

Sportfish Research and Technical Services Unit
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This notebook is current through May 9, 1988.

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SUSITNA RIVER AQUATIC STUDIES
DIVISIONS OF SPORT AND COMMERCIAL FISHERIES

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38b 1986 Stratton, M.E. 1986. Summary of juvenile chinook and coho salmon winter studies in the middle Susitna River, 1984-85. Part 2 of: ADF&G. Winter studies of resident and juvenile anadromous fish (October 1984-May 1985). Susitna Aquatic Studies Program. Report No. 11 (Volume 2). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #3063. 3063

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- 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, Anchorage, Alaska. APA Document #1612.

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.

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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.

- 1a Barrett, B.M. 1975. December investigations on the upper Susitna River watershed between Devil Canyon and Chulitna River. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska. APA Document #1609.

These investigations were intended to provide "information on fry distribution and abundance and winter conditions in the sloughs and in (the mainstem of) the Susitna River." Data collection field trips were conducted in December 1974, January 1975, and February 1975 that encompassed four, five, and seven days, respectively.

Age and length data is reported for coho Oncorhynchus kisutch fry. With the exception of one rainbow trout, Salmo gairdneri, no other fry were reported as being caught.

Dissolved oxygen, pH, relative water height, ice thickness and cover, snow depth, air and water temperature, and flow data were collected at Sloughs 8, 8A, 9, 9A, 11, 12, 13, 14, 15, Indian River, Lane Creek, Gold Creek, and at three mainstem Susitna River sites (at Gold Creek, Chase, and at the Anchorage-Fairbanks Highway). Settleable, non-filterable, and total suspended solids were reported for the mainstem sites. Flow data is limited to present or not, except for one measured flow at Lane Creek (7.21 CFS on 12/6/74).

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1a Cont. The report is divided into three sections, by sample trip. Each trip report includes methods or procedures, discussion, results, and recommendations. The recommendations are limited to suggestions about further sampling.

- 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. APA Document #549.

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:

	<u>1974</u>	<u>1975</u>
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.

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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 Chulitna 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 (stoneflies) and Diptera ("no-see-ums") represented the dominant orders. Simuliidae (black flies), Ephemeroptera (mayflies), Trichoptera (caddis flies) were also present.

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

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

- 3 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. APA Document #1610.

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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 33,300 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.

- 4 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. APA Document #75.

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.

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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.

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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.

- 5 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. APA Document #3281.

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.

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

- 6a Alaska Department of Fish and Game (ADF&G). 1981. Aquatic Studies Procedures Manual (1980-1981). (Volume 1 of 2). Susitna Hydro Aquatic Studies. Phase 1. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document # ?.

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

- 6b Alaska Department of Fish and Game (ADF&G). 1981. Aquatic Studies Procedures Manual (1980-1981). (Volume 2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 1. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document # ?.

- 7 Alaska Department of Fish and Game (ADF&G). 1981. 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. APA Document #324.

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

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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 5₂, 4₁, and 4₃ 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.

- 8 Alaska Department of Fish and Game (ADF&G). 1981. 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. APA Document #322.

This study was designed to gather information describing the presence, abundance, geographical and seasonal distribution, age class composition, length distribution, and smolt migration timing

RTS No.

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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.

- 9 Alaska Department of Fish and Game (ADF&G). 1981. Resident fish investigation on the Lower 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. APA Document #318.

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

RTS No.9
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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 known 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

RTS No.

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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.

- 10 Alaska Department of Fish and Game (ADF&G). 1981. 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. APA Document #316.

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:

RTS No.

10 Arctic grayling (Thymallus arcticus), burbot (Lota lota), slimy
 Cont. 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.

11a Alaska Department of Fish and Game (ADF&G). 1981. 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. APA
 Document #1307.

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.

11b Alaska Department of Fish and Game (ADF&G). 1981. Aquatic habitat and
 instream flow project. Susitna Hydro Aquatic Studies. Phase 1
 final draft report. Volume 2 (Section 1 of 2: Appendices EA-EH).
 Subtask 7.10. Alaska Department of Fish and Game, Anchorage,
 Alaska. APA Document #311.

RTS No.

11b 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).

11c Alaska Department of Fish and Game (ADF&G). 1981. Aquatic habitat and instream flow project. Susitna Hydro Aquatic Studies. Phase 1 final draft report. Volume 2 (Section 2 of 2: Appendices EI-EJ). Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #312.

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.

11d Alaska Department of Fish and Game. 1982. Aquatic Studies Procedures manual, Phase I. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska. APA Document #*?*

This document details the objectives, technical procedures, data procedures, quality control, schedule, and personnel qualifications (as of May 1981) of the Su-Hydro Aquatic Studies. The technical and data procedures are divided into those used by the adult anadromous fisheries, resident and juvenile anadromous fisheries, and the aquatic habitat and instream flow study groups.

Appendices included describe sonar installation and operation, oscilloscope operation, fishwheel operation, fish tagging, electroshocking instructions, habitat site locations, resident and juvenile sampling, techniques, and aquatic habitat instruction manuals.

12 Alaska Department of Fish and Game (ADF&G). 1982. 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. APA Document #517.

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.

RTS No.

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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.

- 13 Alaska Department of Fish and Game (ADF&G). 1982. 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. APA Document #403.

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.

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- 14 Alaska Department of Fish and Game (ADF&G). 1983. Aquatic Studies Procedures Manual (1982-1983). Susitna Hydro Aquatic Studies. Phase 2. Subtask 7.10. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #938.

- 15a Alaska Department of Fish and Game (ADF&G). 1983. 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. APA Document #96.

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

- 15b Alaska Department of Fish and Game (ADF&G). 1983. Adult anadromous fish studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 final report. Volume 2 (Section 1 of 2). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #588.

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).

- 15c Alaska Department of Fish and Game (ADF&G). 1983. Adult anadromous fish studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 final report. Volume 2 (Section 2 of 2: Appendices A-H). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #589.

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 (Section 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

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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.

- 15d Alaska Department of Fish and Game (ADF&G). 1983. 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 (Section 1 of 2). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #486.

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.

- 15e Alaska Department of Fish and Game (ADF&G). 1983. 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 (Section 2 of 2: Appendices). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #487.

- 15f Alaska Department of Fish and Game (ADF&G). 1983. Aquatic habitat and instream flow studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 4 (Section 1 of 3: Part I and II). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #585.

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

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15f defined. Backwater effects at slough, tributary, and side channel
 Cont. 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 ($\pm 15\%$).

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.

15g Alaska Department of Fish and Game (ADF&G). 1983. Aquatic habitat and instream flow studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 4 (Section 2 of 3: Appendices A-C). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #587.

15h Alaska Department of Fish and Game (ADF&G). 1983. Aquatic habitat and instream flow studies, 1982. Susitna Hydro Aquatic Studies. Phase 2 basic data report. Volume 4 (Section 3 of 3: Appendices D-J). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #587.

15i Alaska Department of Fish and Game (ADF&G). 1983. 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. APA Document #590.

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

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15i Cont. 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.).

- 16a Alaska Department of Fish and Game (ADF&G). 1983. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (Section 1 of 2). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #40.

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.

- 16b Alaska Department of Fish and Game (ADF&G). 1983. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (Section 2 of 2: Appendices A-K). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #40.

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 (Section 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.

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

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confluence. Appendix B in: ADF&G. Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (Section 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. gorbuscha, 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).

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 (Section 2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

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 (Section 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.

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 (Section 2 of 2: Appendices). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska.

RTS No.

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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.

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 (Section 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.

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 (Section 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.

RTS No.

16b
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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).

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 (Section 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.

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 (Section 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.

Suchanek, P.M., and S.S. Hale. 1983. Age-length curves and growth of Arctic grayling and rainbow trout. Appendix J in: ADF&G.

RTS No.

16b
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Synopsis of the 1982 aquatic studies and analysis of fish and habitat relationships (Section 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.

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 (Section 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.

- 17 Alaska Department of Fish and Game (ADF&G). 1983. Winter aquatic studies (October 1982-May 1983). Susitna Hydro Aquatic Studies. Phase 2 report. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #309. Incorrect: 309 is draft, 397 is final

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

RTS No.

17
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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

RTS No.

- 17 early February to mid-March. Burbot showed some preference for
Cont. areas with upwelling.

- 18a Alaska Department of Fish and Game (ADF&G). 1984. Susitna Hydro Aquatic Studies Procedures Manual (May 1983 - June 1984) (Volume 1 of 2). Susitna Hydro Aquatic Studies. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #885.

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.

- 18b Alaska Department of Fish and Game (ADF&G). 1984. Susitna Hydro Aquatic Studies Procedures Manual (May 1983 - June 1984) (Volume 2 of 2: Appendices). Susitna Hydro Aquatic Studies. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #886.

- 19 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. APA Document #1450.

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).

RTS No.

- 20 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. APA Document #1784.

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.

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.

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 (Oncorhynchus 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.

RTS No.

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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.

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.

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.

RTS No.

- 20 Cont. 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.

- 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.

- 21a-j 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. APA Document #1930-1939.

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.

- 21a 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. APA Document #1930.

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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.

- 21b 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-October 1983. Susitna Hydro Aquatic Studies. Report No. 3. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #1931.

Channel geometry data have been collected by the Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Feasibility Study

RTS No.

21b Team since 1982 at twenty-one side channel, upland and side slough
 Cont. 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.

21c 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. APA Document
 #1932.

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 from 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.

RTS No.

- 21d 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. APA Document #1933.

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 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.

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 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 MacClaren 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.

RTS No.

- 21e 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. APA Document #1934.

Eulachon (Thaleichthys pacificus [Richardson]) are an anadromous member of the smelt family. Studies to determine naturally occurring hydraulic and temperature relationships to eulachon immigration 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.

- 21f 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. APA Document #1935.

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

RTS No.

21f sloughs and side channels indicate that the period from August 20 to
 Cont. 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.

21g 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. APA Document #1936.

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.

RTS No.

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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.

- 21h 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. APA Document #1937.

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

RTS No.

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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.

- 21i 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. APA Document #1938.

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

RTS No.

21i 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.

21j 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. APA Document #1939.

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.

22 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. APA Document #2049.

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.

RTS No.

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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.

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

RTS No.

22 maintain a "trophy" fishery on a sustained yield basis, a catch
 Cont. 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.

- 23 Alaska Department of Fish and Game (ADF&G). 1985. Adult Anadromous
 Studies Procedures Manual (June 1984 - June 1985). Draft. Susitna
 Hydro Aquatic Studies Program. Alaska Department of Fish and Game,
 Anchorage, Alaska (Unpublished report). APA Document #*?*

Technical procedures and data procedures used by Adult Anadromous
 Studies personnel during the period June 1984 - June 1985 of the
 Susitna Hydro Aquatic Studies Program are detailed.

An Adult Anadromous Studies procedures manual was not actually
 produced. Instead objectives and procedures for the period June
 1984 - June 1985 were extracted from Barrett, et al, 1985, ADF&G
 Susitna Hydro Aquatic Studies Report No. 6; APA Document #2748, RTS
 #29.

- 24 Alaska Department of Fish and Game (ADF&G). 1985. Resident and Juvenile
 Anadromous Studies Procedures Manual (May 1984 - April 1985).
 Draft. Susitna Hydro Aquatic Studies Program. Alaska Department of
 Fish and Game, Anchorage, Alaska (Unpublished report). APA Document
 #3014.

Technical procedures and data procedures used by the Resident and
 Juvenile Anadromous Studies personnel during the period May 1984 -
 April 1985 of the Susitna Hydro Aquatic Studies Program are detailed
 here.

- 24a Alaska Department of Fish and Game (ADF&G). 1985. Aquatic Habitat and
 Instream Flow Studies Procedures Manual (May 1984 - April 1985).
 Draft. Susitna Hydro Aquatic Studies Program. Alaska Department of
 Fish and Game, Anchorage, Alaska (Unpublished report). APA Document
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Technical procedures and data procedures used by the Aquatic Habitat
 and Instream Flow Studies personnel during the period May 1984 -
 April 1985 of the Susitna Hydro Aquatic Studies Program are detailed
 here.

- 25 Keklak, T., and T. Quane. 1985. Continuous water temperature
 investigations. Susitna Aquatic Studies Program. Task 32 Support
 Technical Report. Alaska Department of Fish and Game, Anchorage,
 Alaska. APA Document # ?.

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

RTS No.

25 model J-90 temperature recorders, or Omnidata two channel datapod
 Cont. 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.

26 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. APA Document #2658 and 2659.

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.

26a 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. APA Document #2658.

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

RTS No.26a
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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

RTS No.

26a that the predictive equation of Wangaard and Burger are an adequate
Cont. model to use in predicting rates of chum salmon development of the
 middle Susitna River.

26b Keklak, T., and T. Quane. 1985. 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. APA Document #2659.

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.

RTS No.

- 27 Quane, T., P. Morrow, and I. Queral. 1985. 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. APA Document #2704.

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.

- 28 Quane, T., P. Morrow, and I. Queral. 1985. 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. APA Document #2736.

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.

- 29 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. APA Document #2748.

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.

RTS No.

- 30a,b 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 (2 Volumes: Parts 1-2 and Part 3). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #2836 and 2837.

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.

- 30a 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 (Volume 1). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #2836.

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+

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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.

30a Hale, S.S. 1985. Time series analysis of discharge, turbidity, and juvenile salmon outmigration in 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 (Volume 1). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #2836.

30a 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 (Volume 1). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #2836.

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

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30a Cont. these species did not always decline at high discharges, however, because of the compensating effect of a larger surface area.

- 30a 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 (Volume 1). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #2836.

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 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 70,000 cfs 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.

- 30b 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 (Volume 2). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #2837.

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

RTS No.30b
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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.

- 31 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. APA Document #2846.

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

RTS No.31
Cont.

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 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.

- 32 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. APA Document #2749.

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.

RTS No.

- 33 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. APA Document #2854.

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.

- 34 Keklak, Theresa, and Tommy Withrow. 1985. Tasks 29 and 37 support technical report: continuous water temperature investigations. Alaska Department of Fish and Game, Susitna Aquatic Studies, Anchorage, Alaska. APA Document #2867.

RTS No.

34 Cont. Surface and intragravel water temperatures were recorded on a continuous basis at 18 selected tributary, slough, side channel, and mainstem locations in support of Tasks 29 and 37. This technical report presents a summary of the data collection methods and the findings of these temperature investigations from October 1984 through April 1985. The 18 temperature sites were selected by task 29 and 37 personnel to meet specific task objectives.

The tributary data collection included sites at Lane Creek, Fourth of July Creek, and Indian River. The slough sites include Bushrod Slough (RM 139.0), Curry Slough (RM 119.7), and Slough 10 (RM 115.0). Side channel sites included Mainstem 2 (RM 115.0), Upper Side Channel 11 (RM 136.0), and Upper Side Channel 21 (RM 141.6). The mainstem sites were located at river miles 117.9, 118.9, 127.1, 129.8, 131.3, 132.9, 137.5, and 139.0.

Refer to the Task 28 and 37 summary reports for the criteria used to select these study sites. No conclusions were drawn in this report. The data is summarized in the narrative, tables, and graphs.

35 Seagren, D.R., and R.G. Wilkey. 1985. Preliminary evaluations of potential fish mitigation sites in the middle Susitna River. Susitna Aquatic Studies Program. Report No. 10. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document 2908.

This report is one of a series of reports prepared for the Alaska Power Authority (APA) by the Alaska Department of Fish and Game (ADF&G) to provide information to be used in evaluating the feasibility of the proposed Susitna Hydroelectric Project. The ADF&G Susitna River Aquatic Studies Program was initiated in November 1980.

The studies described in this report were conducted in support of mitigation planning being done by ENTRIX, Inc., the primary mitigation contractor. This report includes studies conducted from July 1984 through April 1985 in the middle reach of the Susitna River from Talkeetna (RM 98.0) to the mouth of Devil Canyon (RM 150.0). The study examined general habitat characteristics during the open-water season and site specific incubation conditions during the ice-covered season.

The open-water study examined general habitat characteristics (surface water quality, substrate, upwelling, passage, temperature, salmon spawning, etc.) of 44 slough and side channel sites in order to evaluate their potential to mitigate for adverse effects to salmon spawning and incubation habitats as a result of the proposed hydroelectric project. The ice-covered study examined incubation conditions (surface and intragravel water quality and temperature, and substrate composition) in these sites to further determine their suitability as potential mitigation sites. Each site studies exhibited general conditions (passage, substrate, etc.) that were similar to those found in other sites that proved to be limiting to salmon spawning.

RTS No.

- 35 Cont. The combined data from these open-water and ice-covered studies will be used by ENTRIX, Inc. to help determine the suitability of habitat types (side slough, upland slough, side channel) and habitat modification methods for mitigation of adverse impacts to salmon spawning and incubation environments as a result of the proposed hydroelectric development.

- 36 Seagren, D.R., and R.G. Wilkey. 1985b. Summary of water temperature and substrate data from selected salmon spawning and groundwater upwelling sites in the middle Susitna River. Susitna Aquatic Studies Program. Technical Data Report No. 12. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #2913.

