ALASKA DEPARTMENT OF FISH AND GAME

SUSITNA AQUATIC STUDIES

ANNOTATED BIBLIOGRAPHY (DRAFT)

1 Barrett, B.M. 1974. An assessment of the anadromous fish populations in the upper Susitna River watershed between Devil Canyon and the Chulitna River. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska.

Fishwheels operating in the lower portion of the middle Susitna River (RM 101.7 and RM 104.0) provided migrational timing, age-length-sex composition and abundances levels by salmon species. Chum (Oncorhynchus keta) and pink (O. gorbuscha) salmon dominated the catches. The major pink salmon migration occurred during the last week of July and the first week of August, and correspondingly for chum salmon in the second and third weeks of August. Three- and four-year old fish comprised 81.6 percent of the chum salmon catch. Coho salmon were abundant in the river from mid-August to mid-September. Age samples indicated that coho escapement was predominantly four-year old fish.

Twenty-one sloughs were identified on the Susitna River between the Chulitna River confluence and Devil Canyon and surveyed for the first time: rearing coho (O. kisutch) fry were observed in twelve of these, and spawning chum salmon in nine of the sloughs. In four of the sloughs, sockeye (O. nerka) salmon co-spawned with chum salmon.

Pink salmon spawned in Indian River, Fourth of July, Lane, Portage, and Gold creeks; chum salmon also spawned in these streams, with the exceptions of Lane and Gold creeks.

Pink salmon spawned primarily during the first three weeks of August. The major period of chum spawning occurred in the streams from mid-August to mid-September, and in the sloughs during the first three weeks of September.

Spawning coho salmon were recorded in Indian River, Fourth of July, Portage, Whiskers, and Chase creeks.

An estimated 24,286 chum, 5,252 pink, and 1,008 sockeye salmon migrated at the fishwheel station as determined from the tag and recovery program. The coho salmon population was estimated to range from 4,000 to 9,000 individuals. Tag returns from chum, pink, and sockeye salmon spawning below the fishwheel station suggest that a significant but unknown proportion of the salmon captured in the fishwheels were milling fish and not migrating to spawning grounds above the tagging station.

A minimum of 1,036 pink, 2,753 chum, 307 coho, and 104 sockeye salmon spawned in the streams and sloughs of the Susitna River between the Chulitna River tributary and Portage Creek as determined from peak slough and stream index escapement counts.

Twelve of the sloughs surveyed were barren of spawning salmon. Although Slough 10 is included in these, it contained a relatively abundant population of rearing coho fry, during the month of August. Springs are prevalent in this slough, and the surface stratum is composed of approximately 95 percent sandy silt and 5 percent cobbles and boulders. The author suggests that the slough has the potential to support a spawning population of chum salmon, and it would be feasible to weir a portion of the slough and force spawn a donor stock of chum salmon above the structure.

The water levels in the sloughs are maintained in part by the Susitna River. Stream surveyors noted less rearing in the sloughs during low water periods, but significantly higher densities of fry milling in the confluences of the sloughs with the river. Physical access into the sloughs for the escapement was considered optimum during the period of August 28 to September 7, which coincided with a flood period on the Susitna River. Reduction in the water flow of the Susitna River in the last two weeks of September resulted in less than adequate accessibility for the salmon into the upper spawning pools of Slough 21.

Significant gravel displacement occurred in the streams during the late August-early September flood. A portion of the pink salmon spawn may have been destroyed as a consequence.

2 Alaska Department of Fish and Game (ADF&G). 1976. Fish and Wildlife studies related to the Corp of Engineers Devil Canyon, Watana Reservoir Hydroelectric Project. Alaska Department of Fish and Game, Anchorage, Alaska.

3 Friese, N.V. 1975. Preauthorization assessment of anadromous fish populations of the upper Susitna River watershed in the vicinity of the proposed Devil Canyon Hydroelectric Project. Commercial Fisheries Division Section in: ADF&G. Fish and wildlife studies related to the Corp of Engineers Devil Canyon, Watana Reservoir Hydroelectric Project. Alaska Department of Fish and Game, Anchorage, Alaska.

Gross indications of migrational timing, abundance by species and age-length-sex data was obtained from fishwheel operation in the lower study area. The total catch of salmon during the 1975 season was less than 1974. Chum (Oncorhynchus keta) and pink (O. gorbuscha) salmon dominated the fishwheel catches. Population estimates were determined by the Petersen mark and recapture method. The population estimates for 1974 and 1975 were:

	1974	1975
Chum	24,386 ± 2,602	11,850 ± 4,044
Pink	5,252 ± 998	6,257 ± 261
Sockeye	1,008 ± 224	1,835 ± 337

Comparative data is not available for chinook (O. tshawytscha) and coho (O. kisutch) salmon. Tag recoveries from chum, pink, sockeye, (O. nerka) and coho salmon below the fishwheel sites indicate a significant, but unknown, proportion of the salmon captured were possibly milling and not migrating to spawning grounds above the tagging project.

Twenty-one sloughs were identified and surveyed on the Susitna River during 1974. An additional seven sloughs were identified during winter and summer 1975. Rearing fry were observed in 22 of the slough areas. Adult salmon were found spawning in eight of the sloughs. Adult sockeye salmon were observed in four sloughs and adult chum salmon were observed in six slough areas. Pink, king, and coho salmon were found exclusively in clearwater tributaries. Chum salmon were observed spawning in Lane Creek and Indian River, and sockeye spawned in Fourth of July Creek, McKenzie Creek, and Indian River, clearwater tributaries of the Susitna River.

A minimum of 575 pink, 568 chum, 242 sockeye, and 62 king salmon spawned in the streams and sloughs of the Susitna River between the confluence of the Chulitna River and Portage Creek as determined from peak slough and stream index escapement counts.

Thirteen sloughs and two clearwater streams were identified and surveyed on the Talkeetna River between its confluence with the Susitna River and Clear Creek in 1975. Coho fry were rearing in

eight sloughs and one clearwater stream. Rearing chum salmon fry were observed in three sloughs in June. Chum salmon were the only salmon species observed spawning in the slough areas of the Talkeetna River. Pink salmon were, however, observed in Clear Creek by the escapement survey crew. The presence of spawning sockeye, coho, and pink salmon was confirmed by sport fishermen's tag returns in Chunilna Creek, Clear Creek, and Stephan Lake.

Winter surveys of the slough and mainstem Susitna River established the presence of rearing coho (O. kisutch) fry in both areas. Suspended solid levels of the mainstem river were extremely low during fall and winter months resulting in clear water conditions. The combination of partial slough dewatering and clear water conditions were contributing factors of fry emigration into the mainstem river for rearing.

Artificial substrate sampling and fry foregut analysis was conducted to determine species composition of invertebrates within the study area and the importance of benthic invertebrates as food items to rearing fry. Insects comprised 100 percent of the benthic organisms found in the substrate samples. The number of species of benthic organisms identified was extremely low. The contributing factors are the time of year they were installed and the length of time they remained in the sampling locations. The Plecoptera (stonefiles) and Diptera ("no-see-ums") represented the dominant orders. Simuliidae (black flies), Ephemeroptera (mayflies), Tricoptera (caddis flies) were also present.

4 Riis, J.C. 1976. Preauthorization assessment of the Susitna River Hydroelectric Projects: preliminary investigations of water quality and aquatic species composition. Sport Fish Division Section in: ADF&G. Fish and wildlife studies related to the Corp of Engineers Devil Canyon, Watana Reservoir Hydroelectric Project. Alaska Department of Fish and Game, Anchorage, Alaska.

Biological investigations of the Susitna River and selected tributaries were conducted from February 10, 1975 to September 30, 1975 to obtain baseline data regarding indigenous fish populations, available aquatic habitat, and water quality which will aid in the definition of biological areas of concern requiring additional study prior to authorization of hydroelectric development.

There is evidence that resident and rearing anadromous fish migrate out of the tributaries and into the mainstem in the fall and return to the tributaries in the spring. Coho (Oncorhynchus kisutch), chinook (O. tshawytscha), chum (O. keta), grayling (Thymallus arcticus, sculpin (Cottus cognatus), burbot (Lota lota), whitefish (Coregonus sp.), and sucker (Catostomus catostomus) were found overwintering in the mainstem Susitna River.

Five Dolly Varden (Salvelinus malma) ranging from 85 mm to 142 mm were trapped in early April in Willow Creek, and four chinook fry were trapped in Montana Creek. Minnow traps generally were not effective as under-ice sampling gear in tributaries because water depths were too shallow.

Electroshockers were the most effective sampling gear. During the summer salmon fry, rainbow trout (Salmo gairdneri), and grayling were scarce in the turbid mainstem Susitna River whereas whitefish, sculpin, and suckers were commonly captured. Occurring in most of the clearwater tributaries, Arctic grayling are the most common recreationally important resident fish species. Aquatic insects collected in both the mainstem and tributaries are typical of cleary cold water streams in Alaska.

Water samples were collected on a bi-weekly basis at bridge crossings of each major east side tributary. Parameters measured included temperature, pH, turbidity, conductivity, total alkalinity, total hardness, and dissolved oxygen. Temperatures were also monitored using a Ryan thermograph in the Susitna River, Birch Creek, and Willow Creek. Similar trends in water temperature fluctuations were noted for the mainstem and tributaries with the exception of Birch Creek which is the outlet for Fish Lake. Temperatures there were considerably warmer and flows did not fluctuate as much as in other tributaries.

Specific conductance in the mainstem in substantially higher than in the tributaries. There was no consistent trend in turbidity among the tributaries. Fluctuations appear to be linked to precipitation.

5 Riis, J.C. 1977. Preauthorization assessment of the proposed Susitna River Hydroelectric Projects: preliminary investigations of water quality and aquatic species composition. Alaska Department of Fish and Game, Sport Fish Division, Anchorage, Alaska.

Biological, water quality, and water quantity investigations were conducted from July 1, 1976 through September 30, 1976 to obtain baseline data on indigenous fish populations and the existing aquatic habitat as part of an ongoing environmental study to assess the potential impacts of the proposed Watana/Devil Canyon hydroelectric project upon the aquatic ecosystem of the Susitna River drainage.

Long term ecological changes to this drainage may be significant. The level and flow patterns of the Susitna River will be altered and will affect the fish and wildlife resources.

Between May 12 and June 12, 1976, mainstem Susitna River discharge ranged from 11,900 cfs to 33,3000 cfs. Stage fluctuations within clearwater sloughs were directly related to mainstem discharge. Nine of the 12 sloughs monitored were isolated pools or completely dry when mainstem flows were 7,000 cfs, the proposed post-project flow.

Baseline water temperature data was collected with thermographs at the Parks Highway Bridge, upstream of Chase Creek, and between Devil

Canyon and Portage Creek. Temperature trends were similar at the three sites. Water temperature was measured with a pocket thermometer at other study sites. Slough temperatures were generally more stable than those of the mainstem.

Total suspended solid levels and turbidity were directly related to Susitna River discharge. Oxygen concentrations were close to saturation throughout the study. The range of pH measured at each station remained relatively stable over the study period.

Seven artificial substrate baskets were installed in the mainstem Susitna River to collect baseline data on benthic invertebrates present. A total of 118 specimens from two baskets were collected and identified. Of these, 63 percent were classified as "sensitive" to changes in water quality.

Aerial and ground escapement surveys were conducted to estimate the relative abundance of fish. Chinook (Oncorhynchus tshawytscha) escapement was estimated to be 50,499. Other species of salmon were observed, but their numbers were not estimated.

6 Alaska Department of Fish and Game (ADF&G). 1978. Preliminary environmental assessment of hydroelectric development on the Susitna River. Alaska Department of Fish and Game, Anchorage, Alaska.

7 Riis, J.C. and N.V. Friese. 1978. Fisheries and habitat investigations of the Susitna River: a preliminary study of potential impacts of the Devil Canyon and Watana Hydroelectric Projects. Section I in: ADF&G. Preliminary environmental assessment of hydroelectric development on the Susitna River. Alaska Department of Fish and Game, Anchorage, Alaska.

Biological and water quality and quantity investigations were conducted from May 1, 1977 through March 7, 1978 to obtain baseline data on indigenous fish populations and the existing aquatic habitat of the Susitna River drainage.

