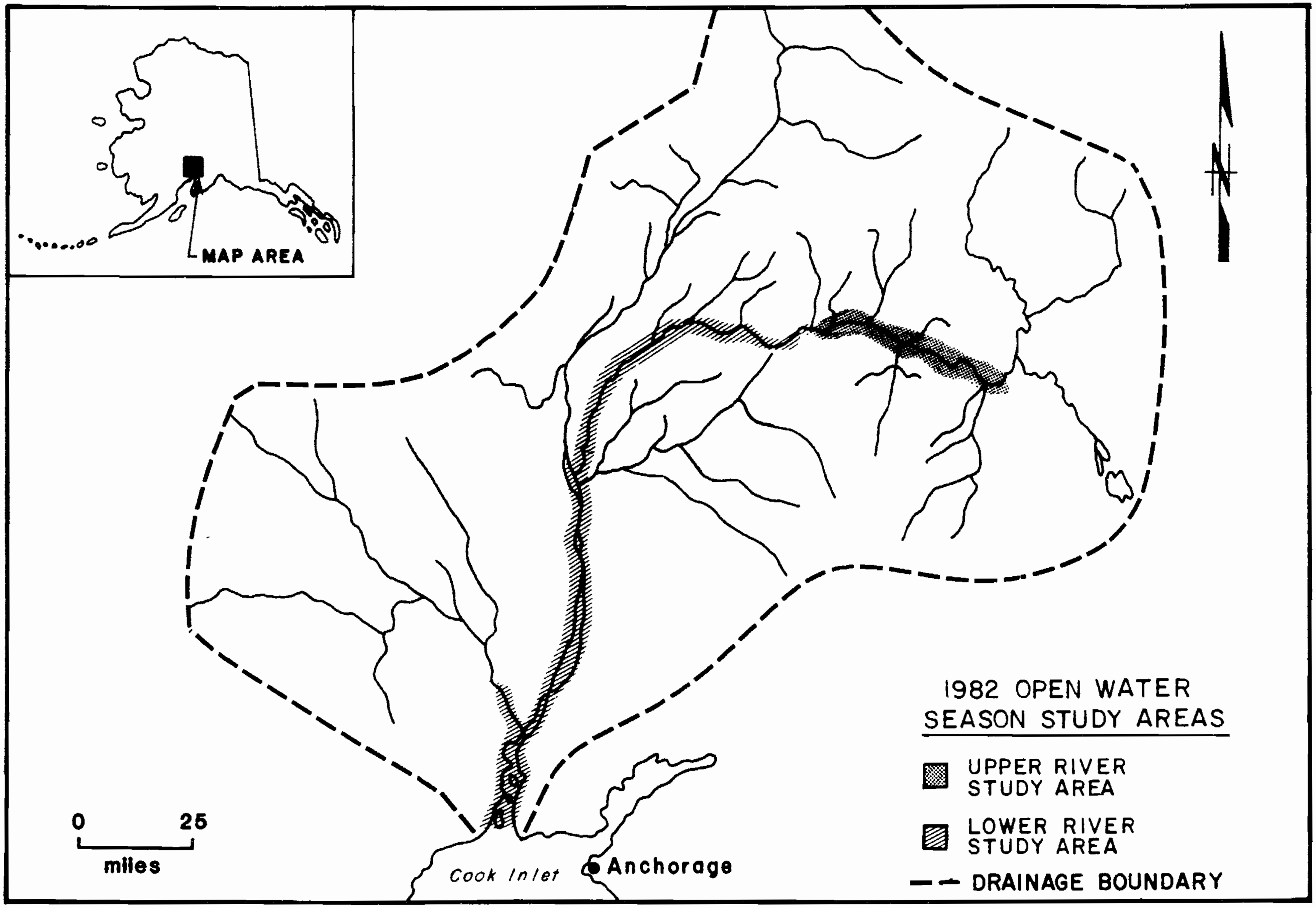

Figure C. 1982 ADF&G open water season (May through October) study area.

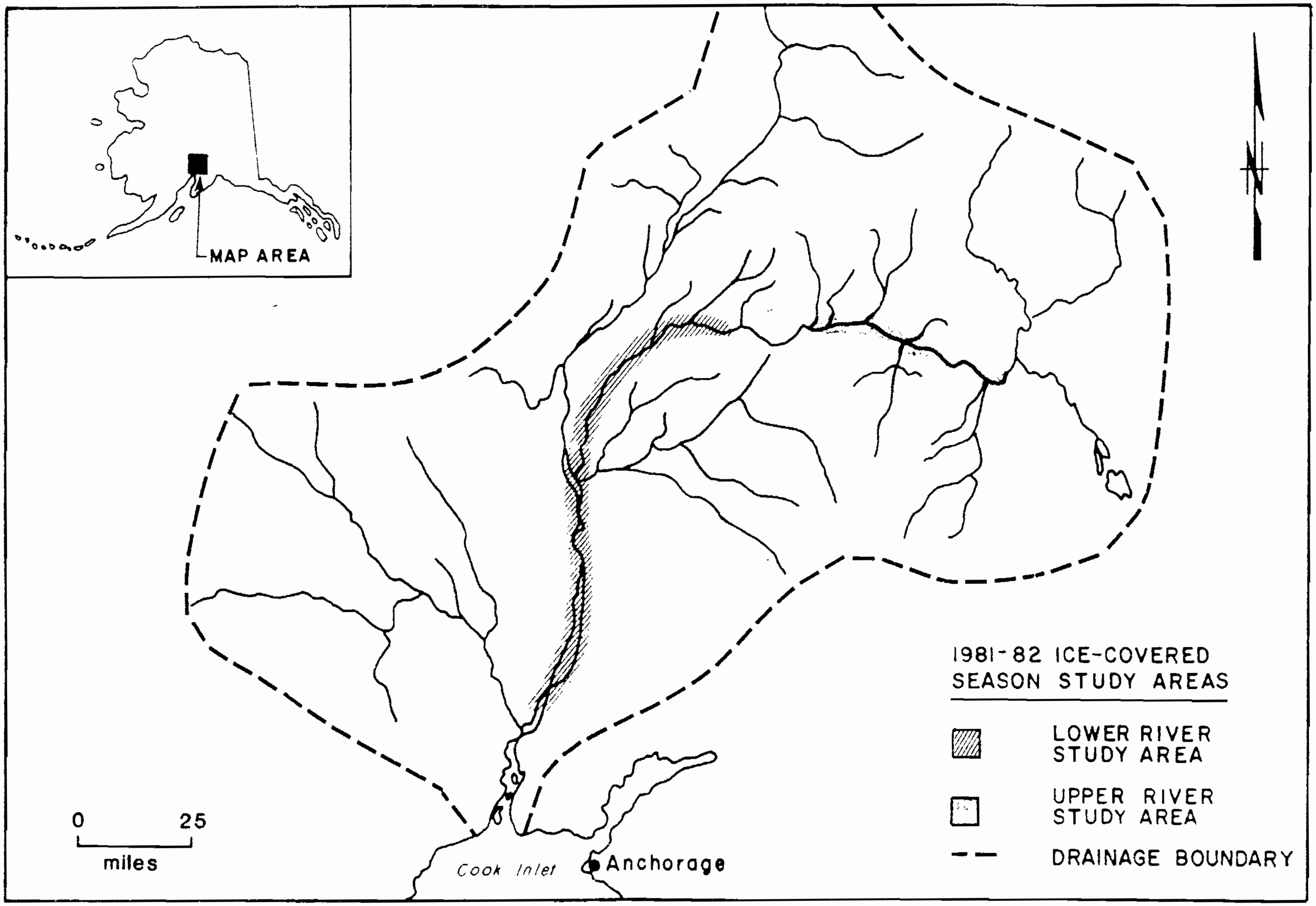

Figure D. 1981-82 ADF&G ice-covered season (October through May) study area.

Questions concerning these reports should be directed to:

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1. INTRODUCTION

1.1 Purpose of report

This report is designed to integrate, on a species level, data collected by the Alaska Department of Fish and Game (ADF&G) Su Hydro Aquatic studies during 1981 and 1982. The material is reported separately for study areas above and below Devil Canyon because of the different types of impacts anticipated.

The report provides a synopsis of the findings on each of the target species of both resident and anadromous fish, and an analysis of fish and habitat data contained in the ADF&G 1982 Phase II Basic Data reports (1983a, b, c, d). With the exception of summary tables or figures, data and analysis presented in the Basic Data reports are not repeated. The reader of this report should refer to those volumes when supporting or more specific data are desired. Extensive literature reviews for the species of fish discussed have not been included. Literature reviews of the freshwater habitat relationships for some of the species have been compiled by the U.S. Fish and Wildlife Service and are available for a broader perspective on the Susitna River fish species (see Bibliography). Life histories for all species mentioned have been summarized by Hart (1973), Morrow (1980), and Scott and Crossman (1973). A glossary of common and scientific names is enclosed at the end of the report.

1.2 Study objectives

Detailed study objectives are reported in earlier ADF&G reports (1979, 1981a, b, c, d, e) and a synopsis of the major objectives is repeated below:

a. Determine the seasonal distribution and relative abundance of adult anadromous fish populations within the study area.

b. Determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area.

c. Characterize the seasonal habitat requirements of selected anadromous and resident fish species within the study area and the influence of mainstem discharge on the availability of these habitats.

Specific analytical components are presented in the appendix of this report to complement the major findings discussed in this report.

1.3 Utility of the report in impact analysis and mitigation planning

The mitigation of adverse impacts of the project by appropriate flow management can be analyzed by use of the same types of data that are used to determine potential impacts of the project. The response of the fish populations to a particular flow regime can be estimated by determining the response of their habitat to natural variations in discharge under pre-project conditions. Adverse flow related impacts of the project have the potential to be avoided or minimized by developing downstream flow release schedules that provide hydraulic and water quality conditions suitable for the fish species present.

This report and associated data analysis provides information to assist with:

1. Preparation of the impact statement necessary for application of the Federal Energy Regulatory Commission (FERC) license.

2. Description of the existing environment and the magnitude of the resource that will potentially be impacted.

3. Determination of the effects of natural flow alterations on adult anadromous species, important resident fish species, rearing anadromous fish species, and the habitat necessary to sustain populations of those species.

This report is also useful in evaluating other potential effects of the project such as thermal alteration, geomorphological changes, icing conditions, and alterations of water quality.

2. RESULTS AND DISCUSSION OF THE FISH AND HABITAT STUDIES ON THE SUSITNA RIVER BELOW DEVIL CANYON

The current state of knowledge concerning the life history of each of the major species of resident and anadromous fish that have been found in the Susitna River below Devil Canyon is discussed in the following sections.

2.1 Chinook salmon

Chinook salmon, more commonly called king salmon in Alaska, are an important sport fishing species in the Cook Inlet area with use by subsistence fisheries and incidental harvest by the commercial fisheries. Figure 2-1 depicts the periodicity of the various life stages of chinook salmon in macro-habitat areas that have been identified in the Susitna River above the Chulitna River confluence. This section of the report discusses the fresh water phases of the chinook salmon life cycle that occur in the portion of the Susitna basin that may be affected by the proposed Susitna Hydroelectric project.

2.1.1 Adult phase of life cycle

The Susitna River escapement of chinook salmon peaks in late June and is essentially completed by mid July (ADF&G 1983a). During this migration, very little commercial harvest occurs. This species is a major sport fish in the Cook Inlet area and is sought after extensively

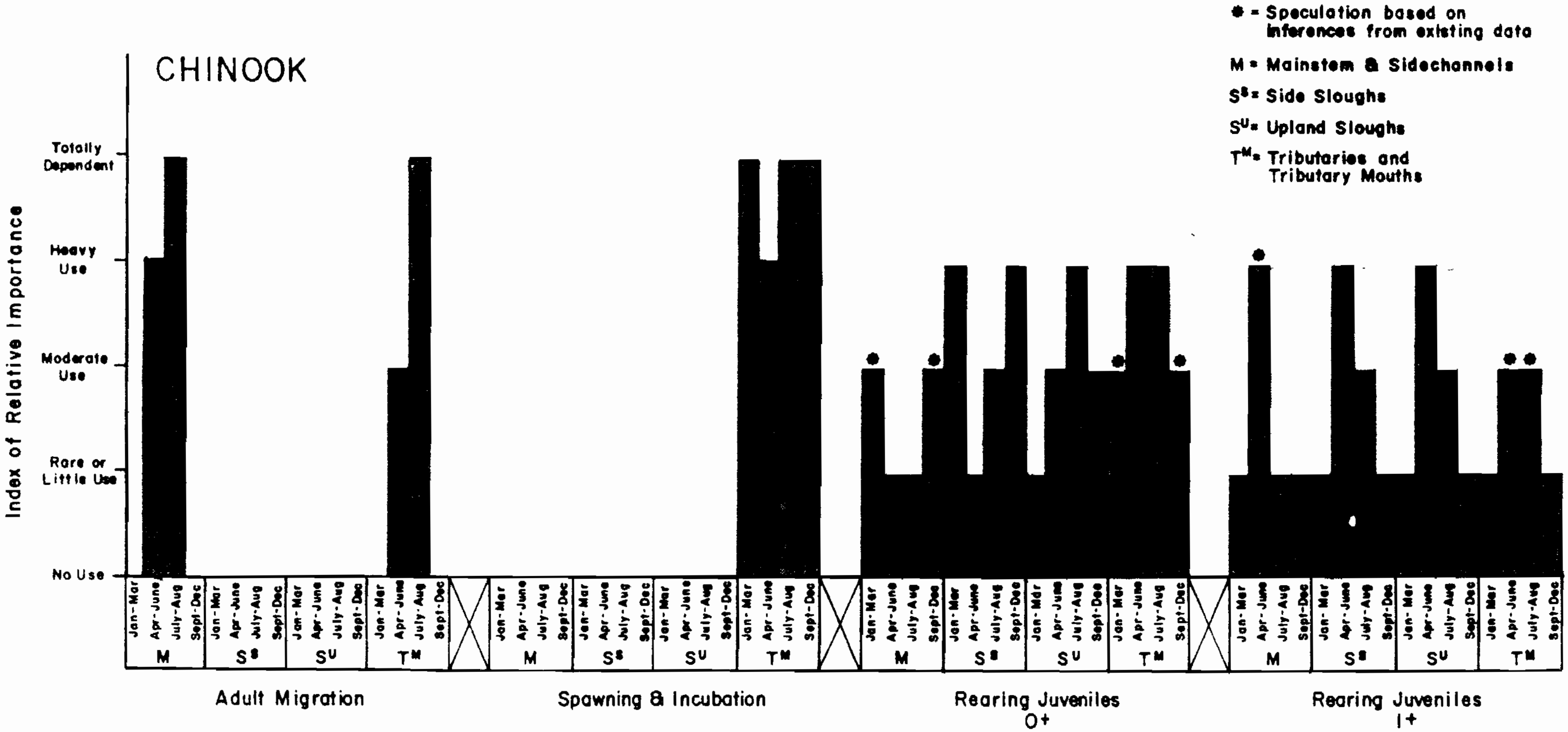

Figure 2-1. Seasonal use of macro-habitat by chinook salmon above the Chulitna River confluence (RM 98.5). Data summary from ADF&G (1983a, 1983b).

in portions of the Susitna River basin and elsewhere in the Cook Inlet area. There is also a small subsistence fishery at Tyonek. Historically, chinook were an important commercial species; during the 1950's, large numbers were harvested.

2.1.1.1 Adult harvest by sport, commercial, and subsistence fisheries

The harvest estimate is illustrated in Figure 2-2. Although none of the clear water tributaries above the Chulitna River confluence are currently open to sport fishing for chinook greater than 20 inches in length, some fish migrating to spawning grounds in these tributaries are probably harvested when they hold at the mouth of lower river tributaries such as the Deshka River, Willow Creek, Sheep Creek, and Montana Creek. This holding behavior was commonly observed by the radio telemetry studies in both the 1981 and 1982, (ADF&G 1981a, 1983a).

A commercial harvest of Cook Inlet chinook occurs incidentally to the sockeye salmon harvest. Most of these chinook salmon are harvested from the stocks destined for the Kasilof and Kenai Rivers. Susitna River chinook do not contribute significantly to this fishery. The village of Tyonek, on the west side of Cook Inlet, is currently authorized a harvest of chinook salmon for subsistence purposes. Up to 4,200 fish are allotted annually for this purpose and a harvest of 1,500 fish was recorded in 1981. The take of chinook salmon in sport fisheries in the Susitna River was estimated to be 7,250 fish in 1981 (Mills 1982). This estimate includes "immature" fish (less than 20 inches in length).

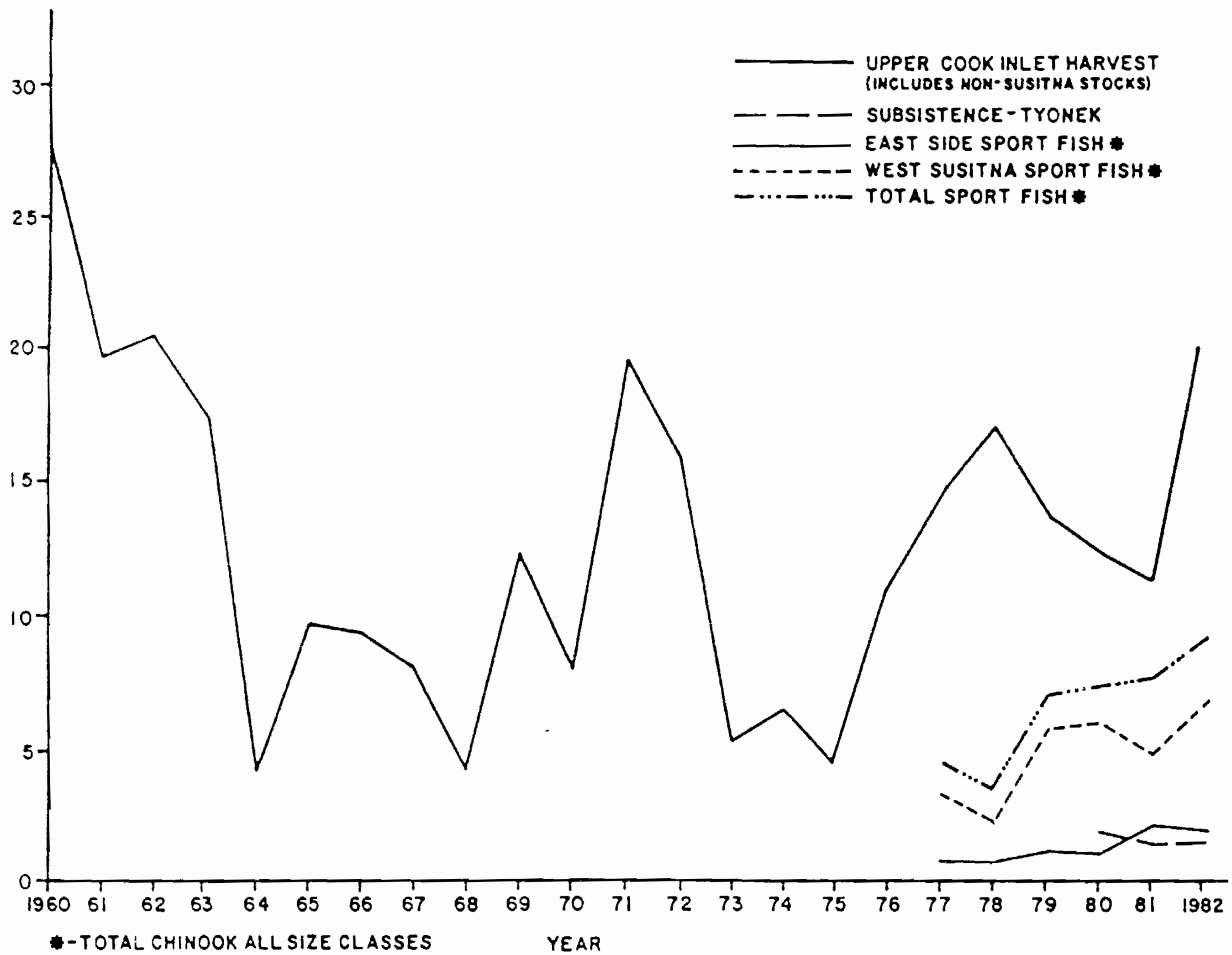

Figure 2-2. Harvest summary of Cook Inlet and Susitna River chinook salmon stocks. Harvest data from ADF&G (1981f) and K. Florey (Personal communication, ADF&G, Anchorage), subsistence catch data from Foster (1982) and sportfish catch data from Mills (1982). Data from 1982 are preliminary.

2.1.1.2 Adult escapement

A complete estimate of escapement of adult chinook salmon into the Susitna river drainage is not available. The annual sport fish aerial survey counts in clear water tributaries have provided escapement indices (Figure 2-3). These surveys were conducted during the peak of chinook salmon spawning from 1977 to 1982. Aerial survey chinook counts in the last years of these surveys have been very low due to limited visibility caused by high water conditions present during the peak spawning period.

Aerial survey data can be compared with the escapement estimates that were made using Petersen estimates at the ADF&G Sunshine, Talkeetna, and Curry field stations during the 1982 season (Figure 2-3). The numbers of chinook salmon indicate the number of fish passing the fishwheel tagging stations but not necessarily the total number of chinook that spawn above these sites because significant numbers of tagged chinook were observed in lower river tributaries downstream of the tagging operation.

Differences between the aerial survey population estimates and the Petersen estimates can be explained by two sources of error. First, the aerial counts miss some of the fish that have not yet entered the clear water drainage or have spawned and died, thus providing an underestimate of the total numbers of spawners. Second, mark-recapture estimates are probably overestimates because some of the fish initially migrating past these sites later spawn below the Sunshine, Curry or Talkeetna

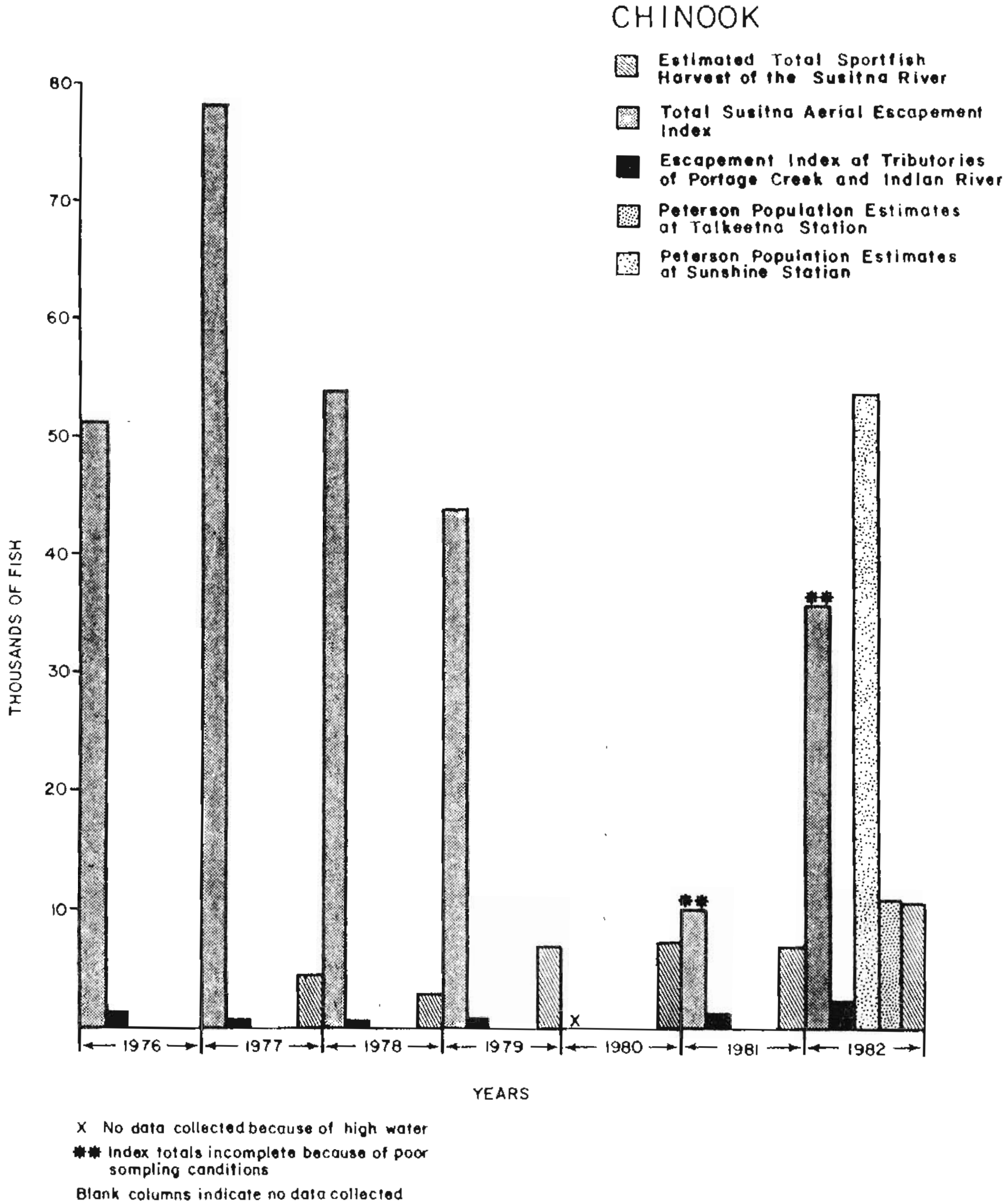

Figure 2-3. Summary of the population estimate and sportfish harvest for adult chinook salmon within the Susitna River. Sportfish harvest data from Mills (1982) and escapement and population estimates from ADF&G (1983a).

fishwheel sites. Some of the biases of the fishwheel capture and sonar apportionment methods used and suggestions of the possible reasons for differences in estimates made by the two methods are discussed in Appendix A and in ADF&G (1983a).