This report is one of a series of reports prepared for the Alaska Power Authority (APA) by the Alaska Department of Fish and Game (ADF&G) to provide information to be used in evaluating the feasibility of the proposed Susitna Hydroelectric Project. The ADF&G Susitna River Aquatic Studies Program was initiated in November 1980.

The studies described in this report were conducted in support of mitigation planning being done by ENTRIX, Inc., the primary mitigation contractor. This report includes studies conducted from July 1984 through May 1985 in the middle reach of the Susitna River from Talkeetna (RM 98.0) to the mouth of Devil Canyon (RM 150.0). The study examined general habitat characteristics at selected salmon spawning and groundwater upwelling sites during the open-water season and site specific surface and intragravel water temperatures and substrate conditions during the ice-covered season.

The combined data from these open-water and ice-covered studies will be used by ENTRIX, Inc. to assist in determining the suitability of side channel and mainstem sites as replacement salmon spawning habitats to mitigate for adverse impacts to present salmon spawning and incubation habitats as a result of the proposed hydroelectric development.

- 37 Bigler, Jeff, and Kim Levesque. 1985. Lower Susitna River preliminary Chum Salmon spawning habitat assessment. Draft technical memorandum. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. APA Document #**3504

This draft technical memorandum describes methods and presents habitat and biological data collected at six side channels of the lower Susitna River (from the Talkeetna River to the Kashwitna River) during the 1984 open water field season. IFG modeling techniques were used to evaluate rearing habitat for juvenile salmon. It is noted that unexpectedly high numbers of mainstem and side channel spawning chum salmon were found. A preliminary baseline evaluation of the newly discovered spawning habitat was conducted. "The objective of this preliminary assessment is to

RTS No.

37 evaluate selected baseline habitat conditions and their relationship to mainstem discharge to determine if further studies are required to assess the impacts of with-project flows in these habitats."

Cont.

The report concludes that "several of the physical variables evaluated may be critical to availability of spawning habitat and to the viability of incubating chum salmon embryos deposited in these habitats." The report states that the study sites with the higher mainstem discharges provided more WUA (weighted useable area) for chum salmon spawning than those with lower mainstem controlling discharges. Groundwater is noted to be a critical factor in embryo overwintering success. The amount of groundwater varied with mainstem stage. Upwelling is noted as important for embryo survival. "Water temperature did not seem to pose a threat to incubating embryos at any of the study sites as long as sufficient groundwater upwelling was present." The conclusion section notes that significant numbers of chum, chinook, coho, and sockeye salmon utilize mainstem and side channel habitats for overwintering.

- 37a Alaska Department of Fish and Game (ADF&G). 1985. FY 87 Plan of Study. Proposal with recommendations for Spring 1988. Alaska Department of Fish and Game. Anchorage, Alaska. APA Document #**.*.

Includes presentations made during a three day project review to a review team composed of ADF&G regional supervisors and biometricians. This is essentially the proposed FY 87 plan of study for the Susitna Aquatic Studies.

Presentations were made for the following projects: lower river salmon escapement; middle river salmon escapement (Susitna River adult salmon investigations); middle river outmigrant evaluation (Susitna River juvenile salmon outmigration monitoring); lower river spawning habitat evaluation (chum salmon spawning and passage habitat assessment in lower river mainstem and side channel habitats); middle river resident fish study; aquatic habitat monitoring (aquatic habitat and instream flow investigations); and long term monitoring strategies (for water quality and dissolved gas, sonar evaluation, resident fish populations, and adult and juvenile salmon).

- 37b Alaska Department of Fish and Game (ADF&G). 1985. An overview of the Susitna Aquatic Studies Program: Its history and future direction. Susitna Aquatic Studies staff. Division of Commercial Fisheries. Region II. Anchorage, Alaska. APA Document #3502.

Commissioner Collinsworth has requested that a briefing paper, which provides a concise overview of the Susitna Aquatic Studies Program, its history and future direction, be prepared to assist the Department in its review and policy development regarding the proposed Susitna hydroelectric development. In accordance with this request, the following discussion of the Susitna Aquatic Studies Program is presented. This discussion describes the recent history

RTS No.

37b of the project, its relationship to the Federal Energy Regulatory
 Cont. Commission (FERC) licensing process, its accomplishments, and the
 projected future direction of the program.

It must be emphasized, however, that this paper outlines only one aspect of the Department's overall association with the Susitna hydroelectric development evaluation. Integral to a more complete understanding of the Department's involvement and responsibility for a project with the magnitude and complexity of the Susitna Hydro Project are the significant roles played by the Division of Game which has been responsible for a major portion of the terrestrial studies program and the Habitat Division which has the regulatory review responsibility for the project. A listing of significant correspondence from which this document has been synthesized is included as Attachment 3.

38a Sundet, R.L. 1986. Winter resident fish distribution and habitat studies conducted in the Susitna River below Devil Canyon, 1984-85. Part 1 of: ADF&G. Winter studies of resident and juvenile anadromous fish (October 1984-May 1985). Susitna Aquatic Studies Program. Report No. 11 (Volume 1). Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #3062.

This report is one of a series of reports prepared for the Alaska Power Authority (APA) by the Alaska Department of Fish and Game (ADF&G) to provide information to be used in evaluating the feasibility of the proposed Susitna Hydroelectric Project. The ADF&G Susitna River Aquatic Studies Program was initiated in November 1980.

38a This report covers winter studies (RSA Task 34) conducted from
 Cont. October 15, 1984 through May 15, 1985 on juvenile salmon and resident fish species of the Susitna River. In addition, some radio telemetry monitoring data is also included for resident fish that were radio tagged in September and early October 1984. This volume is divided into two parts.

Part 1 presents the results of winter resident fish studies in both the lower and middle river. Monitoring of selected resident fish movements through the use of radio tags was continued. Efforts were also made to describe the overwintering habitat associated with rainbow trout, burbot, and Arctic grayling, and to identify the timing and locations of burbot spawning in the lower river.

Part 2 discusses the juvenile chinook and coho salmon studies during the winter of 1984-85 in the middle river. Findings from this study using cold branding/mark-recapture techniques further define the distribution and relative abundance of overwintering juvenile salmon and generate site specific population estimates and an estimate of the number of juvenile chinook which overwinter in the middle reach.

38b Stratton, M.E. 1986. Summary of juvenile chinook and coho salmon winter studies in the middle Susitna River, 1984-85. Part 2 of: ADF&G.

RTS No.

- 38b Winter studies of resident and juvenile anadromous fish (October
Cont. 1984-May Cont. 1985). Susitna Aquatic Studies Program. Report
No. 11 (Volume 2). Alaska Department of Fish and Game, Anchorage,
Alaska. APA Document #3063.

This report is one of a series of reports prepared for the Alaska Power Authority (APA) by the Alaska Department of Fish and Game (ADF&G) to provide information to be used in evaluating the feasibility of the proposed Susitna Hydroelectric Project. The ADF&G Susitna River Aquatic Studies Program was initiated in November 1980.

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Part 2 discusses the winter studies of juvenile chinook and coho salmon that were conducted in the middle river. Findings from this study define the distribution and relative abundance of fish within

specific overwintering sites, document limited movements of marked fish between overwintering sites, and present information on fish lengths over the course of the winter. This report also presents mark-recapture data which can be used to generate site specific population estimates of juvenile chinook salmon that overwinter in the middle reach of the Susitna River.

- 39 Thompson, F.M., S.N. Wick, and B.L. Stratton. 1986. Adult salmon investigations: May-October 1985. Susitna Hydro Aquatic Studies. Report No. 13. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #3412.

This report concludes five years of data collection on adult salmon in the Susitna River, Southcentral Alaska, by the Susitna Aquatic Studies Team of the Alaska Department of Fish and Game. These data were collected to provide baseline information in preparation for proposed hydroelectric development on the Susitna River at Watana and Devil Canyons. This year's report is similar to the previous years' reports in format and content. Population estimates, escapement timing, length, age and sex ratio, and spawning distribution information is reported for all five species of Pacific salmon utilizing the river. The fecundity of chinook and coho salmon and egg retention of sockeye and chum salmon is also reported to aid associated studies on juvenile salmon.

RTS No.

39
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A different population estimate methodology was affected this season. In previous years a Petersen model for closed systems was utilized. This year, a stratified, open model was used where the design allowed.

As might have been expected, the specific goals of the program have changed from year to year depending on the amount of funding available and the data needed to meet within year objectives. To meet 1985 objectives, Flathorn, Sunshine and Curry stations were operated by Susitna Aquatic Studies staff. Yentna Station, a Susitna Aquatic Studies camp from 1981 until 1984, was operated by the Alaska Department of Fish and Game, Commercial Fisheries Division, Soldotna staff in 1985. Readers interested in the data collected from Yentna Station should contact the Soldotna office of the Alaska Department of Fish and Game.

The primary objectives of the 1985 Adult Salmon Studies were:

1. Estimate the escapements of chinook (Oncorhynchus tshawytscha), sockeye (O. nerka), pink (O. gorbuscha), chum (O. keta), and coho (O. kisutch) salmon at Flathorn, Sunshine and Curry stations.
2. Evaluate the adult salmon migrational timing and travel rates between sampling stations.
3. Using fishwheel catches, monitor the age, length and sex composition of the adult salmon escapements at Flathorn, Sunshine, and Curry stations.
4. Determine the relative importance of middle-river [River Mile (RM) 98.6-161.0] main channel, slough and tributary habitats as salmon spawning areas.

Secondary objectives included:

1. Determine the fecundity of chinook and coho salmon at Sunshine Station. Fecundities of sockeye, pink and chum salmon were evaluated in previous years' studies.
2. Provide estimates of egg retention for sockeye and chum salmon which spawn in middle river slough habitats.

All objectives were met.

- 40 Roth, K.J., D.C. Gray, J.W. Anderson, A.C. Blaney and J.P. McDonnell. 1986. The migration and growth of juvenile salmon in the Susitna River, 1985. Susitna Aquatic Studies Program. Report No. 14. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document #3413.

RTS No.

40

Cont.

This report presents the results of the juvenile salmon outmigration studies conducted on the Susitna River between Cook Inlet and Devil Canyon during the 1985 open-water season. Five Pacific salmon species were studied: chinook (Oncorhynchus tshawytscha), coho (O. kisutch), sockeye (O. nerka), chum (O. keta), and pink (O. gorbuscha).

The methods, results, and a discussion of the use of a stationary inclined plane outmigrant trap to define juvenile salmon size, migration timing, and their response to changing habitat conditions in the Susitna River from Cook Inlet to Devil Canyon is presented. Use of stationary traps, mobile traps, coded wire tagging, and cold branding is reported. Appendices A-E, respectively, report discharge, temperature, and turbidity; cold brand symbols, etc.; a cold branding experiment; juvenile salmon catch data; and juvenile salmon length and weight data.

Data pertaining to catch per unit effort, size, mark-and-recapture, and population estimates are reported for chinook, coho, sockeye, chum, and pink salmon by age class. A "Results and Discussion" section is presented for each species. No separate conclusion section is presented.

- 41 Cannon, R. 1986. Susitna River Aquatic Studies Review: Findings and recommendations of the Susitna program review team. Division of Commercial Fisheries. Susitna Aquatic Studies Program. Alaska Department of Fish and Game. Anchorage, Alaska. APA Document #3501.

This report provides a discussion of the background and findings of the 1985 Susitna Aquatic Studies program review which was held on October 2 and 3 in Anchorage by the Alaska Department of Fish and Game.

Commissioner Collinsworth in his June 18, 1985 memorandum (Reorganization of the Susitna Aquatic Studies), assigned the project coordinator of the Susitna Aquatic Studies program under the direction of the Commercial Fisheries Division regional supervisor, Central Region, with the responsibility for planning and coordinating all departmental salmon escapement activities on the Susitna River. In addition, the coordinator was to administer the contract between the Alaska Power Authority (APA) and the Division of Commercial Fisheries. The coordinator was also instructed to prepare a technical data report which summarized all salmon escapement data collected to date for the Susitna River by the combined efforts of the Divisions of Sport Fisheries and Commercial Fisheries and was to coordinate a cooperative effort among the fisheries divisions to ensure proper planning for future Susitna River escapement studies.

In order to accomplish these tasks, the Division of Commercial Fisheries has initiated the following: 1) staff orientation and

RTS No.

41 coordination activities for staff assigned to Susitna River
 Cont. projects, 2) the preparation of the Susitna salmon escapement
 summary, and 3) a Susitna program review.

 This bibliography is stored on IBM Displaywriter diskette at:

Alaska Department of Fish and Game
 Division of Sport Fisheries/RTS
 Anchorage, Alaska 99518-1599

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to develop
Key word
Abstracts

Key words
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etc.

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another version
too)

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Key words: Preliminary draft 8/2.

abundance
access
access corridor
aerial photograph
age
age and growth
age-length relationship
Alaska
anadromous fish
anesthesia
angling
arcane
Arctic grayling
Arctic lamprey
artifact
available habitat
backwater
Bering cisco
biased
binary criteria
biology
biomass
breaching
breaching discharge
Burbot
Calibration
catch per unit effort
Catostomus catostomus
cell
Cheechako Creek
Chinook Creek
Chinook salmon
Chum salmon
clearwater plume
coded wire tagging
Coho salmon
cold branding (freeze branding)
commercial fishery
conductivity
controlling breaching discharge
Coregonus laurettae
Coregonus pidschian
Cottus cognatus
cover
CPUE
creel census
critical reach
cross section
datapod
Deadman Creek
Deadman Lake

Dist to staff 10-01-85

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Denali Highway
depth
Devil Canyon
Devil Creek
diel activity
diet
DIHAB
discharge
dissolved gas study
distribution
DO
Dolly Varden
drift net
duration curve
egg retention
eggs
electroshocking (electrofishing)
elevation of zero flow
Entosphenus tridentatus
Esox lucius
Eulachon
extrapolation limits
flow duration curve
fecundity
feeding
first run
fishing gear
fishery
fishery management
fishwheel
flooding
flow
floy anchor tagging
Fog Creek
food study
fortuitous
freeze branding (cold branding)
fry
FT-4 spaghetti tags
gaging station
Gasterosteus aculeatus
Gilbert-Rich aging
gill net
Goose Creek
gradient
gross surface area
growth
habitat
habitat curve
habitat index
habitat modeling
habitat suitability
habitat use
habitat variable

Key words

CEV ✓

(2076)

HABTAT
harvest
hatching
head
Humpback whitefish
hydraulic control
hydraulic model
hydraulic simulation modeling
hydrolab
ice covered season
identification
IFG-2
IFG-4
IFIM
impoundment
inclined plane
incremental
incubation
initial breaching discharge
instantaneous survival rates
instream flow
Instream Flow Incremental Methodology
interpolate
intragravel
invertebrate
Jay Creek
Joint Preference Factor
juvenile salmon
Kosina Creek
Lake trout
Lampetra japonica
length
length-age relations
length frequency composition
life history data
Longnose sucker
Lota lota
lower reach Susitna
macrohabitat
mainstem
Manning's N
mark-recovery
marking (tagging)
Maximum Grouped Value
microcomputer data entry programs
microhabitat
middle reach Susitna
migration
Minimal Irregular Fluctuations
Minimal Peakedness
Minimal Sample Variance
modeling
models
mortality

Key Words

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movements (migration)
MS-222
netting
Ninespine stickleback
Northern pike
Oncorhynchus gorbuscha
Oncorhynchus keta
Oncorhynchus kisutch
Oncorhynchus nerka
Oncorhynchus tshawytscha
open water season
Oshetna River
otoliths
outmigration
overflow channel
Pacific lamprey
passage
passage depth
passage reach
Peakedness Index
Petersen disc
Petersen estimates-model
pH
PHABSIM
photoperiod
Pink salmon
Platichthys stellatus
population estimate
post-spawners
predation
preference
pre-spawning
project datum
Prosopium cylindraceum
Pungitius pungitius
radio tag
radio telemetry
Rainbow trout
rating curve
recaptures
recruitment
redds
relative abundance
representative reach
reproduction
resident fish
Round whitefish
Sally Lake
Salmo gairdneri
salmon escapement
Salvelinus malma
sampling method
scale analysis
scaled frequency

Key words

(496)

CEV

Schnabel population estimate
Sculpin
seasonal effect (variation)
second run
serendipity
set net
sex determination
sex ratios
sexual development
side channel
side scan sonar
side slough
Slimy sculpin
sloughs
smolt
smolt (outmigrant) trap
smoltification
Sockeye salmon
spawners
spawning
spawning habitat
spawning habitat curve
species composition
sport fishery
staff gage
stage
stage-discharge relationship
stage of zero flow
Starry flounder
stocks
stream crossing
streambed elevation
streamflow
streams
subsistence fishery
substrate
substrate classification
suitability criteria
suitability index
supersaturation
survival estimate
Susitna River
synthetic data
tag loss
Talkeetna
temperature
Thaleichthys pacificus
thalweg
thalweg profile
thermal infrared imagery
thermograph
Threespine stickleback
Thymallus arcticus
time series

Key words

(566)

CEV

time series analysis
timing
transect
traps
transmission corridor
tributary
tributary mouths
Tsusena Creek
turbidity
Tyone River
upland slough
upper reach Susitna
upwelling
USGS water year
utilized
utilization curve
utilization data
velocity
velocity adjustment factor
verification
vertical
vertical distribution
Watana Creek
water quality
water surface elevation (levels) (levels)
water surface profile model
water year
weighted usable area
wetted surface area
winter aquatic studies
WSEL
WSP
WUA
year class

Key words

(6 of 6)

CEV ✓

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An Assessment Study of the Anadromous Fish Populations
in the Upper Susitna River Watershed Between
Devil Canyon and the Chulitna River

(COE
PHASE)

by Bruce M. Barrett

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Alaska Department of Fish and Game
Division of Commercial Fisheries
Anchorage, Alaska

November 1974

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TABLE OF CONTENTS

	<u>PAGE</u>
List of Figures	i
List of Tables	ii-iii
List of Appendix Figures	iv
List of Appendix Tables	v
Introduction	1-3
Materials and Methods	3-8
Results	8-30
Migrational Investigations	8-15
Bearing Fry and Escapement Investigations	15-25
Historic Information	25-28
Climatological Observations	28-30
Discussion and Summary	30-34
Acknowledgements	35
Appendix	36-56

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BARNETT (#13)

INTRODUCTION

The Susitna River watershed, located in the northern sector of the Cook Inlet basin, encompasses an area exceeding 19,000 square miles. Its fishery resources contribute a major proportion of the Cook Inlet commercial salmon harvest and provide a recreational base of sport fishing for Anchorage and the surrounding area. The Susitna River, of glacial origin in the Alaska range, is a migrational corridor for the five species of Pacific salmon from Devil Canyon to its point of discharge into Cook Inlet (Figure 1). The primary spawning and rearing areas are the clear water lakes and streams in the watershed.