The relative abundance, distribution, and migrational timing of adult salmon (Oncorhynchus spp.) were determined within the Susitna River drainage through tag and recovery programs during 1977. The salmon escapement from June 29 through August 14 was estimated to be approximately 237,000 sockeye (O. nerka), 50,000 coho (O. kisutch), and 105,000 chum (O. keta) salmon. An escapement estimate in excess of 100,000 fish was determined for chinook salmon (O. tshawytscha) through aerial surveys. Population estimates of pink (O. gorbuscha) salmon utilizing the drainage in the area of the Susitna and Chulitna river confluences were determined as a part of this study.

Documentation of the outmigration of salmon fry from tributary rearing areas into the mainstem Susitna River was accomplished by intensive investigation of two clearwater tributaries. The

objective of these studies was to determine utilization of the mainstem river for rearing during winter months. A total of 25,176 chinook salmon fry were marked in Montana Creek between July 19 and August 4. A gradual downstream movement of fry was noted from the latter part of August to February. A drastic reduction in population density was found in February and was attributed to lower flows which prevailed at the time. Chinook fry were documented overwintering in the Susitna River. No distinct movement of fry was observed in Rabideux Creek.

The relative abundance, distribution, age, length, and weight characteristics, and feeding habits of juvenile salmonids were monitored in sloughs and tributaries of the Susitna River from Portage Creek downstream to the Chulitna River confluence from July 1 through October 5, 1977. The predominant rearing species were chinook and coho salmon. Water quality and quantity determinations were made in conjunction with all juvenile salmon surveys.

The Susitna River was floated from its intersection with the Denali Highway to Devil Canyon during the first two weeks of July to inventory fish species present and survey the aquatic habitat in the areas to be inundated. Arctic grayling (Thymallus arcticus) were abundant in all of the clearwater tributaries within the proposed impoundment area. The headwaters of these tributaries and upland lakes were also surveyed by separate crews. It is apparent that the Watana reservoir, which is projected to have substantial seasonal fluctuations, will alter the fisheries habitat.

Measurements of hydrological and limnological parameters associated with the Susitna River and selected tributaries and sloughs were obtained between the Denali Highway and Montana Creek. A cooperative agreement between the United States Geological Survey (USGS) and the ADF&G was initiated to determine discharge, sediment loads, and standard water quality analysis of the mainstem Susitna River.

Long term ecological changes to the drainage may be significant due to dam construction. The level and flow patterns of the Susitna River will be altered and will affect the fisheries resources.

The effects of impoundment and construction activities which alter natural flow regimes, water chemistry, mass transport of materials, and quantity of wetted habitat areas are of primary concern. These changes may disrupt the trophic structure and habitat composition and reduce or eliminate terrestrial and aquatic populations. These populations and vegetation in and around the free-flowing rivers have evolved to their current levels due to natural flow variations. Some species may be present only because this particular hydrologic regime exists.

8 Alaska Department of Fish and Game (ADF&G). 1979. Fish and wildlife studies proposed by the Alaska Department of Fish and Game. Preliminary final plan of study. Alaska Department of Fish and Game, Anchorage, Alaska.

Alaska Department of Fish and Game proposed a five-year study program to assess the potential impacts of hydroelectric development on the Susitna River. Phase I study proposals were designed to provide baseline information for accomplishing this. Six general objectives were outlined:

1) Determine the relative abundance and distribution of adult anadromous fish populations within the drainage.

2) Determine the distribution and abundance of selected resident and juvenile anadromous fish populations.

3) Determine the spatial and seasonal habitat requirements of anadromous and resident fish species during each stage of their life histories.

4) Determine the economic, recreational, social, and aesthetic values of the existing resident and anadromous fish stocks and habitat.

5) Determine the impact the Devil Canyon project on the aquatic ecosystems and any required mitigation prior to construction approval decision.

6) Determine a long term study plan, if the project is authorized, to monitor the impacts during and after project completion.

9 Alaska Department of Fish and Game (ADF&G). 1981a. Aquatic Studies Procedures Manual (1980-1981). (1 of 2). Susitna Hydro Aquatic Studies. Phase 1. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

Technical procedures and data procedures used during Phase I of the Susitna Hydroelectric Aquatic Studies Program are detailed.

10 Alaska Department of Fish and Game (ADF&G). 1981b. Aquatic Studies Procedures Manual (1980-1981). (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 1. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

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

Salmon escapement was monitored at four stations on the Susitna River between Cook Inlet and Devil Canyon and one station on the Yentna River. These stations were operational from late June to mid-September 1981. Methods used included side scan sonar counters and fishwheels. Chinook (Oncorhynchus tshawytscha) salmon escapement surveys were conducted in late July and early August on tributary streams. A radio telemetry tagging program monitored the

migrational movements of adult chinook, chum (O. keta), and coho (O. kisutch) salmon between late June and early September. The Susitna River mainstem was surveyed for spawning activity by three crews from late July through September using primarily drift gill nets, electroshocking equipment, and egg deposition pumps. Set netting was effected at river mile (RM) 150 in the Susitna River mainstem immediately below Devil Canyon (RM 151) from late July to mid-September. Susitna River tributary streams and sloughs between the Talkeetna River confluence (RM 99) and Devil Canyon were surveyed on foot for spawning salmon from late July through September.

Fishwheel catch and sonar enumeration data indicate the chinook salmon migration was underway before the fishwheels and sonar counters were placed. Peak migration timing was determined at Sunshine (RM 80), Talkeetna (RM 103), and Curry (RM 120) stations. Commencement of migration was recorded only at Curry Station. A correlation may exist between river discharge and upstream migration. The 1981 Susitna River chinook salmon escapement was dominated by four year old fish. Length measurements segregated by age and sex indicate that chinook salmon at Talkeetna and Curry stations were significantly larger than those intercepted at Sunshine Station. Early smolting is a possible cause based on a higher percentage of Talkeetna and Curry station fish having spent less than one winter in freshwater before smolting. Radio telemetry investigations indicate that the confluence of the Talkeetna,

Chulitna, and Susitna rivers (RM 99) is a probable chinook salmon milling area and also that some upper Susitna River chinook salmon stocks use lower Devil Canyon (RM 151) as a milling area.

The Susitna River basin chinook salmon escapement in 1985 was generally above average based on comparative recent year surveys.

Sockeye (O. nerka), pink (O. gorbuscha), chum, and coho salmon escapements and timing were documented at each mainstem sampling station. The data indicate that the majority of 1981 Susitna River sockeye, pink, chum, and coho salmon escapement originated in the Susitna River reach above (upstream of) the Yentna River confluence (RM 28). Escapement samples collected from fishwheel interceptions indicate average length differences in sockeye and pink salmon stocks between the Yentna River subdrainages and the Susitna River basin above the Yentna River confluence.

Scale samples collected at the mainstem sampling stations indicate Susitna River sockeye, chum, and coho salmon stocks were comprised predominantly of age 5_2, 4_1, and 4_3 fish, respectively.

Twelve Susitna River mainstem salmon spawning sites were located between RM 64.5 and RM 135.2. Chum salmon were found spawning in the same area as chum salmon at two sites.

Sockeye, chum, and coho salmon were gill netted in the Susitna River mainstem less than one mile below Devil Canyon (RM 151) indicating a milling area exists in the lower canyon.

Eight additional salmon spawning sloughs and streams were identified in the Susitna River reach between the Chulitna River (RM 99) and Devil Canyon (RM 151).

Radio telemetry investigations on chum and coho salmon indicate that both species display milling behavior in the Susitna River mainstem above Talkeetna (RM 99). Coho salmon displayed the greatest milling movement; radio tagged coho salmon were found in the Susitna River several miles upstream of their spawning area. Necropsies of radio tagged coho and chum salmon indicate successful spawning occurred.

12 Alaska Department of Fish and Game (ADF&G). 1981d. Juvenile anadromous fish study on the Susitna River (November 1980-October 1981). Susitna Hydro Aquatic Studies. Phase 1 final draft report. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

This study was designed to gather information describing the presence, abundance, geographical and seasonal distribution, age class composition, length distribution, and smolt migration timing of juvenile salmon in the Susitna River between Cook Inlet and Devil Canyon as part of a feasibility study regarding the proposed Susitna Hydroelectric project.

Field collection of data on juvenile salmon (Oncorhynchus spp.) species took place from November 1980 to October 1981. Sampling gear included variable mesh gillnets, minnow traps, beach seines, electrofishing units, and dip nets.

Juvenile chinook (O. tshawytscha) salmon were captured throughout the study area. The majority of juvenile chinook salmon captured during winter between Cook Inlet and Devil Canyon occurred at slough and mainstem Susitna River sites and in summer at tributary mouth sites. Two age classes (0+ and I+) were captured. Age I+ were not captured after July between Talkeetna and Devil Canyon and were not captured after August in the Cook Inlet to Talkeetna reach.

Juvenile coho (O. kisutch) salmon occurred throughout the study area. The majority of juvenile coho salmon captured between Cook Inlet and Talkeetna during winter and summer occurred at tributary mouth sites. Between Talkeetna and Devil Canyon occurrence was greater at slough sites in winter and at slough and tributary mouth sites in summer. Three age classes (0+, I+, and II+) were captured. Age II+ were not captured after May in the Talkeetna to Devil Canyon reach and were not captured after mid-June in the Cook Inlet to Talkeetna reach.

Relatively small numbers of juvenile pink (O. gorbuscha), chum (O. keta), and sockeye (O. nerka) salmon were collected in 1980-81. Sampling scheme bias imposed by gear types and by location of effort

can account for the limited numbers of these juvenile salmon species encountered. Further seasonal distribution, relative abundance, and biological information on these three juvenile salmon species is needed to evaluate their life histories.

Further information is needed on the winter distribution and habits of all five species of juvenile salmon.

Further information is needed on the timing on the smolt outmigration and also on the incubation of embryos of all five juvenile salmon species.

13 Alaska Department of Fish and Game (ADF&G). 1981e. Resident fish investigation on the Lower Susitna River (November 1980-October 1981). Susitna Hydro Aquatic Studies. Phase I final draft report. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

Rainbow trout (Salmo gairdneri) were captured throughout the Susitna River between Cook Inlet and Devil Canyon, with the mouths of tributary streams producing higher catches per unit effort than mainstem river locations. The mean fork length of the 395 rainbow trout captured was 285 mm. Fork lengths of rainbow trout in the Cook Inlet to Talkeetna reach was consistently 20 to 40 mm longer in each age class than those recorded in the Talkeetna to Devil Canyon reach. The most prevalent age classes captured were Age III, Age IV, and Age V.

Peak catches of Arctic grayling (Thymallus arcticus) occurred in May and September. Cache Creek slough, Montana Creek, and Portage Creek had the largest catches per unit effort. The mean fork length of fish captured was 202 mm and the most prevalent age classes were Age V and Age VI.

Burbot (Lota lota) were captured at 43 of the 44 habitat locations between Alexander Creek and Portage Creek with peak catch rates recorded in late August and early September. The mean length of 457 burbot measured was 428 mm. The most prevalent age classes were Age III, Age V, and Age VIII.

Round whitefish (Prosopium cylindraceum) occurred throughout the study area but the more productive sites tended to be upstream of Talkeetna. Age IV fish were the most common and had a mean length of 261 mm.

Humpback whitefish (Coregonus pidschian) were captured at approximately half the habitat locations throughout the study area but were generally more abundant at sites downstream of Talkeetna. The mean fork length of 344 fish measured was 284 mm. Age IV and Age VI were the most prevalent age classes.

Eight hundred, thirty-four Bering cisco (Coregonus laurettae) were captured at sites ranging from Kroto Slough to a site just upstream of Talkeetna in the late summer and early fall. This species was

not know to occur in the Susitna River drainage prior to this study. The mean fork length of measured fish was 332 mm and Age IV was the most prevalent age class. Spawning was observed at three sites between river mile 74 and mile 79. Peak spawning occurred during the second week of October.

Longnose suckers (Catostomus catostomus) occurred throughout the study area. The mean fork length of 532 suckers measured was 259 mm and the most prevalent age class was Age VI.

Dolly Varden (Salvelinus malma) were captured at sites ranging from Alexander Creek to Portage Creek with the highest catch per unit effort recorded at the mouths of tributary streams. The mean fork length was 196 mm. Dolly Varden captured in minnow traps on upper Indian River and upper Portage Creek had a mean fork length of 94 mm.

Threespine stickleback (Gasterosteus aculeatus) were widespread and abundant in the Susitna River below Devil Canyon during the early summer. The catch in minnow traps at habitat locations generally decline after late June. Threespine sticklebacks were caught at a site two miles below the confluence of Portage Creek, approximately 50 miles further upriver than previously reported. The mean total length of fish measured was 79 mm. Three age classes (0+, I+, II+) were present during the summer.