2.1.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle (upstream migration, passage and spawning)

During the upstream migration adult chinook encounter environmental conditions that may reduce spawning success. The most obvious influences are the discharge and temperature of the mainstem Susitna and of the natal tributaries. By monitoring the behavior of chinook during natural variations in discharge and temperature, and by examining the hydraulic conditions at the mouths of the clear water tributaries, insight can be obtained into the effects of flow alteration on the Susitna chinook salmon.

2.1.1.3.1 Discharge, water quality, and temperature relationships with the adult chinook salmon migration

The U.S. Geological Survey (USGS) monitors the discharge of the mainstem Susitna above and below the Chulitna River confluence. The gages are located at the Gold Creek Bridge and at the Parks Highway bridge near Sunshine Creek (called the Sunshine station). These flow data are used as the primary basis to compare responses of the fish and other physical habitat parameters to changes in mainstem flow. Temperature data are also collected at several mainstem locations. The effects of mainstem temperature on adult salmon behavior is examined in Appendix B.

There are two sources of biological information that are used to correlate the effects of these environmental variables on fish migratory behavior. The movement of the fish upstream has been monitored by use of fishwheels, sonar and ground surveys, and the movement of individuals has been monitored by radio telemetry. Within the natural variations in temperature, no effect of temperature on fish migration was observed during the 1982 migration. The influence of discharge on the behavior of the fish was detectable at the higher discharge levels. At higher discharge levels, an inverse correlation exists. Upstream movement of adult chinook was slowed when peak flows occurred during the migration. Although chinook salmon movement also correlates with a decrease in temperature, the discharge variation was greater and is believed to be the dominant factor causing the decreased rate of movement. This behavior was also observed during the 1981 chinook migration. Similar effects have been observed with the other species of salmon. Variation in discharge in the lower flow regimes were not observed to influence the behavior of adult chinook salmon.

Passage of chinook salmon through lower Devil Canyon was documented for the first time by the Alaska Department of Fish and Game during 1982. Chinook salmon were observed spawning at the confluence of two small clear water tributaries within the Devil Canyon impoundment zone and spawning chinooks were also observed in the same two tributaries. These sites were not examined prior to 1982 during the peak of the chinook migration. The relatively low flows that occurred during the chinook run of 1982 may have allowed these fish to move into these areas.

Hydraulic conditions supporting passage of fish into the mouths of the clear water tributaries, Indian River and Portage Creek, has been examined in detail (Trihey 1983). The influence of mainstem flow on the passage of chinook salmon into these tributaries was analyzed by examination of the stream mouth gradient and associated water velocities and the distance that such velocities are likely to occur under alternative flows of the mainstem Susitna. This analysis concludes that passage into these two tributaries is not likely to be affected by lower flows.

When encountering high concentrations of supersaturated dissolved gas at the base of hydroelectric projects, adult salmon are known to suffer from gas bubble disease (Weitkamp and Katz 1982). Measurements of total dissolved gas concentration below the Devil Canyon rapids gave readings up to 116% of saturation. Levels of over 120% of saturation are predicted for discharges over 50,000 cubic feet per second (cfs) at Gold Creek (ADF&G 1983c). The relatively low flow period of August and September, 1982, produced levels of 113 percent total dissolved gas, when the gas levels were being continuously monitored. These levels could create serious problems for juvenile fish in hatcheries if they could not escape the gas concentrations by sounding to deeper areas. The levels are below the threshold that would be expected to adversely affect adult or juvenile chinook salmon below the rapids where sufficient depth is available (Weitkamp and Katz, 1982). The relatively low rates of dissipation of the naturally entrained dissolved gas in the reach of river below the rapids suggests that higher levels of supersaturation that may be created by water spillage at either of the proposed dams would not dissipate sufficiently to reduce the hazard to either adult or juvenile chinook salmon as well as other species of salmon.

Habitat requirements for chinook salmon spawning in the Susitna River have not been established because this species spawns primarily in the tributaries. However, such information would be useful in assessing if adverse effects of the project can be mitigated through flow regulation to support spawning populations in the mainstem under post-project conditions. The lack of a data base on this aspect of the life history of Susitna chinook stocks forces the analysis to be limited to literature values for the species at this time.

One limiting factor to chinook salmon spawning in the mainstem Susitna and side channels is probably the amount of suitable substrate available. High velocities during the spawning period and the associated probability of redd scouring may limit spawning habitat. Because of the early timing of the chinook runs, the August floods that commonly occur in the system could destroy mainstem redds. The substrate is very unstable during these periods, with major shifts and movements of spawnable gravels occurring frequently. Because of the high velocities in the mainstem, much of the channel of the reach of river above the Chulitna confluence is armored cobble, unsuitable for spawning. The stability of the substrate and velocities that occur in selected side channel areas of the mainstem under various discharges has not yet been quantified. Thermal, substrate, velocity, and depth data collected at areas currently used by spawning chinook salmon in Portage Creek and Indian River could be used to provide an estimate of the post-project potential for these side channels areas to support chinook salmon redds.

2.1.1.3.2 Other factors that influence the spawning success of chinook salmon

The limitations to spawning by chinook salmon in the Susitna River are largely unknown. The influence of turbidity on the selection of redds, insufficient dissolved oxygen for incubating eggs resulting from the settling of suspended sediment, and the cover or depth requirements to provide cover from predators, may all limit the ability of the mainstem Susitna to support chinook salmon spawning.

Ice processes may be a major factor. During the ice formation process, channels can become dewatered, and bed scouring may occur in isolated areas. Intragravel temperatures may vary greatly in a short period of time, and may adversely effect embryo or alevin survival. An understanding of the effects that ice processes have on flow patterns in potential spawning sites and the effects on winter thermal characteristics are essential to define limits to spawning under current flow conditions or under regulated conditions.

2.1.2 Juvenile rearing and migration phases

Unlike the spawning, incubation, and emergence phases of the life cycle, the chinook rearing phase occurs in habitats that are directly affected by mainstem Susitna discharge, turbidity, and temperature.

The focus of the 1981 and 1982 Juvenile Anadromous Studies was on determining the relative abundance of each species and the general habitat types associated with their rearing. The general distribution data has been used to select specific sites for more detailed investigations regarding the suitability of selected habitat areas for juvenile chinook salmon, and for measuring the response of these habitat areas to changes in mainstem discharge. This has provided the first step in assessing the response of juvenile salmon to incremental alterations in flow.

2.1.2.1 Relative abundance of juvenile chinook salmon

Juvenile chinook salmon emerge from the gravel of their natal clear water tributaries in March or April. From this time until they outmigrate into Cook Inlet, usually the following summer, they are actively feeding and are dependent upon suitable habitat for rearing. Young of the year chinook (Age 0+) apparently spend the first two months in the vicinity of their natal areas after emergence (Morrow 1980). They begin redistributing downstream shortly afterward and have been collected in small numbers at habitat sites associated with the mainstem Susitna (Figure 2-4). Some rearing by young of the year chinook salmon also occurs within clear water tributaries where significant numbers of fish are present until fall. After the second week in August, most of the population apparently outmigrates into the mainstem Susitna to overwinter. Most of the juveniles that compose the populations of chinook salmon from Portage Creek and Indian River, are dependent upon habitat conditions in the mainstem Susitna during this period (late August to May of the next year).

An outmigrant trap was operated from June 18 to October 12, 1982 at river mile 103.0. Age 0+ chinook were collected throughout the summer with peaks in July and September. This probably reflects a general redistribution into rearing sloughs and tributary mouths or small backwater areas throughout the system. The Age 1+ fish made up 40 percent of the fish collected during the period that the trap was in place. Because it is suspected that larger numbers outmigrated before the smolt trap became operational, those juvenile chinook salmon which were spawned in the reach of the Susitna River above the Chulitna confluence may use this reach for most of their fresh water rearing cycle.

The trapping efforts that occurred at sloughs and tributaries above the Chulitna River during the 1981 and 1982 open water seasons indicated a substantial difference in catch rates between the years, when the same locations were compared. Three hypotheses that could account for these differences are:

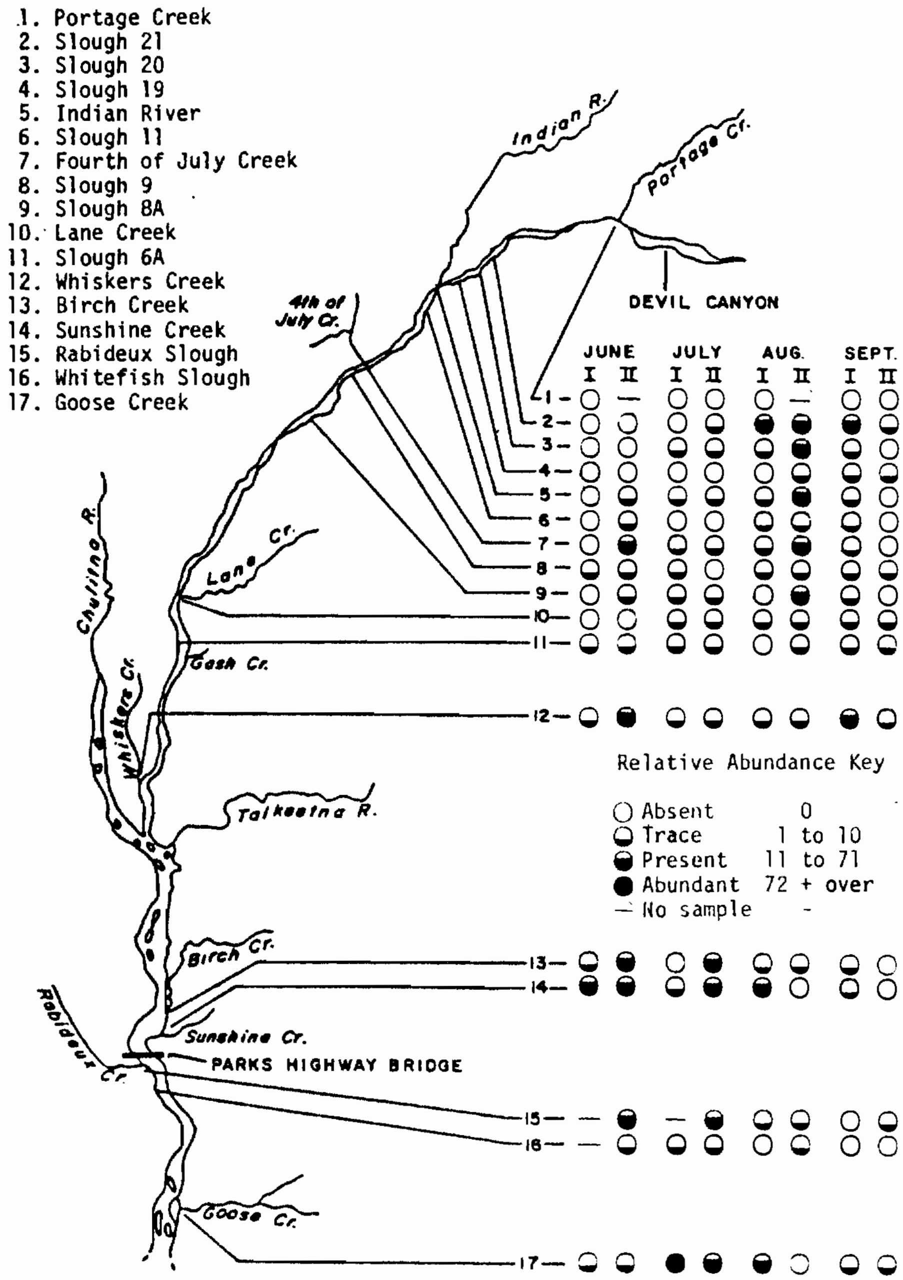

Figure 2-4. The seasonal variation in distribution and relative abundance of chinook salmon juveniles at DFH sites on the Susitna River, June through September, 1982. Taken from ADF&G (1983b).

(1) The 1981 spawning was less successful than 1980 spawning and/or the incubation portion of the 1981 brood year life cycle had a lower survival than the 1980 brood year which caused a decrease in number of fish at the sites examined above the Chulitna River.

The only data that directly support this hypothesis are the low numbers or non-existent catches during the limited sampling effort that was undertaken in Portage Creek and Indian River. Numbers collected during the 1981 open water season were also quite low although large increases in the catch from these tributaries occurred during the 1981 fall outmigration.

(2) The low flow conditions of the mainstem Susitna River during the 1982 open water season reduced the capability of juveniles to pass into the sloughs and tributary mouth areas, and therefore decreased the utilization of these habitat types in the upper river.

This hypothesis is inferred from the examination of distributional data between 1981 and 1982. At sloughs and other sites sampled both years, the catch per unit effort was substantially lower. The catch of outmigrants of Age 0+ and 1+ at the outmigrant trap suggests that movement of chinook occurs in the mainstem during the course of the summer and may reflect a continual downstream displacement into suitable rearing habitat. Since data were not collected on outmigration rates during the 1981 open water season, we have no comparable data to determine what factors may have affected the catch rates at the outmigrant trap.

(3) The decreased catch rates at the designated habitat sites may reflect a loss of usable habitat at these sites because of decreased stage related to lower mainstem Susitna flows.

Qualitative data on the availability of cover at the sloughs and tributary mouths influenced by mainstem back up suggests cover may decrease substantially with decreasing mainstem discharge. Areas of brush, undercut banks, logs, and other types of overhead cover were often dewatered under the 1982 low flow conditions. These conditions may have contributed to the lower numbers of juveniles at these sites because of a behavioral response to the lack of cover.

The change in abundance of juvenile chinook salmon observed in the major habitat types may be explained by any or a combination of the above three hypotheses. The 1983 open water study design should provide information that will help establish the importance of these factors in influencing the relative abundance of chinook juveniles in the system. Variations in the distribution of chinook fry within the specific habitat sites and possible causes are addressed in the following section.

2.1.2.2 Habitat and environmental factors associated with the juvenile phase of the life cycle

The habitat utilized by juvenile chinook was investigated during 1981 and 1982. During the 1981 field season, habitat data collection demonstrated the range of conditions that were associated with minnow trap catches of juvenile chinook. This habitat data was collected to obtain distributional information over the general habitat types that occur in the system (ADF&G 1982).

The 1982 sampling program was designed to provide additional distributional data on chinook salmon juveniles and to specifically test factors that may affect their distribution. During the 1981 investigations, it had been noted that the slough habitats and tributary mouths consistently provide a higher catch per unit of effort (CPUE) than other habitats. It was also observed that the CPUE varied considerably with the time of year and the location. It was hypothesized that these influences reflected the migratory behavior of this species so that the CPUE data often reflected these conditions rather than micro-habitat conditions.

Influences of the mainstem discharge caused two major effects on many of these habitat sites. The high water flows that overtopped the head of many of the sloughs during the open water season created sudden and substantial increases in discharge within these areas and altered habitat significantly. The mainstem also created a backwater effect, dependent on stage of the mainstem, that extended up into the sloughs and tributary mouths. This area extended for over a mile in some of the low gradient sites, or less than 50 feet where the mouth of the tributary or slough had a relatively steep gradient. The surface areas of the backwater regions are dependent upon tributary flow, flow overtopping the head of some of the sites, and the extent of backup at the mouth. The juvenile study program was designed to determine the response of the surface area of these backwater "zones" to changes in mainstem discharge and to test if the CPUE was different between these zones and other adjacent sites at any given point in time. By combining these two components, an estimate of the influence of mainstem discharge on juvenile salmon habitat can be made. The analysis of this data is presented in Appendix F and is used as the basis for the following discussion.

2.1.2.2.1 Physical habitat conditions of rearing juveniles

Discharge (velocity and depth) relationships and their effects on indices of available habitat

Investigations examining the effects of discharge on rearing habitat of juvenile fish frequently have employed hydraulic models to simulate reaches of streams under variable discharges. The resultant model predictions of depth and velocity have been compared with the velocities and depths associated with the natural distribution of fish. By incorporating the natural selectivity of fish for particular depths and velocities into a habitat simulation model, the available habitat at any particular discharge has been estimated (Bovee 1982).

The ADF&G Susitna studies employed a similar concept but used a more general approach to addressing the response of juvenile chinook to mainstem discharge changes. Seventeen designated habitat locations at the mouths of tributaries and sloughs, which had relatively high CPUE rates during the 1981 investigations, were selected. There were twelve sites above the Chulitna River confluence and five below. All of these sites were selected primarily because of importance to juvenile fish during the previous season, the logistical convenience of sampling, and because they provided a good representation of the various habitat types present. The response of the physical habitat component was based on the Gold Creek gaging station of the USGS for the upper reach of river and the Sunshine station for the lower.

The effects of mainstem discharge on chinook salmon juvenile rearing habitat at representative sites are presented in Appendix F (Appendix Figures F-3 to F-6). The habitat response to discharge is limited to the study area defined in the appendix at each of the designated habitat locations. Because these locations were selected due to their comparative importance to rearing juveniles, responses to mainstem discharge of the habitat at these sites probably reflects habitat conditions for many of the fish within the reach of river examined.

There was little difference in distribution of chinook salmon in backwater zones and the areas not backed up by the mainstem. Therefore, the projected changes in habitat, as reflected by these zones, paralleled the surface area of all zones. This information reflects only the minimum decreases or increases in habitat with changes in mainstem Susitna discharge.

Water quality and thermal relationships

The water quality parameters investigated with respect to juvenile chinook distribution included dissolved oxygen, conductivity, pH, and turbidity. During the open water season, temperature and turbidity are probably the main factors that influence the distribution of juvenile chinook.

Temperature affects the basic metabolism of fish and the warmer areas of a cold water river system such as the Susitna often attract juvenile fish (Appendix F). Where there were significant thermal differences at the mouth of clear water tributaries, juveniles were frequently found in the warmer water. This may also explain why some sloughs that have warmer temperatures during the winter also have higher densities of juvenile chinook during the winter.

Turbidity affects the distribution of juvenile salmon in several ways. It provides cover from predation but also limits primary production, food availability, and probably feeding efficiency. However, the 1982 studies did not demonstrate any effects of turbidity on chinook distribution (Appendices F and G).

2.1.2.2.2 Timing of outmigration from the tributaries, sloughs and mainstem and its relationship to environmental changes.

The timing of outmigration and the factors that influence outmigration of fish in the Susitna system have been investigated. The following factors probably play some role in determining outmigrant timing.

(1) Photoperiod. The response to the length of day is probably an inherited behavioral stimulus for outmigration. The outmigration timing probably corresponds with optimal survival conditions in the estuary or ocean environment and may correspond to plankton blooms.

(2) Size of juvenile. There are some data available that indicate that juveniles salmon that grow faster may outmigrate earlier. Studies on the Deshka (Delaney et al. 1981), indicate that during even year pink salmon runs when juvenile chinook feed heavily on pink salmon eggs the young of the year juvenile chinook outmigrated into the mainstem Susitna and do not overwinter in the Deshka River system. Juveniles in other tributaries have been observed to remain until the next spring. These fish are generally smaller than the earlier outmigrants.

(3) Physical habitat conditions. Water temperature can influence the rate of development, and therefore alter the outmigration timing of juvenile chinook. Other factors that will affect their available food supply, such as changes in turbidity and flow stability, will also affect their growth rate and may cause alterations in the outmigration timing as discussed in (2) above. Other effects that are more likely to be observed include the response of juveniles to the discharge fluctuations of the mainstem Susitna. The rates of outmigration of juvenile chinook have been positively correlated with the daily mainstem discharge measurements at Gold Creek (Appendix H).

Reasons for this correlation include the influence on access in and out of slough rearing habitats by the stage of the mainstem. Increased depths and velocities during outmigration probably provide a behavioral stimulus to move out into the mainstem.

In summary, observed timing of outmigration can be influenced by several factors, but has probably evolved to maximize survival of the juveniles. Mainstem discharge probably influences the short term movements of fish into the system but the size of the individual and behavioral response to photoperiods may be the dominant factors controlling outmigration.

2.1.2.2.3 Food supply for rearing juveniles and its relationship to other parameters and preference dependency of species in the system.

The 1982 studies initiated an investigation of the selectivity of chinook juveniles for aquatic invertebrates at slough and tributary mouth sites. Comparisons were also made between the invertebrate community composition of the different types of sites. These studies were designed to provide some initial insight as to whether or not the use of different types of habitat associated with the Susitna River can be explained in terms of food type availability and selectivity.

The species composition of the invertebrate community was dissimilar at all sites examined with chironomid larvae the dominant form present. The larvae of the chironomid was also consumed in greater numbers and frequency by juvenile chinook and thus appeared to be a preferred food item. However, food item selectivity data did not suggest that invertebrate community composition had a major influence on the distribution of juvenile chinook which points to invertebrate density as a major factor. However, no attempt was made to quantify the invertebrate communities present. The relationship between invertebrate densities and the density or growth rates of juvenile chinook awaits further study.

Terrestrial insects also comprise a significant portion of the juvenile chinook diet, suggesting the presence of overhanging vegetation or comparatively large amounts of stream bank per unit of wetted surface area, may provide important sources of food for rearing juveniles. This hypothesis is supported by the observation that juvenile chinook rearing at Fourth of July Creek mouth which has the largest amount of bank and overhanging vegetation of the seven food habitat study sites had the highest percentage use by chinook juveniles of terrestrial insects.

The qualitative investigation conducted has established the primary taxa utilized by juvenile chinook salmon but has not provided any quantitative comparisons of habitat and invertebrate communities. To establish the potential of the mainstem to rear juvenile chinook, and to determine the possible response of the invertebrate communities to mainstem flow alterations, further studies would be required. This data base would also provide information as to the possible effects that mainstem flow alterations may have on aquatic invertebrate communities in the slough environments.

2.1.2.2.4 Other physical and biological constraints

The distribution and abundance of juvenile chinook salmon is undoubtedly influenced by many other parameters, both physical and biological. Predation by other fish, such as Dolly Varden and burbot, may effectively restrict their distribution into areas of heavy cover because of behaviroal avoidance of these predators. They may also compete for food resources with other species, such as sculpin or coho juveniles. Preference for overhead cover, may be related to predation by terrestrial predators, such as Arctic terns, gulls, or king fishers.

2.2 Coho salmon

Coho salmon, also known as silver salmon, support a substantial sport fishery in the Susitna River and contribute to the upper Cook Inlet commercial fisheries. Each of the freshwater phases of the life cycle of this species that occurs in a portion of the Susitna basin that may be affected by the proposed hydroelectric project is discussed in the following narrative. Figure 2-5 depicts the periodicity of the various life stages in macro-habitat areas that have been identified in the system.

2.2.1 Adult phase of life cycle

Migration of adult coho salmon into the Susitna begins in the middle of July and continues through September.

2.2.1.1 Adult harvest by sport and commercial fisheries

Before entering the Susitna River, coho salmon are harvested by the Cook Inlet commercial fisheries. They are also harvested by a sport fishery within the Susitna River drainage. The adult coho may be the most sought after of the anadromous sport fish, with the exception of chinook salmon. The harvest estimate of coho is illustrated in Figure 2-6. This figure indicates substantial increases in the commercial harvest in recent years.

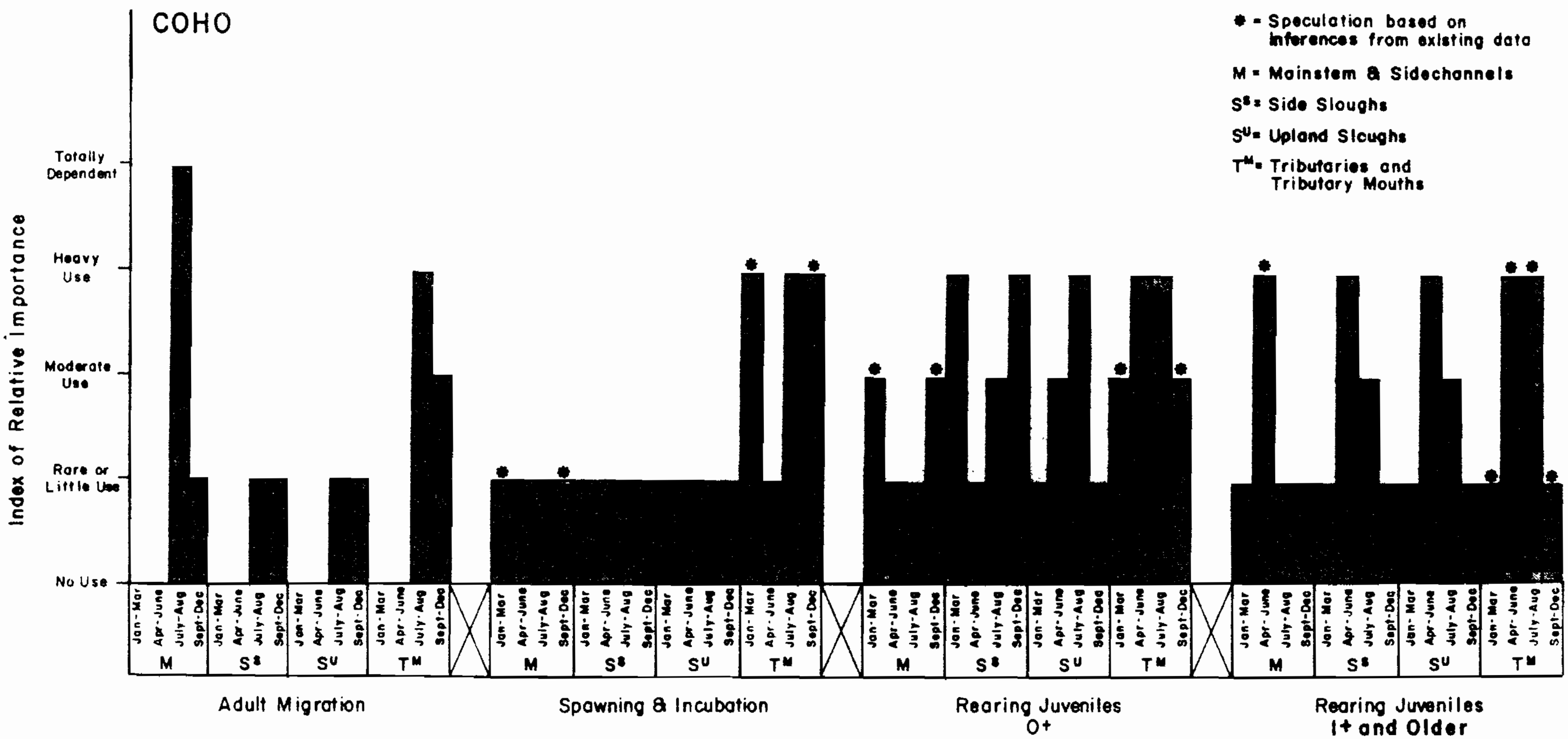

Figure 2-5. Seasonal use of macro-habitat by coho salmon above the Chulitna River confluence (RM 98.5). Data summary from ADF&G (1983a, 1983b).