Anticipated population development in southcentral Alaska has stimulated interest in harnessing hydropower for electrical energy. The Corps of Engineers has proposed a dam for Devil Canyon at a site located approximately three miles above Portage Creek, the northern most salmon rearing and spawning stream of the Susitna watershed.

Recent information is not available on the extent of salmon utilizing the Susitna River and its tributaries between Devil Canyon and its confluence with the Chulitna River. Field investigations conducted by the Fish and Wildlife Service in 1956 document the presence of salmon in the Susitna River and in four tributary streams between Gold Creek and the proposed damsite (Anonymous, 1957). Anadromous species were not found to range above Devil Canyon. To obtain information pertinent toward assessing the impact of a hydroelectric complex at Devil Canyon, on anadromous fish habitat in the upper Susitna River between the proposed site and the Chulitna River, an inventory program was initiated in 1974 to

Anonymous 1957 Progress Report, 1956 Field Investigations Devil Canyon Damsite, Susitna River Basin. U.S. Fish and Wildlife Service, Juneau, Alaska, 15pp.

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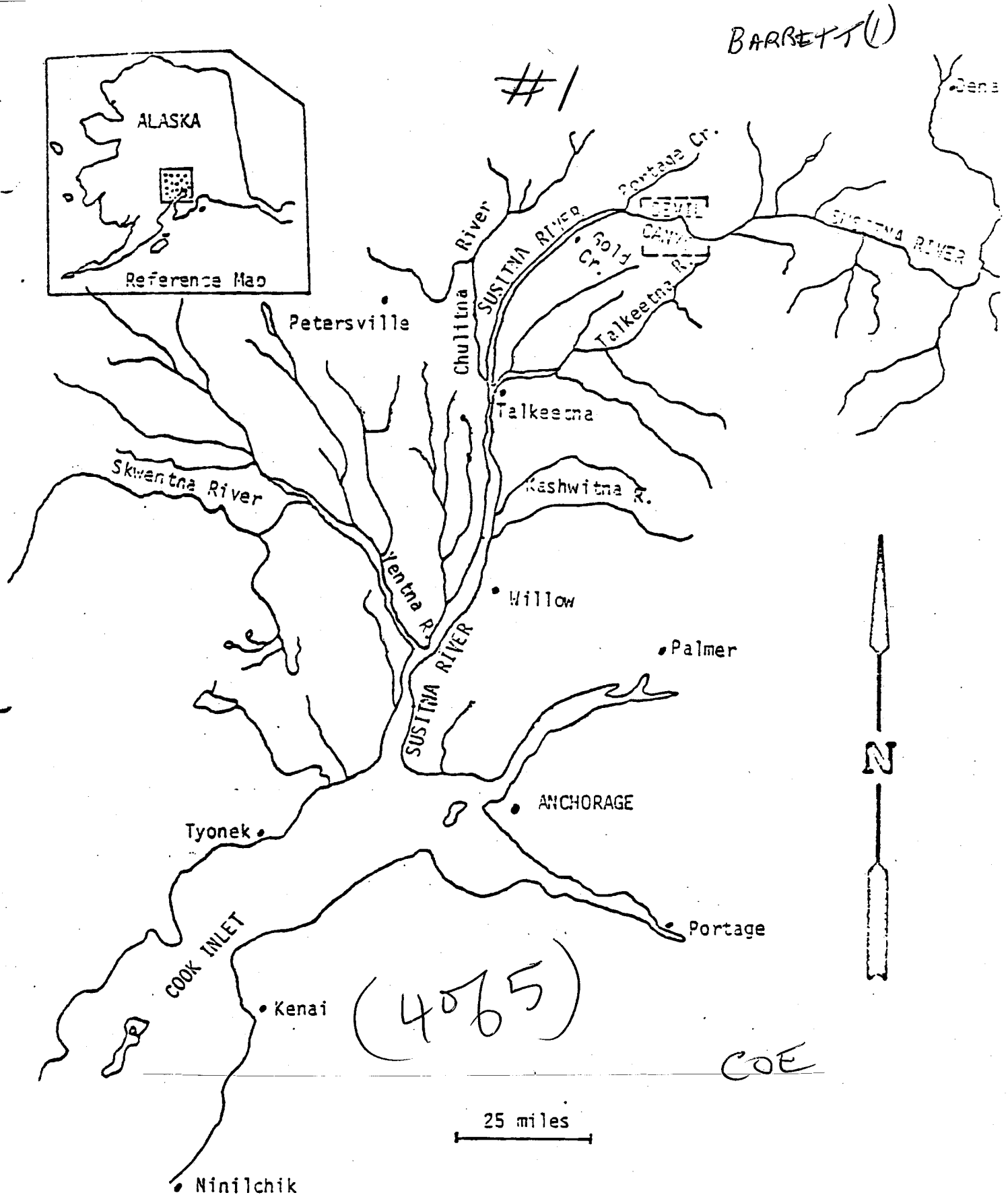


Figure 1. Devil Canyon in reference to the Susitna River watershed and northern Cook Inlet, Devil's Canyon Project, 1974.

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BARRETT (1)

determine spawning distribution, relative abundance, migrational timing, representative age-length-sex composition by species, and juvenile nursery areas.

The following report is a summary of the techniques employed and results obtained during the 1974 field season commencing July 1 and extending through September 27.

MATERIALS AND METHODS

An aerial reconnaissance of the study area was conducted June 30th to evaluate the physical characteristics of the river, to locate potential fishwheel sites and a stream survey camp. Construction of two portable fishwheels for the project commenced July 1 and extended to July 18. The fishwheels were the two paddle - two basket design (Figure 2). The basket frames were constructed from one-inch diameter water pipe and electrical conduit. Each basket was 7.5 feet long and 6 feet wide. The paddle frames also constructed from water pipe were the same dimensions as the baskets. Plywood panels, 6.5 feet in length formed the surface area of each paddle. Herring seine was tied on each basket and the fish chutes were constructed of plywood. The baskets and paddles were sprocketed into a 9.5 foot long steel axle with bearings. Floatation was provided by styrofoam logs shielded by a plywood covering. Steel axle mounts, which were adjustable in height, permitted maintenance changes in the fishing depth of the baskets. A live box was attached to the river bank side of each fishwheel for holding fish.

Fishwheels were operated from July 23 through September 11 at sites on the Susitna River. One fishwheel was located adjacent to the east bank of the river approximately 5 miles upstream from the town of Talkeetna, Alaska and a second at a site adjacent to the west bank of the river approximately 2.3 miles downstream of the first (Figure 3). Both fishwheels were operated on a scheduled twenty-four hour a day basis. Fishing efforts were not continuous due to structural

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(Dec. - Feb 1974-75)

Barrett, Bruce M. 1975
APA Doc #1629
ADFG (#1A)

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December Investigations on the Upper Susitna River
Watershed Between Devil Canyon and Chulitna River

ADFG
1975

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INTRODUCTION

In December of 1974 the Division of Commercial Fisheries, contracted by the National Marine Fisheries Service, commenced a series of monthly winter investigations on the Upper Susitna River below Devil Canyon. Previous investigations denoted 21 relatively major and minor salmon spawning and rearing sloughs adjoining the Susitna River between Devil Canyon and the Chulitna River (Figure 1). Chum salmon were the primary spawning species and coho fry the dominate rearing species.

The presence of age 0.0 coho fry and the absence of adult coho spawners in the sloughs suggests that fry immigrate, in early spring, from the spawning streams to the Susitna River and enter the sloughs for rearing. Some emigration into the Susitna River was observed in the late fall of 1974 corresponding with partial slough dewatering. Rearing fry may inhabit both the Susitna River and the sloughs during winter months. Sloughs void of adult spawning populations may be due to their incapability to buffer winter conditions. The winter investigations are intended to provide qualitative information on fry distribution and abundance and winter conditions in the sloughs and in the Susitna River.

PROCEDURES

The first survey was conducted during the period of December 3 through 6 from a field station established at Gold Creek. Travel to the sloughs was achieved primarily through the use of two twin track snow vehicles. Sloughs that were accessible were sampled for D.O., pH, relative water height, ice thickness and cover, snow depth, temperature and flow. Minnow traps baited with salmon roe were fished in sloughs having sufficient water depth.

(#1A)

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ANCHORAGE, ALASKA

ESTES

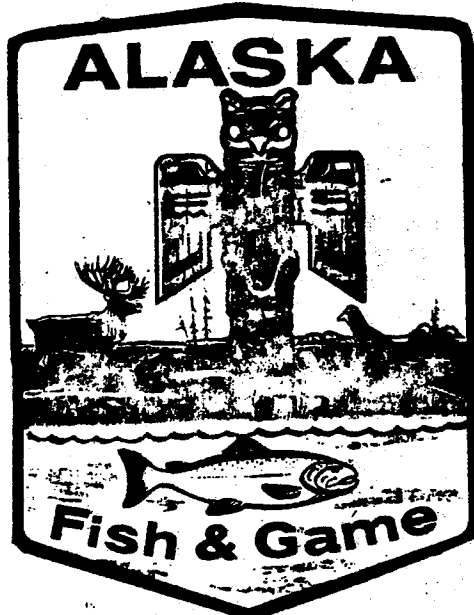
SOUTH CENTRAL RAILBELT AREA - SUSITNA RIVER BASIN

FISH AND WILDLIFE STUDIES RELATED TO THE CORPS OF ENGINEERS
DEVIL CANYON, WATANA RESERVOIR HYDROELECTRIC PROJECT



COE
Cover SHEET 5
(1 of 2)

STUDIES WERE CONDUCTED BY THE ALASKA DEPARTMENT OF
FISH AND GAME UNDER A CONTRACT AGREEMENT WITH THE
U. S. FISH AND WILDLIFE SERVICE



FEBRUARY 1976

2.

APA Doc #549

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

January 19, 1976

JAY S. HAMMOND, GOVERNOR

333 RASPBERRY ROAD
ANCHORAGE 99502

Mr. Gordon Watson
Fish and Wildlife Service
U.S. Department of the Interior
813 D Street
Anchorage, Alaska 99501

Dear Mr. Watson:

Contained herein are reports submitted by the Alaska Department of Fish and Game to fulfill contract obligations to the U. S. Fish and Wildlife Service for studies of the proposed Susitna River hydroelectric project.

The biological studies attached were conducted by three separate divisions of this agency, resulting in a segmented report. The Game Division conducted studies of moose and caribou within and adjacent to the impoundment area. The Commercial Fish Division studied primarily the anadromous fish populations and aquatic habitat downstream of the proposed impoundment site, and the Sport Fish Division conducted a limnological study supplemented with fishery information for both resident and anadromous fish species.

The full impacts of hydroelectric development of the Susitna River are as yet undetermined. The potential impacts depicted in each of the fish division report segments are not necessarily impacts this project will have, but illustrate areas of biological concern. As stated previously, inadequate funding and time have been limiting factors in carrying out more extensive studies.

We think the collective findings of these reports will be valuable as preliminary baseline data and as an aid in planning future investigations.

If I may be of assistance in interpreting or clarifying any of the attached study findings feel free to contact me.

Yours truly,

Larry J. Heckart

Larry J. Heckart
Mgt-Research Coordinator
Division of Sport Fish
Attachments:

FISH (#2A, B)
WILDLIFE (#2C)

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(FISH #2A
#2B)

(wildlife
#2C)

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PREAUTHORIZATION ASSESSMENT OF ANADROMOUS FISH POPULATIONS
OF THE UPPER SUSITNA RIVER WATERSHED IN THE VICINITY
OF THE PROPOSED DEVIL CANYON HYDROELECTRIC PROJECT

COE

by:
Nancy V. Friese
Fisheries Research Biologist

(1863)

Alaska Department of Fish and Game
Division of Commercial Fisheries
Anchorage, Alaska

November, 1975

(#2A)

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TABLE OF CONTENTS

(2013)

	<u>Page</u>
List of Tables	iii
List of Figures	v
Introduction	1
Description of Study Area	2
Methods of Investigation	2
Sampling Procedures	2
Winter Sampling	2
Spring Sampling	6
Summer Sampling	6
Laboratory Analyses	8
Results	8
Adult Investigations	8
Rearing Fry and Escapement Investigations	16
Susitna River Winter Sampling	16
Susitna River Summer and Fall Surveys	22
Escapement Surveys	29
Talkeetna and Chulitna River Investigations	32
Climatological Observations	35
Discussion and Summary	35
Potential Impacts and Recommendations	42
Acknowledgements	48
Literature Cited	49
Appendixes:	
I Maps of sloughs and clearwater streams on the Susitna, Talkeetna and Chulitna Rivers	50

COE

(# 2 A)

FRIESE

TABLE OF CONTENTS (cont.)

Estes ✓

Page

Appendixes (cont.)

II	Escapement surveys of sloughs and tributary streams of the Susitna River tributaries and Talkeetna River	93
III	Notes on the more common benthic invertebrates found in the Susitna River tributaries	105
IV	Estimated monetary values of the Susitna River salmon stocks . .	107

(3-13)

COE

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ESTES ✓

PRE-AUTHORIZATION ASSESSMENT
OF THE
SUSITNA RIVER HYDROELECTRIC PROJECTS:
PRELIMINARY INVESTIGATIONS OF
WATER QUALITY AND
AQUATIC SPECIES COMPOSITION

SPORT FISH SECTION

BY

JAMES C. RIIS
FISHERIES BIOLOGIST

(10/2)

ALASKA DEPARTMENT OF FISH AND GAME
SPORT FISH DIVISION
ANCHORAGE

(#2 ~~B~~)

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TABLE OF CONTENTS

	Page No.
LIST OF TABLES	ii
LIST OF FIGURES	iv
INTRODUCTION	1
STUDY AREA	2
MATERIALS AND METHODS	2
RESULTS AND DISCUSSION	3
FISHERIES	3
BENTHOS	8
LIMNOLOGY	11
CONCLUSION	44
ACKNOWLEDGMENTS	44
POTENTIAL IMPACTS	45
RECOMMENDATIONS	47
LITERATURE CITED	49
APPENDIX	50

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PRE-AUTHORIZATION ASSESSMENT

OF THE

SUSITNA RIVER HYDROELECTRIC PROJECTS:

A LIMITED WILDLIFE STUDY

GAME DIVISION SECTION

BY

CARL MCILROY

GAME BIOLOGIST

AND

TED SPRAKER

GAME BIOLOGIST

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(10/2)

ALASKA DEPARTMENT OF FISH AND GAME

GAME DIVISION

ANCHORAGE

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TABLE OF CONTENTS

	Page No.
INTRODUCTION	1
PROCEDURES	1
RESULTS	2
Moose Distribution, June 1974	2
Moose Wintering Distribution, 1974-75	2
Evaluation of Moose Wintering Range, Moose Conditions, Loss of Winter Range by Inundation.	3
Caribou Distribution and Trails	6
Harvests and Hunting Pressure	6
Observation of other Mammals	7
DISCUSSION AND CONCLUSIONS	7
MITIGATIVE ACTIONS	9
REFERENCES CITED	11

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PRE-AUTHORIZATION ASSESSMENT
OF THE
PROPOSED SUSITNA RIVER HYDROELECTRIC PROJECTS:
PRELIMINARY INVESTIGATIONS OF WATER QUALITY
AND AQUATIC SPECIES COMPOSITION

by

JAMES C. RIIS
Fisheries Biologist

COE (1043)

#3.