The slimy sculpin (Cottus cognatus) was present at almost all habitat locations between Cook Inlet and Devil Canyon. The mean total length of 476 fish measured was 70 mm.

Forty Arctic lamprey (Lampetra japonica) were captured at sites in the lower 100 miles of the Susitna River.

One Age IX female northern pike (Esox lucius) measuring 715 mm fork length was captured in Kroto Slough on September 11, 1981. Northern pike are expanding their range from the Bulchitna Lake area; this is the first record of one captured in the mainstem Susitna River.

Information obtained to date has described the geographic and seasonal distribution, relative abundance, length distribution, and age distribution of adult residents during the period June through September. The data on male/female ratios are less complete.

Relatively small numbers of juvenile resident fish were collected in 1980-81. Sampling scheme bias imposed by gear types and by location of effort can account for the limited numbers of juvenile residents encountered. Further seasonal distribution, relative abundance, and biological information on juvenile residents is needed to evaluate their life histories.

Spawning sites were located for the round whitefish and Bering cisco. More information is needed on location of mainstem and

slough spawning sites and on spawning habits and timing for all species. More information is also needed on the incubation of embryos.

Further information is needed on the winter distribution and habits of all species.

Although many fish were tagged during this study, there have been few recaptures to date. As more recaptures are made, the migrations and movement of the various species can be better described.

14 Alaska Department of Fish and Game (ADF&G). 1981f. Resident fish investigation on the upper Susitna River (May-October 1981). Susitna Hydro Aquatic Studies. Phase 1 final draft report. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

The seasonal distribution and relative abundance of resident fish species was evaluated in eight major tributaries of the Susitna River above Devil Canyon. Eight different species were captured: Arctic grayling (Thymallus arcticus), burbot (Lota lota), slimy sculpin (Cottus cognatus), Dolly Varden (Salvelinus namaycush), Longnose sucker (Catostomus catostomus), humpback whitefish (Coregonus pidschian), and round whitefish (Prosopium cylindraceum). No juvenile or adult salmon (Oncorhynchus spp.) were captured or observed in the study area between Fog Creek (RM 173.9) and the Oshetna River (RM 226.9). Observations in May 1981 indicate that

Arctic grayling (Thymallus arcticus) spawn during late April or early May under the ice or in flood waters immediately following ice out. Schnabel population estimates, based on tag and and recapture data, were generated for Arctic grayling in tributaries and in the study area. The estimate for the upper Susitna River was 10,279 fish.

15 Alaska Department of Fish and Game (ADF&G). 1981g. Aquatic habitat and instream flow project (December 1980-October 1981). Susitna Hydro Aquatic Studies. Phase 1 final draft report. Volume 1. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

This report is one of a series of reports on studies conducted during Phase 1 of the Susitna Aquatic Studies Program. Analysis of data is limited to first stage reduction.

Fishery habitat evaluation studies were performed during the 1981 winter and summer field seasons on the Susitna River between the mouth and the Oshetna River. Data was collected in conjunction with the resident and juvenile anadromous and adult anadromous fish investigations. Velocity, depth, and substrate were collected regularly at fish sampling gear placement sites and incidentally where fish were observed. General habitat evaluations provided the necessary data to describe and map the overall habitat characteristics of each site.

In addition, water quality, morphometric, and discharge data were collected at five selected sites to evaluate the relationships of mainstem hydraulic and water quality conditions to fisheries habitat in slough areas between Talkeetna and Devil Canyon. Water quality parameters included temperature, pH, dissolved oxygen, conductivity, and turbidity.

Analysis of data was limited to first stage reduction, and the discussion of results is limited to descriptions, rather than comparisons, of study sites.

16 Alaska Department of Fish and Game (ADF&G). 1981h. Aquatic habitat and instream flow project. Susitna Hydro Aquatic Studies. Phase 1 final draft report. Volume 2 (1 of 2: Appendices EA-EH). Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

Volume 2 consists of maps and data tables summarizing data collected during 1981. Part 1 contains site maps, a methods supplement, and data tables (physiochemical, temperature, stage, cross section survey, discharge, and incidental data).

17 Alaska Department of Fish and Game (ADF&G). 1981i. Aquatic habitat and instream flow project. Susitna Hydro Aquatic Studies. Phase 1 final draft report. Volume 2 (2 of 2: Appendices EI-EJ). Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

Volume 2 consists of maps and data tables summarizing data collected during 1981. Part 2 contains depth, velocity, and substrate data collected at fish sampling gear placement sites during 1981. Winter data collected in early 1981 is also presented.

Objectives, technical procedures, and data reduction procedures as used by each component of the Susitna Hydro Aquatic Studies Program during 1982-83 are described.

18 Alaska Department of Fish and Game (ADF&G). 1982a. Aquatic studies program (November 1980-October 1981). Susitna Hydro Aquatic Studies. Phase 1 final draft report. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

This report represents a partial synthesis of the 1981 fishery and habitat data collected by the ADF&G Susitna Aquatic Studies Program. Fishery/habitat relationships are discussed to the extent possible. The relationships between individual aquatic habitat parameters and discharge are described. Various predictive models developed by other research groups involved with the project are discussed.

When compared to discharge data, daily sonar counts indicate that salmon (Oncorhynchus spp.) movement decreased during periods of high flow and increased as flows subsided after major flood events. Burbot (Lota lota) catches during low flow conditions were primarily restricted to the mainstem and deeper sloughs and side channel

habitats. During high flows, burbot were captured at a greater number of habitats, including shallow side channels, sloughs, and tributary mouths. Percent incidence of rainbow trout (Salmo gairdneri) caught is related to mainstem discharge and their seasonal migration patterns, whereas that of chinook (O. tshawytscha) fry is apparently a function of fish growth and independent of discharge. The availability of suitable substrate and adequate flows to permit access into sloughs from the mainstem are two of the factors determining the suitability of salmon spawning habitat. Tributary and ground water flow which contribute to slough flow may be critical during periods of low mainstem discharge. At sites above Devil Canyon, Arctic grayling (Thymallus arcticus) were generally more abundant in channels with large deep pools and/or cutbanks and streamflows less than 2.0 feet/second. Availability of suitable substrate within the study area was not a limiting factor in the distribution and abundance of grayling.

Mainstem turbidity generally increases with discharge. Slough turbidity remains low as mainstem discharge increases until a certain threshold level at which point the turbidity/discharge relationship in sloughs resembles that of the mainstem.

Temperature was found to be related to mainstem discharge, intragravel flow, and tributary discharge. The HEC-2 hydraulic model was used to predict water surface elevation (WSEL) at approximately 70 mainstem cross sections for a range of mainstem

discharges. The model generally predicted a smaller than observed change in mainstem WSEL when the discharge values are below 20,000 cfs.

19 Alaska Department of Fish and Game (ADF&G). 1982b. Adult anadromous fisheries project. Stock separation feasibility report. Susitna Hydro Aquatic Studies. Phase 1 final draft report. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

Past efforts to estimate the Susitna River's contribution to the upper Cook Inlet commercial salmon harvest has been limited almost exclusively to sockeye (Oncorhynchus nerka) salmon, the most economically valuable of the five species. The Susitna River appears to be a major producer of coho (O. kisutch), pink (O. gorbuscha), and chum (O. keta) salmon; however, contributions of river systems on the west side of Cook Inlet are unknown and need to be assessed before implementing a stock identification program. Chinook (O. tshawytscha) migration begins well before the commercial fishing season opens. Thus, Susitna River stocks are not significantly exploited in the upper Cook Inlet fishery and a stock separation program is not necessary at this time.

20 Alaska Department of Fish and Game (ADF&G). 1983a. Aquatic Studies Procedures Manual (1982-1983). Susitna Hydro Aquatic Studies. Phase 2. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska.

21 Alaska Department of Fish and Game ADF&G). 1983b. Summarization of Volumes 2, 3, 4, Part I and II, and 5. Susitna Hydro Aquatic Studies. Phase 2 basic data report (October 1981-October 1982). Volume 1. Alaska Department of Fish and Game, Anchorage, Alaska.

This report presents a synopsis of the information contained in Volumes 2 through 4 of the Phase II reports.

22 Alaska Department of Fish and Game (ADF&G). 1983c. Adult anadromous fish studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 final report. Volume 2 (1 of 2). Alaska Department of Fish and Game, Anchorage, Alaska.

Tag recapture techniques and sonar counters were used to estimate escapement and determine the timing and nature of the migration of Pacific salmon into the Susitna River. Stream surveys were conducted to identify salmon spawning sites in the mainstem and peripheral habitats and to evaluate their relative importance. Radio tags were implanted in chinook (Oncorhynchus tshawytscha), chum (O. keta), and coho (O. kisutch) salmon to monitor and characterize their migration upriver.

Two runs of eulachon in May/June were documented and characterized. Bering cisco (Coregonus laurettae) were intercepted by fishwheels at Susitna Station (RM 26), Yentna Station (TRM 04), and Sunshine Station (RM 80).

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

24 Bernard, D.R., G. Oliver, W. Goshert, and B. Cross. 1983. Comparison of scale patterns from sockeye salmon sampled from different stocks in the Susitna River in 1982. Appendix H in: ADF&G. Adult anadromous fish studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 final report. Volume 2 (2 of 2: Appendices A-H). Alaska Department of Fish and Game, Anchorage, Alaska.

Scale pattern analysis with linear discriminant functions was used to examine the probable fate of sockeye salmon fry spawned upstream of Curry Station on the Susitna River. Scale samples were taken from sockeye salmon collected at Talkeetna Station, at Curry Station, from the Tokositna River, and from the confluence of the outlet from Larson Lake and the Talkeetna River. Fish aged 1.3 dominate the samples and are used in the analysis. Growth during the first season of life (1977) is the most discriminating scale pattern variable. Scale patterns from fish sampled at Tokositna River and at Larson Lake are most different. Fish from Larson Lake grew slower for a longer period of time than did fish from the Tokositna River. Fish from Talkeetna Station on the Susitna River are more like fish sampled at Larson Lake on the Talkeetna River. Fish from Curry Station are misclassified as being from Tokositna

River or from Larson Lake more often than from upstream of Curry Station. Sockeye salmon passing Curry Station are probably not a separate stock, but are strays from Talkeetna and Chulitna rivers. Fry hatched upstream of Curry Station most probably die or move to the lower Susitna to rear.

25 Alaska Department of Fish and Game (ADF&G). 1983e. Resident and juvenile anadromous fish studies on the Susitna River below Devil Canyon, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 3 (1 of 2). Alaska Department of Fish and Game, Anchorage, Alaska.

Studies were conducted to assess the potential impact that hydroelectric development on the Susitna River would have on resident and juvenile anadromous fish species. Data were collected concerning the seasonal distribution and relative abundance of the various fish species utilizing the mainstem and peripheral habitats. Emergence, outmigration, and food habits of juvenile salmon (Oncorhynchus spp.) were also studied.

26 Alaska Department of Fish and Game (ADF&G). 1983f. Resident and juvenile anadromous fish studies on the Susitna River below Devil Canyon, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 3 (2 of 2: Appendices). Alaska Department of Fish and Game, Anchorage, Alaska.

27 Alaska Department of Fish and Game (ADF&G). 1983g. Aquatic habitat and instream flow studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 4 (1 of 3: Part I and II). Alaska Department of Fish and Game, Anchorage, Alaska.

Studies were conducted to evaluate existing aquatic habitat conditions and define their relationship to mainstem Susitna River discharge. Available and usable habitat areas at various discharges were evaluated using computer modelling. The influence of the mainstem Susitna River discharge on hydrological and water quality characteristics in selected slough, tributary, and mainstem habitats was investigated.

Changes in mainstem water surface elevation generally ranged from 3 to 5 feet for mainstem discharges between 8,000 and 32,000 cfs. The stage/discharge relationship for that range of flows is well defined. Backwater effects at slough, tributary, and side channel mouths was dependent on mainstem discharge and the morphology of the specific site. Most side sloughs between Talkeetna and Devil Canyon were found to breach as mainstem discharge at Gold Creek passed from 20,000 cfs to 26,000 cfs (±15%).

Surface water temperature was monitored at twelve sites in the mainstem Susitna River between Talkeetna and Devil Canyon. Intragravel and surface water temperatures were monitored at six side sloughs. Surface water temperature fluctuated more than

intragravel temperature did. Specific conductance, pH, dissolved oxygen, water temperature and turbidity were collected at study sites between River Mile (RM) 5.0 and RM 258.0. Values measured in the mainstem Susitna River appeared to be relatively homogenous and independent of mainstem discharge, location, or date of collection. In some sloughs, water quality was very similar during both breached and unbreached flows.