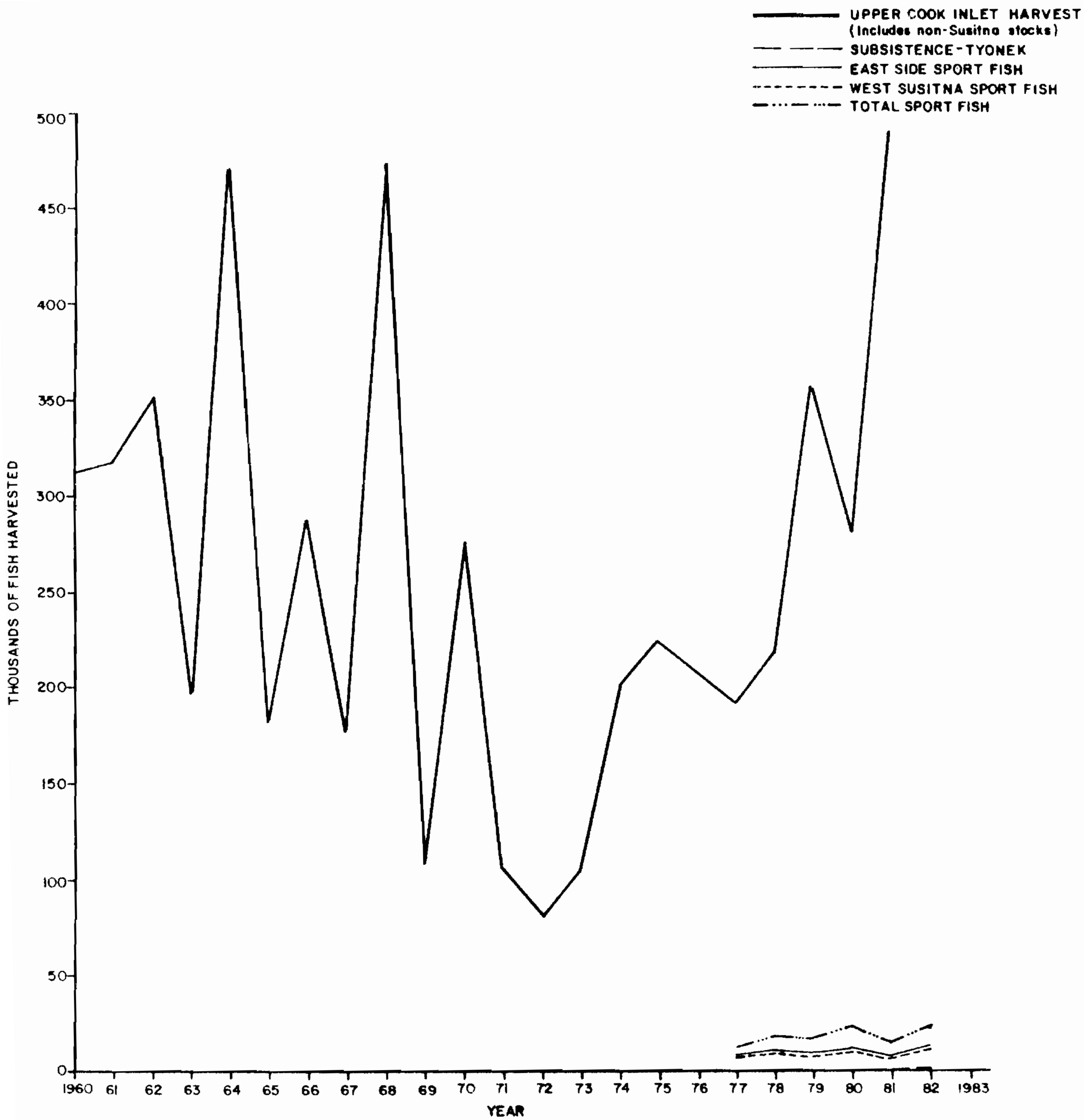

Figure 2-6. Harvest summary of Cook Inlet and Susitna River coho salmon stocks. Harvest data from ADF&G (1981f) and K. Florey (Personal communication, ADF&G, Anchorage), subsistence catch data from Foster (1982) and sportfish catch data from Mills (1982). Data from 1982 are preliminary.

2.2.1.2 Adult escapement

The escapement of adult coho salmon into the Susitna is probably the lowest of any of the Pacific salmon species, but a complete estimate is not available. The escapement estimate that was made with Peterson population estimates at the Sunshine, Talkeetna, and Curry stations during the 1982 season is shown in Figure 2-7. The numbers depicted indicate the number of fish passing the capture site fishwheels, but not necessarily the total spawners that escape above these sites. An estimate of 36,800 coho in 1981 and 79,800 in 1982 in the Susitna River was made by combining the Yentna sonar counts with the Sunshine Station Peterson estimate. This estimate excludes the tributaries between river mile 6 and river mile 77 with the exception of the Yentna River.

2.2.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle

The most obvious factors which influence the success of coho spawning are the discharge and temperature of the mainstem Susitna and of the natal tributaries. As with chinook salmon, the behavior of coho during natural variations in discharge and temperature of the mainstem may provide insight into what may occur if the dam were constructed.

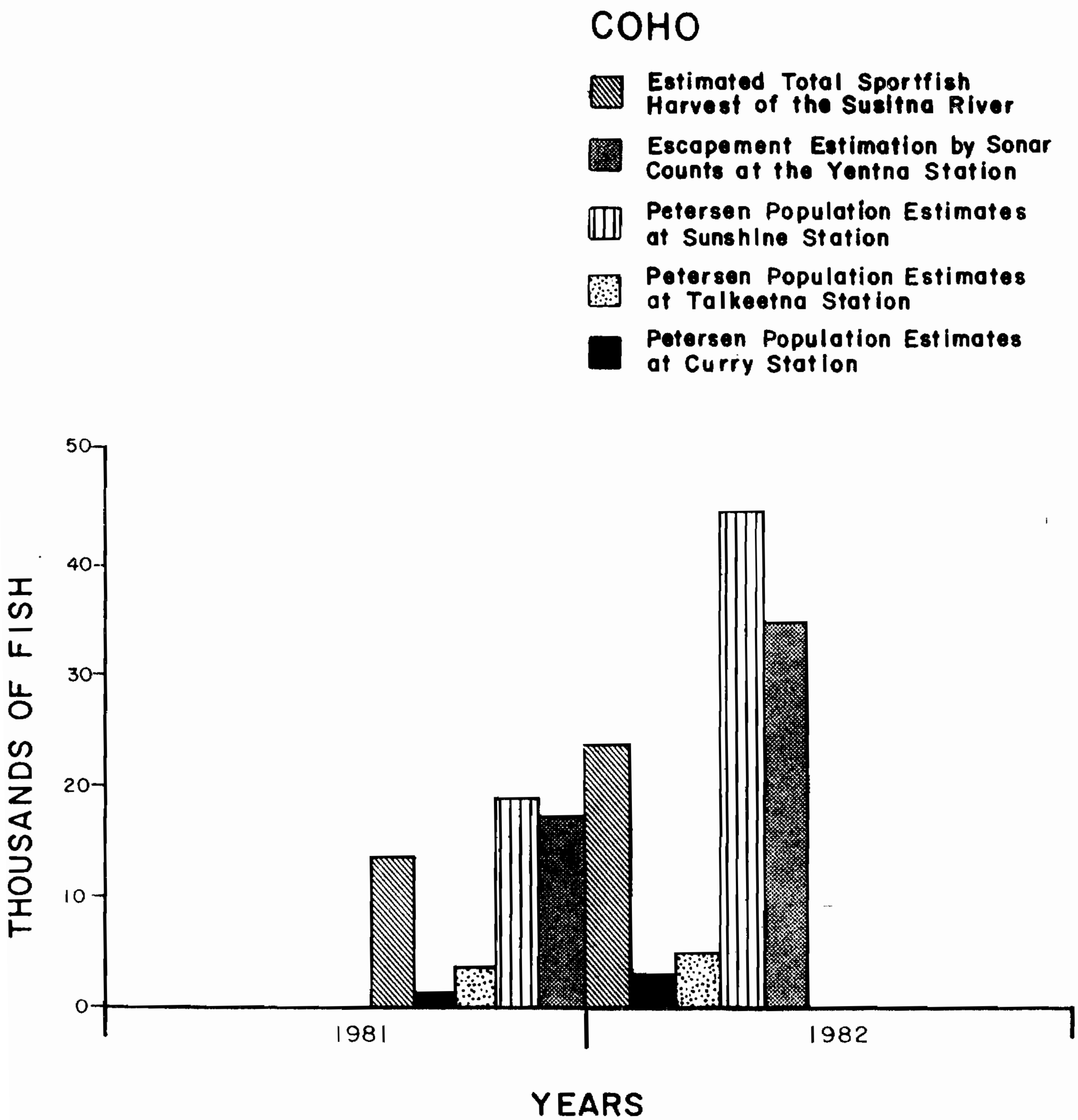

Figure 2-7. Summary of the population estimate and sportfish harvest for adult coho salmon within the Susitna River. Sportfish harvest data from Mills (1982) and escapement and population estimates from ADF&G (1983a).

2.2.1.3.1 Discharge, water quality, and temperature relationships with adult salmon migration

The discharge and temperature data collection was described previously for chinooks. The plots of mean daily discharge and temperature are plotted against the movement of coho salmon in Appendix Figure B-2. Within the natural variations in temperature, no effect on coho migrations was observed during 1982. The influence of discharge on fish behavior is apparent at the higher discharge levels. An inverse correlation exists when peak flows occurred during migration. Peak flows also caused a decrease in temperature. This relationship was observed during the 1981 coho migration as well and similar effects have been observed with the other species. Within the range of flows that occurred during the migration, no influence on the behavior of the fish at the lower end of the flow regime was observed.

Coho salmon have not been observed during 1981 and 1982 passing through lower Devil Canyon. Passage of fish into the mouths of clear water tributaries, Indian River and Portage Creek, has been examined in more detail (Trihey 1983). By examination of the stream mouth gradient and associated water velocities and the distance that such velocities are likely to occur under alternative flows of the mainstem Susitna, predictions of the influence of mainstem flow on tributary passage of coho salmon can be made. Trihey concluded that salmon passage into the tributaries is not likely to be affected, regardless of the flow of the mainstem Susitna.

Coho often use the smaller tributaries for spawning in addition to the major tributaries. Gash Creek, a small tributary near river mile 111.6, has had significant numbers of spawning coho during 1981 and 1982. This creek flows through a culvert under the Alaska Railroad. Dewatering of the side-channel during very low flow periods could potentially block access. This potential has not been quantatively examined yet. Lower McKenzie Creek and Whiskers Creek also have substantial numbers of coho. Substrate stability at the mouth of these streams has been addressed by studies by R and M Consultants (1982).

Possible influences of dissolved gas supersaturation on salmon adults migrating into Devil Canyon has been discussed previously under chinook salmon and is not repeated here.

Habitat requirements associated with spawning have not been established for this species because minimal spawning is associated with areas influenced by the Susitna mainstem. This observation suggests there are limitations to spawning cohos in sloughs and the Susitna mainstem. Temperature, substrate, velocity, and depth at areas used by spawning coho in some of the clear water tributaries can be incorporated into an analysis that will provide an estimate of the potential for side channel areas of the Susitna to support post-project coho spawning and incubation.

2.2.1.3.2 Other factors that influence the spawning success of coho salmon

The limitations to spawning of coho salmon in the Susitna basin above the Chulitna River confluence are not totally known. The influence of turbidity on the selection of redds, the suffocation of redds by suspended sediment, and the cover or depth requirements to provide cover from predators, may all limit the ability of the mainstem Susitna to support coho salmon spawning. Ice processes must be a major concern. During the ice formation process, channels can become dewatered and bed scouring may occur in isolated areas. Intragravel temperatures may vary greatly in a short period of time and may adversely affect egg or alevin survival. An understanding of the effects that ice processes have on flow patterns in potential spawning sites and on winter thermal characteristics is essential to define limits to spawning under current flow conditions or under regulated conditions.

2.2.2 Juvenile rearing and migration phases

Coho rearing is often associated with habitats that are affected by mainstem Susitna discharge, turbidity, and temperature. The focus of the 1981 and 1982 juvenile anadromous studies has been on determining the relative abundance and general habitat types associated with the rearing of this and other anadromous species. The general distribution data have been used to select specific sites for more detailed investigations regarding habitat suitability for juvenile salmon and for measuring the response of these habitat areas to changes in mainstem discharge. This has provided the first step in assessing the response of juvenile salmon to incremental alterations in flow.

2.2.2.1 Relative abundance of juvenile coho salmon

Juvenile coho salmon probably emerge from the gravel in their natal clear water tributaries in March or April. From this time until they outmigrate into Cook Inlet, they are actively feeding and are dependent upon suitable habitat for rearing. Age (0+) coho apparently spend the first two months after emergence in the vicinity of their natal areas (Morrow 1980). They apparently begin redistributing downstream shortly after this initial period and are collected in small numbers at habitat sites associated with the mainstem Susitna (Figure 2-8). Rearing by the young of the year also occurs within the clear water tributaries with significant numbers present until late fall. At this time, apparently a substantial portion of the populations outmigrates into the mainstem Susitna. From this period until May of the next year, some of the juveniles that originate in Portage Creek and Indian River and other clear water tributaries are dependent upon habitat conditions in the mainstem Susitna.

Age 0+ fish were collected at the outmigrant trap throughout the summer with a larger portion captured in the fall, when compared with the other species. This probably reflects a general redistribution into rearing areas in sloughs and tributary mouths or small backwater areas throughout the system. The Age 1+ and 2+ fish made up 15.2 percent of the population outmigrating during the period that the trap was in

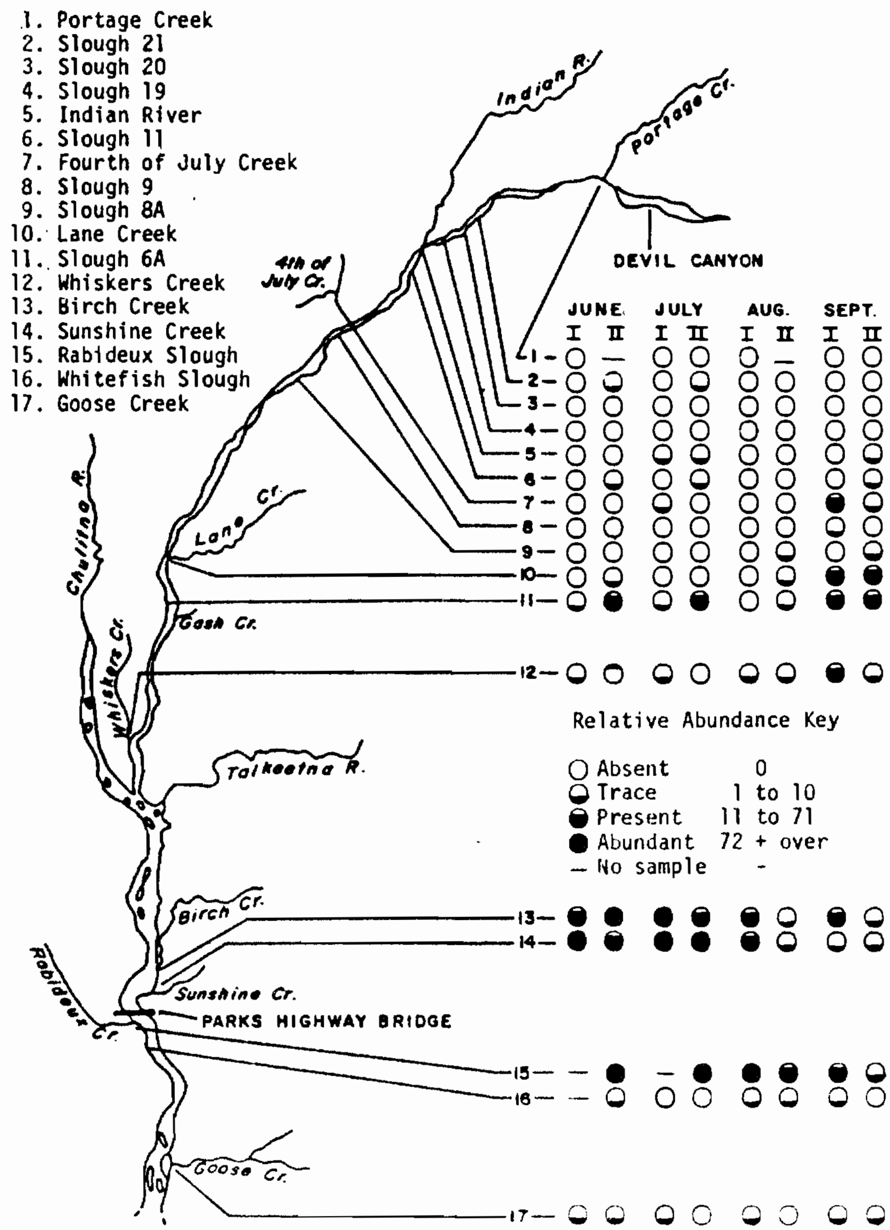

Figure 2-8. The seasonal variation in distribution and relative abundance of coho salmon juveniles at DFH sites on the Susitna River, June through September, 1982. Taken from ADF&G (1983b).

place. The outmigration of these older fish was considerably more regular throughout the summer than other species of salmon (Appendix H).

The trapping efforts that occurred at sloughs and tributaries during the 1981 and 1982 open water seasons indicated a substantial difference in catch rates between the years. This followed a similar pattern for chinook juveniles; possible hypotheses as to the cause were discussed in the chinook salmon section.

Variations in the distribution of coho fry within the specific habitat sites and possible causes are addressed in the following section.

2.2.2.2 Habitat and environmental factors associated with the juvenile phase of the life cycle

The juvenile coho habitat utilization was investigated during 1981 and 1982. During the 1981 field season, habitat data collection was coupled with the collection of distributional information identical to that described for chinook (ADF&G 1982).

The analysis of this data is presented in Appendix F for all juvenile salmon and is used as the basis for the following discussion on coho salmon.

2.2.2.2.1 Physical habitat conditions of rearing juveniles

Discharge (velocity and depth) relationships and their effects on indices of available habitat.

The studies addressing the response of juvenile coho to mainstem discharge changes were similar to those for chinook juvenile studies. The reach of river above the Chulitna confluence was investigated using designated habitat locations at the mouths of tributaries and sloughs that had relatively high catch per unit effort rates during the 1981 investigations. Five other sites were selected in the reach of river below the Chulitna confluence. These were primarily based on high catch rates during the previous season and the logistical convenience of sampling. The response of the physical habitat component has been based on the Gold Creek gaging station of the U.S.G.S. for the upper reach of river and the Sunshine station for the lower.

The effects of mainstem discharge on coho salmon juvenile rearing habitat at Sunshine Creek and Side Channel, Birch Creek and Slough, and Lane Creek and Slough 8 are illustrated in Appendix Figures F-7, F-8, and F-9. The habitat response to discharge is limited to the study area defined in Appendix E at each of these study sites.

The definition of habitat used in the above example limits the literal interpretation of the figure as actually representing lost habitat. With coho salmon, we observed that the distribution of the fish within the backwater zones influenced by the mainstem was significantly lower than areas not backed up by the mainstem. Therefore, the projected changes in habitat as reflected by Appendix Figures F-7, F-8, and F-9, increase with the decreasing backwater zone.

This has provided a very general method of estimating the loss or gain of habitat used by juvenile coho. The advantages of this method include requiring a relatively low level of resources so a relatively large number of sites can be sampled. The evaluation of habitat value at a particular site is estimated based on the actual observed distribution of fish at the sites. This eliminates the problems associated with distribution being influenced by other factors such as migration, proximity to natal areas, etc. The biggest disadvantage of this approach for coho is that micro-habitat changes within the zones that occur with flow will not provide any effect on the habitat availability indices calculated. Observations of the effects of discharge on available cover and the apparent dependence of coho salmon on this cover suggest that this component of habitat may be an important factor that affects the distribution of juvenile salmon.

Water quality and thermal relationships

The water quality parameters studied, with respect to juvenile coho distribution, included dissolved oxygen, conductivity, pH, and turbidity. During the open water season, temperature and turbidity are probably the main factors that influence the distribution of juvenile coho.

Temperature affects the basic metabolism of these species; warmer water frequently acts as an attractant to these fish. This may also be a factor in the densities of juvenile coho observed in sloughs that have warmer temperatures during the winter months because of groundwater influences.

Turbidity may also affect the distribution of the species, providing cover from predation, but also limiting primary production, food availability and probably feeding efficiency. Coho salmon juveniles appear to be found in clear water as opposed to turbid areas and were most abundant in clear water tributaries. The tributary mouth habitat with low velocities created by morphological pools or by backed up water from the mainstem, often had substantial numbers of coho juveniles when there was available cover in the form of emergent vegetation. If cover was low in the lower pools, concentrations were often found in the faster water of the tributary upstream of the mainstem influences. Since cover was not taken into account in the analysis of the habitat indices, the preference for the portions of the study sites that did not have water backed up from the mainstem was the dominant influence on the habitat values projected (Appendices F and G).

2.2.2.2.2 Timing of outmigration from the tributaries, sloughs and mainstem and its relationship to environmental changes.

The timing of outmigration and the factors that influence outmigration have been of much interest in the Susitna system. Factors influencing coho salmon outmigration are probably similar to those listed for chinook salmon.

There are some data available that indicate that juvenile coho salmon may outmigrate earlier if densities are higher and if winter development rates are higher (Hartman et al. 1982). The rate of outmigration of juvenile coho in 1982 had statistically significant but modest correlations with the daily mainstem discharge measurements at Gold Creek (Appendix H). Juvenile coho salmon outmigration was more evenly distributed than other species throughout the period the outmigrant trap was operating. The response of this species to short term peak discharge before sufficient fresh water growth occurs has suggested to other investigators possible value in regulating flow (Hartman et al. 1982). The size of the individual and behavioral response to photoperiods may be less important in controlling outmigration than for the other species of salmon (Hartman et al. 1982).

2.2.2.2.3 Food supply for rearing juveniles and its relationship to other parameters and preference dependency of species in the system.

The 1982 studies initiated an investigation of the selectivity of rearing coho juveniles for aquatic invertebrates at slough and tributary mouths as was described for chinook.

The food habits of the coho were similar to the chinook salmon described earlier with minor differences observed between the species. The general level of resolution of this study did not allow association of invertebrate communities with micro-habitat. The invertebrate communities were different among the sites studied but did not follow a consistent pattern.

The qualitative investigation conducted has established the primary taxa utilized by juvenile salmon but further studies would be required to provide any quantitative comparisons of habitat and invertebrate communities to mainstem flow alterations. Relating food availability to juvenile coho requirements would also require additional investigation.

2.2.2.2.4 Other physical and biological constraints

As with the other salmon juveniles, the distribution and abundance of juvenile coho salmon are undoubtedly influenced by many other parameters, both physical and biological. Predation by other fish, such as Dolly Varden and burbot, may effectively restrict their distribution to areas of heavy cover. They may also compete for food resources with other species, such as chinook juveniles, which may in turn affect to their micro-habitat preference (Hall and Knight 1981).

Preference for overhead cover may be related to predation by avian predators, such as Arctic terns, gulls, and kingfishers.

2.3 Sockeye salmon

The sockeye salmon, also referred to as red salmon in Alaska, is the most important commercial salmon species in the Cook Inlet area. It also contributes to an important sport fishery. The distribution of the fish species by life history stage in macro-habitat areas that have been identified in the Susitna River drainage is depicted in Figure 2-9. This report discusses the fresh water phases of the sockeye salmon's life cycle that occur in the portion of the Susitna basin that may be affected by the proposed hydroelectric project.

2.3.1 Adult phase of life cycle

In Cook Inlet, two distinct migrations of sockeye salmon can be observed. An early migration that begins in June is followed by a July migration. The early migration was thought to be primarily associated with the Kenai River, but 1982 studies on the Susitna River identified a small early migration into the Talkeetna River drainage. The commercial harvest of the Susitna stock is primarily directed at the late run which is the larger of the two.