Alaska Department of Fish and Game
Sport Fish Division
Anchorage
May 1977

APA Doc #1610

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TABLE OF CONTENTS

	Page Number
LIST OF FIGURES	iii
LIST OF TABLES	iv
LIST OF APPENDIX A, TABLES	v
ABSTRACT	1
INTRODUCTION	1
STUDY AREA	3
METHODS	6
Water Quantity	6
Water Quality	7
Benthic Invertebrates	7
Fisheries	7
FINDINGS	8
Flow Regimens	8
Temperature	17
Suspended Solids and Turbidity	17
Water Chemistry	22
Benthic Invertebrates	25
Fisheries	26
DISCUSSION	35
Flow Regimens	35
Water Quality	37
Fisheries	37
CONCLUSION	38
ACKNOWLEDGEMENTS	39
LITERATURE CITED	40
APPENDICES	
Appendix A, Tables 1-32.	41
Appendix B, Selected Bibliography on Dam Impacts	73

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ABSTRACT

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/Devils 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.

INTRODUCTION

The U.S. Army Corps of Engineers has been considering several sites within the Susitna River drainage for construction of a hydroelectric complex. The current plan includes construction of dams and power plants on the Susitna River at Devils Canyon and Watana Creek with transmission lines to the southcentral railbelt. A timetable suggested by the dams' chief advocate, U.S. Senator Mike Gravel, calls for construction authorization in 1981 and Watana Dam completion in 1986. Devils Canyon Dam will be completed in 1990.

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PRELIMINARY ENVIRONMENTAL ASSESSMENT
OF HYDROELECTRIC DEVELOPMENT
ON THE SUSITNA RIVER

(1 of 2)

Prepared for the
United States Fish and Wildlife Service

by the
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska

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#4 MASTER
#4A FISH
#4B FISH
#4C Wildlife
#4d Wildlife

1978

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TABLE OF CONTENTS

Section I Fisheries and Habitat Investigations of the Susitna River

Page

Summary	I-7
Background	I-9
Description of Area	I-10
Procedures	I-11
Findings and Discussion	I-17
Conclusion	I-47
Recommendations	I-48
Acknowledgements	I-50
Literature Cited	I-51

Section II Moose Movements and Habitat Use Along the Upper Susitna

River

Summary	II-3
Background	II-4
Description of Area	II-7
Procedures	II-8
Findings	II-11
Discussion	II-26
Conclusion	II-31
Recommendations	II-34
Acknowledgements	II-34
Literature Cited	II-36

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Fisheries and Habitat Investigations
of the Susitna River—A Preliminary Study of
Potential Impacts of the Devils
Canyon and Watana Hydroelectric Projects

by
James C. Riis
and
Nancy V. Friese

Alaska Department of Fish and Game
Divisions of Sport and Commercial Fish

March 1978

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TABLE OF CONTENTS

	<u>Page</u>
List of Figures	4
List of Tables	5
List of Appendix Tables	6
Summary	7
Background	9
Description of Area	10
Procedures	11
Fisheries	13
Adults	13
Juvenile salmon migration	13
Juvenile studies	14
Water Quantity	16
Water Quality	17
Findings and Discussion	17
Fisheries	17
Adults	17
Juvenile salmon migration	23
Juvenile studies	28
Aquatic insects and juvenile salmon gut contents	30
Impoundment area fisheries investigations	37
Water Quantity	40
Water Quality	43
Conclusion	47
Recommendations	48
Acknowledgements	50
Literature Cited	51

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Page

Appendix I	53
Appendix II	73
Appendix III	96

TABLE OF CONTENTS (cont.)

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SUMMARY

Summary pp I-7 to p 9

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. These investigations conclude a four year series of environmental baseline inventories. They were designed to generate sufficient biological information to enable the Alaska Department of Fish and Game (ADF&G) to prepare a comprehensive biological study plan in the event a final environmental impact study is initiated to determine the feasibility of constructing the proposed Watana and Devils Canyon hydroelectric dams on the Susitna River. (1 of 3)

The relative abundance, distribution and migrational timing of adult salmon (Oncorhynchus sp.) 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 salmon (O. keta) (Friese, in prep.). An escapement estimate in excess of 100,000 fish was determined for chinook salmon (O. tshawytscha) through aerial surveys (Kubik, 1977; Watsjold, 1977). Population estimates of pink salmon utilizing the drainage in the area of the Susitna and Chulitna river confluence 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

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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 low flows which prevailed at the time. Chinook fry were documented overwintering in the Susitna River. No distinct movement of fry was observed in Rabideaux Creek.

(Summary
2/63)

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 Devils 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

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quality analysis of the mainstem Susitna River. This data, along with the water quality and quantity data collected in conjunction with the fisheries studies, will be extremely valuable for future comparisons.

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. Extensive research is necessary both upstream and downstream of the proposed dams to adequately assess the potential effects of these impacts on fisheries resources.

(Summary 3063)

The effects of impoundments 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.

BACKGROUND

Background knowledge of the Susitna River basin is limited. The proposed hydroelectric development necessitates gaining a thorough knowledge of its natural characteristics and populations prior to final dam design approval and construction authorization to enable protection of the aquatic and terrestrial populations from unnecessary losses.

The Susitna River basin has long been recognized as an area of high recreational and aesthetic appeal. It is also important habitat to a wide variety of fish species, both resident and anadromous. Five species of Pacific salmon (chinook, coho, chum, pink, and sockeye) utilize the

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Taylor/Ballard (#4c)

Moose Movements and Habitat Use
Along the Upper Susitna River--A Preliminary Study of
Potential Impacts of the Devils
Canyon Hydroelectric Project

(II-1)
T6C
1972

by
Kenton-P. Taylor
and
Warren B. Ballard

Alaska Department of Fish and Game
Division of Game

Robert A. Rausch, Director

March 1978

ESTES ✓

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CONTENTS

Taylor/Ballard (#4c)

	Page
Summary	3
Background.	4
Description of Area	7
Procedures.	8
Findings	11
Numbers of Moose Captured.	11
Movements.	13
Devil Mountain Area	13
Watana Creek.	16
Susitna Bend Area	20
MacLaren River Area	22
Habitat Use.	24
Discussion.	26
Conclusions	31
Recommendations	34
Acknowledgements.	34
Literature Cited.	36
Appendix I.	39
Appendix II	76

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Table of Contents

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SUMMARY

II-3

Taylor/Ballard

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During October 1976 and March 1977, 18 radio and 21 visual collars were placed on moose along the Susitna River from the mouth of the Maclaren River downstream to Devil Creek. Radio tracking flights over 13 months yielded 270 observations of radio-collared moose. Visual collars were located 43 times. Movements were slight for radio-collared moose between Jay Creek and Devil Mountain, generally within 48 km². One visual collar from Devil Creek was seen near Lone Butte, 84 km east of her tagging location. Movements of moose collared east of Jay Creek were substantially longer, and migrations up to 103 km were observed. Radio-collared moose were found most often (70 percent) in spruce dominated habitats during all seasons. Seven of the eight cows that had calves gave birth in spruce vegetation. The bend of the Susitna River from Goose Creek to the mouth of Tyone River was identified as important winter habitat for moose from many areas of the Susitna River drainage. Lower elevations along the Susitna River were found to be important as both wintering and calving areas for resident populations, particularly on the south side, east of Stephan Lake. Collared moose crossed the Susitna a minimum of 26 times during this study, 15 of which were across that portion which would be inundated by dam construction.

Movement data gathered over a period of only 13 months are insufficient to accurately delineate separate moose populations. Evidence to date suggests that moose from many portions of the Susitna River drainage utilize habitats adjacent to or portions of the area which will be flooded by dam construction. Intensive vegetative studies and research

(Summary 1 of 2)

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Taylor / Ballard

(#4d)

on movements both upstream and downstream are needed to adequately assess the impacts of the proposed construction (Appendix II).

BACKGROUND

Feasibility studies on providing hydroelectric power from the Susitna River to the railbelt area of southcentral Alaska have been conducted since 1948. Potential dam sites were identified by the U.S. Bureau of Reclamation, the Alaska Power Administration and the Henry J. Kaiser Company. Proposed hydroelectric projects have included from 2 to 12 dams within the Susitna River basin, along with associated maintenance facilities and transmission lines to Anchorage and Fairbanks (Dept. of Army 1975).

The Devils Canyon-Watana dam system has been selected by the Army Corps of Engineers as the most viable of several alternatives (Fig. 1). This system would theoretically provide 6.1 billion kilowatt-hours of electrical power annually from a dependable capacity of 1,568 megawatts (Army Corps of Engineers 1975). The Devils Canyon dam would be a concrete structure 193 m high, and the Watana dam would be a rock fill impoundment rising 247 m above the river bottom. A 103 km road from Chulitna to the Watana site including a 198 m bridge across the Sustina would be constructed for transporting materials and personnel to the dam sites. Five hundred eighty-six km of transmission line corridors, 57-64 m wide, would be cut across the mountains between Anchorage and Fairbanks. Warehouses, vehicle storage buildings and permanent living quarters would be erected at the dam sites. The total projected cost of completing this project

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SUSITNA HYDROELECTRIC PROJECT

Preliminary Final Plan of Study

Fish and Wildlife Studies

proposed by the

Alaska Department of Fish and Game

November 1979

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APA Doc # 3281

AD 746 79

TABLE OF CONTENTS

80's APA

<u>LIST OF FIGURES</u>	ii
<u>LIST OF TABLES</u>	iii
<u>PROGRAM JUSTIFICATION</u>	1
Federal/State Laws	1
State Laws	3
<u>ISSUES, PROBLEMS CONCERNS AND RECOMMENDATIONS REGARDING THE SUSTINA HYDRO PLAN OF STUDY</u>	6
Project Review & Interagency Coordination	6
Phase I Studies Initiation	7
Phase II Studies	8
Socioeconomic Considerations	8
Administrative Overhead & Time Delays	10
Monitoring & Surveillance	10
Estuarine Studies	11
<u>AQUATIC STUDIES</u>	12
Introduction	12
Study Proposals	13
Stock Assessment of Adult Anadromous Fish Populations	15
Stock Assessment of Adult Resident Fish & Juvenile Resident & Anadromous Fish Populations	23
Seasonal & Spatial Habitat Studies	34
<u>REFERENCES</u>	40
<u>BUDGETS-SUSITNA HYDRO FISHERIES STUDIES</u>	43
Administration & Support	43
Anadromous Adult-Stock Assessment	45
Resident & Juvenile Anadromous Fishery Study	52
Spatial & Seasonal Habitat Studies	57
<u>WILDLIFE STUDIES</u>	61
Introduction	61
Moose Distribution, Movements, & Habitat Use	62
Wolf Distribution, Abundance, Habitat Use & Prey Selection	68
Wolverine Distribution, Abundance, Movements, Patterns, & Habitat Use	70
Bear Distribution, Movements, Abundance & Habitat Use	72
Caribou Herd Identity, Migration Patterns & Habitat Use	74
Distribution & Abundance of Dall Sheep	77

APPENDIX

Attachment I, Letter to Eric Yould, APA, from Theodore Smith,
ADNR, October 26, 1979.

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ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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Subtask 7.10

AQUATIC STUDIES PROCEDURES MANUAL

PHASE I - Final Draft

(vol. 1)

-by-

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

-for-

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York 14202

(# 6a.)

TABLE OF CONTENTS

Vol II

#6a

I.	INTRODUCTION	
	Objective 1	4
	Objective 2	4
	Objective 3	4
II.	TECHNICAL PROCEDURES	
	ADULT ANADROMOUS FISHERIES STUDIES	
	Study Description and Rationale	6
	Sonar Counters	7
	Tag/Recapture	8
	Survey	10
	Stock Assessment	15
	Radio Tagging	15
	RESIDENT AND JUVENILE ANADROMOUS FISHERIES STUDIES	
	Study Description and Rationale	18
	Summer Field Operations	18
	Winter Field Operations	20
	Study Habitat Locations	20
	Tributary Stream Mouth Sites	22
	Slough Sites	22
	Mainstem River Sites	23
	Upper Susitna River Tributary Sites	23
	Selective Sampling of Fish Concentrations	26
	Study Methods	26
	Tagging of Resident Adult Species	27
	Resident Adult Tag Recovery	27
	Radio Telemetry	27
	Level of Effort	28
	AQUATIC HABITAT AND INSTREAM FLOW STUDIES	
	Study Description and Rationale	29
	Fishery Habitat Evaluations	29
	Selected Habitat Evaluations	32
	Study Site Locations	33
	Fishery Habitat Evaluations Sites	33
	Selected Habitat Evaluations Sites	33
	Methods	35
	Water Quality	35
	Hydrology	39
	Substrate	46
	Mapping	47
	Level of Effort	52
III.	DATA PROCEDURES	
	ADULT ANADROMOUS FISHERIES STUDIES	
	Sonar Data Collection and Preparation	53
	Escapement Sampling-Age & Length Data	60
	Labeling Procedures	64
	Tag/Recapture Data Collection and Preparations ...	70
	Survey Data Collection and Preparation	75

(25/2)

(25/2)

CEV

Estes

RESIDENT AND JUVENILE ANADROMOUS FISHERIES STUDIES	
Biological Data	78
Juvenile Anadromous	78
Rainbow Trout, Dolly Varden/Arctic Char, Round Whitefish, Humpback Whitefish, Lake Trout, and Longnose Sucker	78
Arctic Grayling	83
Burbot	83
Threespine Stickleback, Cottids, and Lamprey	83
AQUATIC HABITAT AND INSTREAM FLOW STUDIES	
Assigning Gear Placement Numbers (GPSN)	84
Geographic Code	84
Personal Log Book	86
Completing Aquatic Habitat Forms	87
IV. QUALITY CONTROL	
Adult Anadromous Studies	95
Resident and Juvenile Anadromous	95
Aquatic Habitat and Instream Flow Studies	96
Data Routing	97
V. SCHEDULE	
All Projects	99
VI. PERSONNEL	
All Projects	101
VII. LITERATURE CITED	104

APPENDICES

V2

I.	Sonar Installation and Operation Manual
II.	Oscilloscope Operation
III.	Fishwheel Operation
IV.	Fish Tagging
V.	Electro-Shocking Instructions
VI.	Habitat Site Locations
VII.	RJ Sampling Techniques
VIII.	AH Instruction Manuals

Vol. 2

6b.

for ARA
(1 of 1)

↑
Appendices

ESTES

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

APA
80's

Subtask 7.10
Phase 1 Final Draft Report
Adult Anadromous Fisheries Project
ADF & G / Su Hydro 1981

by
Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

7.

for

APA Doc # 324

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York, 14202

(10/3)

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TABLE OF CONTENTS

(# 7)

Estes ✓

PAGE

1. SUMMARY	E-1-1
2. INTRODUCTION	E-2-1
3. OBJECTIVES	E-3-1
4. METHODS	E-4-1
4.1 <u>Mainstem Escapement Sampling</u>	E-4-1
4.2 <u>Survey Investigations</u>	E-4-10
4.2.1 <u>Chinook Salmon Escapement Surveys</u>	E-4-10
4.2.2 <u>Sockeye, Pink, Chum and Coho Salmon Surveys</u>	E-4-10
4.2.2.1 <u>Mainstem Surveys</u>	E-4-10
4.2.2.2 <u>Slough and Tributary Stream Surveys</u>	E-4-15
4.3 <u>Radio Telemetry Investigations</u>	E-4-17
4.4 <u>Data Analysis</u>	E-4-28
5. RESULTS AND DISCUSSION	E-5-1
5.1 <u>Chinook Salmon Investigations</u>	E-5-1
5.1.1 <u>Mainstem Escapement Sampling</u>	E-5-1
5.1.2 <u>Radio Telemetry Investigations</u>	E-5-19
5.1.3 <u>Escapement Surveys</u>	E-5-29
5.2 <u>Sockeye, Pink, Chum and Coho Salmon Investigations</u>	E-5-32
5.2.1 <u>Escapement Sampling</u>	E-5-32
5.2.1.1 <u>Sockeye Salmon</u>	E-5-37
5.2.1.2 <u>Pink Salmon</u>	E-5-56
5.2.1.3 <u>Chum Salmon</u>	E-5-62
5.2.1.4 <u>Coho Salmon</u>	E-5-70
5.2.2 <u>Survey Investigations</u>	E-5-75
5.2.2.1 <u>Mainstem Surveys</u>	E-5-75
5.2.2.2 <u>Escapement Surveys</u>	E-5-80

(263)

APA

(7)

Estes

	PAGE
5.2.3 <u>Radio Telemetry Investigations</u>	E-5-9
5.2.3.1 <u>Chum Salmon</u>	E-5-9
5.2.3.2 <u>Coho Salmon</u>	E-5-1
6. ACKNOWLEDGEMENTS	E-6-1
7. LITERATURE CITED	E-7-1