Preliminary salmon spawning habitat investigations in the mainstem indicate that the majority of the habitat available is unsuitable because the substrate is cemented. Chum salmon (Oncorhynchus keta) were found spawning in the mainstem, however, the majority were observed spawning in clear backwater habitats situated in side channels which were cut off from mainstem water influence at their heads. All species of salmon except chinook (O. tshawytscha) were observed spawning in slough habitats. Chum salmon appeared to prefer areas with upwelling present.

Access to spawning areas in sloughs and side channels is the most critical factor in determining the suitability of the site. Because access is mostly a function of water depth, reduced discharge can make otherwise suitable habitat unavailable to spawning fish.

28 Alaska Department of Fish and Game (ADF&G). 1983h. Aquatic habitat and instream flow studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 4 (2 of 3: Appendices A-C). Alaska Department of Fish and Game, Anchorage, Alaska.

29 Alaska Department of Fish and Game (ADF&G). 1983i. Aquatic habitat and instream flow studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 4 (3 of 3: Appendices D-J). Alaska Department of Fish and Game, Anchorage, Alaska.

30 Alaska Department of Fish and Game (ADF&G). 1983j. Upper Susitna River impoundment studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 5. Alaska Department of Fish and Game, Anchorage, Alaska.

Water quality, fish habitat evaluation, and resident fish species distribution and abundance were investigated in the upper Susitna River between RM 152.0 to RM 239.0 above the proposed Devil Canyon impoundment. Water quality of tributaries, mainstem, sloughs, and Sally Lake was evaluated by dissolved oxygen, pH, turbidity, conductivity and temperature measurements. Mainstem turbidity may influence the distribution of Arctic grayling (Thymallus arcticus) which prefer clearwater tributaries. Arctic grayling distribution, abundance, age, length, sex, and migration in tributary and mainstem habitats were investigated. Other resident fish species noted were burbot (Lota lota), longnose sucker (Catostomus catostomus), round whitefish (Prosopium cylindraceum), and humpback whitefish (Coregonus pidschian). Morphometric data, water quality data, and a contour map were collected at Sally Lake. Lake trout (Salvelinus namaycush) and Arctic grayling (Thymallus arcticus) were present in the lake.

Chinook and Cheechako creeks, located within lower Devil Canyon are the only two tributaries within the proposed impoundment areas that are presently known to be utilized by spawning salmon (Oncorhynchus spp.).

31 Alaska Department of Fish and Game (ADF&G). 1983k. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (1 of 2). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

This report provides a synopsis of the findings on each of the target species of resident and anadromous fish, and an analysis of fish and habitat data contained in the 1982 ADF&G Phase II Basic Data Reports. Specific analytical components are presented in 11 appendices to complement the major findings of this report.

32 Alaska Department of Fish and Game (ADF&G). 1983l. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices A-K). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

33 Thompson, F.M., and B.M. Barrett. 1983. Analysis of the species selectivity of fishwheels for the capture of adult salmon in the Susitna River. Appendix A in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

A statistical Chi-square test showed that fishwheels were significantly species selective (P 0.001) at two of five sites on the Susitna River. These over or under catch rates should be considered when estimating species escapements.

34 Trihey, E.W., L.J. Vining, and C.C. Estes. 1983. Timing and passage of adult salmon in the mainstem Susitna River and access into selected sloughs upstream of the Chulitna River confluence. Appendix B in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

Timing and passage of five salmon species (Oncorhynchus nerka, O. keta, O. gorbushcha, O. kisutch, and O. tshawytscha) to spawning habitat in the Susitna River were monitored by fishwheel catches, spawning habitat surveys and passage surveys in 9 sloughs between Talkeetna (RM 103.0) and Devil Canyon (RM 157.0). Comparisons were made between a low water year (1982) and a high water year (1981).

35 Salasky, S., R. Sinnott, and A. Hoffmann. 1983. Qualitative analysis of salmon spawning habitat in sloughs located within the Talkeetna to Devil Canyon reach of the Susitna River. Appendix C in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

36 Sinnott, R., K. Sylvester, A. Hoffmann, and C.C. Estes. 1983. Modelling of hydraulic conditions and chum salmon spawning habitat in selected Susitna River sloughs. Appendix D in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

Available hydraulic conditions in four sloughs (8A, 9, 21, and Chum Channel) were modelled as a function of slough discharge. Water depth and velocity were evaluated over a wide range of predicted slough discharge.

The influence of slough hydraulic conditions on the selection of redd sites by chum salmon (Oncorhynchus keta) was modelled by analyzing the frequency distribution of chum redds among available water depths, velocities, and substrate types at low flows in sloughs 8A, 9, and 21. Available water depths, velocities, and substrate types at a predicted slough flow of 5 cfs and the frequency distributions of chum salmon redds were evaluated using a habitat suitability model developed for sloughs 8A, 9, and 21.

37 Marshall, B. 1983. Effects on mainstem Susitna discharge on total wetted backwater surface area at selected study sites. Appendix E in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

Additional information beyond that discussed in previous reports concerning the response of backwater surface areas to changes in mainstem discharge is presented. The relationship between backwater and wetted surface areas, and data on the abundance of pools formed by berms in free flowing stream areas at study sites is also discussed.

Fourteen sites were sampled: Sloughs 6A, 8A, 9, 11, 19, 20, and 21; Whiskers Creek and Slough, Birch Creek and Slough, Sunshine Creek and Side Channel, Lane Creek, Whitefish Slough, Goose Creek and Side Channel, Rabideux Creek and Slough.

38 Hale, S.S. 1983. Influence of habitat parameters on distribution and relative abundance of juvenile salmon and resident species. Appendix F in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationship (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

The proposed hydroelectric project could create physical-chemical conditions which are outside the limits of natural variation with regard to timing, magnitude, or both. This appendix presents an analysis of the cause-effect relationships observed between natural variations in physical and chemical conditions and the distribution and abundance of fish (primarily juvenile salmon) during the 1982 open water season. A habitat classification system was developed

for dividing the study sites into nine possible zones so that changes in physical habitat with changing discharge could be monitored without an intensive data collection effort. An estimate of how juvenile salmon habitat changes with variations in mainstem discharge was developed by combining the catch variations between zones with the changes in the surface area of the zones.

39 Suchanek, P.M., and S.S. Hale. 1983. Use of major habitat types by juvenile salmon and resident species. Appendix G in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

An analysis of habitat preferences of resident fish and juvenile salmon during the open water season is presented. Six major habitat types occurring on the Susitna River between Cook Inlet and Devil Canyon were identified: tributary mouths, side channels with large tributary mouths, side sloughs with large tributary mouths, or ground water input, upland sloughs, and mainstem channels or side channels.

Chi-square and graphic analysis were used. Data were extracted from Volume 3 of the Basic Data Report ( ). Juvenile salmon species considered were: chinook (Oncorhynchus tshawytscha), coho (O. kisutch), chum (O. keta), and red (O. nerka) salmon. Pink (O.

gorbuscha) salmon were not included due to low numbers captured. Resident species included: round whitefish (Prosopium cylindraceum), Arctic grayling (Thymallus arcticus), longnose sucker (Catostomus catostomus), slimy sculpin (Cottus cognatus), burbot (Lota lota), humpback whitefish (Coregonus pidschian), rainbow trout (Salmo gairdneri), and Dolly Varden (Salvelinus malma).

40 Hale, S.S. 1983. Habitat relationships of juvenile salmon outmigration. Appendix H in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

The relationship between the outmigration timing of juvenile salmon and the environmental variables for the Susitna River between the Chulitna River confluence and Devil Canyon were analyzed in order to evaluate the influence environmental factors have on the outmigration of juvenile salmon (Oncorhynchus gorbuscha, O. tshawytscha, O. keta, O. kisutch, and O. nerka). Parameters examined included were mainstem discharge, water temperature, turbidity, and photoperiod. Other related factors were time of season and variation in size (mean length) of juvenile salmon.

41 Schmidt, D.C. 1983. A model of the effects of incremental increases in sport fishing on population structure of Arctic grayling above Devil Canyon. Appendix I in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

The opening of access roads into the impoundment area of the proposed Susitna Hydroelectric project, can be expected to create a substantial Arctic grayling sport fishery in this previously seldom-fished drainage. This study was initiated to examine the effect of increased mortality rates due to fishing pressure on the age structure and abundance of the Arctic grayling (Thymallus arcticus) populations in the clearwater tributaries studied to date. Fish were sampled using hook and line and then tagged. Mark and recapture, and age-length data were collected over two open water seasons at eight major clearwater tributaries in the proposed impoundment area.

42 Suchanek, P.M., and S.S. Hale. 1983. Age-length curves and growth of Arctic grayling and rainbow trout. Appendix J in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

Age-length curves and regressions were examined for Arctic grayling (Thymallus arcticus) to determine if the growth of the population in the proposed impoundment area above Devil Canyon was significantly different from that of the population below Devil Canyon. Age-length curves for rainbow trout (Salmo gairdneri) were also analyzed.

43 Sandone, G., and J. Sautner. 1983. Evaluation of Arctic grayling spawning and rearing habitat and notes on salmon spawning in the impoundment study area of the Susitna River . Appendix K in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

Arctic grayling (Thymallus arcticus) spawning and rearing habitats were surveyed and documented above and below the proposed impoundment elevation (PIE) along eleven major tributaries which would be partially inundated by the proposed impoundment. Inundation would result in loss of existing habitat in the lower reaches; therefore, continued spawning and rearing of Arctic grayling in these streams depends upon the quantity, quality, and availability of habitat above the PIE.

Chinook and Cheechako creeks, located within lower Devil Canyon are the only tributaries within the proposed impoundment areas at which salmon are known to spawn. ADF&G documented chinook (Oncorhynchus tshawytscha) salmon spawning in the glacial/clearwater mixing zones of these creeks. A semi-dewatered redd was observed at the water's edge approximately 150 feet downstream from the mouth of Cheechako Creek, indicating that spawning had occurred during a higher discharge period.

44 Alaska Department of Fish and Game (ADF&G). 1983m. Winter aquatic studies (October 1982-May 1983). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

A. 1983 Winter Aquatic Studies, October 1982-May 1983, Continuous Surface and Intragravel Water Temperature Study. Andrew Hoffmann.

Water surface and intragravel water temperatures were continuously monitored with Omnidata datapod recorders at 13 slough and mainstem sites in the Susitna River from August 1982 to June 1983. This study provided baseline data and allowed comparisons of temperatures of sites known to be used or not used by spawning salmon (Oncorhynchus spp.). Intragravel temperatures in sloughs were generally warmer and more stable than surface water temperatures. However, slough water temperatures were affected by upwelling ground water.

B. 1983 Winter Aquatic Studies, October 1982-May 1983, Salmon Incubation and Emergence Studies. L. Vining and J. Quinn.

Physical and chemical conditions of surface and intragravel water were related to development of sockeye (Oncorhynchus nerka) and chum salmon (O. keta) embryos and alevins in the Susitna River. Datapods and standpipes were used to measure temperature, dissolved oxygen, pH and conductance in slough and side channel spawning sites. Temperature units and time required for development were similar to those recorded for these species elsewhere in Alaska.

C. 1983 Winter Aquatic Studies, October 1982-May 1983, Burbot Spawning in the Susitna River below Devil Canyon. R. Sundet.

The timing and habitat characteristics of burbot (Lota lota) spawning were studied in the Deshka River, a tributary of the Susitna River. Physical and chemical characteristics of two sites on the Deshka River (Susitna RM 40.6) were measured: ice thickness, water depth, under ice water velocity, dissolved oxygen, specific conductance, pH, and water temperature. Timing of spawning was determined from monthly necropsies of samples (n = 69) to determine gonad maturity. Otoliths were collected to determine age and fish length was measured. Monthly examinations of sexually ripe gonads showed that the size increased from early December to mid-January, then progressively decreased in size through March.

D. 1983 Winter Aquatic Studies, October 1982-May 1983, Winter Radio Telemetry Investigations of Selected Resident Fish. M. Wenger, R. Sundet, and M. Stratton.