2.3.1.1 Adult harvest by sport and commercial fisheries

A summary of the sport and commercial harvests is presented in Figure 2-10. Overall commercial harvests have increased in recent years, suggesting improved escapement of parent stock or improved environmental conditions. Sport fishing on the Susitna River for sockeye does occur

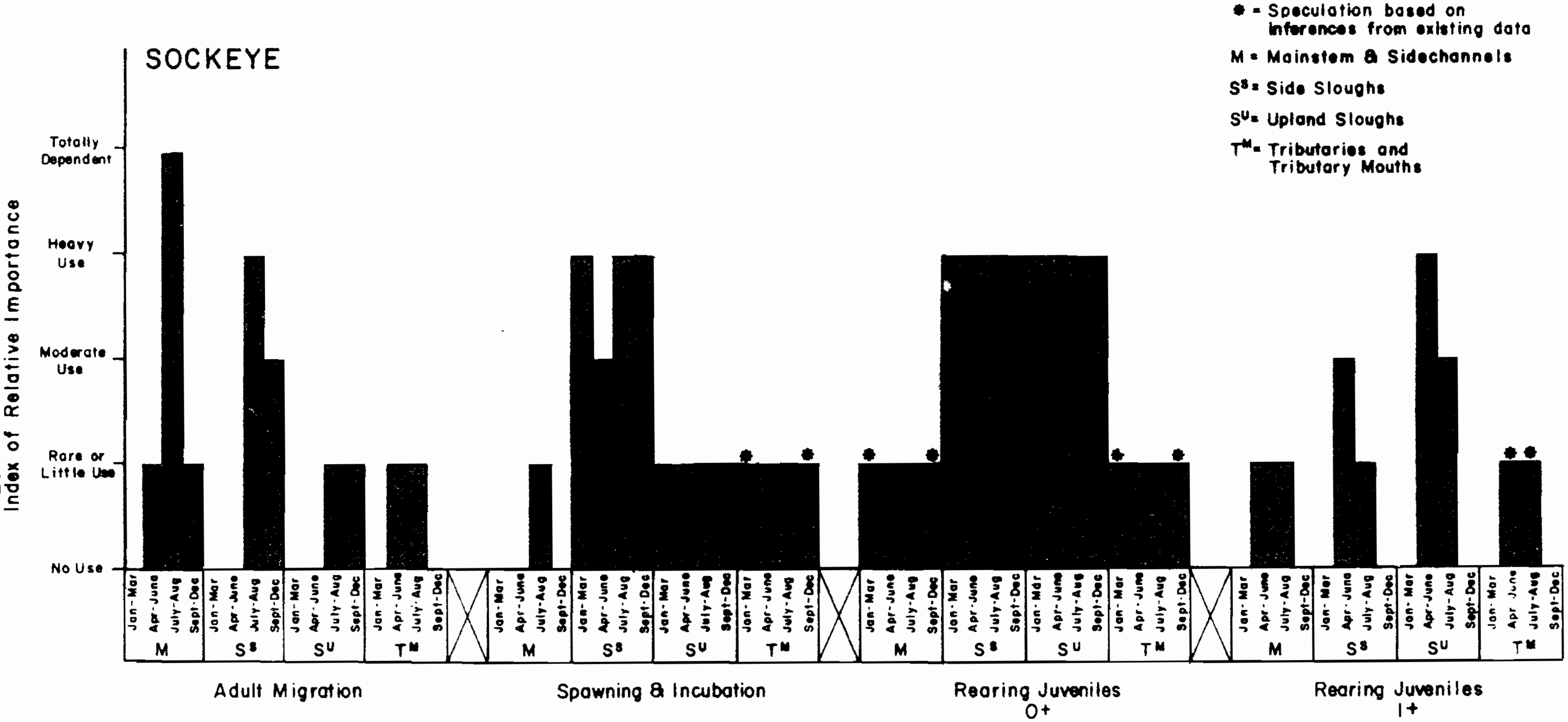

Figure 2-9. Seasonal use of macro-habitat by sockeye salmon above the Chulitna River confluence (RM 98.5). Data summary from ADF&G (1983a, 1983b).

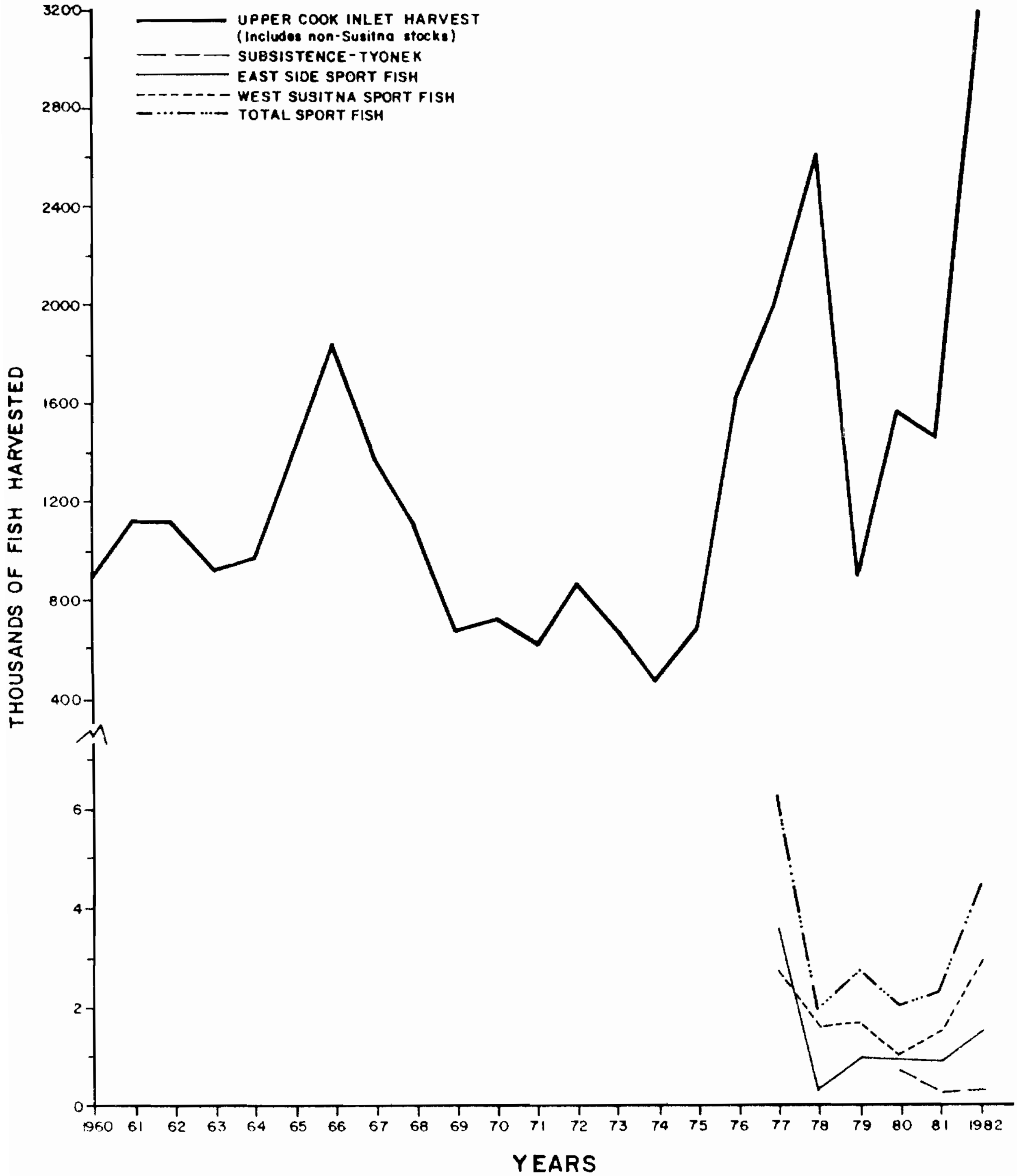

Figure 2-10. Harvest summary of Cook Inlet and Susitna River sockeye salmon stocks. Harvest data from ADF&G (1981f) and K. Florey (Personal communication, ADF&G, Anchorage), subsistence catch data from Foster (1982) and sportfish catch data from Mills (1982). Data from 1982 are preliminary.

but the catches are not large when compared with those of the other species.

2.3.1.2 Adult escapement

An estimate of the adult sockeye salmon escapement into the Susitna River is not available. An escapement estimate has been produced from the 1981 and 1982 Su-Hydro surveys by combining the sonar counts of the Yentna River with the Petersen estimates of Sunshine sampling station. This estimate of 265,000 sockeye in 1982 and 273,000 in 1981 excludes the tributaries, except the Yentna River, below Susitna river mile 77 and above river mile 6 . Petersen estimates of the escapement for the other sampling stations are depicted in Figure 2-11. This demonstrates a marked reduction in sockeye salmon numbers in the Susitna above the Chulitna River confluence.

2.3.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle (upstream migration, passage and spawning).

During the upstream spawning migration, sockeye salmon are influenced by environmental variables that may ultimately affect their spawning success. The sockeye escapement in the upper Susitna above the Chulitna confluence is primarily into sloughs with perhaps a small number running into the Chase Creek drainage. As with other salmon species, sockeye may be influenced behaviorally by discharge and water temperature conditions of the mainstem Susitna.

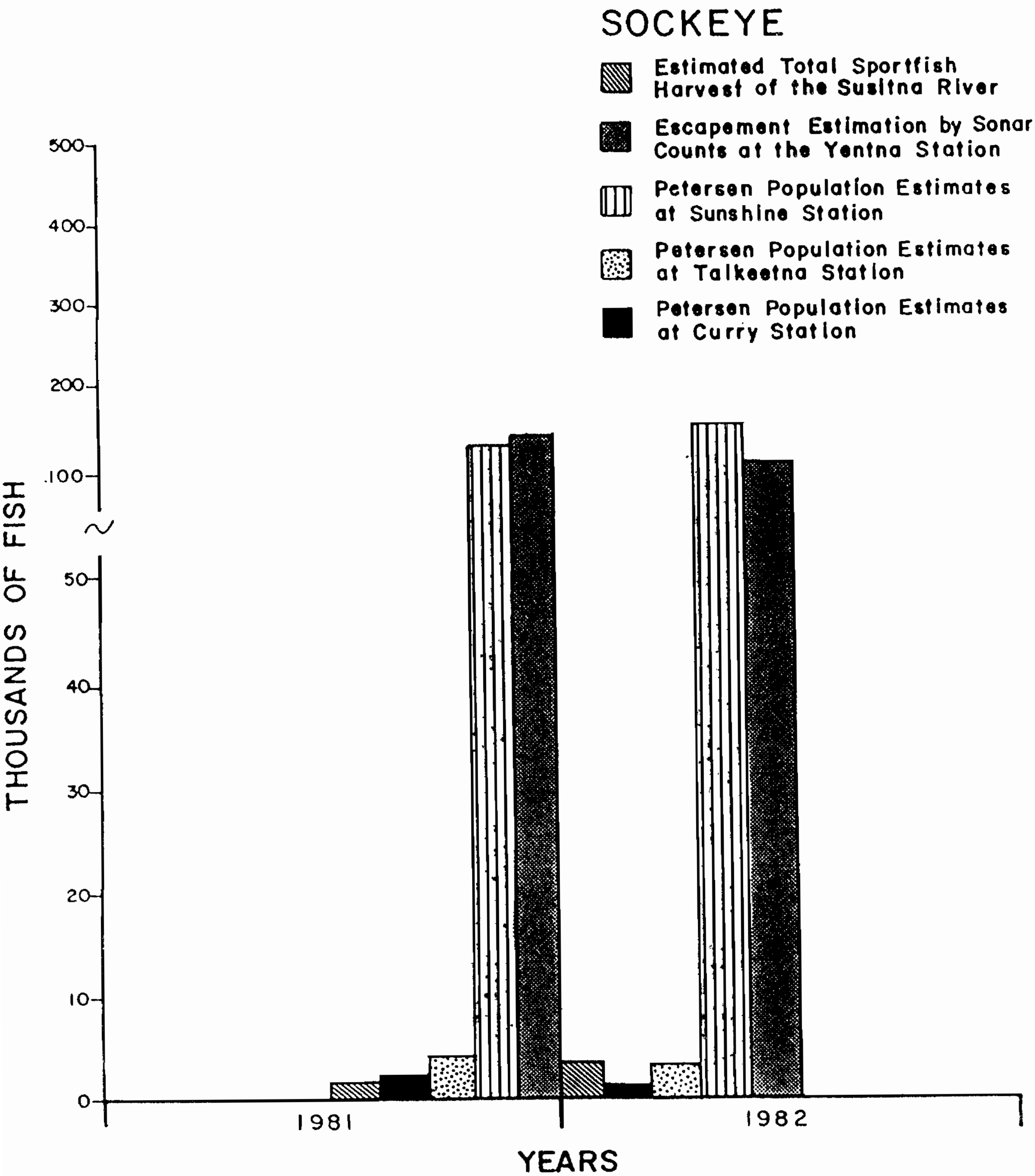

Figure 2-11. Summary of the population estimate and sportfish harvest for adult sockeye salmon within the Susitna River. Sportfish harvest data from Mills (1982) and escapement and population estimates from ADF&G (1983a).

2.3.1.3.1 Discharge, water quality, and temperature relationships with adult sockeye salmon migration

The timing of sockeye salmon migrations in the Susitna River have been compared with temperature and mainstem discharge, similar to that presented earlier for chinook and coho. These movements are illustrated in Appendix Figure B-5 and the analysis is described in Appendix B. The peak of the sockeye migration in 1982 was inversely correlated with discharge. The movements appear to decrease as discharge increases and increased movement occurs as discharge decreases.

Access to tributaries is not a major factor for sockeye salmon with perhaps the exception of Chase Creek. Although escapement was not documented in Chase Creek in 1982, earlier studies (ADF&G 1974) documented sockeye salmon spawning in this drainage. The problems of access into the smaller tributaries at lower mainstem flows is addressed by a report by R&M Consultants (R&M 1982).

Since the spawning of this species occurs almost exclusively in slough habitats in the Susitna River above Talkeetna, most of the analysis has concentrated on the effects of discharge on passage and the availability of spawning habitat in these sloughs.

Passage into the sloughs of the upper Susitna is addressed in Appendix B, which also outlines the methodology used to develop passage estimates. For sockeye salmon adults, passage into Sloughs 11, 8A, and

21 appears most critical because they had the highest observed counts of sockeye during the spawning period. Sockeye were also found in Moose Slough, Slough B, Slough 8B, Slough 9, Slough 8C, Slough 9B, and Slough 9A. The effect of discharge on salmon passage into sloughs is described in Appendix B and is summarized in Appendix Table B-2.

In addition to passage into sloughs, the availability of suitable spawning conditions has been evaluated for Sloughs 8A, 21 and 9. By the use of IFG-IV models, an analysis of the physical habitat under variable flow conditions has been produced in Appendix D.

Although information is available on the physical habitat, the analysis has not yet included usage by sockeye salmon because of limited data. Suitable discharge and temperature conditions during other phases of the life cycle must also be considered in addition to adequate passage and spawning conditions. Optimal passage and spawning conditions may provide very little benefit to the freshwater production of sockeye smolts if incubation and rearing are the major limits on production. These other factors are addressed in the following discussion.

2.3.1.3.2 Substrate type associated with spawning

Substrate quality and quantity may be critical factors for successful spawning and incubation (Cooper 1965 as cited in Bell 1980). The stability of the substrate after spawning also has to be considered. Because of the possible critical nature of the substrate for successful reproduction, adult sockeye probably have behavioral instincts to select substrate suitable for successful reproduction. Appendix C addresses the substrate preferences by chum and sockeye salmon at selected sloughs and their tendency to key on areas of upwelling.

These data can be used in future analysis of the potential of other non-slough habitats for enhanced production of sockeye and can be also used in further analysis of the effects of high water on substrate stability in these sloughs.

An important factor which is not addressed in these studies is the effect of suspended sediment on the substrate. The deposition of suspended sediment on the gravels used by the spawning sockeye has been documented to adversely affect survival of incubating embryos, generally by suffocation (Iwamoto et al. 1978). Substrate used by the spawners, needs to be periodically cleansed by highwater velocities to remove the deposited sediments. However, if the velocities become excessive, the gravel can be completely washed out, and suitable spawning substrate will be replaced with a larger bed material which is unsuitable for spawning.

2.3.1.3.3 Other physical and biological constraints on spawning success

During spawning, other factors can become significant in reducing spawning success. The lower end of the discharge that provides sufficient passage and adequate habitat conditions for spawning, may not be sufficient for protection from predation by bears or predatory birds. Although not possible to quantify under the constraints of this study, low flows could potentially reduce spawning success.

2.3.2 Incubation and emergence phase of life cycle

The incubation of sockeye salmon eggs after spawning and the subsequent emergence of juvenile sockeye from the gravel encompasses the period of time from early September until June of the following year. Ongoing investigations will provide more data on timing of egg incubation and emergence and will be included in a winter report summary. An additional controlled study of the effects of temperature on sockeye egg incubation is being undertaken by the U.S. Fish and Wildlife Service.

Important effects of mainstem discharge on incubation and emergence include the possible disruption of redds by fall floods. Scouring flows after sockeye eggs are deposited in the gravel can be expected to severely decrease survival of the redds. The effects of ice processes during the fall and winter can also be quite adverse. Initial observations of winter mainstem flow through Slough 8A, indicates that a sudden and prolonged decrease in temperature occurred and the developmental rates of juveniles were delayed. An apparent increase in egg mortality may also be related to this event. A more complete analysis of egg incubation processes will be included in the 1982-1983 winter report.

2.3.3 Juvenile rearing and migration phases

The rearing phase of sockeye juveniles in the Susitna River above the Chulitna River confluence has been puzzling. Although substantial numbers of sockeye adults consistently return to selected sloughs above the Chulitna River confluence, juvenile rearing above the confluence has been difficult to document. Since sockeye are plankton feeders and most frequently rear in lake environments, similar types of habitat were thought to be required for successful rearing of this species. Analysis of the adult sockeye scales and the operation of an outmigrant trap has provided the bulk of the evidence as to the nature of the juvenile sockeye rearing but major questions still remain.

2.3.3.1 Relative abundance of juvenile sockeye salmon

During 1982, the use of beach seines and electrofishing gear provided some information on the distribution of sockeye juveniles. Sockeye were collected at all of the sixteen sampling sites between Goose Creek and Slough 21 during the summer (Figure 2-12). With the exception of a small number of Age 1+ juveniles collected at Slough 6A, these sockeye were all young of the year (Age 0+). The outmigrant trap, which began operation on June 18, provided more specific results. The Age 0+ juveniles were collected during the summer period with peak catch/hour occurring during the second week in July. Less than 3 percent of the juvenile sockeye collected at the smolt trap were Age 1+.

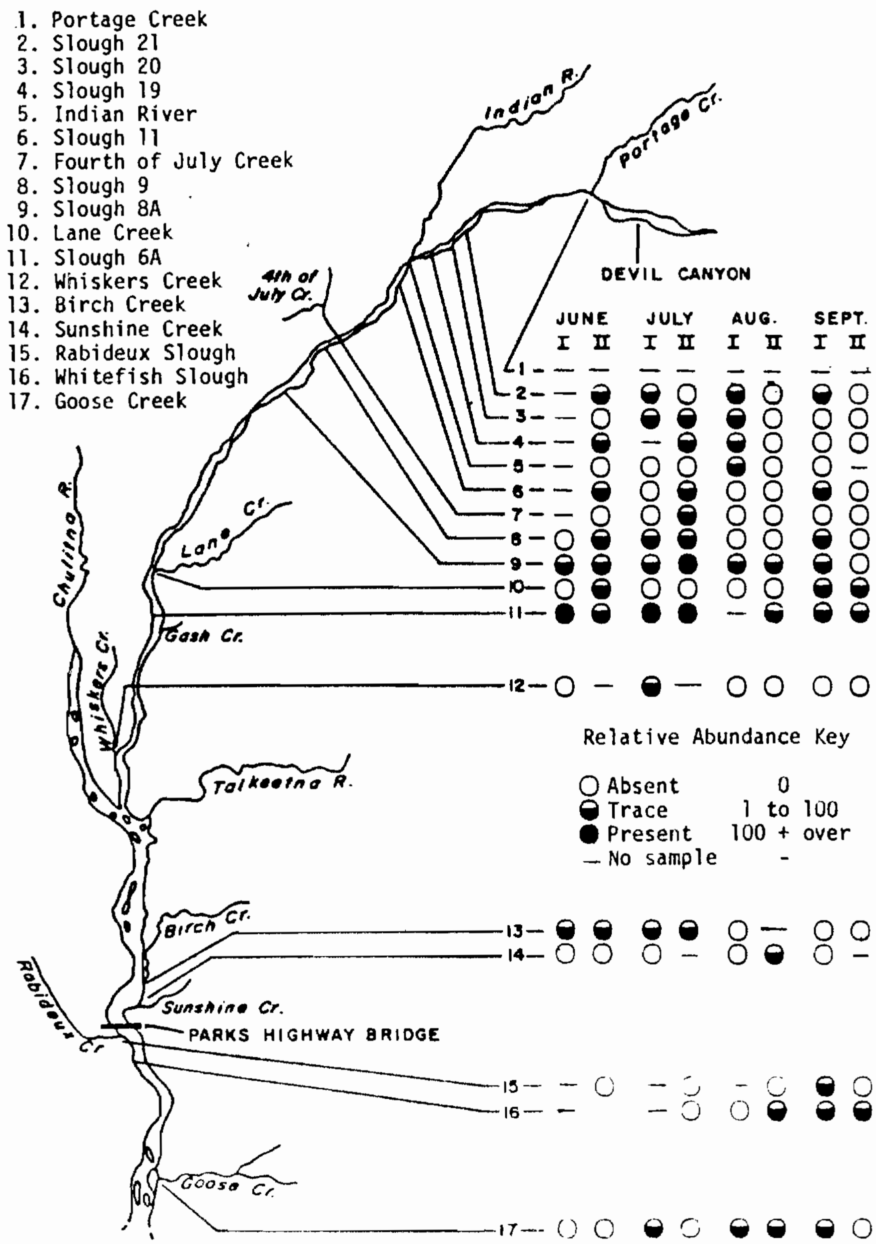

Figure 2-12. The seasonal variation in distribution and relative abundance of sockeye salmon juveniles at DFH sites on the Susitna River, June through September, 1982. Taken from ADF&G (1983b).

The analysis of adult sockeye scale patterns suggests that they are rearing in freshwater during their juvenile life phase. The majority of the returning adult sockeye salmon outmigrated at Age 1+, thus indicating two summers of growth in freshwater. In addition, scale pattern analysis of upper Susitna sockeye did not find that these stocks were significantly distinguishable from stocks of the Chulitna or the Talkeetna drainage (Bernard et al., 1983). Based on the assumption that no fry rear above Curry Station, the authors suggested that these fry most likely die or move to areas in the Susitna River below the Chulitna confluence to rear.

The movement of Age 0+ sockeye monitored by the outmigrant trap and the limited numbers of juveniles collected at first appears to support this hypothesis. However, substantial numbers of rearing juveniles may have outmigrated by the time the outmigrant trap was installed (June 18). Further, the collection of Age 0+ juveniles in the outmigrant trap indicated continual growth during the summer. The food habits investigation indicated active feeding of juvenile sockeye in the sloughs during the summer with planktonic forms in addition to larger insects being used.

Finally, initial observations of outmigration during the spring of 1983 at Slough 11 suggests a significant number of Age 1+ sockeye are present. The viability of this stock will best be resolved through monitoring the returns of the coded wire tagging program currently in progress. Because the monitored populations of Age 1+ sockeye are small, it is questionable that studies of sockeye rearing in the lower river would provide any definitive results, but the analysis of scale patterns and the frequency of the coded wire tagged returning adults should resolve this issue.

2.3.3.2 Habitat and environmental factors associated with the juvenile phase of the life cycle

Assuming that the juvenile sockeye are rearing successfully in the upper Susitna drainage, it is important to determine how this population responds to changes in their physical environment. The following discussion addresses primarily the distribution and associated habitat of the Age 0+ sockeye in the study areas investigated during the 1982 field season.

2.3.3.2.1 Physical habitat conditions of rearing juveniles

The 1982 sampling program was designed to provide distributional data on sockeye juveniles and to identify factors that affect their distribution. The rationale for the development of the study design has been described earlier for chinook salmon. The sampling program for juvenile sockeye was also designed to determine the areas where this species reared. Previous years studies provided little distributional information, primarily because of the limitations of the collecting gear used. The analysis of juvenile sockeye habitat data presented in Appendix F is used as the basis for the following discussion.

Discharge (velocity and depth) relationships and their effects on indices of available habitat

The effects of mainstem discharge on juvenile sockeye salmon rearing habitat in Slough 8A, Birch Creek and Slough, and Slough 19 is outlined in Appendix F, and illustrated in Appendix Figure F-10, F-11, and F-12. The habitat response to discharge is limited to the study areas defined in Appendix E at these sites.

The pattern of catches observed indicates that the juvenile sockeye preferred low velocity areas and were most often associated with the backed up area of the mainstem Susitna. Frequently, the concentrations of juvenile sockeye were near their natal sloughs. An important exception was Slough 6A which did not have any sockeye spawning and consistently provided habitat for rearing juveniles. This slough has relatively clear water, is heavily vegetated around its perimeter, and has no limitations on access. The presence of high concentrations of juvenile sockeye in this slough suggests that access into sloughs by rearing juveniles may be an important factor affecting their survival.