(3 of 3)

Estes✓

ALASKA POWER AUTHORITY

APA 80's

SUSITNA HYDROELECTRIC PROJECT

(185)

**Subtask 7.10
Phase 1 Final Draft Report
Juvenile Anadromous Fish Study
on the Lower Susitna River
ADF&G / Su Hydro 1981**

8.

by
Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
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APA Doc # 322

for

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York 14202

(2665)

Estes ✓

TABLE OF CONTENTS

<u>Title</u>	<u>Page</u>
1. SUMMARY.....	E-1-1
2. INTRODUCTION.....	E-2-1
3. SPECIES REPORTS - JUVENILE ANADROMOUS FISH.....	E-3-1
3.1 CHINOOK SALMON JUVENILES.....	E-3-1
3.1.1 Abstract.....	E-3-1
3.1.2 Introduction.....	E-3-3
3.1.3 Methods.....	E-3-5
3.1.4 Results and Discussion - Winter.....	E-3-6
3.1.4.1 Distribution and Relative Abundance.....	E-3-6
3.1.4.2 Age and Length Composition.....	E-3-12
3.1.5 Results and Discussion - Summer.....	E-3-15
3.1.5.1 Distribution and Relative Abundance.....	E-3-15
3.1.5.2 Age and Length Composition.....	E-3-35
3.2 COHO SALMON JUVENILES.....	E-3-50
3.2.1 Abstract.....	E-3-50
3.2.2 Introduction.....	E-3-51
3.2.3 Methods.....	E-3-53
3.2.4 Results and Discussion - Winter.....	E-3-54
3.2.3.1 Distribution and Relative Abundance.....	E-3-54
3.2.3.2 Age and Length Composition.....	E-3-64
3.2.5 Results and Discussion - Summer.....	E-3-68
3.2.5.1 Distribution and Relative Abundance.....	E-3-68
3.2.5.2 Age and Length Composition.....	E-3-82
3.3 OTHER JUVENILE SALMON.....	E-3-96
3.3.1 Abstract.....	E-3-96
3.3.2 Introduction.....	E-3-96
3.3.3 Methods.....	E-3-97
3.3.4 Results and Discussion.....	E-3-97

(#8)

Estes

<u>Title</u>	<u>Page</u>
3.3.4.1 Distribution and Relative Abundance.....	E-3-97
3.3.4.2 Age and Length Composition.....	E-3-100
4. LITERATURE CITED.....	E-4-1
5. ACKNOWLEDGEMENTS.....	E-5-1

(365)

(#8)

Estes ✓

(465) (#8)

1. SUMMARY

- (1) 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.
- (2) Field collection of data on juvenile salmon fish species took place from November, 1980 to October, 1981. Sampling gear used included variable mesh gillnets, minnow traps, beach seines, electrofishing units, and dip nets.
- (3) Five juvenile salmon species were captured during the course of this study.
- (4) Juvenile chinook 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.
- (5) Juvenile coho 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

(585)

Estes

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.

- (6) Relatively small numbers of juvenile pink, chum and sockeye salmon were collected in 1980-1981. 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.
- (7) Further information is needed on the winter distribution and habits of all five species of juvenile salmon.
- (8) Further information is needed on the timing of the smolt outmigration and also on the incubation of embryos of all five juvenile salmon species.

(#8)

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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

(16/5)

Subtask 7.10
Phase 1 Final Draft Report
Resident Fish Investigation
on the Lower Susitna River
ADF&G / Su Hydro 1981

#9.

by
Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

APA Doc #318

for

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York 14202

TABLE OF CONTENTS

(#9)

Estes ✓

(2015)

<u>Title</u>	<u>Page</u>
1. SUMMARY.....	E-1-1
2. INTRODUCTION.....	E-2-1
3. SPECIES REPORTS - RESIDENT FISH.....	E-3-1
3.1 RAINBOW TROUT.....	E-3-1
3.1.1 Abstract.....	E-3-1
3.1.2 Introduction.....	E-3-2
3.1.3 Methods.....	E-3-3
3.1.4 Results and Discussion.....	E-3-4
3.1.4.1 Distribution and Relative Abundance.....	E-3-4
3.1.4.2 Age, Length, and Sex Composition.....	E-3-8
3.1.4.3 Tagging and Recapture.....	E-3-11
3.2 ARCTIC GRAYLING.....	E-3-16
3.2.1 Abstract.....	E-3-16
3.2.2 Introduction.....	E-3-16
3.2.3 Methods.....	E-3-18
3.2.4 Results and Discussion.....	E-3-18
3.2.4.1 Distribution and Relative Abundance.....	E-3-18
3.2.4.2 Age, Length, and Sex Composition.....	E-3-19
3.2.4.3 Spawning.....	E-3-24
3.2.4.4 Tagging and Recapture.....	E-3-27
3.3 BURBOT.....	E-3-29
3.3.1 Abstract.....	E-3-29
3.3.2 Introduction.....	E-3-29
3.3.3 Methods.....	E-3-31
3.3.4 Results and Discussion.....	E-3-31
3.3.4.1 Distribution and Relative Abundance.....	E-3-31
3.3.4.2 Age, Length, and Sex Composition.....	E-3-38
3.3.4.3 Spawning.....	E-3-42
3.3.4.4 Tagging and Recapture.....	E-3-45

(#9)

Estos ✓

(345)

	<u>Page</u>
3.4 ROUND WHITEFISH.....	E-3-47
3.4.1 Abstract.....	E-3-47
3.4.2 Introduction.....	E-3-47
3.4.3 Methods.....	E-3-48
3.4.4 Results and Discussion.....	E-3-49
3.4.4.1 Distribution and Relative Abundance.....	E-3-49
3.4.4.2 Age, Length, and Sex Composition.....	E-3-51
3.4.4.3 Spawning.....	E-3-55
3.4.4.4 Tagging and Recapture.....	E-3-55
3.5 HUMPBACK WHITEFISH.....	E-3-59
3.5.1 Abstract.....	E-3-59
3.5.2 Introduction.....	E-3-59
3.5.3 Methods.....	E-3-62
3.5.4 Results and Discussion.....	E-3-63
3.5.4.1 Distribution and Relative Abundance.....	E-3-64
3.5.4.2 Age, Length, and Sex Composition.....	E-3-71
3.5.4.3 Spawning.....	E-3-71
3.5.4.4 Tagging and Recapture.....	E-3-71
3.6 BERING CISCO.....	E-3-75
3.6.1 Abstract.....	E-3-75
3.6.2 Introduction.....	E-3-76
3.6.3 Methods.....	E-3-77
3.6.4 Results and Discussion.....	E-3-77
3.6.4.1 Distribution and Relative Abundance.....	E-3-77
3.6.4.2 Age, Length, and Sex Composition.....	E-3-79
3.6.4.3 Spawning.....	E-3-84
3.6.4.4 Tagging and Recapture.....	E-3-91
3.7 LONGNOSE SUCKER.....	E-3-95
3.7.1 Abstract.....	E-3-95
3.7.2 Introduction.....	E-3-95
3.7.3 Methods.....	E-3-97
3.7.4 Results and Discussion.....	E-3-97

(#9)

Estes✓

(465)

	<u>Page</u>
3.7.4.1 Distribution and Relative Abundance.....	E-3-97
3.7.4.2 Age, Length, and Sex Composition.....	E-3-98
3.7.4.3 Tagging and Recapture.....	E-3-103
3.8 DOLLY VARDEN.....	E-3-107
3.8.1 Abstract.....	E-3-107
3.8.2 Introduction.....	E-3-107
3.8.3 Methods.....	E-3-108
3.8.4 Results and Discussion.....	E-3-108
3.8.4.1 Distribution and Relative Abundance.....	E-3-108
3.8.4.2 Length Frequency.....	E-3-112
3.8.4.3 Tagging.....	E-3-112
3.9 THREESPINE STICKLEBACK.....	E-3-116
3.9.1 Abstract.....	E-3-116
3.9.2 Introduction.....	E-3-116
3.9.3 Methods.....	E-3-118
3.9.4 Results and Discussion.....	E-3-118
3.9.4.1 Distribution and Relative Abundance.....	E-3-118
3.9.4.2 Age, Length, and Sex Composition.....	E-3-121
3.10 COTTIDS.....	E-3-123
3.10.1 Abstract.....	E-3-123
3.10.2 Introduction.....	E-3-123
3.10.3 Methods.....	E-3-124
3.10.4 Results and Discussion.....	E-3-124
3.10.4.1 Distribution and Relative Abundance.....	E-3-124
3.10.4.2 Age, Length, and Sex Composition.....	E-3-127
3.11 ARCTIC LAMPREY.....	E-3-129
3.11.1 Abstract.....	E-3-129
3.11.2 Introduction.....	E-3-129
3.11.3 Methods.....	E-3-131
3.11.4 Results and Discussion.....	E-3-131

(#9)

Estes ✓

	<u>Page</u>
3.11.4.1 Distribution and Relative Abundance.....	E-3-131
3.11.4.2 Age, Length, and Sex Composition.....	E-3-134
3.12 NORTHERN PIKE.....	E-3-136
3.12.1 Abstract.....	E-3-136
3.12.2 Introduction.....	E-3-136
3.12.3 Methods.....	E-3-137
3.12.4 Results and Discussion.....	E-3-137
3.12.4.1 Age, Length and Sex Composition.....	E-3-138
4. LITERATURE CITED.....	E-4-1
5. ACKNOWLEDGEMENTS.....	E-5-1

(#9)

(5 of 5)

Estes✓

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

(1073)

**Subtask 7.10
Phase 1 Final Draft Report
Resident Fish Investigation
on the Upper Susitna River
ADF&G / 1981**

#10.

by
Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

APA Doc#316

for

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York 14202

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(263)

(#10)

TABLE OF CONTENTS

<u>Title</u>	<u>Page</u>
LIST OF FIGURES.....	iv
LIST OF TABLES.....	vi
LIST OF PLATES.....	ix
LIST OF APPENDIX TABLES.....	x
1. SUMMARY.....	E-1-1
2. INTRODUCTION.....	E-2-1
2.1 Objectives.....	E-2-1
2.2 Methods.....	E-2-11
3. SPECIES REPORTS - RESIDENT FISH.....	E-3-1
3.1 ARCTIC GRAYLING.....	E-3-1
3.1.1 Abstract.....	E-3-2
3.1.2 Introduction.....	E-3-3
3.1.3 Methods.....	E-3-5
3.1.4 Results and Discussion.....	E-3-5
3.1.4.1 Distribution and Relative Abundance.....	E-3-5
3.1.4.2 Age, Length and Sex Composition.....	E-3-21
3.1.4.3 Spawning.....	E-3-33
3.1.4.4 Tagging and Recapture.....	E-3-34
3.1.4.4.1 Introduction.....	E-3-34
3.1.4.4.2 Population Estimation.....	E-3-38
3.1.4.4.3 Migration.....	E-3-41
3.2 BURBOT.....	E-3-67
3.2.1 Abstract.....	E-3-67
3.2.2 Introduction.....	E-3-67
3.2.3 Methods.....	E-3-69
3.2.4 Results and Discussion.....	E-3-69
3.2.4.1 Distribution and Relative Abundance.....	E-3-69
3.2.4.2 Age, Length and Sex Composition.....	E-3-72
3.2.4.3 Tagging and Recapture.....	E-3-77

(3063)

(#10)

3.3	ROUND WHITEFISH.....	E-3-79
3.3.1	Abstract.....	E-3-79
3.3.2	Introduction.....	E-3-79
3.3.3	Methods.....	E-3-80
3.3.4	Results and Discussion.....	E-3-81
3.3.4.1	Distribution and Relative Abundance.....	E-3-81
3.3.4.2	Age, Length and Sex Composition.....	E-3-81
3.3.4.3	Tagging and Recapture.....	E-3-85
3.4	LONGNOSE SUCKER.....	E-3-87
3.4.1	Abstract.....	E-3-87
3.4.2	Introduction.....	E-3-87
3.4.3	Results and Discussion.....	E-3-88
3.4.3.1	Distribution and Relative Abundance.....	E-3-88
3.4.3.2	Age, Length and Sex Composition.....	E-3-91
3.4.3.3	Tagging and Recapture.....	E-3-91
3.5	COTTIDS.....	E-3-94
3.5.1	Abstract.....	E-3-94
3.5.2	Introduction.....	E-3-94
3.5.3	Methods.....	E-3-95
3.5.4	Results and Discussion.....	E-3-95
3.5.4.1	Distribution and Relative Abundance.....	E-3-95
3.5.4.2	Age, Length and Sex Composition.....	E-3-97
3.6	LAKE TROUT.....	E-3-98
3.6.1	Abstract.....	E-3-98
3.6.2	Introduction.....	E-3-98
3.6.3	Results and Discussion.....	E-3-99
3.6.3.1	Distribution and Relative Abundance.....	E-3-99
3.6.3.2	Age, Length and Sex Composition.....	E-3-99
3.6.3.3	Tagging and Recapture.....	E-3-101
3.7	MISCELLANEOUS SPECIES.....	E-3-102

Estes

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

(1063)

Subtask 7.10

Phase 1 Final Draft Report Vol. 1

Aquatic Habitat & Instream Flow Project

ADF & G / Su Hydro 1981

by

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

for

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Buffalo, New York 14202

11a.

APA Doc# 1307

ESTES✓

TABLE OF CONTENTS

VOLUME ONE

<u>Title</u>	<u>Page</u>
LIST OF FIGURES.....	iii
LIST OF TABLES.....	iv
LIST OF PLATES.....	v
LIST OF APPENDIXES.....	vi
1. SUMMARY.....	E-1-1
2. INTRODUCTION.....	E-2-1
3. OBJECTIVES.....	E-3-1
4. STUDY DESCRIPTION AND RATIONALE.....	E-4-1
4.1 Fisheries Habitat Evaluation.....	E-4-1
4.1.1 Point Specific Evaluation.....	E-4-3
4.1.2 General Habitat Evaluation.....	E-4-3
4.2 Selected Habitat Evaluation.....	E-4-3
4.2.1 Water Quality and Discharge	
Data Collection.....	E-4-4
4.2.2 Surveying and Discharge	
Measurements.....	E-4-4
5. STUDY APPROACH.....	E-5-1
5.1 General Habitat Evaluation.....	E-5-1
5.1.1 Methods.....	E-5-1
5.1.1.1 Physiochemical.....	E-5-1
5.1.1.2 Site Selection.....	E-5-6
5.1.1.3 Winter Methods.....	E-5-12
5.1.2 Findings.....	E-5-12
5.1.2.1 Habitat Descriptions of Each	
General Habitat Evaluation Study	
Site by River Reach.....	E-5-12
5.1.2.1.1 Yentna Reach.....	E-5-15
5.1.2.1.2 Sunshine Reach.....	E-5-23
5.1.2.1.3 Talkeetna Reach.....	E-5-31
5.1.2.1.4 Gold Creek Reach.....	E-5-38
5.1.2.1.5 Impoundment Reach.....	E-5-51
5.1.2.2 Physiochemical Data for Each General	
Habitat Evaluation Study Site.....	E-5-65
5.1.2.3 Temperature Data.....	E-5-65
5.1.2.4 Stage Data.....	E-5-65
5.1.2.5 Incidental Data.....	E-5-183

CE ✓

TABLE OF CONTENTS (Continued)

(3063)

(#11a)

<u>Title</u>	<u>Page</u>
5.1.2.6 Point Specific Data.....	E-5-183
5.1.2.7 Winter Data.....	E-5-183
5.2 Selected Habitat Evaluation.....	E-5-184
5.2.1 Methods.....	E-5-184
5.2.1.1 Physiochemical.....	E-5-184
5.2.1.2 Surveying.....	E-5-185
5.2.1.3 Site Selection.....	E-5-190
5.2.2 Findings.....	E-5-191
5.2.2.1 Site Descriptions.....	E-5-191
5.2.2.2 Morphometry Data.....	E-5-195
5.2.2.3 Stage/Discharge Data.....	E-5-195
5.2.2.4 Physiochemical Data.....	E-5-220
6. REFERENCES.....	E-6-1
7. CONTRIBUTORS.....	E-7-1
8. ACKNOWLEDGEMENTS.....	E-8-1

VOLUME TWO

9. APPENDIXES.....	EA-1
Part 1 - Appendixes EA-EH.....	EA-1
Part 2 - Appendixes EI-EJ.....	EI-1

CE✓

ESTES ✓

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

(1062)

Subtask 7.10

Phase 1 Final Draft Report Vol. 2 Pt. 1

Aquatic Habitat & Instream Flow Project

ADF & G / Su Hydro 1981

11b.

by

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

APA Doc# 311

for

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York 14202

ESTES ✓

TABLE OF CONTENTS

VOLUME TWO

APPENDIXES EA-EJ

<u>Title</u>	<u>Page</u>
LIST OF FIGURES.....	ii
LIST OF TABLES.....	iii
APPENDIXES.....	EA-1

PART 1

EA. General habitat evaluation site planimetric maps.....	EA-1
EB. Physiochemical data tables for each general habitat evaluation study site.....	EB-1
EC. Temperature data tables for each thermograph site.....	EC-1
ED. Stage data tables for AA fishwheel and sonar sites.....	ED-1
EE. Cross section survey data of each selected habitat evaluation study site.....	EE-1
EF. Mainstem Susitna River discharge at Gold Creek versus time (May-October, 1981).....	EF-1
EG. Methods supplement.....	EG-1
EH. Incidental data.....	EH-1

PART 2

EI. Point specific data.....	EI-1
EJ. Winter data.....	EJ-1

Estes

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

ESTES

(10/2)

Subtask 7.10

Phase 1 Final Draft Report Vol. 2 Pt. 2

Aquatic Habitat & Instream Flow Project

ADF & G / Su Hydro 1981

by

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

for

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York 14202

#11c.