Three species of resident fish in the Susitna River were radio tagged to determine winter movements, overwintering locations, or spawning habitat and timing. Radio transmitters were implanted in live fish in September-October 1982 and monitored by air, boat, and snowmobile until May 1983. Ten rainbow trout (Salmo gairdneri) migrated 14-76.6 miles downstream to overwintering locations. Fifteen Arctic grayling (Thymallus arcticus) migrated 2.1 to 50.8 miles from tributaries down the mainstem, in September to early October, to two main areas on concentration. Six burbot (Lota lota) migrated 1 to 113.6 miles to winter spawning grounds in September to mid-January. They spawned mid-January to early February and migrated again early February to mid-March. Burbot showed some preference for areas with upwelling.

45 Alaska Department of Fish and Game (ADF&G). 1984a. Susitna Hydro Aquatic Studies Procedures Manual (May 1983-June 1984) (1 of 2). Susitna Hydro Aquatic Studies. Alaska Department of Fish and Game, Anchorage, Alaska.

Objectives, technical procedures, and data reduction procedures are described for each component of the Susitna Hydroelectric Aquatic Studies Program during the period of May 1983-June 1984.

46 Alaska Department of Fish and Game (ADF&G). 1984b. Susitna Hydro Aquatic Studies Procedures Manual (May 1983-June 1984) (2 of 2: Appendices). Susitna Hydro Aquatic Studies. Alaska Department of Fish and Game, Anchorage, Alaska.

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

Eulachon (Thaleichthys pacificus) migrated into the Susitna River in two runs during late May-early June 1983. Pre-spawning males were more numerous than females in the first, smaller run, while pre-spawning females outnumbered males in the second, larger run. This suggests that individual male eulachon ripen earlier and spawn over a longer period than females following ice-out at water temperatures between 6.0°C and 9.0°C. About 70 percent of the fish spawned within the first 29 miles from the mouth. No fish were observed spawning in clearwater sloughs or tributaries. Age data indicated that three year olds accounted for 92-97 percent of spawning fish in both runs. Weight/length data showed that three year old males were significantly larger in the first run than in the second. Spawning habitat was described in terms of water depth, velocity, temperature, and substrate. The first run included several hundred thousand fish, while the second escapement reached several million eulachon. Escapement of chum (Oncorhynchus keta),

chinook (O. tshawytscha), coho (O. kisutch), pink (O. gorbuscha), and red (O. nerka) salmon occurring in the Susitna River was monitored at three points on the Susitna River using fishwheels, Petersen tag-recapture techniques and side scan sonar. Age, length, weight, and fecundity data were collected. Streams and sloughs were surveyed for salmon spawning activity. Results are presented by species and river location.

Bering cisco (Coregonus laurettae) were incidentally sampled at Yentna (TRM 04), Sunshine (RM 80), Talkeetna (RM 103), and Curry (RM 120) stations in 1983. Relative abundance, distribution, and migrational timing were determined, and age, length, and sex data were collected. The documented distribution of Bering cisco was extended from Talkeetna Station (RM 103) to Fourth of July Creek (RM 131.1).

48 Schmidt, D.C., S.S. Hale, D.L. Crawford, and P. Suchanek, editors. 1984. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Report No. 2 includes juvenile salmon and resident species studies conducted during the period May to October 1983. The majority of these studies took place in the Susitna River between the Chulitna River confluence and Devil Canyon. Very limited sampling (primarily for resident species) was conducted downstream of the Chulitna River confluence.

The report is divided into seven separate papers addressing topics from four general subject areas: distribution and relative abundance, movement and migration, population dynamics, and habitat/species relationships.

49 Roth, K.J., D.C. Gray, and D.C. Schmidt. 1984. The outmigration of juvenile salmon from the Susitna River above the Chulitna River confluence. Part 1 in: D.C. Schmidt, S.S. Hale, D.L. Crawford, and P.M. Suchanek, editors. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Population estimates of juvenile chum (Oncorhynchus keta) and sockeye (O. nerka) salmon were obtained by mark-recapture using a unique application of half-length coded wire tags. Fry were tagged at four sloughs and one tributary of the Susitna River between the Chulitna River confluence and Devil Canyon. Downstream migrant traps were used to recapture tagged fry during June, July, and August 1983. Chinook (O. tshawytscha), coho (O. kisutch), and pink (O. gorbuscha) salmon were also collected during the sampling season.

50 Dugan, L.J., D.A. Sterritt, and M.E. Stratton. 1984. The distribution and relative abundance of juvenile salmon in the Susitna River drainage above the Chulitna River confluence. Part 2 in: D.C.

Schmidt, S.S. Hale, D.L. Crawford, and P.M. Suchanek, editors. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Thirty-five sites, representing four macrohabitat types within the Susitna River drainage, were sampled from May through September 1983 to determine the seasonal distribution and abundance of juvenile salmon (Oncorynchus spp.). Limited sampling was also conducted during October and November. Distribution of all species was found to be significantly related to macrohabitat type and time of year.

51 Suchanek, P.M., R.P. Marshall, S.S. Hale, and D.C. Schmidt. 1984. Juvenile salmon rearing suitability criteria. Part 3 in: D.C. Schmidt, S.S. Hale, D.L. Crawford, and P.M. Suchanek, editors. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Habitat attributes were measured and juvenile salmon (Oncorhynchus spp.) were sampled at representative sites on the Susitna River between the Chulitna River confluence and Devil Canyon. Suitability criteria for percent cover, cover type, velocity, and depth were developed for juvenile (O. tshawytscha), coho (O. kisutch), sockeye (O. nerka), and chum (O. keta) salmon. Composite weighting factors were formulated and correlated with observed fish catch.

52 Marshall, R.P., P.M. Suchanek, and D.C. Schmidt. 1984. Juvenile salmon rearing habitats models. Part 4 in: D.C. Schmidt, S.S. Hale, D.L. Crawford, and P.M. Suchanek, editors. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Using habitat models, the effects of mainstem discharge on rearing habitat of juvenile salmon (Oncorhynchus spp.) in the Susitna River between the Chulitna River confluence and Devil Canyon were quantified. Data collected include hydraulic characteristics, cover, water quality, water surface area, and fish density. Weighted usable areas were calculated for selected species at each site. A habitat index was calculated for site comparisons.

53 Sundet, R.L., and M.N. Wenger. 1984. Resident fish distribution and population dynamics in the Susitna River below Devil Canyon. Part 5 in: D.C. Schmidt, S.S. Hale, D.L. Crawford, and P.M. Suchanek, editors. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Using radio telemetry and mark and recapture methods, the seasonal distribution of rainbow trout (Salmo gairdneri) and estimates of local abundance for other resident species were obtained for the Susitna River between the Chulitna River confluence and Devil

Canyon. Seasonal distribution of round whitefish (Prosopium cylindraceum), burbot (Lota lota), Arctic grayling (Thymallus arcticus), and Dolly Varden (Salvelinus malma) are described. Selected sites were established to monitor catch per unit effort for resident fish species and their response to flow regulation of the proposed hydroelectric project.

54 Suchanek, P.M., R.L. Sundet, and M.N. Wenger. 1984. Resident and fish habitat studies. Part 6 in: D.C. Schmidt, S.S. Hale, D.L. Crawford, and P.M. Suchanek, editors. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Habitat distribution and suitability were evaluated for rainbow trout (Salmo gairdneri), Arctic grayling (Thymallus arcticus), round whitefish (Prosopium cylindraceum), and longnose suckers (Catostomus catostomus) in the Susitna River drainage between the Chulitna River confluence and Devil Canyon. Electrofishing, beach seine, and hook-and-line catch data and habitat data were collected at radio telemetry relocation sites for rainbow trout and burbot (Lota lota) and at spawning sites (round whitefish). Suitability criteria for velocity, depth, and object cover were fit to the distribution of resident fish.

55 Hale, S.S., P.M. Suchanek, and D.C. Schmidt. 1984. Modelling of juvenile salmon and resident fish habitat. Part 7 in: D.C. Schmidt, S.S. Hale, D.L. Crawford, and P.M. Suchanek, editors. Resident and juvenile anadromous fish investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 2. Alaska Department of Fish and Game, Anchorage, Alaska.

Instream Flow Group (IFG) hydraulic models were used to evaluate the effect of mainstem discharge on rearing habitat for juvenile salmon and resident species at seven sites on the Susitna River between the Chulitna River confluence and Devil Canyon. Overtopping of side slough heads by mainstem discharge causes abrupt changes in rearing habitat which are positive benefit to some species/life stages and negative for others.

56 Estes, C.C., and D.S. Vincent-Lang, editors. 1984. Aquatic habitat and instream flow investigations, May-October 1983 (10 volumes: Chapters 1-10). Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Report No. 3 is divided into two parts: Part I (Chapters 1-4), Hydrological and Water Quality Investigations, is a compilation of the physical and chemical data collected by the ADF&G Susitna Hydroelectric Aquatic Studies team during 1983. Part II (Chapters 5-10), Adult Anadromous Fish Habitat Investigations, describes the subset of available habitat between Cook Inlet and Devil Canyon that is utilized by adult anadromous fish. Primary emphasis is upon slough and side channel habitats.

57 Quane, T., P. Morrow, and T. Withrow. 1984. Stage and discharge investigations. Chapter 1 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Baseline hydrological data have been collected within the Susitna River basin since 1981 in conjunction with the baseline fisheries studies being conducted by the Alaska Department of Fish and Game Susitna Hydroelectric Aquatic Studies Feasibility Team. The primary objective of the data collection program has been to collect baseline hydrological data (stage/water surface, elevation, stream flow, and discharge) within the variety of fish habitats that are present in the Susitna River basin and to determine the influences of mainstem discharge conditions on the hydrological characteristics of these habitats. Although these investigations have been conducted throughout this large glacially-fed river system, effort has been concentrated in the reach of river extending from Talkeetna (RM 97) to Devil Canyon (RM 150) as impacts from the construction and operation of the proposed hydroelectric development are expected to be greatest in this river reach.

Six major fishery habitat types are located in the reach of river from Talkeetna to Devil Canyon; mainstem, side channel, side slough, upland slough, tributary mouth, and tributary. Sufficient data was collected to describe the relationship of mainstem discharge on the

water surface elevation of the mainstem at 46 sites. Based on these data, this relationship is fairly well defined for the range of discharges from 5,000 to 30,000 cfs (as referenced to the USGS Gold Creek mainstem discharge gaging station). Mainstem discharge was also found to influence, to varying degrees, the hydraulic characteristics of side channels and side slough habitats by creating backwater areas and by overtopping the heads of these habitats. Prior to overtopping events, flow in these habitats was found to be generally clear and low, originating from ground water upwelling and surface water runoff. Subsequent to overtopping, flow in these habitats was found to increase dramatically and become directly governed by mainstem discharge. The heads of upland slough habitats are never found to breach, with the only influence of mainstem discharge on these habitats being backwater effects. The stream flow regimes of the major clearwater tributaries in this reach were also evaluated to determine the relative contribution of the tributaries to the overall discharge of the Susitna River watershed.

Information from these studies will be used by other project biologists and engineers to evaluate the impact of hydroelectric development on the Susitna River.

58 Quane, T., I. Queral, T. Keklak, and D. Seagren. 1984 Channel geometry investigations of the Susitna River basin. Chapter 2 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream

flow investigations, May- tober 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Channel geometry data have been collected by the Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Feasibility Study Team since 1982 at twenty-one side channel, upland and side slough and tributary habitats located in the Talkeetna to Devil Canyon reach of the Susitna River. These data have been used to describe the channel characteristics of these study sites. Thalweg profiles, depicting the overall gradient, extent of backwater, and substrate composition of the site, were constructed from the data for four side channels and thirteen upland and side sloughs. Cross section profiles, illustrating the cross sectional channel characteristics and wetted surface area as a response to stage changes, were also developed for selected stage/discharge monitoring stations within these study sites. These data are used by other project biologists and engineers to evaluate the impact of hydroelectric development on the Susitna River.

59 Keklak, T., and T. Quane. 1984. Continuous water temperature investigations. Chapter 3 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Surface and intragravel water temperature data have been recorded on a continuous basis at selected locations throughout the Susitna River Basin since 1981 by the Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Feasibility Team to characterize the water temperature regimes of the mainstem Susitna River and its peripheral habitats. During the 1983 open water season (May-October 1983) baseline surface and intragravel water temperature data were recorded in the mainstem Susitna River and its peripheral side channel, side slough, upland slough, and tributary habitats. Although data were collected from the estuary (RM 0.0) to above the Oshetna River (RM 235.7), the study concentrated on the reach of the river from the Parks Highway Bridge (RM 83.9) to the Oshetna River (RM 233.4). During the 1983 open water season surface water temperatures in the mainstem Susitna River generally increased downstream from RM 235.7 to RM 103.0. Surface water temperatures recorded at RM 83.9 were colder reflecting the influences of the Talkeetna and Chulitna rivers. Intragravel temperatures were recorded at sites form RM 103.3 to RM 142.3. Warmest intragravel temperatures were recorded at the most upstream site. The influence of mainstem temperatures on surface water temperatures in side sloughs or side channels resulting from mainstem breaching discharges was observed in side channels 10, upper 11, and 21, and in side slough 9 and 21. Intragravel temperatures recorded in side channels and side sloughs were influenced by ground water upwelling or mainstem temperatures. Variability in intragravel temperatures recorded within a side channel or side slough was observed in upper side channel 11 and slough 8A.