The Appendix F analysis has provided a very general method of estimating the loss or gain of habitat used by juvenile sockeye. The advantages and disadvantages of this method have been previously described for coho and chinook salmon and will not be repeated.

Water quality and thermal relationships

The factors which dominate the distribution of sockeye salmon are probably temperature and turbidity within the sloughs, in addition to the hydraulic parameters discussed earlier. Slough 6A, where the head is rarely, if ever, breached, had large concentrations of juvenile sockeye. Slough 11, where the head rarely breaches, also had significant numbers of rearing sockeye. Assuming slough rearing sockeye have similar requirements to their lake rearing relatives, the low velocities and low turbidity levels of sloughs where the heads are not open to the passage of mainstem water may be important prerequisites for successful rearing.

The water quality parameters studied, with respect to juvenile sockeye distribution, include dissolved oxygen, conductivity, pH,and turbidity.

Turbidity provides cover from predation and limits primary production, food availability, and probably feeding efficiency. Areas with low velocities created by morphological pools or by backed up water from the mainstem, often had significant numbers of juvenile sockeye. Since cover was not taken into account in the analysis of the habitat indices, the preference for the portions of the study sites that had water backed up from the mainstem was the dominant influence on the habitat values projected.

2.3.3.2.2 Timing of outmigration from the tributaries, sloughs and mainstem and its relationship to environmental changes

Factors affecting the outmigration of sockeye salmon juveniles can be quite complex. Immediately after emerging, sockeye juveniles generally redistribute into rearing habitat. This redistribution behavior is apparently genetically controlled (Brannon 1972). Juvenile sockeye apparently also pass through a period of time when they are able to successfully smolt. If retained in freshwater past their migration time, their response to the presence of salt water may again resemble that of freshwater fish and they can remain land locked (Foerster 1968).

Outmigration of juvenile sockeye from lakes is also affected by temperature (Foerster 1968).

Outmigrant data did not demonstrate any dramatic response of sockeye juveniles to mainstem environmental variables tested but a positive correlation with discharge changes was apparent (Appendix H). The temperature changes that occur in the mainstem Susitna in the spring were largely completed when the monitoring of outmigrants began in 1982. Other factors which may influence the smolting and outmigration process have been previously discussed for chinook and coho and would generally apply to sockeye as well.

2.3.3.2.3 Food supply for rearing juveniles

Rearing areas and food supply is probably the limiting factor in production of sockeye salmon in slough environments of the Susitna River above the Chulitna confluence. Sockeye are generally considered lake rearing species although slough populations are not uncommon (Foerster 1968; McCart et al. 1979). Recent studies (McBride 1983) on the East River near Yakutat indicate large returning runs can occur in rivers where major returns are from 0+ Age outmigrants. This suggests limited fresh water rearing. Our limited investigation of food habits indicated that sockeye were feeding on an assortment of aquatic and terrestrial invertebrates but also had significant slough zooplankton in their diet. The downstream migrant distribution noted by the outmigrant trap catch rates may reflect displacement into lower river areas in search of more favorable food supplies. The size and growth measured for the few Age 1+ sockeye that were collected was within the range of growth associated with lake populations in south central Alaska.

2.3.3.2.4 Predation and cover relationships

As with the other juvenile salmon, cover appears to be important for sockeye salmon. However, schools of Age 0+ juvenile sockeye appeared to be much more visible and their general behavior was not as evasive as that associated with chinook or coho juveniles. Further study is needed to quantify effects of cover on the juvenile sockeye distribution.

2.4 Chum salmon

The chum salmon, also referred to as dog salmon, is an important commercial species in Cook Inlet with limited use by sport fishermen. This species makes substantial use of slough habitats for spawning. Chum salmon also spawn in the mainstem and side channels of the Susitna River reach above the Chulitna confluence. With the exception of the even year run pink salmon, it is the most abundant species using this reach of river. Figure 2-13 depicts the distribution of the various life stages of chum salmon in macro-habitat areas that have been identified in the Susitna River drainage above the Chulitna confluence.

2.4.1 Adult phase of life cycle

2.4.1.1 Sport and commercial fisheries harvest

The chum salmon adults provide a major component of the Cook Inlet commercial harvest in addition to a limited sport fishery. A summary of the sport and commercial harvests is presented in Figure 2-14. Commercial harvests have ranged from less than 300,000 to over 1.4 million chum salmon over the past twenty years. The 1982 harvest was the largest on record for this species in Cook Inlet[1]. The long term average is approximately 700,000 fish. The sport fish harvest is quite modest, reflecting the rapid decrease in the quality of this species after it enters fresh water.

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[1] Preliminary data. ADF&G Region 2 Commercial Fish Division.

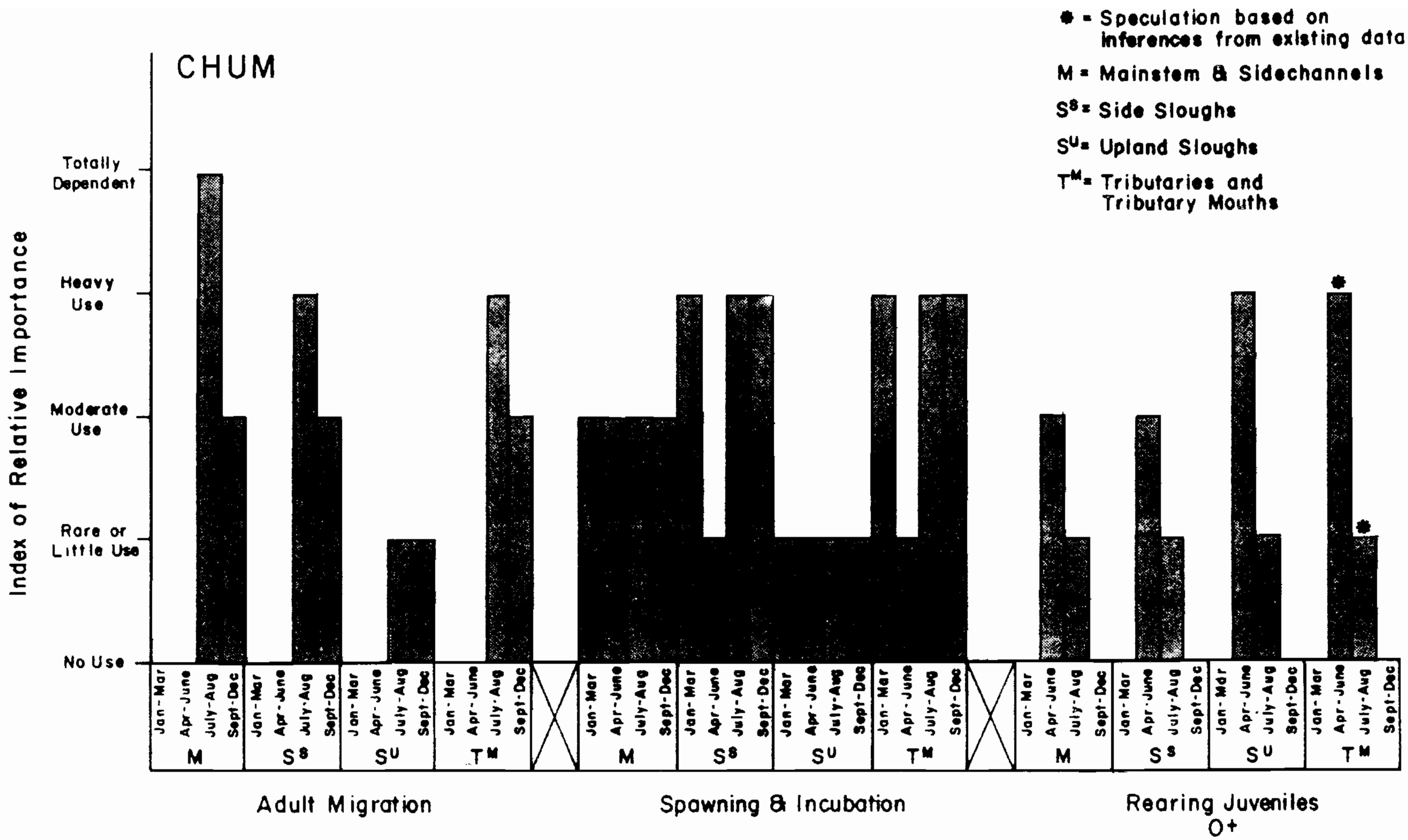

Figure 2-13. Seasonal use of macro-habitat by chum salmon above the Chulitna River confluence (RM 98.5). Data summary from ADF&G (1983a, 1983b).

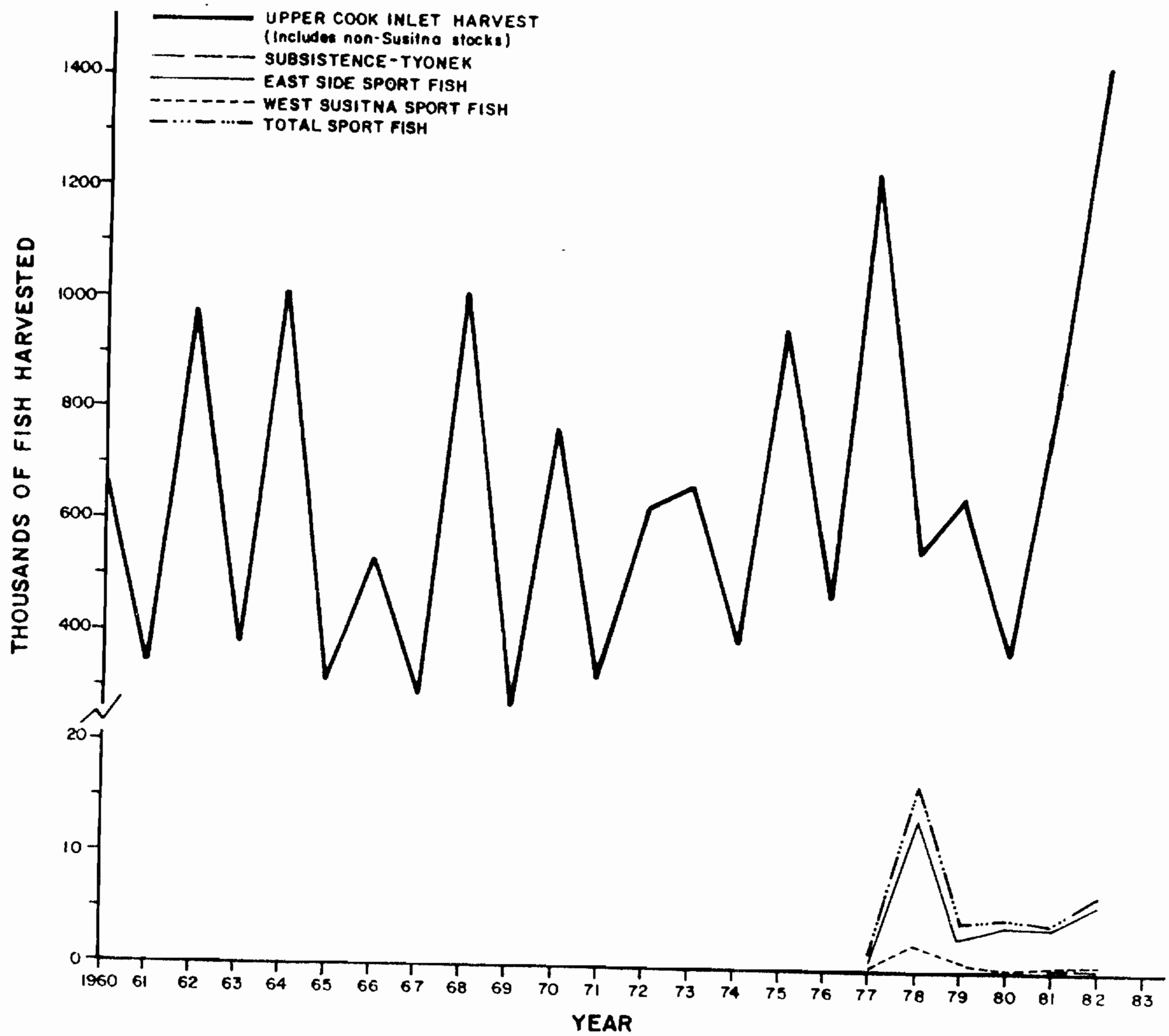

Figure 2-14. Harvest summary of Cook Inlet and Susitna River chum salmon stocks. Harvest data from ADF&G (1981f) and K. Florey (Personal communication, ADF&G, Anchorage), subsistence catch data from Foster (1982) and sportfish catch data from Mills (1982). Data from 1982 are preliminary.

2.4.1.2 Adult escapement

An estimate of the escapement of chum salmon into the Susitna River is not available. An escapement estimate was produced from the 1981 and 1982 Su-Hydro studies by combining the sonar counts at the Yentna River station with the Petersen estimates at Sunshine station. This provided an estimate of 458,500 chum for 1982 and 283,000 chum for 1981. This estimate excludes the tributaries between river mile 6 and river mile 77 with the exception of the Yentna River.

Petersen estimates for each of the sampling sites and the escapement estimate from the Yentna sonar site are depicted in Figure 2-15. The numbers of chum passing the Sunshine station are very large, with approximately 50,000 chum salmon escaping up the Susitna River and its tributaries above the Chulitna confluence.

2.4.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle (upstream migration, passage and spawning)

As with the other species, chum salmon upstream migratory movements can be influenced by the effects of mainstem discharge. Because this species spawns in clear water tributaries, sloughs, and some of the turbid water side channels of the mainstem, a broad array of chum habitat conditions may be affected by mainstem discharge changes.

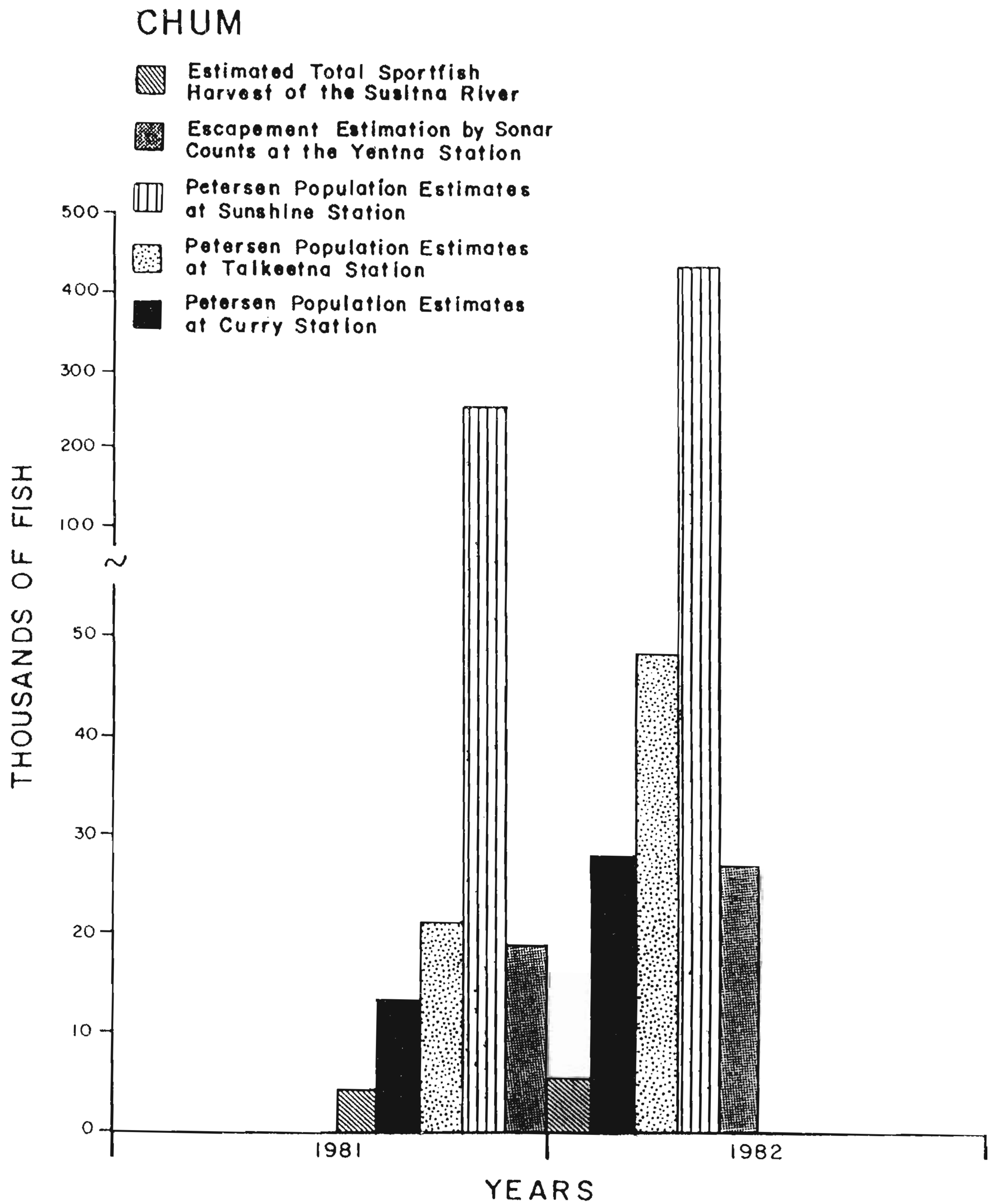

Figure 2-15. Summary of the population estimate and sportfish harvest for adult chum salmon within the Susitna River. Sportfish harvest data from Mills (1982) and escapement and population estimates from ADF&G (1983a).

2.4.1.3.1 Discharge, water quality, and temperature relationships with the adult chum salmon migration

The chum migrations in the Susitna have a minor correlation with discharge; apparently, short duration high water periods cause a decrease in migration rates. This observation is based on both the 1981 and the 1982 data (ADF&G 1982; Appendix B).

Because the mainstem temperature during the chum migration varied inversely with discharge, the effect of cold water, as well as the discharge, may be a factor in decreasing upstream migration.

Access into the tributaries for chums is similar to other species and has been evaluated by Trihey (1983). No access problems at Indian River and Portage Creek are anticipated under a wide range of flow conditions.

Chum were observed at eight streams above the Chulitna River confluence in 1982. Portage Creek, Indian River, Lane Creek and Fourth of July Creek had the largest chum salmon survey index counts. Little Portage Creek, Skull Creek, Fifth of July Creek, and Jack Long Creek also had chums present during the surveys. The tributary and the slough index counts provide only relative abundance of the fish during peak spawning periods. Absolute numbers or percentage of the escapement using the different habitat types have not been determined.

Because of the use of sloughs by this species, much of the analysis has concentrated on passage by adult chums into these areas (Appendix B).

Chums were observed in 17 of 34 sloughs surveyed in 1982. The greatest numbers were recorded at Sloughs 21, 11, 8A, and 9, with over 80 percent of the slough index counts occurring in these areas. The effects of discharge on access into the sloughs are portrayed in Appendix Table B-2.

The low water year of 1982 compared with the relatively high water year of 1981 provides an opportunity to compare the effects of discharge during the spawning season on index counts in the representative sloughs and over the remainder of the river in general (Appendix B). The estimated chum escapement in 1982 was 2.4 times greater past Talkeetna Station than the 1981 escapement counts. Three-hundred-thirty-four fewer salmon were counted in the sloughs in 1982 than in 1981, despite the much larger total escapement estimate. Tributary streams, not affected by the low mainstem discharge, had much higher counts in 1982 than in 1981 in the index areas surveyed.

The numbers observed spawning in the sloughs versus the escapement, the distribution of fish within the sloughs, and their response to the short term changes in discharge (fish remaining in the sloughs during the September high water period were able to move further upstream) provide abundant evidence that some habitat was unavailable and the flows of 1982 had an adverse affect on the success of slough spawning chums.

The effects of discharge on slough-spawning chum salmon have also been evaluated using the IFG-IV model for three sloughs that were studied intensively (Appendix D).

2.4.1.3.2 Substrate type associated with spawning

Because of the limited range of calibration of the hydraulic modeling, the analysis is limited to only those conditions that were present when the data were collected. An examination of substrate availability versus utilization, in the intensively studied sloughs, is described in Appendix C. Substrate quality and quantity ultimately affect spawning success and is probably a major factor in the behavioral selection of redd sites by spawning chums. The modeling results described in Appendix D suggest a decided preference for certain types of substrate.

As with sockeye, this analysis can be used for determining the effects of short term flood events on the substrate. Because of accumulated sediment, occasional flushing flows may be required to clean spawning gravels. However, such floods occurring after the eggs are deposited, may decrease survival. In the case of high flood flows, the substrate may be removed completely, leaving only armored cobble, unsuitable for spawning. This information, combined with the other environmental parameters, should provide an indication as to the conditions that will be necessary to develop possible mitigation for salmon losses associated with the project as well as determining potential uses of other segments of the mainstem Susitna or its side channels under alternative project flow regimes.

2.4.1.3.3 Other physical and biological constraints on spawning success

Other factors may also limit the success of spawning chum. As with sockeye, predation by bears, gulls, and eagles will probably increase as the discharge decreases, because of limited cover. Ice processes and summer floods strongly affect the morphology of the sloughs and side channels, in addition to affecting substrate stability. These processes probably remove beaver dams from the sloughs and side channels and help maintain the spawning conditions at these sites. Virtually all sloughs that have no upper berm that is occasionally overtopped (upland sloughs) have very limited or no spawning by chum salmon or other salmon species. Beaver dams probably create passage problems in addition to causing local sedimentation and decay in the quality of spawning gravels. The beaver dams on Slough 8A appeared to create access problems during the 1982 chum migration.

2.4.2 Incubation and emergence phase of life cycle

The incubation of chum salmon embryos extends from deposition of the eggs in September to alevin emergence from the gravel in mid-April to June. The studies of the effects of environmental variables are currently ongoing and the results will be presented in the upcoming winter report.

Initial observations have indicated that winter overtopping of sloughs may adversely affect intragravel temperatures and subsequently retard development rates and increase embryo mortality. A parallel laboratory study on the effects of temperature on development rates is being conducted by the U.S. Fish and Wildlife Service.

2.4.3 Juvenile rearing and migration phases

The rearing of juvenile chums was first observed in the upper Susitna slough habitats during the summer of 1982. Our field collection program provided information on the distribution and relative abundance of this species which had previously had limited sampling. The first two or three months after emergence may be spent in freshwater and significant growth may occur. The amount of fresh water growth may influence long term ocean survival and subsequent run returns. The juvenile chum studies attempted to establish the distribution and outmigration timing of this species and to determine the influence of mainstem discharge on habitat quality.

2.4.3.1 Relative abundance of juvenile chum salmon

During 1982, the use of beach seines and electrofishing gear, in addition to the minnow traps, provided much more information than in 1981 as to the distribution and relative abundance of juvenile chum salmon. Chum juveniles were collected at all sampling sites above the Chulitna River confluence except for Portage Creek. All sites sampled before the first of July in the reach of river below the Chulitna confluence also had chums present except for Rabideux Creek and Whitefish Slough which were not sampled until after July 1 (Figure 2-16).

The outmigrant trap provided information on the relative timing of the outmigration. However, the data suggests that the peak outmigration may have occurred prior to the installation of the trap on June 18th (Appendix H, Appendix Figure H-4). Numbers of outmigrants peaked about the time of installation and rapidly decreased after this time. Comparison of the length of the juveniles collected at the onset of the traps operation with the juveniles collected toward the end of the observed outmigration, suggests that significant fresh water growth is occurring above the Chulitna confluence reach of the Susitna.

2.4.3.2 Habitat and environmental factors associated with the juvenile phase of the life cycle

Juvenile chum spend as much as three months in freshwater, prior to outmigrating. The rearing opportunities in the Susitna River estuary may be quite limited because of the high turbidity, thus suggesting that fresh water rearing in the mainstem Susitna and its sloughs could be important for this species. These habitats may act as a substitute for rearing habitat associated with estuaries usually utilized by chum during their initial growth phases before migration into the deeper water ocean environments. Although we have limited data which support this hypothesis, observations of juvenile chums within the slough environments in the upper and lower portions of the river suggest this rearing habitat may be very important for the population.