APA Doc #312

LIST OF

TABLE OF CONTENTS

VOLUME TWO
APPENDIXES EA-EJ

(26/2) (#11c)

<u>Title</u>	<u>Page</u>
LIST OF FIGURES.....	ii
LIST OF TABLES.....	iii
APPENDIXES.....	EA-1

PART 1

EA. General habitat evaluation site planimetric maps.....	EA-1
EB. Physiochemical data tables for each general habitat evaluation study site.....	EB-1
EC. Temperature data tables for each thermograph site.....	EC-1
ED. Stage data tables for AA fishwheel and sonar sites.....	ED-1
EE. Cross section survey data of each selected habitat evaluation study site.....	EE-1
EF. Mainstem Susitna River discharge at Gold Creek versus time (May-October, 1981).....	EF-1
EG. Methods supplement.....	EG-1
EH. Incidental data.....	EH-1

PART 2

EI. Point specific data.....	EI-1
EJ. Winter data.....	EJ-1

CE ✓

Estes✓

DRAFT

AQUATIC STUDIES PROCEDURES MANUAL

PHASE I

(1678)

Alaska Department of Fish and Game
Su-Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska
99503

May 1981

(# 11d)

DRAFT

TABLE OF CONTENTS

I. INTRODUCTION	
Objective 1 -----	1
Objective 2 -----	4
Objective 3 -----	4
II. TECHNICAL PROCEDURES	
ADULT ANADROMOUS FISHERIES STUDIES -----	5
Study Description and Rationale -----	5
Sonar Counters -----	5
Tag/Recapture -----	7
Survey -----	8
Stock Assessment -----	11
Radio Tagging -----	12
RESIDENT AND JUVENILE ANADROMOUS FISHERIES STUDIES	
Study Description and Rationale -----	13
Summer Field Operations -----	13
Winter Field Operations -----	14
Study Habitat Locations -----	15
Tributary Stream Mouth Sites -----	15
Slough Sites -----	15
Mainstem River Sites -----	16
Upper Susitna River Tributary Sites -----	16
Selective Sampling of Fish Concentrations -----	16
Study Methods -----	19
Tagging of Resident Adult Species -----	19
Resident Adult Tag Recovery -----	19
Radio Telemetry -----	20
Level of Effort -----	20
AQUATIC HABITAT AND INSTREAM FLOW STUDIES	
Study Description and Rationale -----	20
Fishery Habitat Evaluations -----	20
Selected Habitat Evaluations -----	23
Study Site Locations -----	27
Fishery Habitat Evaluation Sites -----	27
Selected Habitat Evaluation Sites -----	27
Methods -----	27
Water Quality -----	27
Hydrology -----	28
Mapping -----	34
Level of Effort -----	37
III. DATA PROCEDURES	
ADULT ANADROMOUS FISHERIES STUDIES -----	38
Sonar Data Collection and Preparation -----	38
Escapement Sampling-Age & Length Data -----	44
Labeling Procedures -----	48
Tag/Recapture Data Collection and Preparations -	52
Survey Data Collection and Preparation -----	59

(#11d)
(2018)

CEV ✓

RESIDENT AND JUVENILE ANADROMOUS FISHERIES STUDIES	
Biological Data -----	59
AQUATIC HABITAT AND INSTREAM FLOW STUDIES	
Assigning Gear Placement Numbers (GPSN) -----	65
Personal Log Book -----	66
Completing Aquatic Habitat Forms -----	66
IV. QUALITY CONTROL	
All Projects -----	78
Data Routing -----	79
V. SCHEDULE	
All Projects -----	81
VI. PERSONNEL	
All Projects -----	85

APPENDICES

- I. Sonar Installation and Operation Manual
- II. Oscilloscope Operation
- III. Fishwheel Operation
- IV. Fish Tagging
- V. Electro-Shocking Instructions
- VI. Habitat Site Locations
- VII. RJ Sampling Techniques
- VIII. AH Instruction Manuals

LIST OF FIGURES

I. INTRODUCTION	
1. Susitna River Basin (approximate scale 1:2,200,000) -----	2
2. Phase I study areas, Susitna River Basin ----	3
II. TECHNICAL PROCEDURES	
1. Sampling sites in a typical impoundment stream -----	17
2. Resident and Juvenile Anadromous (RJ) and Aquatic Habitat and Instream Flow (AH) Personnel Deployment-Ice Free Months -----	21
3. Resident and Juvenile Anadromous (RJ) and Aquatic Habitat and Instream Flow (AH) Study Personnel Deployment-Ice Covered Months ----	22
4. Aquatic Habitat and Instream Flow Study Program Components -----	23
5. Fishery Habitat Evaluation Components -----	23
6. Selected Habitat Evaluation Components -----	25
7. USGS Type AA Current Meter Rating Table ----	29
8. Measurement of Horizontal Angles (From Buchanan and Somers, 1973) -----	31

CE✓

9. Embeddedness Classification System (From AEIDC, 1980) -----	32
10. Substrate Grid -----	33
11. Cross Sectional Profile Diagram -----	34
12. Example of Morphometric Map with Depths and Elevations in Feet (Modified from Bovee and Cochnauer, 1977). -----	36
13. Large River Velocity and Depth Procedure Diagram -----	37
III. DATA PROCEDURES	
1. Printer tape stamps -----	39
2. Preferred scale, preferred scale zone, and length measurement -----	46
3. Scale selection and mounting on gummed card -	47
4. River Channel Patterns (From Richardson, et. al., 1975) -----	67
IV. QUALITY CONTROL	
1. Data Routing, Phase I, 1981 -----	80
V. SCHEDULE	
1. Adult Anadromous Project Schedule, 1981 -----	82
2. Activity schedule, 1981. Integrated Resident and Juvenile Anadromous Fisheries and Aquatic Habitat and Instream Flow Projects -----	83
3. Reporting Schedule, 1981 -----	84

LIST OF TABLES

II. TECHNICAL PROCEDURES	
1. Sampling Streams Proposed Susitna Impoundment -----	18
2. General Habitat Evaluation Parameters -----	24
3. Selected Habitat Evaluation Parameters -----	25
4. ADF&G/USGS Additional Water Quality Measurements -----	26
III. DATA PROCEDURES	
1. Daily Log for Sicescan Sonar Counter -----	40
2. Side Scanners Counter Log -----	41
3. Side Scanner Counts -----	42
4. Field Counter Calibration -----	43
5. Daily Escapement Data -----	45
5a. Age, Weight and Length (AWL) Form -----	49
5b. Commercial Catch Sampling Information (AWL Codes) -----	50
6. Anadromous Adult Investigations-Susitna Hydro Statistical Codes and Code Samples -----	51
7. Individual Fishwheel Catch Record -----	53
8. Tag Deployment Record -----	54

CEV

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I. INTRODUCTION

The Susitna River, Southcentral Alaska's major river system, drains into Cook Inlet near the City of Anchorage (Figure 1). The drainage encompasses an area of 19,400 square miles and extends north to Mt. Denali and east almost to the town of Glenallen. The mainstem river and its major tributaries are of glacial origin and carry a heavy silt load during ice-free months. Many of the smaller tributaries are perennially silt-free.

Construction of hydroelectric dams will affect portions of the fish and wildlife resources of the Susitna River Basin. The two dam system proposed would inundate in excess of 50,500 acres of an aquatic and terrestrial habitat upstream of Devil Canyon. Historically, the long and short term environmental impacts of hydroelectric dams have adversely altered the sport and commercial fisheries of affected drainages (Keller, 1980; Hagen et al., 1973). Regulation of the mainstem river will substantially alter the natural flow regime downstream. The transmission line corridor, substations, road corridor, and construction pad sites will also impact aquatic and terrestrial communities and their habitat.

The proposed hydroelectric development necessitates gaining a thorough knowledge of its chemical, physical and biological parameters prior to final dam design approval and construction authorization. Preliminary environmental assessments of the project noted deficiencies in the state of knowledge of the Susitna drainage fisheries (FWS-ADF&G, 1978).

To insure adequate information is available to determine the impacts of the proposed hydroelectric project and to design proper mitigative strategies, a two-phase data collection program has been developed. This manual addresses Phase I (July 1, 1980-December 31, 1981) procedures to be conducted within those study areas outlined in Figure 2.

The following objectives are to be addressed in the Phase I. field fisheries studies.

- OBJECTIVE 1. Determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the study area.
- Task 1.1 Enumerate and characterize the runs of the adult anadromous fish.
- Task 1.2 Determine the timing and nature of migration, milling and spawning activities.
- Task 1.3 Identify spawning locations within the study area (i.e., subreaches of the mainstem sloughs and side channels, tributary confluences, lakes and ponds, etc.) and estimate their comparative importance.

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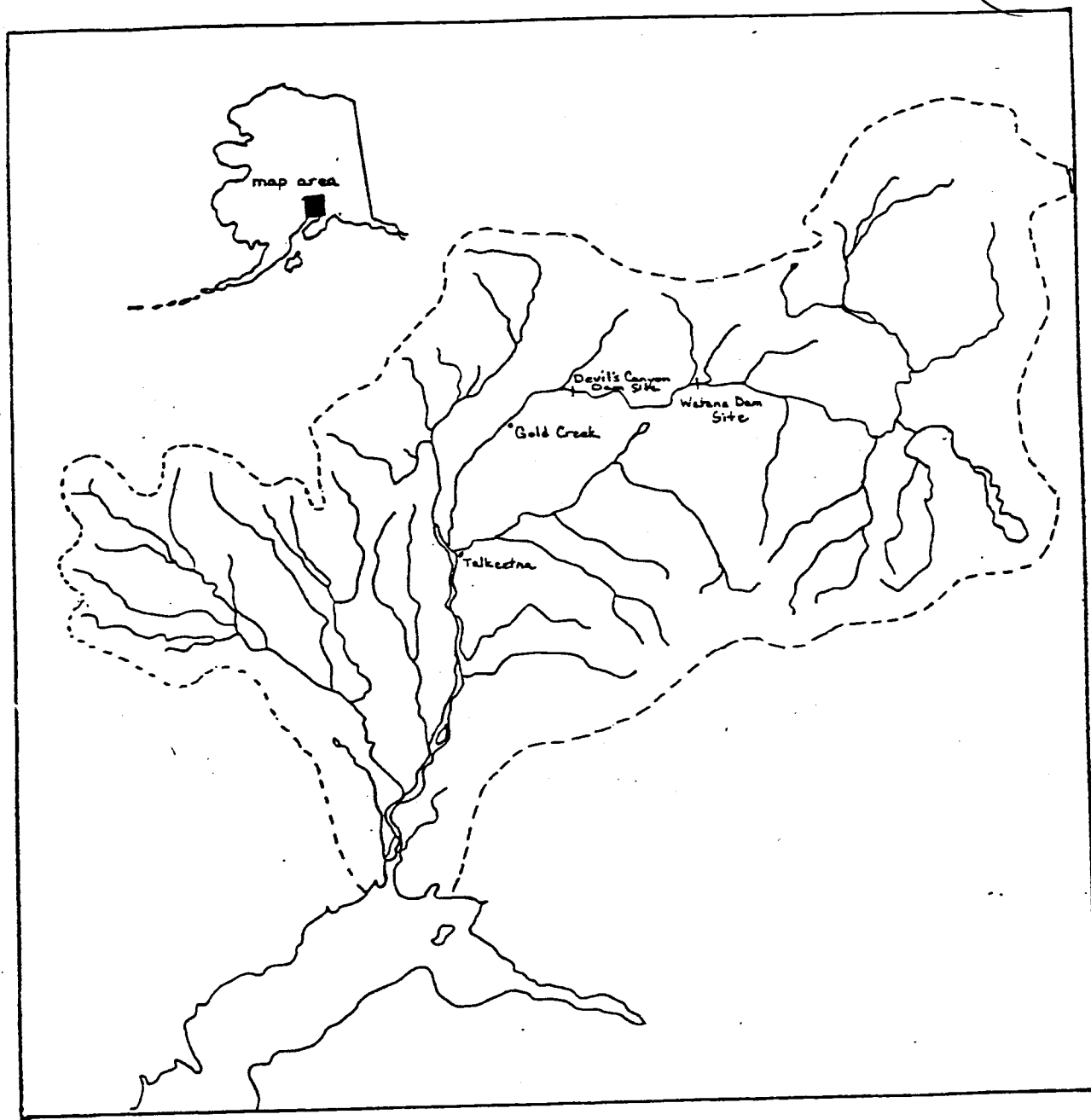


Figure 1. Susitna River Basin (approximate scale 1:2,200,000)

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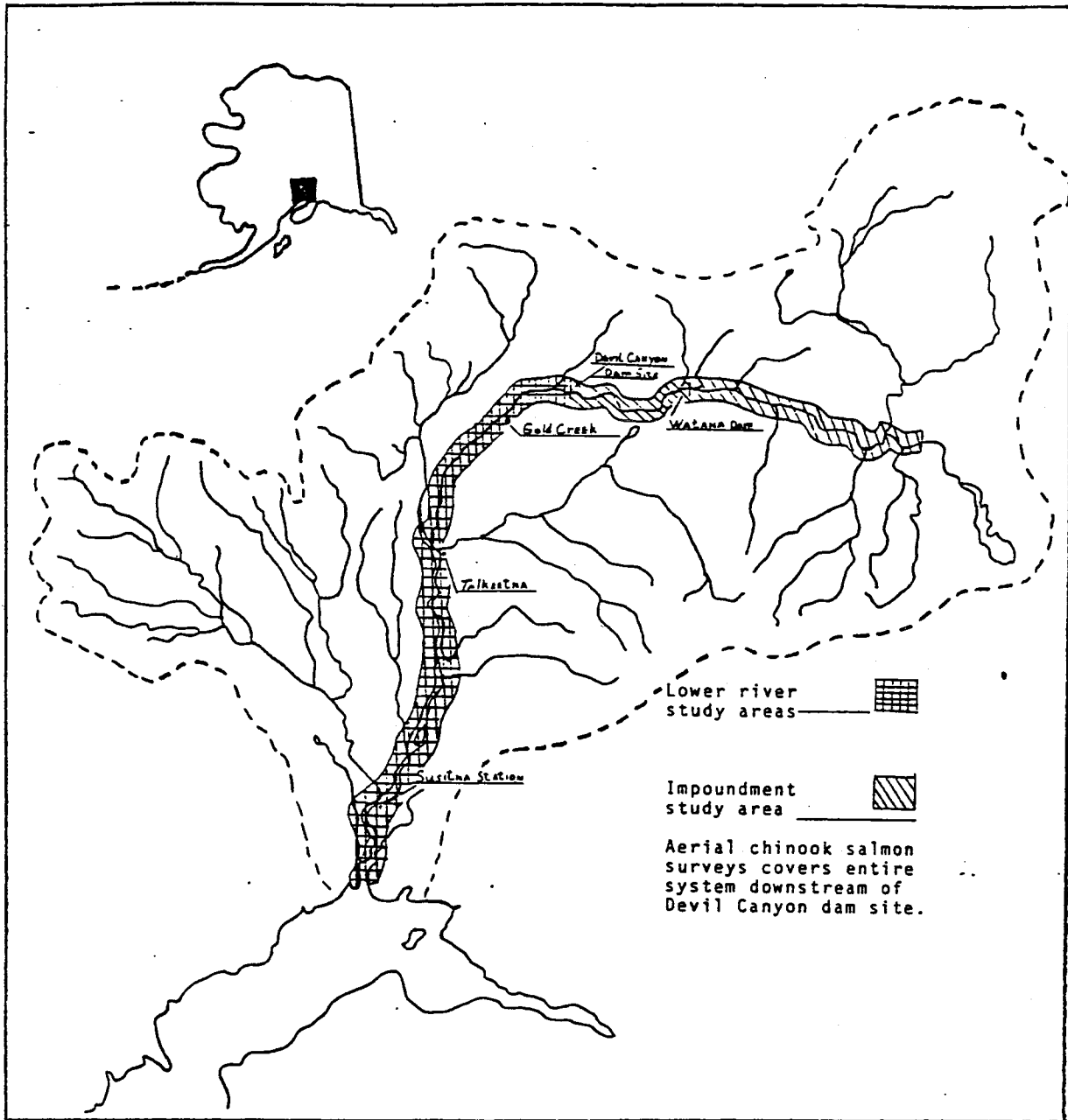


Figure 2. Phase I study areas, Susitna River basin.