Results of these investigations will be used to evaluate the influences that seasonal water temperatures have on fish and fish habitats and to calibrate or validate various temperature models.

60 Sandone, G., and T. Quane. 1984. Water quality investigations. Chapter 4 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Baseline water quality data have been collected within the Susitna River basin since 1981 in conjunction with the baseline fisheries studies being conducted by the Alaska Department of Fish and Game Susitna Hydroelectric Aquatic Studies Feasibility Team. The primary objective of the data collection program has been to collect baseline water quality data (dissolved oxygen, pH, conductivity, temperature, and turbidity) within the habitats selected for fishery studies that are present in the Susitna River basin and to determine the influences of mainstem discharge conditions on the water quality characteristics of these habitats. Although these investigation have been conducted throughout this large glacially-fed river system, effort has been concentrated in the reach of river extending from Talkeetna (RM 97) to Devil Canyon (RM 150) as impacts from the construction and operation of the proposed hydroelectric development are expected to be greatest in this river reach.

The 1983 investigations (summarized in this report), concentrated on mainstem, side channel, side slough and tributary habitats. Water quality measurements of dissolved oxygen, pH, conductivity and turbidity were obtained in the mainstem Susitna River and Talkeetna and Chulitna rivers twice a month on an instantaneous basis except for the Talkeetna fishwheel and Gold Creek camp stations, which were monitored daily. Turbidity measurements were obtained from several side channels and side sloughs in the Talkeetna to Devil Canyon reach twice a month.

Results of these investigations indicate that water quality in the mainstem Susitna River is relatively similar among sampling locations but that specific water quality variables at sampling locations but that specific water quality variables at sampling stations change in relation to mainstem discharge. Increased levels of turbidity in the mainstem were found to correlate to mainstem discharge, but are assumed to result from suspended sediment contributed by the Susitna and MaClaren glaciers. Turbidity levels remain low when glacial melt ceases. Turbidity levels in side channels and side sloughs were found to be independent of mainstem discharge prior to breaching of the heads by the mainstem, however, subsequent to breaching those sites were found to resemble the turbidity of the mainstem with the controlling factor being the relative flow contribution of the mainstem to that of the site flow. Tributary water quality was found to be independent of mainstem Susitna River discharge and was determined to influence to varying

degrees the water quality conditions of the mainstem depending on the relative size of the tributary.

Information from these studies will be used by other project biologists and engineers to evaluate the impact of hydroelectric development on the Susitna River.

61 Vincent-Lang, D.S., and I. Queral. 1984. Eulachon spawning in the lower Susitna River. Chapter 5 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Eulachon (Thaleichthys pacificus [Richardson]) are an anadromous member of the smelt family. Studies to determine naturally occurring hydraulic and temperature relationships to eulachon inmigration and spawning were initiated by the Alaska Department of Fish and Game (ADF&G) in 1982 and continued into 1983. These surveys indicated that eulachon are probably the most abundant species of fish in the Susitna River. Based on 1981 and 1983 catch data, eulachon begin their upstream spawning migration during early to mid-May. Two distinct spawning runs of eulachon enter the Susitna River with no apparent correlation with either mainstem discharge or temperature. Spawning was found to occur over a broad range of hydraulic and substrate conditions along the margins of mainstem habitats from the mouth of the Susitna River (RM 0) upstream to RM 50.3. Based on a representative number of spawning sites selected for further evaluation, it appears that similar physical habitat condition will be present under both decreased and increased mainstem discharge conditions.

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

An interim evaluation of passage conditions for adult Pacific salmon (Oncorhynchus spp.) into and within twelve slough and side channel sites in the middle reach of the Susitna River is presented to determine the effects of mainstem discharge on passage conditions into these habitat types. These habitats were selected for evaluation as they are affected by mainstem Susitna River discharges. A final evaluation will be completed in FY 85. The sites account for the majority of chum, sockeye, and pink salmon which spawn in sloughs and side channels in this reach. The evaluation of salmon passage conditions at each site included the effect of mainstem breaching discharge and backwater staging, and slough flows (local flows) derived from local water sources (e.g., upwelling, tributaries, precipitation). Timing and distribution patterns of salmon were also evaluated as they relate to passage conditions and flow patterns in the Susitna River system.

Daily salmon catch data at three fishwheel sites on the mainstem river were compared to mean daily discharge levels. These discharge

data and survey counts of peak numbers of live and dead salmon in sloughs and side channels indicate that the period from August 20 to September 20 is a critical period for providing passage into and within slough and side channel sites from the mainstem Susitna River. All analyses of passage were therefore restricted to this time period.

Reaches within the study sites which were restrictive to salmon passage (passage reaches) were identified at each site on the basis of water depth requirements for passage by salmon. Depth requirements for successful passage increased with and increase in the length of a passage. The analyses of breaching and backwater discharges and local flow effects on passage reaches were conducted independently and their relative importance is reported on a site by site basis. In general, breaching discharges affect all passage reaches within a site simultaneously; whereas, backwater staging usually affects only one or two passage reaches in the lower portion of a site. Local flow requirements may affect all passage reaches, but vary among sites and among passage reaches. These variations in local flow requirements are due to spatial variations in sources of local flow.

63 Vincent-Lang, D.S., A. Hoffmann, A.E. Bingham, C.C. Estes, D. Hillard, C. Steward, E.W. Trihey, and S. Crumley. 1984. An evaluation of chum and sockeye salmon spawning habitat in sloughs and side channels of the middle Susitna River. Chapter 7 in: C.C. Estes, and D.S.

Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Three sloughs (8A, 9, and 21) and four side channels (10, lower 11, upper 11 and 21) in the middle reach of the Susitna River were evaluated using an Instream Flow Incremental Methodology (IFIM) physical habitat simulation (PHABSIM) modelling approach to evaluate the effects that site flow and mainstem discharge have on chum (Oncorhynchus keta) and sockeye (O. nerka) salmon spawning habitat conditions on these sloughs and side channels are thought to represent the range of spawning habitat conditions that are present in the sloughs and side channels of the middle Susitna River which currently support a majority of chum and sockeye salmon spawning in these habitat types.

Ten hydraulic simulation models were calibrated to simulate depths and velocities associated with a range of site specific flows at these seven modelling study sites. Comparisons between corresponding sets of simulated and measured depths and velocities indicate that the calibrated models provide reliable estimates of depths and velocities within their recommended calibration ranges.

Habitat suitability criteria for chum and sockeye salmon spawning for the habitat variables of depth, velocity, substrate, and upwelling were developed for input into a habitat simulation model. The suitability criteria developed for chum salmon spawning were

based on an analysis of utilization data as modified using limited preference data, literature information, and the opinion of project biologists familiar with middle Susitna River chum salmon stocks. The spawning suitability criteria constructed for sockeye salmon were developed using the same analytical approach used in the chum salmon analysis with the exception that no analysis of preference could be made.

Using a habitat simulation model (HABTAT), the output of hydraulic simulation models and the spawning habitat suitability criteria were linked to project usable area of chum and sockeye salmon spawning habitat (WUA) as a function of flow for each of the seven modelled study sites. Using these relationships and relationships between site flows and mainstem discharge presented in Chapter 1 of this report, the relationships between chum and sockeye salmon spawning habitat as a function of mainstem discharge for the period of controlled site flows were also determined for each modelled study site. These projections of chum and sockeye spawning WUA made at study sites indicate that spawning habitat usability in sloughs and side channels exhibits certain species-specific and site-specific trends. Generally, projections of WUA at study sites peak in the range mainstem discharges from 20,000 to 35,000 cfs, with the controlling factor appearing to be the overtopping of the site by mainstem discharge and the subsequent control of the site flow by mainstem discharge. Assuming that the modelled sloughs and side channels are representative of other non-modelled sloughs and side

channels in the middle reach which currently support spawning, the theoretical maximum WUA for slough and side channel habitats in the middle river reach would occur slightly after the mainstem discharge overtops and controls the hydraulics at a maximum number of these habitats. Based on a review of time series plots of WUA over time of each study site, however, flows at study sites which currently support chum and sockeye spawning are only infrequently controlled by mainstem discharge. For this reason, the WUA at study sites remains relatively low and stable during the period of peak spawning activity (August through September), except during flood events. There appears to be a general positive correlation between projected WUA and habitat use at study sites.

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

Two tributary mouths (Lane Creek and Fourth of July Creek) located in the middle reach of the Susitna River were evaluated to determine the influence that mainstem discharge has on the quantity and quality of chum (Oncorhynchus keta) salmon spawning habitat. During the 1983 field season, chum salmon were observed spawning in the

clearwater plume of Fourth of July Creek, but not within the Lane Creek mouth area. At each study site, the location and surface area of available and usable chum salmon spawning habitat was determined. Available habitat surface area was positively correlated to changes in mainstem discharge at both tributary mouth study sites, whereas usable chum salmon spawning habitat increased with increasing mainstem discharge only at the Fourth of July Creek mouth area. The surface area of usable chum salmon spawning habitat within the Lane Creek mouth decreased as mainstem discharge increased. This difference in usable surface area responses is likely related to the different type of confluence area of each site. Lane Creek flows directly into the mainstem while Fourth of July Creek empties into a side channel. Spawning activity could not be observed beyond the clearwater plume at the Fourth of July mouth area due to high mainstem turbidities. Because of this, the importance of the clearwater plume in determining the area of usable chum salmon spawning habitat at tributary mouth habitats could not be ascertained. If it is subsequently determined that chum salmon spawning does take place outside of the clearwater plume area of tributary mouths, the frequency distribution of spawning depths and velocities reported herein is likely biased towards shallower and slower waters.

65 Vincent-Lang, D.S., A. Hoffmann, A.E. Bingham, and C.C. Estes. 1984. Habitat suitability criteria for chinook, coho, and pink salmon spawning in tributaries of the middle Susitna River. Chapter 9 in:

C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Utilization data for the habitat variables of depth, velocity, and substrate composition were collected at chinook (Oncorhynchus tshawytscha) salmon spawning sites in selected tributaries of the middle reach of the Susitna River. These data were modified using statistical methods and the professional judgements of project biologists familiar with Susitna River chinook salmon stocks to develop suitability criteria for chinook salmon spawning in tributaries of the middle Susitna River. These criteria show that depths ranging from 0.5 to 4.0 feet; mean water column velocities ranging from 0.3 to 4.5 feet/second; and, substrates ranging from small gravels to cobbles are suitable for chinook salmon spawning in these habitats. Suitability criteria were also developed for coho (O. kisutch) and pink (O. gorbuscha) salmon spawning in tributaries of the middle Susitna River based on literature information as modified using the professional judgements of project biologists familiar with Susitna River coho and pink salmon stocks. These criteria show that depths ranging from 0.3 to 4.0 feet; mean water column velocities ranging from 0.1 to 4.0 feet/second; and, substrates ranging from sand intermixed with small gravels to large rubbles are suitable for pink salmon spawning in these habitats. The criteria developed for coho salmon spawning in these habitats show the range of depths from 0.3 to 4.0 feet; mean water column

velocities from 0.1 to 4.0 feet/second; and, substrates from sand intermixed with small gravel to large rubbles are suitable for spawning in tributaries of the middle Susitna River. Suggested applications and limitations of these suitability criteria are discussed.

66 Sandone, G., and C.C. Estes. 1984. Evaluations of the effectiveness of applying infrared imagery techniques to detect upwelling ground water. Chapter 10 in: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska.