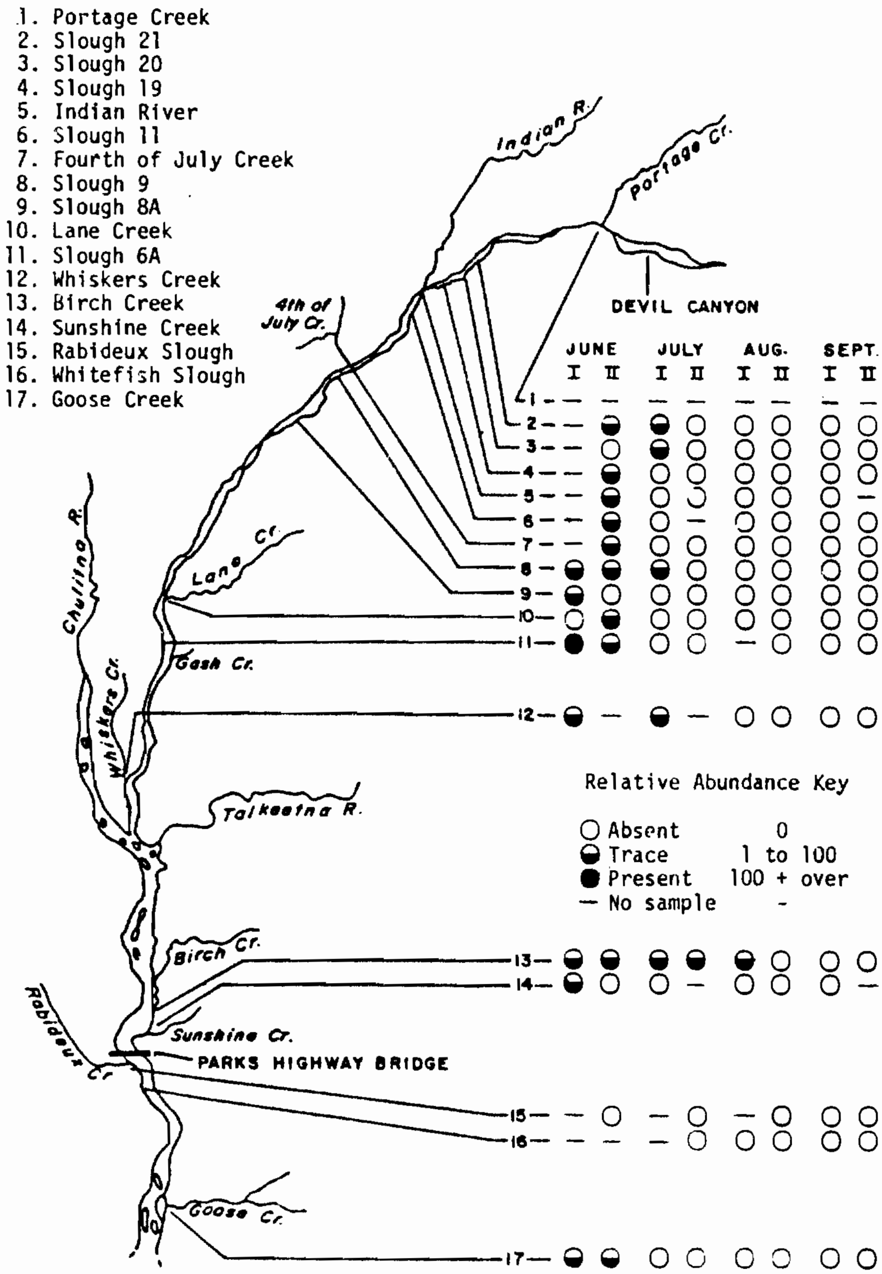

Figure 2-16. The seasonal variation in distribution and relative abundance of chum salmon juveniles at DFH sites on the Susitna River, June through September, 1982. Taken from ADF&G (1983b).

2.4.3.2.1 Physical habitat conditions of rearing juveniles

The 1982 sampling program was designed to provide distributional data on the chum juveniles and to test specific hypotheses as to what factors influence their distribution. The rationale for development of the study design has been described earlier for chinook juveniles and applies equally to the evaluation of the habitat for chum rearing.

Discharge (velocity and depth) relationships and their effects on indices of available habitat

An analysis of the effects of discharge on the usable wetted surface areas of selected sloughs and tributary mouths is described in Appendices E and F. The response of habitat to discharge is limited to the confines of the study design and the study sites described. These study locations were selected because of logistical convenience, in addition to being important for juvenile rearing.

The response of the habitat index to mainstem discharge for chums at these sites is illustrated in Appendix Figures F-13 to F-15. The pattern observed at these sites suggests that juvenile chums prefer lower velocity areas, and are most often associated with the backed up regions near the mouths of the sloughs and clear water tributaries. The distribution of chums, during the June and early July samplings, paralleled that of sockeye salmon so that much of the discussion on sockeye rearing applies to this species as well. Passage into the downstream sloughs and backwater areas after the juveniles leave this natal area may be influenced by the discharge and associated stage of the mainstem. Slough 6A had high concentrations of juvenile chums, even though minimal chum spawning occurred there. As with sockeye juveniles, this may reflect the combination of quality rearing habitat and efficient passage into these areas.

This analysis has provided a general method of estimating chum juvenile habitat availability under a limited range of mainstem flows. The advantages and disadvantages of this method for describing the changes in habitat availability have been described in the chinook juvenile section.

Water quality and thermal relationships

Water quality may have important effects on the rearing habitat used by juvenile chum salmon (Appendices F and G). Chum were found in both clear and turbid water. The concentrations of chum usually followed the numbers of spawning adults. Slough 6A, which had significant concentrations of rearing juveniles during June, also has very high cover, easy access, and non-glacial water, although the tannin staining provides some cover. Although not quantified, the juvenile chum appeared to be found in schools in clear water whereas in turbid area they appeared to be much more broadly distributed as individuals. This type of behavioral influence has been described for pink salmon in the Fraser River Estuary in British Columbia (Vernon 1966).

Temperature is another habitat component that may influence rearing habitat. In areas where a thermal contrast occurred, no obvious influence on distribution was apparent (Appendix F).

2.4.3.2.2 Timing of outmigration from the tributaries, sloughs and mainstem and its relationship to environmental changes

The timing of outmigration for juvenile chum salmon is apparently much more keyed to the time of year or associated daylength than with the other species (Appendix H). The species must migrate to the ocean within a limited period after its emergence for successful development. Changes in growth and development may affect this process and the tolerance of the fish to salt water is affected (Iwata 1982). Access to the mainstem Susitna may be affected by very low water levels in the spring. Fish have occasionally been observed to be trapped in land locked pools.

Data currently available have indicated that at least a portion of the populations rear in the sloughs of the Susitna and outmigrate during the first two weeks of June. Insufficient data were obtained to correlate environmental conditions with the outmigration of this species.

2.4.3.2.3 Food supply for rearing juveniles and its relationship to other parameters and preference dependency of species in the system

Only limited observations on the food habits of rearing chum were made. The few stomachs analyzed from juveniles collected during the 1982 field season, suggest that the fish are actively feeding and that Chironomids may be the primary food item (ADF&G/Su Hydro unpublished data). Because the survival of this species in the Cook Inlet area may be keyed to fresh water growth, further study of the availability of food sources and the dependency of chum on these food sources would be desirable.

2.4.3.2.4 Predation and cover relationships

As discussed for the other rearing species of salmon, cover appears to be an important factor for juvenile chums. This may affect the predation on juvenile chums.

2.5 Pink salmon

Pink salmon, otherwise known as humpback salmon or "humpies", have a two year life cycles which results in distinct odd and even year runs. In the Susitna River, the even year run is the strong run; thus, the 1982 season provided an opportunity to monitor various components of the adult life history. During even years, pink salmon are the most abundant species of salmon in the Susitna River. Figure 2-17 depicts the distribution of pink salmon in the Susitna by life history stages associated with macro-habitat areas in the Susitna River basin.

2.5.1 Adult phase of life cycle

2.5.1.1 Adult harvest by sport and commercial fisheries

The pink salmon of the Susitna River contribute to substantial harvests by both sport and commercial fishermen. A summary of the sport and commercial harvests is presented in Figure 2-18. Harvests of the even year commercial catch have averaged about 1.6 million with odd year averaging less than 10 percent of that number. The commercial harvest fluctuates greatly, even within comparisons of strong and weak year harvests. Even year harvests have varied from over 3,000,000 to fewer than 500,000 fish while the odd year has varied from over 500,000 to a low of 23,000 fish.

The sport catch of pink salmon exceeds that of all other species of salmon combined.

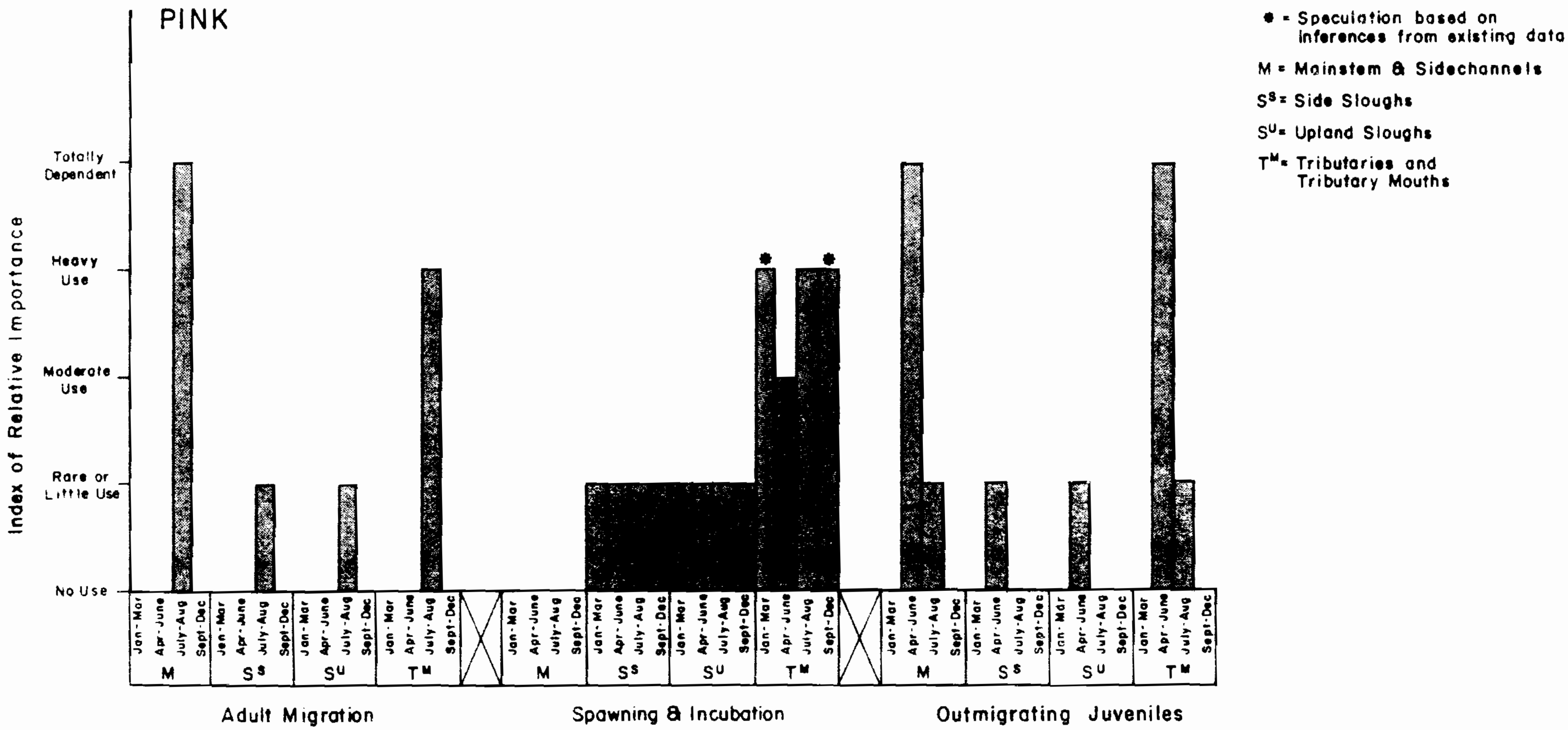

Figure 2-17. Seasonal use of macro-habitat by pink salmon above the Chulitna River confluence (RM 98.5). Data summary from ADF&G (1983a, 1983b).

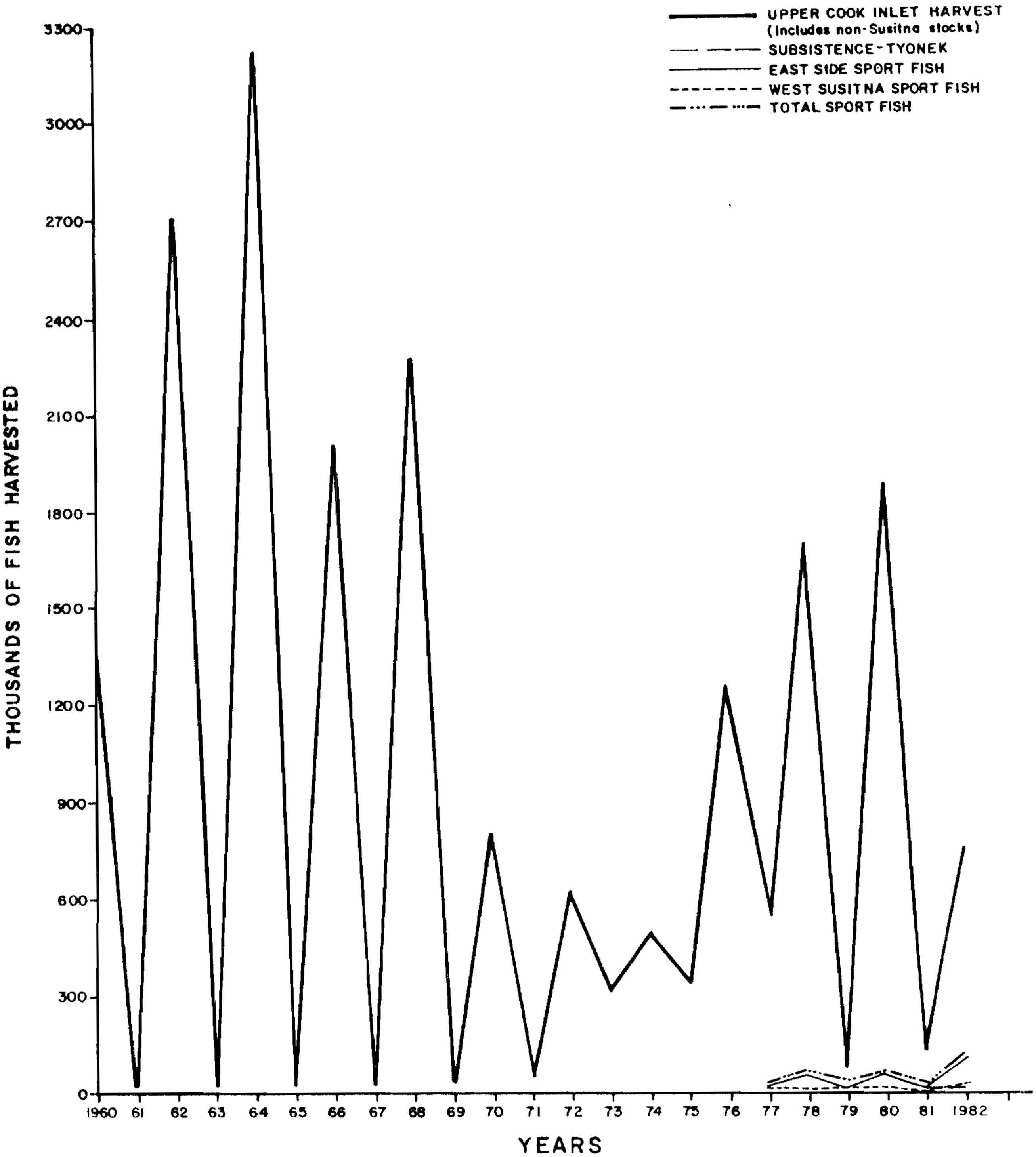

Figure 2-18. Harvest summary of Cook Inlet and Susitna River pink salmon stocks. Harvest data from ADF&G (1981f) and K. Florey (Personal communication, ADF&G, Anchorage), subsistence catch data from Foster (1982) and sportfish catch data from Mills (1982). Data from 1982 are preliminary.

2.5.1.2 Adult escapement

An accurate estimate of pink salmon escapement into the Susitna River is not available. Sonar counts at Susitna Station have provided an escapement index that has been used for management purposes in recent years. An escapement estimate for the Susitna River drainage, that excludes tributary streams below river mile 77 and above river mile 6 with the exception of the Yentna River drainage, has been calculated. The Yentna sonar counts were combined with the Sunshine station Petersen estimates producing a total estimate of 85,600 pink salmon in 1981 and 890,500 pink salmon in 1982 for this portion of the drainage.

Escapement estimates for each of the sampling sites conducted by the Su-Hydro Studies are included in Figure 2-19. These figures use the sonar sites at Yentna Station and the Petersen population estimates at Sunshine, Talkeetna and Curry Stations. Total estimates of 73,000 fish above Talkeetna in 1982 as compared with the 1981 estimate of 2,300 indicate that the even year had a higher proportion of fish using this reach of river then the odd year when compared with the overall Susitna River escapement.

Sonar counts were conducted at Sunshine and Talkeetna, in addition to the estimates obtained by Petersen indices. Differences between the estimates obtained by the Petersen indices and the sonar counts are discussed in ADF&G (1983a) and Appendix A.

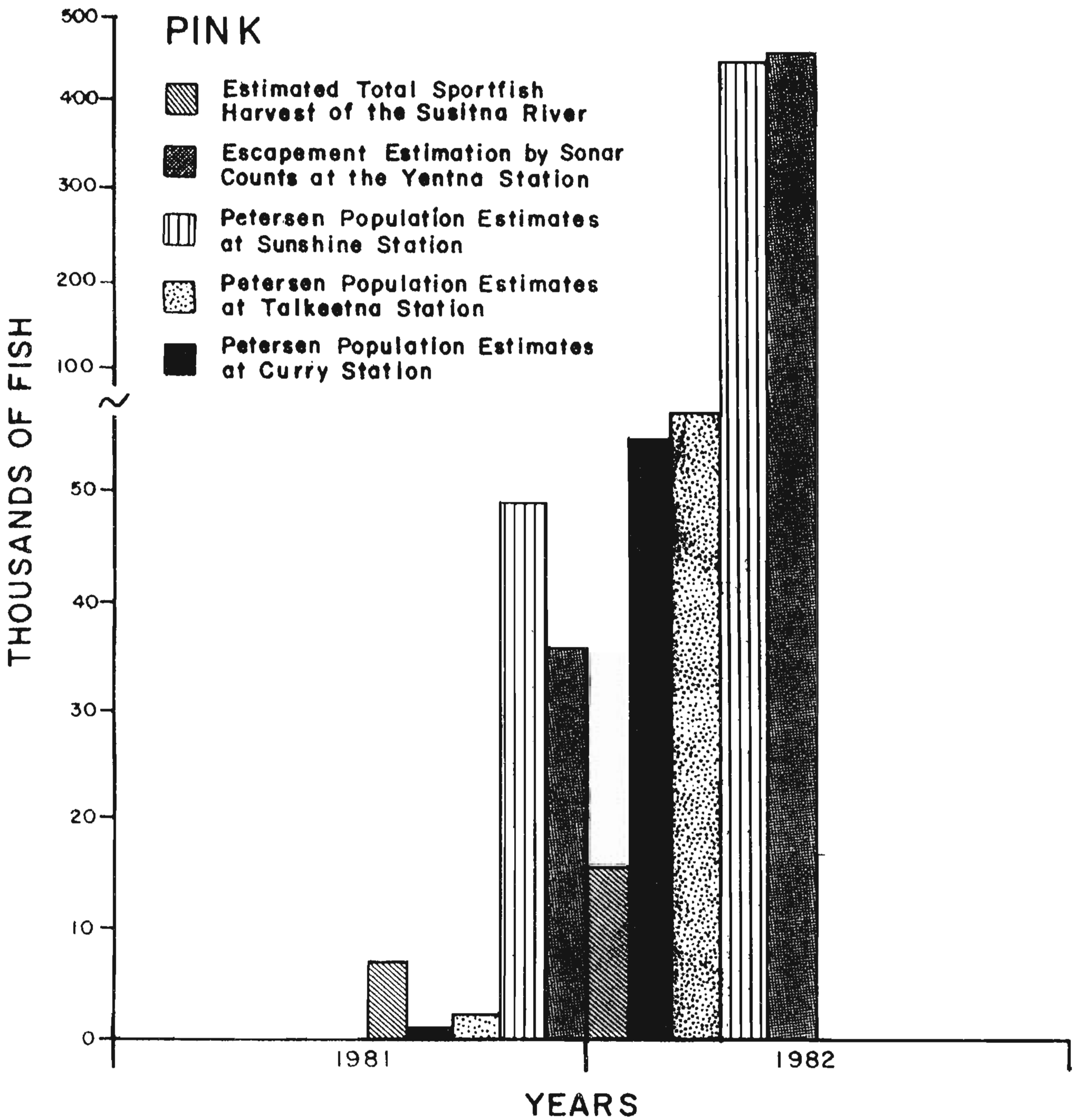

Figure 2-19. Summary of the population estimate and sportfish harvest for adult pink salmon within the Susitna River. Sportfish harvest data from Mills (1982) and escapement and population estimates from ADF&G (1983a).

2.5.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle

As with the other salmon species during the upstream migration in the mainstem Susitna, pink salmon encounter varying environmental conditions, including discharge and temperature variations. As they approach their natal spawning areas, the adult pinks must be able to gain access into the spawning clear water tributaries and sloughs. Pinks spawn primarily in tributaries but limited numbers were observed spawning in sloughs in 1982. Although not as important to the pink salmon population as for the chum or sockeye population, the effects of mainstem discharge on slough passage and usable spawning habitat have some importance to the continued propagation of the species in the Susitna River.

2.5.1.3.1 Discharge, water quality, and temperature relationships with the adult salmon migration

The pink salmon upstream migrations exhibit a minor inverse correlation with discharge as it appears that rapid increases in discharge and perhaps the associated decrease in temperature, decrease the migration rate. All of the adult salmon species were similarly affected.

Access requirements into the major tributaries is similar to the other species and has been evaluated by Trihey (1983). Pink salmon were found in virtually all of the minor tributaries in the Susitna River above the

Chulitna confluence (fourteen in total). Indian River, Fourth of July Creek, Lane Creek and Portage Creek had the highest index counts. Because of the broad distribution of this species, access into the smaller tributaries is also important. Studies of the mouth of some of the smaller tributaries under alternative flow regimes has been conducted by R&M Consultants (R&M 1982).

As previously noted, the clear-water feeder streams support the majority of the pink salmon spawners with sloughs having a minor role. Passage into the sloughs at the various stage levels has been evaluated for those species listed in Appendix B and apply to pink salmon as well. Important sloughs for pink salmon include 11, 20, 21, 6A and 6B. Slough 15, although not assessed, had large numbers of pink salmon present.

An analysis of the hydraulic conditions of Slough 8A, 9 and 21 are presented in Appendix D. Because of the limited use of sloughs by pink salmon, insufficient data were obtained for this species to develop reliable criteria for projecting habitat availability under various flow regimes.

Habitat requirements associated with spawning have not been established for this species because their spawning habitat is generally not associated with the Susitna mainstem. However, such information will be useful to ascertain if adverse effects of the project can be mitigated by development of spawning populations in the mainstem under post-project conditions. The limitations of the existing data base may be partially remedied during the upcoming field season, but the odd year may limit the amount of data collected and not reflect the full spectrum of habitat used by the stronger even year run.

The thermal differences between the sloughs and the clear water tributaries may provide a partial explanation for their apparent preference for tributary habitat. Pink salmon spawn somewhat earlier than other species (except chinook) which accelerates initial development before the winter cold water temperatures begin to retard development rates.

Other factors, such as substrate stability during the incubation period, ice processes, and effective cover during spawning may limit the pink salmon's selection of spawning habitat. The other factors discussed for limitations on mainstem spawning for the other salmon species, apply equally to pink salmon and are not repeated here.

2.5.2 Incubation and emergence phase of life cycle

Because most of the population of pink salmon use the clear water tributaries for spawning and subsequent incubation, little study has been conducted on these phases of the life cycle of this species. To evaluate the potential of the mainstem Susitna under post-project conditions, it is desirable to collect information on the conditions associated with embryo development in the clear water tributaries. Studies of thermal requirements and associated developmental rates of pinks in clear water tributaries are planned for the fall and winter of 1983.

2.5.3 Juvenile rearing and migration phases

Pink salmon usually outmigrate immediately upon emergence from the gravel in the spring and have a very abbreviated freshwater life cycle (Morrow 1980). Most rearing probably occurs during the outmigration through the mainstem and in the lower reaches of the Susitna and its estuary.

2.5.3.1 Timing of outmigration from the tributaries, sloughs and mainstem and its relationship to environmental changes

Studies conducted during the spring of 1983 should provide more insight into the outmigration and emergence of pink salmon. Available data suggest emergence will occur as early as late March and continue through the end of May. The outmigrant trap, which began operation on June 18, collected very few of this species; perhaps outmigration was essentially complete by this time.

Only limited information is available on environmental factors that affect pink salmon development rates during embryo development. Again, ongoing studies should provide more information as to what factors influence this outmigration.

2.5.3.2 Other physical and biological constraints

The freshwater juvenile life phase of pink salmon is rather brief. The major factor affecting freshwater survival after emergence is probably predation by resident fish species or birds. We have no data on the effect of predation on survival of pink salmon juveniles in the Susitna River. However, if a substantial reduction in turbidity of the Susitna were to occur following flow regulation, predation may be accelerated. During the lower flow years on the Fraser River, decreased survival of pink salmon in the estuary was observed (Vernon 1966). Such factors may be equally important in the Susitna River.

2.6 Rainbow trout

Rainbow trout are one of the more important sport fish in the Susitna River drainage. Although not numerous, they are the object of an intensive fishery at areas of local concentrations. Rainbows are normally associated with the clear water tributaries but are found throughout the river. The tributaries of the Susitna River, such as Portage Creek and Indian River, are near the northern-most point of the rainbow trout's natural geographical distribution in North America. Therefore, the species may be very sensitive to environmental changes, particularly with regard to its reproductive cycle.

2.6.1 Adult phase of life cycle

2.6.1.1 Sport fishery harvest

Sport fishing for rainbow trout occurs throughout the open water season. Rainbow trout fishermen in the Susitna drainage generally concentrate their effort at the mouths of clear water tributaries.