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Task 1.4 Identify and determine methods, means and the feasibility of estimating the Susitna Rivers contribution to the Cook Inlet commercial fishery.

OBJECTIVE 2. Determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area.

Task 2.1 Identify spawning and rearing locations of the resident species and the rearing locations of juvenile anadromous species to estimate their comparative importance.

Task 2.2 Record descriptive information on captured fish (species, location of capture site, age class), and discuss seasonal migration patterns of selected adult resident species.

OBJECTIVE 3. Characterize the seasonal habitat requirements of selected anadromous and resident species within the study area.

Task 3.1 Through direct field observations and measurements identify the physical and chemical conditions which appear to be influencing the suitability of various habitat types for the species and life history stages of interest.

Task 3.2 Through direct field observations and measurements characterize the physical and chemical parameters of the various habitat types found in the study area.

To meet the above objectives, the study program is separated into three sections; Adult Anadromous Fisheries, Resident and Juvenile Anadromous Fisheries, and Aquatic Habitat and Instream Flow Studies. The operations of the Anadromous Adult and Resident and Juvenile Anadromous field investigations will be interrelated to and conducted in cooperation with the Aquatic Habitat and Instream Flow studies. The specific procedures for completion of each section of the program are described in this manual.

10 of 10

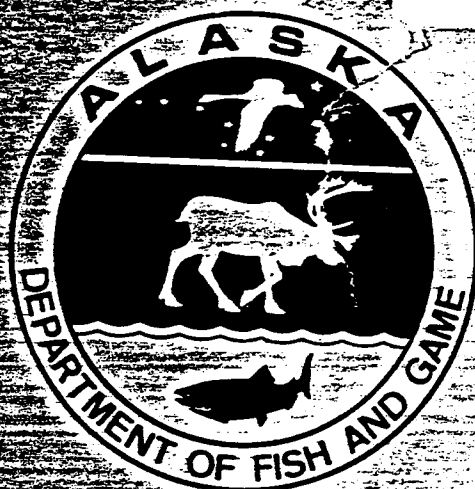


Subtask 7.10

Phase 1 Final Draft Report

Aquatic Studies Program

ADF & G / Su Hydro 1982



(10/3)

12.

APA Doc #517

ESTES

TABLE OF CONTENTS

12 (2063)

Estes✓

	<u>Page</u>
LIST OF FIGURES.....	iii
LIST OF TABLES.....	ix
LIST OF PLATES.....	xii
LIST OF APPENDIX TABLES.....	xiii
1. INTRODUCTION.....	E-1-1
1.1 Background and Objectives.....	E-1-1
1.2 Description of Study Area.....	E-1-7
1.3 Methods.....	E-1-8
2. FISHERIES AND HABITAT RELATIONSHIPS.....	E-2-1
2.1 Introduction.....	E-2-1
2.2 Salmon Periodicity and Sonar Counts in Relation to Discharge.....	E-2-1
2.3 Percent Incidence of Selected Fish Species in Relation to Discharge.....	E-2-12
2.4 Percent Trapping Incidence of Selected Fish Species in Relation to Point Specific Depth and Velocity.....	E-2-24
2.5 Bering Cisco Spawning Habitat Evaluation.....	E-2-30
2.6 Matrixes of Fishery and Physiochemical Observations.....	E-2-35
2.7 Chum and Sockeye Adult Salmon Observations in Selected Sloughs in Relation to Mainstem Discharge.....	E-2-43
2.8 Fisheries and Habitat Relationships in the Proposed Impoundment Area.....	E-2-49
2.8.1 Introduction.....	E-2-49
2.8.2 Water Quality.....	E-2-49
2.8.3 Substrate.....	E-2-57
2.8.4 Streamflow and Channel Morphology.....	E-2-59
2.8.5 Conclusions.....	E-2-61
3. HABITAT RELATIONSHIPS.....	E-3-1
3.1 Introduction.....	E-3-1
3.2 Discharge and Turbidity Relationships.....	E-3-1
3.3 Differences Between Surface Water Temperatures at Mainstem Locations.....	E-3-8
3.4 Diel Surface Water Temperature Fluctuations.....	E-3-8
3.5 Selected Slough Habitat Studies.....	E-3-21

Estes ✓

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.5.1 Introduction.....	E-3-21
3.5.2 Relationships Between Water Quality in the Mainstem River and Selected Sloughs with Respect to Mainstem Discharge.....	E-3-25
3.5.3 Relationships Between Water Quality Characteristics in Study Sloughs.....	E-3-29
4. PREDICTIVE MODELS.....	E-4-1
4.1 Introduction.....	E-4-1
4.2 Stage Analysis.....	E-4-1
4.3 Water Temperature Analysis.....	E-4-13
4.4 Pre-project and Post-project Flow Comparisons.....	E-4-15
5. CONCLUSION.....	E-5-1
6. CONTRIBUTORS.....	E-6-1
7. ACKNOWLEDGEMENTS.....	E-7-1
8. REFERENCES.....	E-8-1
9. APPENDIX.....	E-9-1

(#12)
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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

(1064)

Subtask 7.10
Phase 1 Final Draft
Stock Separation
Feasibility Report
Adult Anadromous Fisheries Project
ADF&G / Su Hydro 1982

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by
Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

APA Doc #403

for

Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New York, 14202

Estes ✓

TABLE OF CONTENTS

1. SUMMARY	E-1
2. INTRODUCTION	E-3
3. OBJECTIVES	E-5
4. METHODS	E-5
5. RESULTS AND DISCUSSION	E-6
5.1 <u>Cook Inlet Commercial Fishery</u>	E-6
5.2 <u>Sockeye Salmon</u>	E-8
5.3 <u>Chum Salmon</u>	E-14
5.4 <u>Coho Salmon</u>	E-16
5.5 <u>Pink Salmon</u>	E-19
5.6 <u>Chinook Salmon</u>	E-21
6. RECOMMENDATIONS	E-24
7. ACKNOWLEDGEMENTS	E-25
8. LITERATURE CITED	E-26

(# 13)
(28/4)

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1. SUMMARY

Five species of Pacific salmon return to freshwater systems, including the Susitna River, in Upper Cook Inlet. The Upper Cook Inlet commercial fishery harvests mixed stocks and species migrating north of Anchor Point, with a long term average catch of 2.8 million fish, worth approximately 17.9 million dollars.

The commercial sockeye salmon harvest has averaged 1.2 million fish the past ten years. This species is economically the most valuable species, receiving greatest emphasis in management and research. A stock identification program using scale pattern analysis has been developed to estimate stock contribution of major river systems to the commercial harvest. Estimates for the 1979 and 1980 fisheries show stock contribution by the Susitna River was 22.7% and 19.2% respectively.

The Upper Cook Inlet chum salmon catch has averaged 707,000 fish the past ten years. Though available escapement data identify the Susitna River as the major producer, river systems on the west side of Cook Inlet are known to support chum salmon populations. Evaluation of west side production is necessary to determine the need for a stock separation program. Electrophoresis and scale pattern analysis are two options for stock identification, should a program prove necessary.

The Upper Cook Inlet coho catch has averaged 204,000 fish the past ten years. Though the Susitna River appears to be the single largest producing system in

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Upper Cook Inlet, contribution of west side river systems must be addressed. Previous stock identification has been attempted with positive results using fish weight and scale pattern analysis. However, prior to implementing a stock identification program, major Upper Cook Inlet systems must be confirmed to estimate Susitna River contribution.

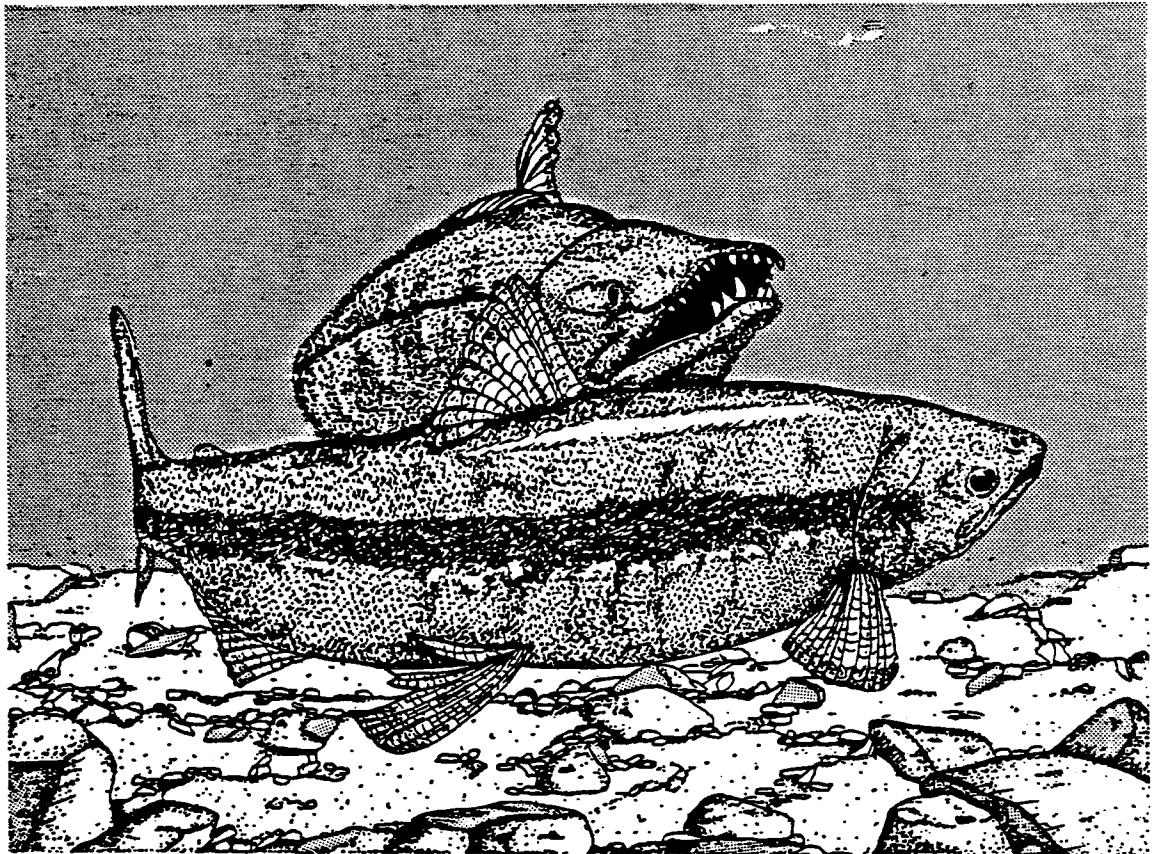
The ten year average catch for Upper Cook Inlet pink salmon is 146,000 and 1.7 million fish for odd and even years respectively. Two leading pink salmon producers are the Kenai and Susitna river drainages. However, production of west shore systems is unknown. When major producing river systems have been defined, electrophoresis and length-weight data should be examined as stock identification techniques.

Because migration timing relative to 25 June commercial season opening, Susitna River chinook salmon currently are not significantly exploited in the Upper Cook Inlet fishery; a stock separation program is not necessary at this time.

(4 of 4)

1 of 12

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Subtask 7.10

AQUATIC STUDIES PROCEDURES MANUAL

PHASE II - Final Draft (2nd ed.)

1982 - 83 (FY 83)

14.



(1 of 4)

EST/ESV

TABLE OF CONTENTSPage

I. INTRODUCTION	1
II. TECHNICAL PROCEDURES	8
A. ADULT ANADROMOUS FISHERIES STUDIES	8
1. Study Description and Rationale	8
2. Sonar Counters	9
3. Tag/Recapture	10
4. Mainstem Surveys	12
5. Slough and Tributary Surveys	15
6. Chinook Salmon Aerial Surveys	17
7. Eulachon Surveys	17
8. Bering Cisco	19
9. Radio Tagging	20
10. Stock Separation	21
B. RESIDENT AND JUVENILE ANADROMOUS FISHERIES STUDIES	23
1. Study Description and Rationale	23
2. Study Design by Objective	23
3. Sub-objectives and Study Design	23
4. Summary of Objectives	31
5. Fish Distribution Study	31
6. Electrofishing and Tagging Surveys	43
7. Radio Telemetry Studies	46
8. Juvenile Incubation, Emergence, and Outmigration Studies	48
9. Food Habits Study Invertebrate and Distribution Study	51
10. Impoundment Area Studies	53
11. Level of Effort	56
C. AQUATIC HABITAT AND INSTREAM FLOW STUDIES	58
1. Study Description and Rationale	58
2. Scope by Geographical Reach of the Susitna River	59
3. Scope of FY-83 Program by Objective	59
4. Administrative Structure and Manpower Distribution	67
5. Field Data Collection Work Plans	70
a. Lower River Fish Habitat Utilization	70
i. Slough Spawning Habitat Studies	70
ii. Mainstem Spawning Habitat Studies	71
b. Instream Flow Evaluations	82
c. Upper River Fish Habitat Utilization	90

(#/4)

(20/4)

Estes ✓

TABLE OF CONTENTS (Continued)

	<u>Page</u>
D. DATA PROCESSING	95
1. Work Plan	95
2. Data Base Management	106
III. DATA PROCEDURES	113
A. ADULT ANADROMOUS FISHERIES STUDIES	113
1. Side Scan Sonar Operations	113
2. Tag/Recapture Operations	120
3. Mainstem Survey Operations	125
4. Slough And Tributary Surveys	125
5. Mainstem Set Netting	125
6. Bering Cisco Monitoring	126
7. Eulachon Survey Operation	126
B. RESIDENT AND JUVENILE ANADROMOUS FISHERIES STUDIES	137
1. Data Forms	137
2. Specific Data to be Collected	150
3. Report Format	151
C. AQUATIC HABITAT AND INSTREAM FLOW STUDIES	153
1. Data Forms	153
2. Data Transfer	169
IV. QUALITY CONTROL	170
A. Adult Anadromous Fisheries Studies	170
B. Resident and Juvenile Anadromous Fisheries Studies	170
C. Aquatic Habitat and Instream Flow Studies	171
D. Data Routing	172
V. REPORT SCHEDULE	173
VI. PERSONNEL	177
VII. LITERATURE CITED	180

#14

(30/4)

Estes ✓

LIST OF FY 83 APPENDIX ADDENDUMSPage

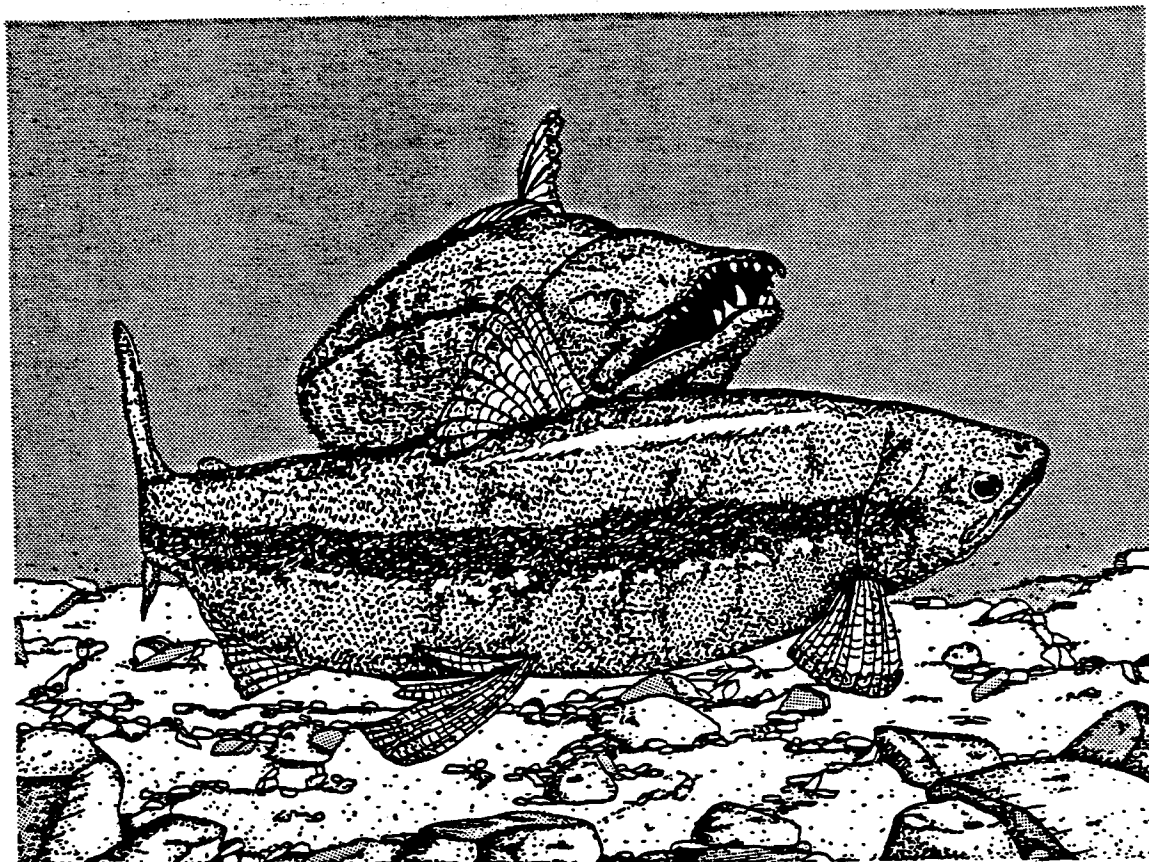
FY 83 ADDENDUM TO APPENDIX ^{IX} ~~X~~	186
FY 83 ADDENDUM TO APPENDIX [✓] ~~IV~~	240

(#14)

(40/4)

2 of 12

ESTESV



(10/6)

SUSITNA HYDRO AQUATIC STUDIES
PHASE II REPORT

Volume I: Summarization of Volumes
2, 3, 4; Parts I and II, and 5.
Alaska Department Of Fish and Game
Su Hydro Basic Data Reports, 1982.