Studies by the Alaska Department of Fish and Game Susitna Hydroelectric Aquatic Studies Team suggest that upwelling ground water is one of the principal variables influencing the suitability of habitat for chum (Oncorhynchus keta) salmon spawning in the middle reach of the Susitna River (ADF&G 1983). Three infrared heat sensing devices (Hughes Probeye, Xedar Pyroscan, and AGA Thermovision) were tested to evaluate the feasibility of using infrared thermal imagery as a remote sensing technique for detecting and quantifying the amount of upwelling ground water in slough habitats of the Susitna River. Results of these investigations indicate that the application of infrared heat sensing devices for locating upwelling is contingent on a host of environmental conditions and the level of detail desired. Areas of upwelling

ground water and their relative magnitude were identified using these techniques; however, some areas known to have upwelling based on ground truthing surveys were not detected. This inconsistency is due to the wide variety of environmental conditions that occur within the Susitna River combined with the physical limitations of the technology. For these reasons, it is doubtful whether this technique can be applied on a large scale for the detection and quantification of upwelling areas.

67 Schmidt, D.C., C.C. Estes, D.L. Crawford, and D.S. Vincent-Lang, editors. 1984. Access and transmission corridor aquatic investigations (May-October 1983). Susitna Hydro Aquatic Studies. Report No. 4 Alaska Department of Fish and Game, Anchorage, Alaska.

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

68 Sautner, J.S., and M.E. Stratton. 1984. Access and transmission corridor studies. Part 1 in: D.C. Schmidt, C.C. Estes, D.L. Crawford, and D.S. Vincent-Lang, editors. Access and transmission corridor aquatic investigations (July-October 1983). Susitna Hydro Aquatic Studies, Anchorage, Alaska.

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

fish species such as Arctic grayling, Dolly Varden, and lake trout. Other impacts which may occur at proposed stream crossing sites include alterations of stream hydraulics, deterioration of water quality, and removal or shifting of substrates.

69 Schmidt, D.C., and M.E. Stratton. 1984. Population dynamics of Arctic grayling in the upper Susitna Basin. Part 2 in: D.C. Schmidt, C.C. Estes, D.L. Crawford, and D.S. Vincent-Lang, editors. Access and transmission corridor aquatic investigations (July-October 1983). Susitna Hydro Aquatic Studies, Anchorage, Alaska.

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

70 Alaska Department of Fish and Game (ADF&G). 1985 (in preparation). Susitna Aquatic Studies Procedures Manual (June 1984-June 1985).

Susitna Aquatic Studies Program. Alaska Department of Fish and Game, Anchorage, Alaska.

71 Keklak, T., and T. Quane. 1985a. Continuous water temperature investigations. Susitna Aquatic Studies Program. Task 32 Support Technical Report. Alaska Department of Fish and Game, Anchorage, Alaska.

Surface water temperatures were collected at 15 mainstem and 8 tributary sites on the Susitna River during the 1984 open water season. Continuous recordings were made with either Peabody-Ryan model J-90 temperature recorders, or Omnidata two channel datapod recorders. Data is presented in tables and plots. The data will be used by the Arctic Environmental and Information Data Center (AEIDC) in a temperature modelling study.

72 Estes, C.C., J. Sautner, and D.S. Vincent-Lang, editors. 1985 Winter aquatic investigations, September 1983-May 1984 (2 volumes). Susitna Aquatic Studies Program. Report No. 5. Alaska Department of Fish and Game, Anchorage, Alaska.

Report No. 5 provides results of the 1983-84 winter studies conducted by the Alaska Department of Fish and Game to evaluate and compare existing chum (Oncorhynchus keta) salmon incubation conditions in selected slough, side channel, tributary, and mainstem habitats of the Susitna River between Talkeetna and Devil Canyon (RM

98-152). The types of data presented include development and survival data for chum salmon embryos, surface and intragravel water quality data (pH, conductivity, temperature, and dissolved oxygen), and substrate composition data. The report is bound in two volumes. Volume 1 presents an evaluation of the incubation life phase of chum salmon in the middle Susitna River. Volume 2 presents an independent evaluation of the surface and intragravel water temperature conditions at incubation study sites as well as other monitoring sites.

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

An evaluation of the pattern of survival and development and chum (Oncorhynchus keta) salmon embryos incubated in artificial redds in slough, side channel, tributary, and mainstem habitats of the middle Susitna River was conducted in conjunction with an assessment of the currently available chum salmon incubation habitat conditions within these habitat types. Chum salmon eggs obtained from local stocks were artificially fertilized, placed within modified Whitlock-Vibert Boxes (WVB's) and then implanted in artificial redds in the streambed at selected study sites. At each of these sites, a

polyvinyl chloride standpipe was also installed to obtain instantaneous intragravel water quality measurements of temperature, dissolved oxygen, pH, and conductivity which were later correlated to the percent survival of embryos (100 percent hatched) at each site. In addition, representative substrate samples were obtained at selected study sites using a modified McNeil substrate sampler to characterize the substrate conditions present at incubation study sites.

The survival rates of embryos in slough, side channel and tributary habitats were 17, 9, and 11 percent, respectively. Survival of embryos in mainstem habitat was 19 percent but did not reflect the effects of dewatering and freezing due to a difference in the method of site location. Thus, estimates of percent survival for this habitat type are probably higher than would be expected for natural conditions.

The largest demonstrated cause of embryo mortality at study sites was due to dewatering and subsequent freezing of the streambed. Greater than 47 percent of the total number of WVB's used to estimate survival became frozen. This effect was greatest in side channels and least in sloughs, and was observed to be directly related to the presence and quantity of upwelling water. Areas particularly vulnerable to the effects of dewatering and freezing include large portions of side channel habitats as well as the mouth areas of slough and tributary habitats which may lack sources of upwelling water.

A quantitative analysis of the effect of each variable on survival was hampered by the high embryo mortality due to dewatering and subsequent freezing of substrate. When frozen embryos were removed from the survival data base, no significant correlations were obtained between measured water quality variables and percent survival of embryos (p 0.5). However, the correlation between dissolved oxygen (mg/l) and percent survival of embryos decreased to zero at dissolved oxygen concentrations below 3.0 mg/l. The percent survival of embryos was also correlated to the percent of fine substrate particles (0.08 in. diameter) contained within WVB's. Although there was no significant correlation, the percent survival of embryos decreased to zero when the percent of fines exceeded 18 percent.

The rate of embryonic development at study sites was found to be strongly influenced by the degree of upwelling present. Chum salmon embryos which were fertilized on August 26, 1983, and incubated in an upwelling area in a side channel, reached the 100 percent hatch in late December, whereas those incubated in a non-upwelling area in the mainstem Susitna River experienced delayed development and did not reach 100 percent hatch until mid-April. Therefore, the presence of upwelling water in middle Susitna River habitats appears to be a key component which maintains the integrity of chum salmon incubation habitats by preventing substrate from dewatering and freezing and by maintaining suitable incubation temperatures which allow embryos to develop properly.

A comparison of the rates of in situ embryo development observed in this study to those observed in the laboratory study of Wangaard and Burger (1983) was hampered by problems encountered with temperature recorders installed at each site. Incomplete temperatures records were obtained at study sites used to compare thermal unit requirements for development. However, based on a quantitative assessment of development data collected in these study sites and a previous ADF&G study (ADF&G 1983), it is the opinion of the authors that the predictive equation of Wangaard and Burger are an adequate model to use in predicting rates of chum salmon development of the middle Susitna River.

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

Surface and/or intragravel water temperature was monitored on a continuous basis at 20 selected sites along the Susitna River between Talkeetna and Devil Canyon during the 1983-84 winter field season.

Sites were located at: LRX 9, LRX 29, LRX 57, slough 8A, 9, 10, 11, and 21, side channel 10, 11, and 21, Fourth of July Creek, Deadhorse Creek, Indian River, and mainstem Susitna at RM 136.1.

Similar surface water temperature patterns were exhibited at all mainstem locations except LRX 9, site 3 where beginning in April, temperatures were warmer and more variable than those at LRX 29 and 57. This was probably due to ground water upwelling.

Surface water temperatures generally decreased to approximately 0°C by October and remained near 0°C through May when they began to increase. Intragravel water temperatures at mainstem sites remained stable through the winter until mid-May.

Temperatures were recorded at one mainstem site in support of the chum salmon (Oncorhynchus keta) incubation study. Intragravel temperatures averaged near 0°C until mid-April when they began to increase. Ground water upwelling was not evident. Surface temperatures during the period March 2-May 3 ranged from -0.1°C to 2.0°C. Temperatures recorded within side channel sites were often dissimilar, reflecting the influences of various ground water sources.

Surface water temperatures generally followed similar trends at all slough sites except lower slough 8A. At that site, temperatures were similar to those recorded in the mainstem. surface water temperatures at other sites were generally warmer, ranging from approximately 1°C to 2°C. Intragravel temperature trends varied, reflecting different ground water sources.

Surface and intragravel temperatures measured at Fourth of July Creek and Indian River followed a trend similar to the mainstem. Temperatures were recorded at Deadhorse Creek in support of the mitigation evaluation study. They remained near 0°C through March and then began to increase and daily fluctuations of up to 3.5°C were observed.

75 Quane, T., P. Morrow, and I. Queral. 1985a. Hydrological investigations at selected lower Susitna River study sites. Susitna Aquatic Studies Program. Task 36 Support Technical Report. Alaska Department of Fish and Game, Anchorage, Alaska.

This technical memorandum provides hydraulic data for May-October 1984 to be used in the Task 36 Lower River Instream Flow Incremental Methodology (IFIM) rearing habitat modelling study. The relationship of mainstem Susitna River discharge to side channel and slough stage, stream flow, breaching and backwater conditions was monitored. The data will be used to model changes in salmon rearing habitat as a function of mainstem discharge.

76 Quane, T., P. Morrow, and I. Queral. 1985a. Hydrological investigations at selected lower Susitna River study sites. Susitna Aquatic Studies Program. Task 14 Support Technical Report. Alaska Department of Fish and Game, Anchorage, Alaska.

This report provides hydraulic data to support the Task 14 Lower River Resident and Juvenile Habitat modelling study. In May-October 1984, 19 side channel and slough sites were evaluated for the relationship of mainstem discharge to stream flow, stage, and backwater. Rating curves were developed for six side channel sites. Thalweg and cross section profiles were surveyed to describe channel geometry at all sites. Mainstem discharge at USGS Sunshine Station ranged from 6,000-104,000 cfs. Initial and controlling breaching discharges were estimated for the study sites.

77 Barrett, B.M., F.M. Thompson, and S.N. Wick, editors. 1985. Adult salmon investigations: May-October 1984. Susitna Aquatic Studies Program. Report No. 6. Alaska Department of Fish and Game, Anchorage, Alaska.

This report presents escapement estimates for the Susitna River for chum (Oncorhynchus keta), chinook (O. tshawytscha), sockeye (O. nerka), pink (O. gorbuscha), and coho (O. kisutch) salmon. Fishwheels were operated at four locations between the confluence of the Chulitna River (RM 0.0) and Devil Canyon (RM 161.0). Fish were tagged with Petersen discs or Floy FT-4 spaghetti tags to monitor migration upstream. Samples from each location monitored age, sex, fork length, and length of fish. A fishwheel and side scan sonar were also operated at one location on the Yentna River. An escapement of 5.4 million salmon into the Susitna was estimated using the Petersen index.

Spawning surveys were performed by visual identification of spawning pairs, redds, or incubating eggs. Spawning sites were mapped and described by channel morphology, substrate, and ground water. Escapement and spawning results and described by location and species.

78 Schmidt, D.C., S.S. Hale, and D.L. Crawford, editors. 1985. Resident and juvenile anadromous fish investigations (May-October 1984). Susitna Aquatic Studies Program. Report No. 7. Alaska Department of Fish and Game, Anchorage, Alaska.

This report covers studies of juvenile salmon and resident species of the Susitna River during the period May through October 1984. In addition, some information is included on overwintering of resident fish radio-tagged in 1983. The majority of the effort during the 1984 open water season was on the lower river (from the mouth to the Chulitna River confluence). No studies were conducted above Devil Canyon.

79 Roth, K.J., and M.E. Stratton. 1985. The migration and growth of juvenile salmon in the Susitna River. Part 1 in: D.C. Schmidt, S.S. Hale, and D.L. Crawford, editors. Resident and juvenile anadromous fish investigations (May-October 1984). Susitna Aquatic Studies Program. Report No. 7. Alaska Department of Fish and Game, Anchorage, Alaska.