The sport fishery for rainbow trout in the reach of river above Talkeetna occurs at Whiskers Creek, Lane Creek, Fourth of July Creek, Indian River and Portage Creek. Information on the extent of the harvest is limited to data available from Mills (1982) and is presented in Table 2-1 for rainbow and all other species of sport fish.

Table 2-1. Summary of resident sport fishery harvest in the Susitna River, 1977-1982.*

Species	Year 1977	1978	1979	1980	1981	1982
Rainbow Trout	13655	18948	23081	20060	21843	19399
Dolly Varden	5824	9148	9518	5771	5911	6214
Arctic Grayling	11883	13325	19578	20206	17110	16272
Northern Pike	132	316	382	232	125	607
Burbot	734	424	881	1073	431	975

* Sport harvest data from Mills (1982) and preliminary 1982 data.

2.6.1.2 Adult population indices

The population information on rainbow trout is derived from relative abundance data collected by electrofishing and trot line catches as recoveries of marked rainbow trout do not provide sufficient information to estimate their abundance. However, the relative magnitude of the population can be estimated with this data. During the 1982 season, 18 of the 195 fish tagged in 1982 and 11 of 206 fish tagged in 1981 were recovered. These data suggest the population is small and perhaps numbers in the thousands. Systematic collection of mark and recapture information over selected reaches of habitat during the 1983 summer, after migratory movement has ended, should provide more precise estimates of local populations.

2.6.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle.

The distribution patterns of rainbow trout and other resident fish are presented in Appendix G. The habitat of the Susitna River has been classified into several major types. These include clear water tributaries, tributary mouths, upland sloughs, side sloughs without major tributaries, side sloughs with major tributaries, and mainstem sites. In addition, the study sites examined most intensively were further sub-divided into zones. The zone classification grouped the collected data into areas influenced by backwater of the mainstem Susitna, areas that had different water sources, and areas that had different water velocities. This analysis is included in Appendix F.

The distribution of rainbow trout followed the expected pattern with tributaries having the highest concentrations and mainstem sites having the lowest. Sloughs were intermediate. The distribution of fish, as indicated by catch per unit effort data, demonstrated a preference for tributary water; the highest concentrations were found in the clear water areas, followed by mixing zones, and the lowest concentrations were in mainstem Susitna water during the open water season. Comparisons of rainbow trout distributions in zones with different velocities, i.e. zones backed up by the mainstem, and zones not influenced by the mainstem, only showed minor differences. This observation agrees with the general distribution of rainbow trout catch data, and reconfirms the close association of this species with clear water tributaries.

During the winter months, rainbow trout apparently move into the mainstem Susitna, as demonstrated by increasing catch rates near the mouths of the clear water tributaries. Radio-tagged fish demonstrate little movement in the mainstem although some downstream migration has occurred during the winter period. The fish appear to concentrate, since catch rates of rainbow at relocation sites of the radio-tagged fish appear to be higher. Further studies of radio-tagged fish are currently in progress and should provide better information on the habitat utilized by this species during the critical overwintering period. Our limited data indicate a possible association with ground water areas which have warmer temperatures and higher levels of conductivity.

2.6.2 Reproductive phase of life cycle and juvenile distribution and abundance

Because of the lack of information on rainbow trout spawning areas in the Susitna drainage, much of this information is inferred from the distribution of juveniles. During the spring, gravid adults have been captured at the mouths of clear water tributaries, such as Fourth of July Creek and Indian River. It is believed that rainbow trout in the Susitna River drainage spawn in the upper reaches of clear water tributaries, although limited investigations in these areas have not documented this event. The numbers of juveniles collected are very few when compared to other clear water spawning species such as Arctic grayling. This suggests that spawning success is low or that the rearing of the juvenile rainbow trout is confined to the tributaries, and not, to any appreciable extent, associated with the mainstem Susitna. Spawning may be a critical factor limiting the northern distribution of this species.

Further investigations of the spawning rainbow trout and of the clear water tributaries are planned during the spring of 1983 and should help resolve this question.

2.7 Burbot

Burbot are common in the mainstem Susitna River and are among the few species that indicate preference for the turbid glacial water. This species is considered a sport fish but the harvest rate is low when compared to its relative abundance in the system. Its apparent preference for glacial water and the possible decreases in turbidity of the upper Susitna River under post-project development has necessitated research on this species.

2.7.1 Adult phase of life cycle

2.7.1.1 Sport fishery harvest

Burbot harvests in the Susitna have been relatively small when compared with other, more popular, species such as Arctic grayling and rainbow trout. A summary of burbot sport fishing harvests is listed in Table 2-1 (Mills 1982). Burbot are primarily harvested by local residents and its flavorful flesh is considered to be of high table quality. The apparent abundance of this species in the river suggests that the current populations could support a higher harvest rate.

2.7.1.2 Adult population indices

Only relative abundance information is available for burbot. Recovery of marked fish during 1982 were limited to three of 265 tagged fish.

Because of their broad distribution, burbot were often caught at mainstem sites. Populations of specific reaches of river have not been obtained, but an intensive mark/recapture program is being initiated in the summer of 1983 to establish reach specific densities. Further discussion of the relative abundance data with respect to macro-habitat differences follows.

2.7.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle

The relative catch per unit effort at the various sampling sites was compared with the macro-habitat conditions at the sites listed in Appendix G. In addition to the habitat conditions within different zones, a further subdivision of the macro-habitat were evaluated for differential catch rates (Appendix F).

As discussed earlier, burbot are primarily associated with the mainstem river and although significant numbers of burbot were taken at tributary mouths by electrofishing methods, this gear type is not as effective in the mainstem habitat and a complete distribution scenario for burbot in the Susitna River is not possible. The distribution by zones suggests a dramatic segregation by habitat with a strong avoidance of clear water. The distribution demonstrates preference for fast water as well as the turbid conditions. On the Tanana River, Mecum (1982) observed a similar avoidance of clear water sloughs and preference for the turbid side channels.

2.7.2 Reproduction phase of the life cycle and juvenile distribution

Habitat conditions associated with burbot spawning have not been established because of difficult winter sampling conditions in the mainstem Susitna. Studies currently under way using radio-telemetry equipment may provide some insight into spawning requirements. Burbot are known to spawn in the winter at the mouths of the larger lower tributaries, such as the Deshka River. This river mouth has relatively deep water and a silt or sand-laden bottom.

Burbot larvae were observed in the Susitna River at several sites above Talkeetna indicating some spawning takes place in this reach. The larvae, collected in June 1982, were associated with the silty, low-velocity areas near the mouths of several sloughs. This suggests that the mainstem Susitna in this region has limited use by spawning burbot. Ongoing studies on the river may provide more insight into the use of the mainstem river and further details on the timing and use of particular habitat conditions by this species.

Intermediate age class fish were collected by the outmigrant trap located 4.5 miles above the Chulitna River confluence. This suggests that rearing burbot as well as the adults use the mainstem. Other than their association with the mainstem, little is known about the specific habitat utilized by the younger age class burbot.

2.8 The Whitefish - Round, Humpback, and the anadromous Bering cisco

Two species of whitefish (Family Coregonidae) are broadly distributed in the Susitna River. The anadromous Bering cisco was found to be present in the Susitna River for the first time during the 1981 studies.

2.8.1 Adult phase of life cycle

2.8.1.1 Sportfishing and other harvests

Although whitefish species are abundant and broadly distributed in the Susitna River drainage, statistics collected by the ADF&G Sport Fish Division indicate that there is little use of these species by sport fishermen. They are, however, utilized by sport and subsistence fishermen in other parts of the State.

2.8.1.2 Adult populations indices

2.8.1.2.1 Round whitefish

Round whitefish were the most abundant of the whitefish species collected in the Susitna River during 1981 and 1982. Catch per unit effort data suggested this species is eight to ten times more abundant than the humpback species. This species is possibly the most abundant resident species occurring in the mainstem Susitna.

2.8.1.2.2 Humpback whitefish complex

Humpback whitefish were collected throughout the study areas but in lesser concentrations than the round whitefish. Although taxonomically complex, the species of humpback whitefish in the Susitna River has been tentatively identified as Coregonus pidschian based on the number of gill rakers observed in a significant sub-sample of specimens. Concentrations of this species occurred near Sunshine Creek and near Portage Creek. Significant numbers were also captured, in September by the fishwheels at Sunshine Station. This indicates a fall upstream spawning migration.

2.8.1.2.3 Bering cisco

Prior to the discovery and identification of Bering cisco in the Susitna River during the 1981 studies, only one confirmation of Bering cisco in Cook Inlet was on record (Morrow 1980). The spawning areas and associated habitat in the Susitna River have now been described.

Although a population estimate of this species was not attempted, over 500 individuals were observed or caught at the spawning areas sampled.

2.8.1.3 Habitat and environmental parameters associated with the adult phases of the life cycle.

The habitat parameters associated with the whitefish species is poorly understood. Because of the lack of economic importance of these species, little research has been conducted on their habitat relationships in northern areas. Even basic life history information is quite limited. For example, the 1982 recapture of a Bering cisco that had been tagged while spawning in 1981, is the only known evidence that this species may be capable of repeated spawning.

Point specific data were recorded for a limited number of spawning sites for these species and are listed in the data reports for 1981 and 1982. The data is most complete for Bering cisco, which were concentrated at the few spawning sites located.

With the exception of burbot and longnose suckers, the whitefish appeared to be more capable of using the mainstem Susitna for rearing habitat. The data suggests that round whitefish migrate into the larger clear water tributaries in the early spring while significant numbers remain in the mainstem Susitna. These mainstem areas are often associated with tributary mouths or clear water sloughs where turbid and clear water mixing occurs.

The humpback whitefish has similar behavior but may also have some of their life cycle associated with the estuary. The small numbers of humpback whitefish catches have precluded obtaining sufficient information on their habitat requirements.

2.8.2 Reproductive phase of life cycle

The majority of the data on spawning habitat conditions has been collected on Bering cisco in the mainstem river. There is also some evidence of round whitefish spawning in the mainstem. Humpback whitefish apparently spawn in the clear water tributaries exclusively, as we did not collect spawned out individuals associated with the mainstem. Most of the upstream migration of humpback whitefish was apparently associated with the Chulitna or Talkeetna drainages, with some spawning in the mainstem or tributaries of the Susitna above the Chulitna confluence.

The hydraulic characteristics for spawning areas used by Bering cisco in 1981 and 1982 near the Parks Highway Bridge, have been described. These data are presented in the basic data reports. Because this species spawns during early October, changes in discharge of the mainstem during freeze-up and during the incubation period could subsequently affect reproduction. Changes in discharge could dewater the incubating eggs while higher velocities could scour the spawning areas. The relatively stable discharges under natural conditions during this period may be indicative of a requirement for successful reproduction of this species.

Sufficient spawning location data to evaluate hydraulic conditions and requirements for the other whitefish species has not been collected.

2.8.3 Juvenile rearing and migration

Substantial numbers of juvenile round whitefish were collected at mainstem sites or adjacent to the clear water sloughs of the Susitna. Throughout the summer of 1982, juveniles of this species were collected by the outmigrant inclined plane trap located 4.5 miles above the Chulitna River confluence.

In August of 1982, substantial numbers of humpback whitefish were also collected in the trap. This species may be anadromous and these catches could be indicative of a juvenile outmigration to the Cook Inlet estuary. Although evidence of juvenile outmigration exists for the other whitefish species, we do not have evidence of riverine rearing or juvenile outmigration for Bering cisco. Instead, it is believed that the young of this species outmigrate as larvae and rear in the Cook Inlet estuary.

The habitat requirements for juveniles of all three species are poorly understood. Although significant numbers have been collected at mainstem sites, they appear to concentrate near the sloughs and tributary mouths.

2.9 Eulachon

Eulachon are probably the most abundant species of fish that occur in the Susitna River drainage. They currently are not significantly exploited but may be very important in the estuarine and pelagic environments as a food item for other species of fish and sea mammals (other investigations are cited by Hart 1973).

2.9.1 Freshwater reproductive phase of life cycle

The Susitna River has two runs of eulachon. In 1982, the first run began in mid May and the second run began on June 1st. The runs progressed rapidly and were essentially over by June 8th. The runs extended upstream in the mainstem Susitna to river mile 48.5 with most of the spawning occurring between river mile 8.5 and the Yentna River confluence.

2.9.1.1 Sport fishery harvest

Eulachon are not heavily exploited. Observations of the sport fishery during the spring of 1982 indicated that the primary effort occurs between river miles 10 and 30. Field personnel estimated that several thousand eulachon were harvested during this period. There currently is no commercial harvest.

2.9.1.2 Adult escapement

The populations of eulachon are very large in the Susitna River and are believed to be composed of millions of fish. Large accumulations of carcasses several feet deep were observed to extend over hundreds of feet, after spawning was completed. Although this species is capable of repeated spawning, mortality rates after the 1981 and 1982 runs observed by ADF&G biologists were apparently very high. Much of the information presented in the (ADF&G 1983a) data report is the first information recorded on the distribution, abundance, and habitat used by this species in the Susitna River.

2.9.1.3 Habitat and environmental parameters associated with spawning

The runs entered the Susitna River apparently without any obvious correlation with water temperature or tidal stage. The species appears to utilize only the mainstem Susitna and the Yentna River before spawning. This species apparently uses a broad range of habitat conditions with the moderate velocity areas being preferred. Spawning takes place in water depths of a few inches to greater than four feet. Substrate varies considerably, but areas of sand and gravel or silt and gravel sites are preferred.

The data base for evaluation of habitat requirements for eulachon is small since this was the first year this species was studied. Further information will be collected during the 1983 spring investigations.

2.9.2 Juvenile emergence, rearing and migration

The juvenile portion of the life cycle and outmigration has not been studied and all information on this subject must be inferred from the timing information obtained on the adult spawning run.

Eulachon eggs hatch in 20 to 40 days (Hart 1973), depending upon the water temperature. Shortly after hatching the young passively migrate as larvae to the Cook Inlet estuary where they rear. The rearing phase of the life cycle is entirely in the estuarine environment (Morrow 1980) which indicates the larvae would be out of Susitna River by mid-July of each year.

2.10 Miscellaneous game species (Arctic grayling and Dolly Varden)

Arctic grayling and Dolly Varden are two common species in the Susitna drainage which are the target of a sport fishery at clear water tributary mouths. Grayling are common above the Chulitna confluence and are frequently caught by sport fishermen. Dolly Varden are common in the Talkeetna River and the Susitna River downstream of the Talkeetna River confluence.

2.10.1 Adult phase of the life cycle

2.10.1.1 Sport fisheries harvest

Harvest data for grayling and Dolly Varden have been compiled by Mills (1980) using data from the statewide angler surveys (Table 2-1). Observations of harvest above the Chulitna confluence indicate grayling are the most commonly caught resident sport fish in this area and rainbow trout are also frequently caught. The sport fisheries are primarily restricted to Indian River, Portage Creek, Lane Creek, Fourth of July Creek and Whiskers Creek, although some harvest occurs at other small tributaries. Dolly Varden are rarely caught in this area as reflected in the relative abundance data presented in the data reports. In the Susitna below the Chulitna confluence, sport fisheries occur at most of the clear water tributaries for both species. Dolly Varden are much more common in this lower area.

2.10.1.2 Adult population indices

The relative abundance of grayling and Dolly Varden have been described in the data reports for 1981 and 1982. Electrofishing in the mainstem and clear water tributary mouths in both reaches indicated migratory movements of both species during the spring. Grayling were also abundant in the fall. Limited sampling in the lower river in the fall of 1982 was probably the reason a similar trend was not observed for Dolly Varden. This data infers that the mainstem Susitna is used by these species from September until the second week in June.

2.10.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle.

The distribution of grayling in macrohabitat areas associated with the mainstem Susitna is reported in Appendix G. Adult grayling were most often associated with the mouths of the clear water tributaries. These areas were essentially, extensions of the tributary during the summer months. The mainstem Susitna was much more important to the younger age classes in the open water season. Since few Dolly Varden were collected above the Chulitna confluence, very little quantitative data was obtained for this species on this reach. They appear however, to follow a pattern similar to the distribution of grayling with migratory movements up the clear water tributaries in the spring and back down in the fall. As this species is known to be a predator on salmon juveniles and salmon eggs, their distribution may be more closely associated with the salmon distribution than the specific environmental conditions. A stunted form of this species resides in the upper areas of the Indian River, Portage Creek and tributaries of the Susitna above Devil Canyon. We have very little data for this stunted form of the species but they appear to be broadly distributed but not abundant. Their habitat requirements are not known. Details of their observed distribution are discussed in the impoundment area data reports.

2.10.2 Reproductive phase of the life cycle

Habitat conditions associated with the spawning of these species have not been established because spawning occurs in the clear water tributaries. Apparently mainstem conditions and the habitat in the sloughs is inadequate for their successful reproduction. The presence of juveniles of both species in the reach of river above the Chulitna confluence suggests successful reproduction does occur in the clear water tributaries in this portion of the Susitna basin.

2.10.3 Juvenile rearing and migration

Juvenile grayling were frequently collected at the mouths of clear water tributaries in addition to mainstem areas which suggests that during the summer months suggest the mainstem is used by this species for rearing of juveniles. The larger fish may occupy the better rearing habitat in the clear water tributaries while the younger age class fish are displaced into the mainstem Susitna. The distribution of juveniles in the mainstem areas were generally at areas of lower velocity.

Juvenile Dolly Varden were collected in insufficient numbers to suggest any trends or hypothesis as to habitat relationships.

2.11 Other species of the Susitna River drainage

The Su-Hydro Aquatic Studies have concentrated on species with significant commercial or sport fishery harvests and on other species that have important biological considerations. The following species to be discussed often are abundant but existing information indicates they have broad environmental tolerances or are rare in the Susitna River habitats that may be affected by the development of the hydroelectric project. These populations could become more important if conditions were to develop under post-project operation that benefit these species to the detriment of the species that are of more economic importance. We currently lack enough information on these species to predict responses by their populations to altered environmental conditions.

2.11.1 Threespine stickleback

Threespine stickleback are most common in the Susitna River below the Chulitna River confluence. Large numbers upstream of the confluence were collected in the vicinity of Whiskers Creek and associated slough in 1981; the 1982 catch data for this reach was much less. The reason for this difference is not known, however the high water during 1981 may be related to the decreases in population. As threespine stickleback may be competitive with rainbow trout or sockeye salmon juveniles, increases in numbers may not be desirable. If the above hypothesis is true for the Susitna River habitats, stabilization of flows could cause substantial increases in numbers, particularly above the Chulitna confluence. Migratory movements during the spawning period for this species suggests they are able to redistribute quite easily. The outmigrant trap catch rates for threespine stickleback in August and September indicated that large number migrate into the lower river upon the onset of winter. Observations in May, 1983 of very large upstream migrations of threespine stickleback in the lower Susitna River suggest that the anadromous variety of this species occurs in the Susitna River drainage.

Factors which affect the abundance of this species are poorly understood. Monitoring of the threespine stickleback population with corresponding measurements of mainstem discharge and associated habitats appears to provide the best method for estimating their longterm responses to discharge variations in the Susitna mainstem.

2.11.2 Longnose suckers

This species is broadly distributed in the mainstem Susitna and utilizes turbid water environments. They are also associated with clear water tributaries as are almost all of the species that occur in the system. Because of their relative abundance, we have collected data associated with their rearing habitat for both adults and juveniles. The spawning areas that have been characterized were associated with the mainstem Susitna. Longnose suckers are broadly distributed and are found in the mainstem Susitna above Devil Canyon. Juveniles have been collected in large numbers in the clear water sloughs above the Chulitna confluence. One unusual finding was the presence of male longnose suckers in spawning condition in the fall. This species is generally considered to be a spring spawner and the presence of ripe males in the fall was unexpected (Morrow 1980). Spawning was not observed and whether ripe males overwinter in this condition or a fall spawning population exists is not known.

2.11.3 Arctic lamprey

Arctic lamprey were not collected in large numbers; however, because the collection methods used were not effective for this species. The species is broadly distributed in the Susitna River with the largest numbers observed below the Chulitna confluence. There appears to be an anadromous form as well as a resident form of this species in the river. Size is used as the primary criterion in distinguishing these forms (Morrow 1980). We did not obtain any evidence of Arctic lamprey being parasitic on other freshwater species collected. Spawning is thought to occur in the clear water tributaries above the Chulitna confluence as concentrations of ammocoetes were collected at Gash Creek and Whiskers Creek. Spawning was observed and habitat conditions recorded in Birch Creek Slough. Other than the distribution associated with collection of adults and immature fish, little information has been obtained on the habitat relationships of Arctic lamprey. Morrow (1980) concludes that there is little information indicating that this species has significant importance to man.

2.11.4 Slimy Sculpin

The slimy sculpin is broadly distributed in the Susitna River basin. This species is common in the clear water tributaries and often appears to be abundant. Lesser numbers are also found in turbid water mainstem environments. This species is almost entirely insectivorous but its feeding habits confine it to bottom organisms and it probably does not compete with salmonids. Morrow (1980) suggests that when large numbers occur they could compete with salmonids although this has never been documented.

We have observed what appears to be a displacement of salmonids in micro habitat areas of the sloughs and clear water tributaries. Riffle areas of moderate velocity that had high numbers of sculpins, usually had few or no chinook juveniles. Peripheral areas with more depth and cover had high concentrations of juvenile chinook. Wangaard (personal communication) observed in the Kenai river, what appeared to be territorial defense by slimy sculpin toward juvenile chinook when they would approach the substrate over which sculpin were feeding. Other than the general distribution of this species in the macro-habitat areas sampled, we have not clearly defined habitat relationships. Their broad distribution suggests that they would not be particularly sensitive to changes in their environment but that local populations might be affected.

2.11.5 Other species

Northern pike is the only other species collected during the course of the Su-Hydro investigations. One northern pike was collected in the lower river in Kroto slough in 1981 and one was captured at the Yentna fishwheel site in 1982. This species has recently become established in the Yentna drainage. The distribution of northern pike may be expanding which is not considered desirable because of the predation potential on salmonids. This was the first record of this species in the mainstem Susitna.

There are probably several other species, not collected by this program, which are present in the river near the estuary. These include the Pacific lamprey, nine-spined stickleback, other species of sculpin, starry flounder, and other species of smelt (Morrow 1980).

3. THE FISHERIES STUDIES WITHIN THE BOUNDARIES OF THE PROPOSED IMPOUNDMENT ABOVE DEVIL CANYON

Studies conducted during 1981 and 1982 above Devil Canyon have been directed at estimating the populations of resident species in the clear water tributaries within this region and of certain portions of the mainstem Susitna within the impoundment zones. This information has been used to estimate the exploitation rate that these streams are capable of sustaining by sport fisheries.

3.1 The fishery resources of the clear water tributaries of the impoundment zones

The fisheries studies over the 1981 and 1982 period have concentrated on the Arctic grayling population associated with the clear water tributaries of the impoundment. These streams are essentially unexploited and offer high quality sport fishing.

The studies included surveys for salmon that have ascended Devil Canyon. Salmon have been documented above the first rapid in Devil Canyon but none have been observed above the rapids below Devil Creek, the uppermost rapids in Devil Canyon.

Other studies included investigations of mainstem habitats and fish populations in Sally Lake. This small lake lies in the Watana Creek drainage and will be inundated by the Watana impoundment.

3.1.1 Population estimates or indices of species present within the clear water tributaries.

Grayling population estimates for reaches of clear water tributaries within the impoundment zone are summarized on Table 3-1. Insufficient data were obtained on the other resident species for population estimates. Estimates of densities of fish have not been obtained for the mainstem Susitna, although the mouths of the clear water tributaries were included in the estimate on Table 3-1.

The grayling populations were calculated for the month of July only based on the August recaptures. Grayling are relatively non-migratory at this time so the estimates provided are indicative of the population densities that occur within specific reaches during the summer.

3.1.2 Population dynamics and harvest effects on grayling in the tributaries

The primary collection technique used for sampling Arctic grayling was hook and line. The high velocity and low conductivity of waters in this area precluded sampling by electrofishing. The catch rates and selectivity of the gear provided the opportunity to analyze the potential effects of incrementally increasing sport fishing on the Arctic grayling populations. This analysis is presented in Appendix I. The Arctic grayling population, under the assumptions of this model, demonstrated a susceptibility to fishing pressure with the larger fish

Table 3-1. Arctic grayling population estimates by tributary habitat evaluation location, Proposed Impoundment Areas, 1982.[e]

Location	Population Estimate[a]	Grayling/ Mile	Grayling/ Acre
Oshetna River	2426	1103	56
Goose Creek	949	791	90
Jay Creek	1592	455	101
Kosina Creek	5544	1232	69
Watana Creek	3925	324	44
Deadman Creek[c]	734	1835	273
Tsusena Creek[d]	1000		
Fog Creek[d]	176	440	
Totals	16,346	664	

[a]correction factor included.

[b]95%.

[c]Includes only that part of Deadman Creek below falls.

[d]1981 estimates.

[e]From ADF&G (1983d).

quickly disappearing from the population under relatively low levels of fishing pressure. The maximum sustained yield, in terms of numbers of fish caught and kept, is approximately four times the level of effort expended by ADF&G crews during July of 1982. This model also demonstrates that the initial years of harvest will provide a relatively high level of catch before the population becomes stabilized at the maximum sustained yield harvest level. The catch per unit effort of the sport fishermen can be expected to decline accordingly following the initial years of harvest.

The onset of construction and the influx of 3,000 or more construction workers and the opening of the area to the public by the construction of access roads, will result in substantial increases in fishing pressure on these streams. Depending on regulations and access control, this model can be used to evaluate the probable effects of the fishing pressure change on the grayling populations in the system and can suggest some type of mitigation strategy.