Studies of salmon spawning, embryo incubation, and juvenile rearing are all critical in understanding the current life history and habitat dynamics of salmon in the Susitna River. However, the final measure of the value of a reach of river to the freshwater life stages of salmon is the number and condition of the fry which outmigrate from the reach to the ocean. Baseline data on salmon outmigration have been collected at Talkeetna Station (RM 103.0) for the past three years. The data from 1982 and 1983 have shown that a substantial number of chinook (Oncorhynchus tshawytscha), coho (O. kisutch), and sockeye (O. nerka) fry outmigrate from the middle river during their first summer. Because the majority of returning adults have spent at least one winter rearing in freshwater, an important question was whether these age 0+ fish overwintered in the lower river or had a low survival rate. To help answer this question, outmigrant traps were also operated near the mouth of the Susitna River (RM 22.4) during 1984. Mark and recapture studies gave population estimates for chum and sockeye fry (marked by coded wire tags) in the Susitna River above Talkeetna Station (middle river) and for chinook fry (marked by cold branding) in Indian River and other rearing sites. The cold branding study also monitored outmigration timing from Indian River and obtained estimates of juvenile chinook residence time in mainstem rearing areas. The Talkeetna River and Deshka River were intermittently sampled to help explain the mainstem outmigrant trap data. A portion of the age 0+ chinook fry apparently outmigrate from the middle river upon reaching a critical size but a large number remain to overwinter and

then outmigrate during their second summer. Coho fry outmigrate at a wider range of lengths than chinook fry so the cumulative biomass of coho fry lags behind the cumulative numbers of individuals by one or two weeks. Age 0+ chinook and coho fry grow about 30 mm in length during the open water season. Juvenile sockeye salmon appear to seek out lake-like rearing areas at a size of about 50 mm. The limited amount of this habitat type in the middle river is the major influence on their redistribution to the lower river. The estimated 1984 middle river population size was about 300,000 for age 0+ sockeye and 2,040,000 for chum fry. Chum fry rearing in the middle river demonstrated by their growth and by analysis of stomach contents.

80 Hale, S.S. 1985. Time series analysis of discharge, turbidity, and juvenile salmon outmigrationin the Susitna River, Alaska. Appendix C of Part 1 in: D.C. Schmidt, S.S. Hale, and D.L. Crawford, editors. Resident and juvenile anadromous fish investigations (May-October 1984). Susitna Aquatic Studies Program. Report No. 7. Alaska Department of Fish and Game, Anchorage, Alaska.

81 Suchanek, P.M., K.J. Kuntz, and J.P. McDonnell. 1985. The relative abundance, distribution, and instream flow relationships of juvenile salmon in the lower Susitna River. Part 2 in: D.C. Schmidt, S.S. Hale, and D.L. Crawford, editors. Resident and juvenile anadromous fish investigations (May-October 1984). Susitna Aquatic Studies Program. Report No. 7. Alaska Department of Fish and Game, Anchorage, Alaska.

Juvenile salmon abundance and distribution were studied in the lower Susitna River (below the Chulitna River confluence) and juvenile salmon rearing habitat was modelled at 20 sites within the reach. Chinook (Oncorhynchus tshawytscha), chum (O. keta), and sockeye (O. nerka) salmon juveniles made use of side channels; however, high turbidity limited use of side channels located in the Chulitna River plume. Coho salmon juveniles were found primarily in tributary mouths; sockeye, chinook and chum salmon also were present in these areas. Sloughs, which were limited in occurrence, were not used heavily by any of the salmon species.

Both tributary mouths and side channel/slough sites were modelled using one of two habitat models. At tributary mouths, an increase in weighted usable area with a rise in mainstem discharge resulted from the formation of backwater areas which led to lower velocities and an expansion of the area and amount of cover inundated. At side channels, chinook weighted usable area increased after overtopping

due to a gain in cover suitability (turbidity), velocity, and area. The weighted usable area response to a rise in mainstem discharge for sockeye and chum salmon juveniles at side channels was also usually positive. Habitat indices at side channels for chinook, chum, and sockeye juveniles at mainstem discharges and side channel flows above the overtopping discharge declined as velocities became unsuitably high. Weighted usable area for these species did not always decline at high discharges, however, because of the compensating effect of a larger surface area.

82 Anderson, J., J. Bigler, and A.G. Hoffmann. 1985. Hydraulic models for use in assessing the rearing habitat of juvenile salmon in six side channels of the lower Susitna River. Appendix D of Part 2 in: D.C. Schmidt, S.S. Hale, and D.L. Crawford, editors. Resident and juvenile anadromous fish investigations (May-October 1984). Susitna Aquatic Studies Program. Report No. 7. Alaska Department of Fish and Game, Anchorage, Alaska.

Six side channels (Island, Mainstem West Bank, Circular, Sauna, Sunset, and Trapper Creek) in the lower reach of the Susitna River were evaluated using an Instream Flow Incremental Methodology (IFIM) physical habitat simulation (PHABSIM) modelling approach to describe the effects that site flow and mainstem discharge have on rearing juvenile salmon habitat. These sites were thought to contain potential habitat for rearing juvenile salmon and were chosen to range greatly in size, shape, and overtopping discharge.

Six hydraulic simulation models (either IFG-2 or IFG-4) were calibrated to simulate depths and velocities associated with a range of site-specific flows at the six modelling study sites. Comparisons between corresponding sites of simulated and measured depths and velocities indicated that the models provide reliable estimates of depths and velocities within their recommended calibration ranges.

The recommended of ranges of mainstem Susitna River discharge over which these models can hydraulically simulate the habitat of rearing juvenile salmon are: Island Side Channel from 35,000 to 70,000cfs mainstem discharge; Mainstem West Bank Side Channel from 18,000 to 48,000 cfs; Circular Side Channel from 36,000 to 63,000 cfs; Sauna Side Channel from 44,000 to 63,000 cfs; Sunset Side Channel from 32,000 to 67,000 cfs; and Trapper Creek Side Channel from 20,000 to 66,000 cfs.

83 Sundet, R.L., and S.D. Pechek. 1985. Resident fish distribution and life history in the Susitna River below Devil Canyon. Part 3 in: D.C. Schmidt, S.S. Hale, and D.L. Crawford, editors. Resident and juvenile anadromous fish investigations (May-October 1984). Susitna Aquatic Studies Program. Report No. 7. Alaska Department of Fish and Game, Anchorage, Alaska.

Studies of resident fish were conducted in both the lower (below Chulitna River confluence) and middle (Chulitna River confluence to

Devil Canyon) Susitna River in 1984. The primary objectives in the middle river were to determine the seasonal distribution, timing of spawning, and spawning areas of rainbow trout (Salmo gairdneri), and to monitor 13 index sites as part of the long term monitoring effort. Most of the rainbow trout data was collected by use of radio telemetry. Results showed that rainbow trout are relatively few in numbers and that spawning occurs at selected areas which are influenced by lakes. Much of the rainbow trout population in the middle river probably originates in lakes which drain into middle river tributaries. Rainbow trout were abundant in lakes located at the headwaters of Fourth of July Creek and in the upper reaches of Portage Creek. Rainbow trout were also found to use Portage Creek more extensively than previously thought. Spawning occurred during the first week of June. All rainbow trout moved out of tributaries by early October (probably triggered by low fall discharges), and most overwintered in the mainstem Susitna River slightly downstream (0.1-4.0 miles) of the tributary where they were captured. Other middle river studies suggest Arctic grayling (Thymallus arcticus) overwinter in the mainstem Susitna then ascend and spawn in tributaries in late May. Arctic grayling also outmigrated from tributaries at the same time as rainbow trout. Catch data at middle river index sites in 1984 were similar to 1982 and 1983 findings. Studies in the lower river reinforced the belief that some humpback whitefish (Coregonus pidschian) are anadromous, and that rainbow trout and Arctic grayling outmigrate from most east side tributaries in September. Lower river studies also found that burbot (Lota lota) move into the Deshka River in mid-September.

84 Hansen, T.F., and J.C. Richards. 1985. Availability of invertebrate food sources for rearing juvenile chinook salmon in turbid Susitna River habitats. Susitna Aquatic Studies Program. Report No. 8. Alaska Department of Fish and Game, Anchorage, Alaska.

Benthic and drifting invertebrates were sampled from May through October 1984 to evaluate available fish food resources and the gain and loss of benthic invertebrate habitat resulting from changes in flow. Four side channel and side slough sites were sampled at head and mid-section locations using drift nets and modified Hess type samplers. Juvenile chinook (Oncorhynchus tshawytscha) salmon were also sampled using electrofishing techniques to correlate the available food sources being utilized.

A total of 52 invertebrate taxa were identified in drift and benthic samples, with Chironomidae being the dominant taxa. The proportions of numbers of invertebrates found in the stomachs of juvenile chinook salmon were closely correlated with the proportions of invertebrates available in the drift. Drift samples collected under breached conditions indicated that invertebrates were being transported from the mainstem into the side channels and side sloughs. The quantity of drifting invertebrates in side channels and side sloughs under unbreached conditions was negligible compared to the drift under breached conditions when total drift was considered.

Habitat suitability criteria were developed and weighted usable area was estimated for invertebrates which were common to drift, benthos, and the diet of juvenile chinook salmon by behavioral type (i.e., burrower, swimmer, clinger, and sprawler). The densities of each of the behavioral types generally correlated with water velocity and substrate type. Depth of water did not appear to be an important factor influencing and density of organisms. Water velocities less than 0.4 feet/second and substrates comprised of silts and sands generally supported the highest mean densities of burrowers which were made up primarily of Chironomidae. Rubble substrates with components of large gravel or cobble and water velocities between 1.6 feet/second and 2.6 feet/second generally supported the highest mean densities of swimmers and clingers. Sprawlers did not appear to preferentially utilize any particular substrate or water velocity.

Projected weighted usable area for each of the behavioral types was clearly a function of mainstem discharge. The minimum controlling mainstem discharge for each of the study sites generally produced the greatest amount of burrower habitat weighted usable area. The maximum amount of weighted usable area for swimmer, clinger, and sprawler habitat at all study sites was reached at a mainstem discharge above 25,000 cfs.

In conclusion, naturally fluctuating mainstem flows which occasionally inundated sampling sites appeared to maintain a diverse

benthic fauna and appeared to provide drifting food organisms within sampling sites, thereby contributing to the overall rearing potential of these sites for juvenile chinook salmon.

85 Hoffmann, A.G. 1985. Summary of salmon fishery data for selected middle Susitna River sites (1981-84). Susitna Aquatic Studies Program. Report No. 9. Alaska Department of Fish and Game, Anchorage, Alaska.

The fishery data collected by the Alaska Department of Fish and Game on the Susitna River is a necessary component for use in evaluating effects of variations in natural flow regimes on the life history cycles of the various species present. These data, used in conjunction with the hydraulic data now available for the river, provide the basis for recommending various flow regimes, mitigation options, etc. for the proposed hydroelectric development with respect to the fishery. This report indexes the fishery data collected by a variety of ADF&G studies under one cover in order to better facilitate this process.

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

An interim evaluation of the effects that mainstem discharge and local flow have on passage conditions for adult salmon at selected slough and side channel habitats of the middle reach of the Susitna River was previously presented in Sautner et al. (1984). Due to the limited data available for this interim evaluation, the Passage Validation Studies (PVS) were initiated during the 1984 open water field season to collect additional physical and biological data to re-evaluate the passage criteria and the local flow and mainstem discharge values required for successful and unsuccessful salmon passage within these habitats. In addition, the methodologies used for the backwater and local flow analyses were revised to reflect the additional data which were collected. Physical data collected included channel cross section and thalweg profiles, substrate assessments, and local flow measurements. Biological data consisted of salmon passage criteria based on visual observations of adult chum salmon (Oncorhynchus keta) movement in selected slough and side channel habitats.

The salmon passage criteria previously presented in Sautner et al. (1984) were re-evaluated and revised based on these data using a modified analytical approach. The revised analysis resulted in the development of a single set of salmon passage criteria thresholds for defining successful and unsuccessful passage conditions at study sites. A total of 85 passage reaches were identified at slough and side channel sites during the 1984 PVS compared to 74 passage reaches identified in Sautner et al. (1984). Using the revised

criteria thresholds as guidelines, a re-evaluation of the breaching, backwater, and local flow analyses for these passage reaches indicates that mainstem discharge and local flow requirements for successful and unsuccessful passage are similar to values previously established. The most significant differences occurred in the backwater analysis for some sites, where required mainstem discharges decreased over 1,000 cfs. Water depth was determined to be the primary physical variable affecting passage conditions at passage reaches; passage conditions were not greatly affected by changes in passage reach length. Variations in channel configuration and substrate size were assumed to have a negligible influence on the salmon passage criteria. The revised passage criteria thresholds are based on an upper thalweg depth of 0.5 feet thereby voiding all previous analyses that utilized 0.67 feet as the upper limit of thalweg depth.