3.1.3 Relationships of growth, population, and production data to general and site specific habitat variables.

The Arctic grayling growth rates in the impoundment do not vary appreciably between tributaries although the rate of growth of Arctic grayling varies among individuals. Statewide, the mean rates appear to decrease as one goes north in latitude (Armstrong 1982). This suggests that the length of the open water season probably affects growth rates more than other variables. A more complete description of growth of

Arctic grayling is presented in Appendix J. The Arctic grayling in the impoundment also have significant migrations between tributaries, suggesting that the populations are not distinctly separate and can be pooled for analysis.

An examination of the habitat variables and variations among the tributaries examined is presented in Appendix K. These factors are most likely affecting the densities observed rather than the growth rates of the fish. The territorial behavior of this species probably influences the numbers of fish that can occupy suitable habitat and the availability of this habitat determines the densities of fish in the system.

3.2 The fishery resources of the mainstem Susitna within the impoundment zones.

The mainstem river primarily serves as a migratory corridor for Arctic grayling but supports populations of burbot, round and humpback whitefish, longnose suckers, and cottids. This habitat also is apparently the overwintering area for the impoundment tributary populations.

Juvenile Arctic grayling were found in sloughs of the mainstem Susitna but quantitative information as to significance of these findings were not obtained. The trend of juveniles and younger age class fish being associated with the mainstem in the lower river below Devil Canyon may well be true in the impoundment.

The mainstem population structure of burbot in the impoundment appears to resemble that of the lower river. No quantitative information on the density of the species in the mainstem is currently available.

The overwintering study is currently in progress and will be described in a separate report. Only limited data have been obtained although it appears that all fish monitored by radio-telementry migrated into the mainstem Susitna to overwinter.

3.3 The fishery resources of the lakes within the impoundment zone.

Sally lake lies on a bench above Watana Creek and is entirely within the impoundment zone. Our studies have indicated a population of Arctic grayling and lake trout in this lake. The Arctic grayling are the most abundant although insufficient data were obtained to estimate the populations. The number of Arctic grayling and lake trout in Sally Lake are probably small, varying from a few thousand to several hundred respectively.

Several other small lakes are also found in the impoundment zone. These lakes have not yet been studied. Investigation of these lakes are planned in the upcoming summer.

4. SUMMARY OF THE INSTREAM FLOW RELATIONSHIPS OF THE FISHERIES RESOURCES DOWNSTREAM OF DEVIL CANYON

4.1 Introduction

The studies of the major habitat types of the Susitna River below Devil Canyon are summarized in this section of the report. The habitat characteristics which are presented in this summarization are only those which are likely to be influenced by mainstem conditions (namely discharge, water temperature, and turbidity) and likely to impact upon fish populations.

The studies downstream of Devil Canyon to the Chulitna confluence (referred to here as upper river) and the findings below the Chulitna confluence (referred to here as lower river) are discussed separately. These reaches differ in physical and biological characteristics, and in the anticipated impacts of the proposed hydroelectric development. Our level of understanding is much more refined above the confluence than below due to the greater level of information available.

4.2 Key findings of fisheries studies downstream of Devil Canyon to the Chulitna confluence

4.2.1 Principal instream habitat types

The principal instream habitat types occurring in this reach of the Susitna River drainage are the mainstem, side channel, side slough, upland slough, tributary, and tributary mouth habitats. Volume 4 of the Basic Data Report describes and defines these general habitat categories (ADF&G 1983c).

4.2.2 Primary species composition and seasonal availability of instream habitat types

4.2.2.1 Mainstem and side channel habitats

The mainstem and side channel habitats of this section of the Susitna River function as a migrational corridor; as rearing/feeding habitat; as overwintering habitat; and as spawning/incubation habitat for many of the resident and anadromous species. The principal fisheries resources are most dependent on this area for migration and overwintering.

Spawning migrations by the five Pacific salmon species are a well established use of this habitat type. Spawning migrations of adult anadromous Arctic lamprey also occur.

Other fish species which probably use the mainstem and side channels for spawning migrations include rainbow trout, burbot, Arctic grayling, round whitefish, threespine stickleback, and longnose sucker.

Outmigration of juvenile salmon primarily occurs during and just following breakup (late March-early June) for pink and chum salmon and throughout the open water season for the other species.

The use of mainstem and side channels as a migrational corridor for rearing and overwintering redistribution is another important characteristic of this habitat. Juvenile chinook, coho, and sockeye salmon, burbot, Arctic grayling, and rainbow trout probably use the mainstem and side channels for both overwintering and rearing redistribution.

The mainstem and side channel habitats are heavily used by burbot, round whitefish, and longnose sucker for rearing and feeding habitat.

Overwintering habitat use of the mainstem and side channels in this reach of river is probably important to juvenile chinook, coho, and sockeye salmon, rainbow trout, and other species as well. However, evidence supporting this use by these species is mostly circumstantial because of limited winter data.

The mainstem and side channel habitat types are used as spawning/incubation habitat by adult chum salmon but is probably of limited importance to the species. Coho salmon were observed spawning in this habitat type in 1981 but not in 1982. This use is also of probable importance, although unsubstantiated, to longnose sucker, burbot, and round whitefish.

4.2.2.2 Side slough habitats

The side slough habitats of the Devil Canyon to Chulitna reach of the river are important for spawning/incubation of chum and sockeye salmon.

Coho and pink salmon also utilize this habitat for spawning/incubation, but it is apparently not as of great importance.

The side slough habitats in this reach of river also function as important rearing and feeding areas for juvenile chinook, coho, and sockeye salmon during the open water season. Since juvenile sockeye catches have not generally been large, data supporting the importance of this habitat for rearing of sockeye is not as convincing as is the case for juvenile chinook and coho. Juvenile chum may also use this habitat for a short rearing period prior to outmigration. Rainbow trout, burbot, round whitefish, and Arctic grayling also utilize this habitat type for rearing/feeding.

The side slough habitat type in this reach of river is also used as overwintering habitat by juvenile chinook, coho, and sockeye salmon. As was the case for the mainstem and side channel habitats, winter sampling conditions have limited data collection. However, in the case of side sloughs with upwelling water sources, it is highly likely that significant overwintering does occur.

4.2.2.3 Upland slough habitats

The upland sloughs habitats of the Devil Canyon to Chulitna reach of river are apparently most important as rearing/feeding areas for juvenile chinook, coho, sockeye, and possibly chum salmon during the open water season. Observations are limited in the cases of sockeye and chum. Rainbow trout, round whitefish, and Arctic grayling also utilize the upland sloughs for rearing/feeding purposes.

The upland sloughs also function as spawning/incubation habitat for small numbers of coho, sockeye, chum, and pink salmon. This use of this habitat is probably not of great importance to these species in terms of overall spawning habitat availability.

In upland sloughs with upwelling or tributary water sources, juvenile chinook, coho, and sockeye salmon overwinter. Again, data substantiating winter uses of habitat are minimal.

4.2.2.4 Tributary and tributary mouth habitats

The distribution and abundance studies of the fisheries resources in the tributaries focused on their confluence with the mainstem river, side channels and slough habitats. Accordingly, most of the observations on the seasonal utilization and species composition are associated with the tributary mouth, with only inferences possible for the tributary habitat. Some data are available on spawning by adult salmon species.

Use of tributary and tributary mouth habitats for spawning/incubation is important and well substantiated for chinook, coho, chum, and sockeye salmon. This habitat is the primary spawning habitat for chinook and pink in this reach of river. Rainbow trout, humpback whitefish, Arctic grayling, and Arctic lamprey also utilize this habitat for spawning/incubation.

Rearing/feeding utilization of this habitat by juvenile chinook, coho, and possibly chum salmon, rainbow trout, burbot, round whitefish, Arctic grayling, and longnose sucker is probably of importance.

4.2.3 Influence of mainstem discharge and water quality on instream habitat types

4.2.3.1 Mainstem and side channel habitats

The influence of mainstem discharge and water quality conditions in the mainstem habitats is obviously a case of complete dependency. The influence upon side channel habitats is nearly as dependent. As flow levels drop, the heads of the side channel are cut off from mainstem flow. At such low flows the side channels resemble side sloughs in that they are cut off from the mainstem at the upstream end and have backwater zones at the downstream end. At most "normal" open water season flow levels, the side channels convey mainstem flow.

The influence of mainstem discharge upon the use of the mainstem and side channel habitat types as migrational corridors (for spawning migrations, redistribution, and outmigration) is basically a question of mediation. Mainstem conditions probably affect the day to day timing and degree of these migrations rather than being an "all or none" relationship.

Mainstem discharge is positively correlated with juvenile salmon daily outmigration rates in the mainstem and side channel habitats although the correlation is small (Appendix H).

The influence of mainstem conditions upon redistribution of fish for rearing/feeding and overwintering, and upon spawning migrations, is currently not well defined. Intuitively, mainstem flow and temperature levels affect the seasonal timing and success of such migrations, but data are lacking to make definitive conclusions.

The use of the mainstem and side channel habitats for rearing/feeding is most likely affected by mainstem discharge, temperature, and turbidity effects. Certain fish species exhibit obvious strong correlations with turbid water. For example, burbot are generally found in turbid water while juvenile coho occur in clearer water (see Appendices F and G). Accordingly, factors which affect the turbidity levels in these habitats would most likely affect the distribution and abundance of such species.

Overwintering success of fish in the mainstem and side channel habitats is probably most closely related to ice formation processes and the distribution and degree of upwelling areas. These habitats are most likely the major sites for overwintering in the area between Devil Canyon and the Chulitna confluence.

The use of the mainstem and side channel habitats in this reach of river for spawning/incubation is not prevalent. The mainstem flow and temperature may affect redd selection. Depth and velocity conditions, present during spawning, and intragravel conditions, present during incubation, are affected by mainstem discharge and temperature. A quantification of the available habitat at any given discharge at mainstem and side channel habitats is not yet available.

4.2.3.2 Side slough habitats

Above certain discharge levels, generally between 20,000 and 25,000 cfs, the side sloughs of the river between Chulitna and Devil Canyon directly connect to the mainstem or side channel flow. At these flows, the side sloughs convey turbid mainstem discharge. At lower flow levels, the mainstem stage creates backwater areas at the mouths of the sloughs. The periodic breaching of slough heads by mainstem flows is an important factor in determining side slough morphology, substrate composition, and terrestrial vegetation encroachment.

Because of the importance of the side slough habitats to salmon in this reach of river, a large amount of the sampling efforts of the various studies have focused upon this habitat type. The critical levels of flow for head breaching and access through the slough mouths for select slough habitats have been evaluated. The influence of mainstem conditions upon the side slough habitats for spawning has been evaluated for a limited range of side slough discharges because basin wide low flow conditions in August, 1982, precluded observation of spawning at flow levels which would have been considered "normal" (Appendix D).

The relationship between mainstem conditions and the rearing/feeding of fish in the side slough habitats has been evaluated. The dynamic nature of the side sloughs, in terms of the opening and closing of the slough heads and the extent of mainstem backwater effects, suggest a system which is highly dependent on mainstem discharge change from day to day and season to season. As was the case for side channels, mainstem effects upon side slough turbidity levels would be expected to impact species which exhibit avoidance of turbid water (or exhibit preference for turbid water). The relationship of selected juvenile salmon and resident fish of different species to the hydraulic zones associated with these side sloughs is presented in detail in Appendix F. These data indicate that species respond differently, with the habitat index for rearing sockeye and chum decreasing with decreasing discharge, the habitat index for juvenile chinook changing minimally, and the habitat index for rearing coho responding positively to flow decreases. Individual sloughs vary considerably from each other with morphological differences being a dominant factor in this variability.

Mainstem influence upon the side slough habitats for use by overwintering fish and incubating salmon embryos is not presently well defined. Such influences are most likely related to indirect impacts such as influences on rates of upwelling water sources and winter overflow of the slough heads caused by ice processes. These effects could increase mortality by dewatering habitat or by creating sudden changes in temperature.

4.2.3.3 Upland slough habitats

The predominant effects of mainstem discharge upon the upland slough habitats between Devil Canyon and the Chulitna confluence are on surface area and associated water depths in these sloughs.

Access of fish into the sloughs for spawning and rearing is related to mainstem discharge levels. A detailed presentation of access into these habitats and side sloughs by adult salmon is presented in Appendix B. Low mainstem flows in the Susitna generally have less effect on access into the upland sloughs than into the side sloughs, but upland sloughs are not as important as spawning/incubation habitat as are the side sloughs. The lack of overflow through an upper berm allows sediment accumulation in these sloughs and also allows beaver dams to become established. These conditions limit the availability of suitable spawning substrate.

The influence of mainstem conditions upon rearing and feeding of fish in the upland slough habitats is similar in nature to the influence in the side sloughs, but the degree of influence is not as extensive. Appendices E and F present a discussion of the impact of mainstem flow upon hydraulic zones and the corresponding relationship with selected species catch rates at some of the upland sloughs habitats in this reach of river. These areas may provide a better rearing habitat because of decreased turbidity, improved cover and stable water velocities.

4.2.3.4 Tributary mouth habitats

The predominant influence of mainstem conditions on the tributary mouth habitats in the Devil Canyon to Chulitna confluence area, similar to the upland slough habitats, is the local effects of mainstem stage. Mouth "perching" can occur on small tributaries if mainstem flow drops to very low levels.

Access by adult salmon spawners into Portage Creek and Indian River has been evaluated by Trihey (1982). The study concluded that mainstem flow variations have little effect on access to these tributaries. Mainstem flow may affect access of juveniles into tributary mouths, but quantitative data are not available.

The upstream extent of the backwater zone within the tributary is furthest for those tributaries which have a gradual gradient versus those which have steep gradient. The backwater area at the mouth of steep gradient streams is minor.

Data demonstrating these relationship of mainstem stage to tributary mouth rearing habitats are presented in Appendices E and F for a few of the tributary mouth habitats in this reach of river. These sites respond similarly to sloughs but the tributary discharge maintains some of the habitat at very low flows of the mainstem Susitna.

4.3 Key findings of fisheries studies downstream of the Chulitna confluence

4.3.1 Principal instream habitat types

The general habitat categories which have been described and defined for the Susitna River drainage downstream of Devil Canyon and upstream of the Chulitna confluence (ADF&G 1983c) also occur in the area downstream of the confluence. However, the character and extent of occurrence of each type below the confluence are different from those areas previously defined. The following discussion summarizes the primary differences between the habitat categories in the upper and lower river.

4.3.1.1 Mainstem/side channel

The character of mainstem habitat below the Chulitna confluence differs substantially from the typical mainstem habitats in the reach of river upstream from the Chulitna confluence. The main channel of the Susitna River below the confluence is highly braided with many channels. The reach of river upstream of the Chulitna confluence has limited braided channels with an easily distinguishable primary channel. The channels in the upper river are comparably more stable with minor changes occurring during high water events. The channels in the lower reach often change in morphological character during these high flow events. The substrate in the lower river mainstem habitats is much less stable than the more or less armored substrate in the upper river mainstem.

In the upper river, side channels are generally easily distinguished from the main channel that conveys the major portion of the Susitna River flow. In the lower river, side channels are difficult to separate from the braided mainstem. Side channel habitat in the lower river is confined to the smaller channels that are separated from the mainstem braided area by stable vegetated islands. An example of this type of habitat is the channel that occurs adjacent to the mouth of Sunshine Creek. This channel generally flows with mainstem Susitna water during the major portion of the open water season.

4.3.1.2 Side slough

Side sloughs in the lower river are usually much larger than the equivalent habitat in the upper river. They generally have a more gradual gradient and are often associated with tributary confluences with the mainstem. Birch Creek Slough is an example of this type of habitat. Although used by spawning salmon, the percentage of the surface area within the slough utilized by spawners is much smaller than in the sloughs upstream of the confluence. This may reflect more limited upwelling or substrate limitations associated with the more gradual channel gradient.

4.3.1.3 Upland Slough

Upland sloughs do not appear to be as common in the lower river as they are in the upper river. The available information in the lower river is limited to one site, named Whitefish Slough. This site dewatered as the mainstem receded in the fall of 1982, suggesting that mainstem flows may have a much larger influence on these types of habitat in the lower river. The reason is that, because of a much broader floodplain in the lower river than in the upper river, the gradient of upland sloughs is less in the lower river.

4.3.1.4 Tributary

The tributaries are similar to those above the confluence but usually have lesser gradients. Substantial use by spawning salmon and by resident species of this habitat type has been documented elsewhere in the data reports (ADF&G 1983a-d).

4.3.1.5 Tributary mouth

Because of their size, tributary mouth habitats are more important in the lower river than in the upper river. These habitats are used extensively by rearing juvenile salmon and are major areas for the important sport fishing of the salmon species in the system. The mouths of the Deshka River and of Sunshine Creek are examples of this type of habitat.

4.3.2 Primary species composition and seasonal availability of instream habitat types

The current level of information on the seasonal distribution and abundance of fish downstream from the confluence is less well defined than above the confluence. Generally, the patterns observed upstream from the confluence are followed downstream. However, the differences in the composition and extent of the various habitat types, and the differences in the abundance of fish below the confluence suggest substantial differences from upstream of the confluence. The following sections highlight the currently known differences.

4.3.2.1 Mainstem/side channel habitats

The primary difference in species composition in the mainstem/side channel habitats below the confluence is the utilization of the habitat by Bering cisco and eulachon for migration, spawning, and incubation. Also, the lower few miles of the river are used by several other species (for example, Pacific lamprey, other sculpin species, ninespine stickleback) that do not occur in the upper river. Use of this habitat for spawning/incubation by chum salmon occurs but is probably of minimal importance.

Juvenile chum and sockeye salmon possibly utilize the mainstem and side channels for rearing. The resident fish rearing use in this habitat is probably similar to that which occurs in the upper river.

Juvenile coho, chinook, and sockeye and probably most of the resident fish overwinter in the mainstem/side channel areas. This use is probably similar to such use in the upper river. However, the number of fish affected is most likely greater, and includes fish with natal areas in the upper river as well as from the lower river sloughs and tributaries.

4.3.2.2 Side slough habitats

The side slough habitats in the lower river are more heavily used by rearing coho than in the side sloughs of the upper river, probably reflecting population differences.

Spawning/incubation in side sloughs is apparently less prevalent in this reach of river for chums, but pink salmon spawning appears to be common.

4.3.2.3 Upland slough habitats

Very little information is available concerning the characteristics of the upland sloughs in this area. The data on Whitefish Slough indicate that these sloughs are less utilized by all fish species as compared to the upland sloughs in the upper river, with the exception of the whitefish species and burbot.

4.3.2.4 Tributary and tributary mouth habitats

The species composition and availability of the tributary and tributary mouth habitats is very similar to that which occurs in the upper river. However, these habitat types are probably of greater importance in this reach of river due to their greater area.

4.3.3 Influence of mainstem discharge and water quality on instream habitat types

Our level of understanding of the relationship between mainstem conditions and instream habitats is much less well defined in the lower river than in the upper river. Generally, the habitats associated with the river downstream of the Chulitna confluence more closely resembles the Chulitna River than the upper Susitna. The overall gradient is lower in this section of river, which generally leads to greater changes in wetted area with discharge changes when compared to the upper river. The following sections highlight the known differences in the influence of mainstem conditions upon the habitat types in this river section.

4.3.3.1 Mainstem/side channel habitats

The primary flow-influenced habitat effect in this reach of river is the instability of substrate conditions. The mainstem and side channels in the lower river change dramatically with high water events. This instability probably results in the lower availability of this habitat type for spawning.

4.3.3.2 Side slough habitats

The general type of impact of mainstem conditions upon this habitat type is essentially the same as that which occurs in the upper river. However, the extent of backwater conditions in the sloughs in this reach of river is generally greater. Bank associated cover for rearing fish is also apparently more prevalent in the lower reach. Such cover is often dewatered with decreases in mainstem flow and the associated decrease in backwater effects. The use of this habitat by spawning salmon is apparently less common.

4.3.3.3 Upland slough habitats

The limited information from Whitefish Slough indicates that the upland sloughs in the lower reach of river may be more affected by the mainstem stage than in the upper river. These sloughs may dewater more extensively with dropping mainstem flow levels than is the case with the upper river upland sloughs.

4.3.3.4 Tributary mouth habitats

The effects of changes in mainstem conditions upon tributary mouth habitats is similar to that observed in side slough mouth habitats in this lower reach of river. Moderate decreases in mainstem flow levels often lead to large decreases in backwater areas, which are used extensively by juvenile salmon and residents for rearing. Adult salmon often mill in these areas and are subjected to intense sport fisheries.

Dewatering of bank associated cover with lower mainstem flows is probably of greater significance in this lower reach tributary mouths than in the upper river.

4.4 Limitations of the available data base

This section of the report has summarized the current level of information as it regards the influence of mainstem conditions upon habitat availability. Some of the limitations to the available data base have already been noted above; the following discussion lists some of the other limitations to this available data base. The general limitation of little to no information concerning the distribution and abundance of fish species and the dynamics of habitat conditions during the winter months is not repeated in the following sections, but does represent a major limitation.

4.4.1 Habitats in the reach downstream of Devil Canyon to the Chulitna confluence

Three representative side sloughs have had intensive hydraulic simulation models developed for predictions of incremental changes on available spawning habitat for chum salmon. These require additional discharge and chum salmon utilization data for reliable predictions of discharge effects on available spawning habitat. To compare these sites with other sloughs in this reach of river, physical habitat data, such as discharge and gradient, have been measured at a larger number of sloughs. Rearing has been evaluated at these sites at representative study areas by monitoring the available surface area of hydraulic zones, such as backwater areas, at different mainstem discharges. These data have provided a general description of habitat availability as a function of flow. Micro-habitat availability under variable discharges and its relationship to rearing fish needs to be determined at a representative set of sites.

Upland sloughs 6A and 19 have been evaluated for available juvenile rearing habitat. Micro-habitat availability at these type of habitats as a function of mainstem discharge requires further quantification.

Side channel habitat has been sampled for abundance of spawners and limited data has been collected on use by juvenile salmon. Habitat availability for many of the life stages remains to be completed.

Because of the limited use of the mainstem habitat by spawning or rearing species, with the exception of selected resident fish, data are limited to relative abundance information. Quantification of habitat availability of mainstem areas has not been collected.

Passage of adult salmon into tributaries through the tributary mouth habitats, as a function of mainstem discharge, has been evaluated for two of the major tributaries, Indian River and Portage Creek. The availability of habitat for spawning at these sites has not been quantified although general availability of juvenile and resident rearing habitat as a function of mainstem discharge has been examined for representative sites.

As the tributaries are not directly affected by mainstem discharge, data are required only on the distribution and use of micro-habitat by stocks of resident and anadromous species. This information can be used to determine the limitations of the mainstem habitats for the particular life stages of these species. In addition, this information will suggest if regulated flows of the mainstem have any prospect for improving available habitat for these species.

4.4.2 Habitats in the reach downstream of the Chulitna confluence

Available data for the lower river are much more limited than in the upper river. Physical conditions of one side channel area called Chum Channel and a tributary mouth at Rabideux Creek have been intensively measured but at a limited range of flows. No attempt has been made to project available habitat for spawning or rearing fish at these sites.

Juvenile habitat availability has been estimated using the general hydraulic zone/surface area relationships at five sites. These include the tributary mouths and associated sloughs at Rabideux Creek, Birch Creek, and Sunshine Creek. A side slough near the mouth of Goose Creek and one upland slough, named Whitefish Slough have been evaluated. Additionally, distributional data and site habitat data have been collected for spawning eulachon, Bering cisco, and limited chum salmon spawning areas but availability of this habitat has not been estimated. The quantification of rearing micro-habitat and of spawning habitat for eulachon, Bering cisco, and chum salmon has not been completed. Basic data on the distribution, rearing, and spawning of most of the species in the lower river are quite limited and overall knowledge is probably an order of magnitude below the level of understanding of the upper river. Virtually nothing is known about the several other species (for example, ninespine stickleback, Pacific lamprey, pond smelt) which occupy the lower few miles of river, but which have not been collected by this program.

Important questions, such as the degree of growth and utilization of rearing habitat by outmigrating chums, the distribution of spawning adults in peripheral areas, and the rearing habitat of other resident and juvenile salmonids, have not been answered.

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9. GLOSSARY OF COMMON AND SCIENTIFIC NAMES

Scientific Name	Common Name
Entosphenus tridentatus (Gairdner)	Pacific lamprey
Lampetra japonica (Martens)	Arctic lamprey
Coregonus laurettae (Bean)	Bering cisco
Prosopium cylindraceum (Pallas)	Round whitefish
Coregonus pidschian (Gmelin)	Humpback whitefish
Salmo gairdneri (Richardson)	Rainbow trout
Salvelinus malma (Walbaum)	Dolly Varden
Oncorhynchus gorbuscha (Walbaum)	Pink salmon
Oncorhynchus tshawytscha (Walbaum)	Chinook salmon
Oncorhynchus keta (Walbaum)	Chum salmon
Oncorhynchus kisutch (Walbaum)	Coho salmon
Oncorhynchus nerka (Walbaum)	Sockeye salmon
Thymallus arcticus (Pallas)	Arctic grayling
Thaleichthys pacificus (Richardson)	Eulachon
Esox lucius (Linnaeus)	Northern pike
Catostomus catostomus (Forster)	Longnose sucker
Lota lota (Linnaeus)	Burbot
Gasterosteus aculeatus (Linnaeus)	Threespine stickleback
Pungitius pungitius (Linnaeus)	Ninespine stickleback
Cottus cognatus (Richardson)	Slimy sculpin
Platichthys stellatus (Pallas)	Starry flounder