15a.

APA Doc #96

ESTESV

(2016) (#152)

TABLE OF CONTENTS

PAGE

1.0	INTRODUCTION.....	1
1.1	Specific Project Objectives.....	1
2.0	VOLUME 2 SUMMARY - ADULT ANADROMOUS STUDIES.....	9
2.1	Eulachon (<u>Thaleichthys pacificus</u>).....	9
2.2	Adult Salmon (<u>Onchorhynchus sp.</u>).....	10
2.2.1	Chinook Salmon (<u>O. tshawytscha</u>).....	10
2.2.2	Sockeye Salmon (<u>O. nerka</u>).....	15
2.2.3	Pink Salmon (<u>O. gorbuscha</u>).....	17
2.2.4	Chum Salmon (<u>O. keta</u>).....	20
2.2.5	Coho Salmon (<u>O. kisutch</u>).....	23
2.3	Bering Cisco (<u>Coregonus laurettae</u>).....	25
3.0	VOLUME 3 SUMMARY - RESIDENT AND JUVENILE ANADROMOUS FISH STUDIES.....	28
3.1	Distribution and Abundance Studies.....	28
3.1.1	Rainbow Trout (<u>Salmo gairdneri</u>).....	30
3.1.2	Arctic Grayling (<u>Thymallus arcticus</u>).....	31
3.1.3	Burbot (<u>Lota lota</u>).....	32
3.1.4	Round Whitefish (<u>Prosopium cylindraceum</u>).....	32
3.1.5	Humpback Whitefish (<u>Coregonus pidschian</u>).....	33
3.1.6	Longnose Sucker (<u>Catostomus catostomus</u>).....	34
3.1.7	Dolly Varden (<u>Salvelinus malma</u>).....	35
3.1.8	Threespine Stickleback (<u>Gasterosteus aculeatus</u>).....	36
3.1.9	Slimy Sculpin (<u>Cottus cognatus</u>).....	37
3.1.10	Arctic Lamprey (<u>Lampetra japonica</u>).....	37
3.1.11	Chinook Salmon (<u>Oncorhynchus tshawytscha</u>) juveniles.....	38
3.1.12	Coho Salmon (<u>O. kisutch</u>) juveniles.....	39
3.1.13	Chum Salmon (<u>O. keta</u>) juveniles.....	39
3.1.14	Sockeye Salmon (<u>O. nerka</u>) juveniles.....	40
3.1.15	Pink Salmon (<u>O. gorbuscha</u>) juveniles.....	40
3.2	Emergence and Outmigration Studies.....	40
3.3	Food Habits and Distribution of Food Organisms.....	43
4.0	VOLUME 4 SUMMARY - AQUATIC HABITAT AND INSTREAM FLOW STUDIES.....	46
4.1	Introduction.....	46

TABLE OF CONTENTS (Continued)

PAGE

(386)

#152

4.2 Part 1 - Summary.....	46
4.2.1 Stage/Discharge Studies.....	46
4.2.1.1 Talkeetna to Devil Canyon.....	47
4.2.1.1.1 Mainstem Habitats.....	47
4.2.1.1.2 Slough Habitats.....	48
4.2.1.1.3 Tributary Habitats.....	50
4.2.1.2 Talkeetna to Cook Inlet.....	51
4.2.1.2.1 Mainstem Habitats.....	51
4.2.1.2.2 Slough Habitats.....	52
4.2.1.2.3 Slough Habitats.....	53
4.2.2 Thalweg Profile.....	54
4.2.3 Backwater Area Studies.....	55
4.2.4 Open Channel Studies.....	56
4.2.5 Water Temperature Studies.....	57
4.2.5.1 Talkeetna to Devil Canyon.....	58
4.2.5.1.1 Mainstem Habitats.....	58
4.2.5.1.1.1 Instantaneous Surface Water Temperature....	58
4.2.5.1.1.2 Continuous Surface Water Temperature....	58
4.2.5.1.1.3 Intragravel Water Temperature....	59
4.2.5.1.2 Slough Habitats.....	59
4.2.5.1.2.1 Instantaneous Surface Water Temperature....	59
4.2.5.1.2.2 Continuous Surface Water Temperature....	59
4.2.5.1.2.3 Instantaneous Intragravel Water Temperature....	61

E stas ✓

TABLE OF CONTENTS (Continued)

PAGE

4.2.5.1.2.4	Continuous Intragravel Water Temperature....	61
4.2.5.1.3	Tributary Habitats.....	63
4.2.5.1.3.1	Instantaneous Surface Water Temperature....	63
4.2.5.1.3.2	Continuous Surface Water Temperature....	63
4.2.5.1.3.3	Intragravel Water Temperature....	64
4.2.5.2	Talkeetna to Cook Inlet.....	64
4.2.5.2.1	Mainstem Habitats.....	64
4.2.5.2.1.1	Instantaneous Surface Water Temperature....	64
4.2.5.2.1.2	Continuous Surface Water Temperature....	64
4.2.5.2.1.3	Intragravel Water Temperature....	65
4.2.5.2.2	Slough Habitats.....	65
4.2.5.2.2.1	Instantaneous Surface Water Temperature....	65
4.2.5.2.2.2	Continuous Surface Water Temperature....	66
4.2.5.2.3	Tributary Habitats.....	66
4.2.5.2.3.1	Instantaneous Surface Water Temperature....	66
4.2.5.2.3.2	Continuous Surface Water Temperature....	66

Estes

TABLE OF CONTENTS (Continued)

PAGE

4.2.6 Other Basic Field Parameter Studies.....	67
4.2.6.1 Talkeetna to Devil Canyon.....	68
4.2.6.1.1 Mainstem Habitats.....	68
4.2.6.1.2 Slough Habitats.....	68
4.2.6.1.2.1 Upland Slough Habitats.....	69
4.2.6.1.2.2 Side Slough Habitats.....	70
4.2.6.1.3 Tributary Habitats.....	71
4.2.6.2 Talkeetna to Cook Inlet.....	71
4.2.6.2.1 Mainstem Habitats.....	71
4.2.6.2.2 Slough Habitats.....	72
4.2.6.2.3 Tributary Habitats.....	72
4.2.7 Dissolved Gas Studies.....	73
4.3 Part 2 - Summary.....	75
4.3.1 Mainstem Salmon Spawning Studies.....	75
4.3.2 Slough Salmon Spawning Studies.....	77
4.3.2.1 Specific Slough Studies.....	78
4.3.2.2 General Slough Studies.....	82
4.3.3 Eulachon Studies.....	83
4.3.4 Bering Cisco Studies.....	84
4.3.5 Juvenile Anadromous Habitat Studies.....	86
4.3.6 Resident Fish Habitat Studies.....	89
5.0 VOLUME 5 SUMMARY - UPPER SUSITNA RIVER IMPOUNDMENT STUDIES.....	91
5.1 Introduction.....	91
5.2 Aquatic Habitat Studies.....	92

Estes ✓

TABLE OF CONTENTS (Continued)

PAGE

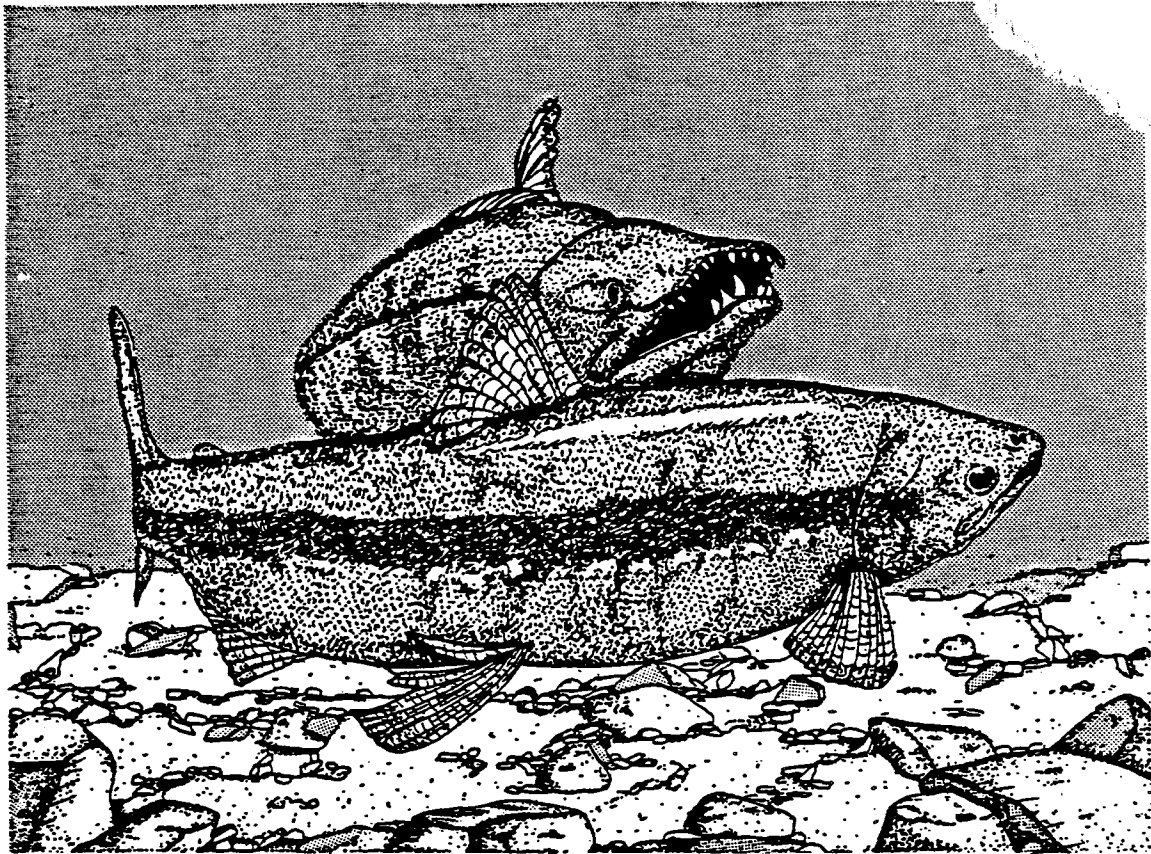
5.2.1	Introduction.....	92
5.2.2	Tributary Habitat Studies.....	93
5.2.3	Mainstem Habitat Studies.....	97
5.2.4	Lake Habitat Studies.....	98
5.3	Resident Fisheries Studies.....	99
5.3.1	Introduction.....	99
5.3.2	Tributary Studies.....	100
5.3.3	Mainstem Studies.....	101
5.3.4	Lake Studies.....	102
6.0	LITERATURE CITED.....	104
7.0	APPENDIX.....	107
7.1	Table of Contents.....	107
7.1.1	Volume 2.....	107
7.1.2	Volume 3.....	114
7.1.3	Volume 4.....	118
7.1.4	Volume 5.....	124

(6 of 6)

Ester

~~3 of 12~~

ESTES



(1028)

SUSITNA HYDRO AQUATIC STUDIES
PHASE II FINAL DATA REPORT

Volume 2, Adult Anadromous
Fish Studies, 1982.



15b.

APA Doc #588

TABLE OF CONTENTS

(2018) (#156)

PAGE

PREFACE.....	i
TABLE OF CONTENTS.....	viii
LIST OF FIGURES.....	xv
LIST OF TABLES.....	xxii
LIST OF PLATES.....	xxix
PRINCIPAL CONTRIBUTORS.....	xxxii
ACKNOWLEDGMENTS.....	xxxiii
LIST OF APPENDIX FIGURES.....	Part B
LIST OF APPENDIX TABLES.....	Part B
LIST OF APPENDIX REPORTS.....	Part B
1.0 OBJECTIVES.....	1
2.0 METHODS.....	2
2.1 Eulachon.....	2
2.1.1 Estuary.....	2
2.1.2 Main Channel.....	4
2.2. Adult Salmon.....	7
2.2.1 Main Channel.....	7
2.2.1.1 Sonar.....	9
2.2.1.2 Fishwheel.....	10
2.2.1.3 Tagging.....	12

ESTES

(3018)

(#15b)

	PAGE
2.2.1.4 Age, Length and Sex	14
2.2.1.5 Radio Telemetry.....	14
2.2.1.6 Lower Devil Canyon Gill Netting.....	16
2.2.1.7 Stock Separation.....	16
2.2.2 Spawning.....	17
2.2.2.1 Main Channel.....	17
2.2.2.2 Sloughs and Streams.....	18
2.2.2.2.1 Chinook Salmon Index Surveys.....	20
2.3 Bering Cisco.....	20
2.3.1 Main Channel Escapement.....	20
2.3.2 Main Channel Spawning.....	21
2.4 Data Analysis and Evaluation.....	21
2.4.1 Eulachon Length Data.....	21
2.4.2 Salmon Tag and Recapture Escapement Estimates.....	22
2.4.3 Presentation of Salmon Escapement Estimates.....	24
2.4.4 Calculation of Main Channel Escapement Timing.....	28
2.4.5 Age Determination.....	28
3.0 RESULTS AND DISCUSSION.....	29
3.1 Eulachon.....	29
3.1.1 Estuary.....	29
3.1.2 Main Channel.....	34
3.2 Adult Salmon	51
3.2.1 Chinook Salmon.....	51
3.2.1.1 Estuary to Talkeetna.....	51

Estes ✓

(4068)

(# 15b)

	PAGE
3.2.1.1.1 Main Channel Escapement.....	51
3.2.1.1.2 Main Channel Spawning.....	57
3.2.1.2 Talkeetna to Upper Devil Canyon.....	57
3.2.1.2.1 Main Channel Escapement.....	57
3.2.1.2.2 Radio Telemetry.....	66
3.2.1.2.3 Lower Devil Canyon Milling.....	71
3.2.1.2.4 Spawning.....	74
3.2.1.2.4.1 Main Channel.....	74
3.2.1.2.4.2 Sloughs and Streams.....	74
3.2.1.3 Escapement Index Surveys.....	79
3.2.2 Sockeye Salmon.....	84
3.2.2.1 Estuary to Talkeetna.....	84
3.2.2.1.1 Main Channel Escapement	84
3.2.2.1.1.1 First Run.....	84
3.2.2.1.1.2 Second Run.....	86
3.2.2.1.2 Spawning.....	96
3.2.2.1.2.1 Main Channel.....	96
3.2.2.1.2.2 Sloughs and Streams.....	96
3.2.2.1.2.2.1 First Run.....	96
3.2.2.1.2.2.2 Second Run.....	98
3.2.2.2 Talkeetna To Upper Devil Canyon	100
3.2.2.2.1 Main Channel Escapement.....	100
3.2.2.2.1.1 First Run.....	100
3.2.2.2.1.2 Second Run	100
3.2.2.2.2 Lower Devil Canyon Milling.....	105
3.2.2.2.3 Spawning.....	106
3.2.2.2.3.1 Main Channel.....	106
3.2.2.2.3.2 Sloughs and Streams.....	106
3.2.2.2.4 Stock Separation.....	108
3.2.3 Pink Salmon.....	108
3.2.3.1 Estuary to Talkeetna.....	108
3.2.3.1.1 Main Channel Escapement.....	108

(568)

(#15b)

	PAGE
3.2.3.1.2 Main Channel Spawning.....	113
3.2.3.2 Talkeetna To Upper Devil Canyon.....	113
3.2.3.2.1 Main Channel Escapement.....	113
3.2.3.2.2 Lower Devil Canyon Milling.....	117
3.2.3.2.3 Spawning.....	119
3.2.3.2.3.1 Main Channel.....	119
3.2.3.2.3.2 Sloughs and Streams.....	119
3.2.4 Chum Salmon.....	121
3.2.4.1 Estuary to Talkeetna.....	121
3.2.4.1.1 Main Channel Escapement.....	121
3.2.4.1.2 Main Channel Spawning.....	130
3.2.4.2 Talkeetna To Upper Devil Canyon	130
3.2.4.2.1 Main Channel Escapement.....	130
3.2.4.2.2 Radio Telemetry.....	135
3.2.4.2.3 Lower Devil Canyon Milling.....	138
3.2.4.2.4 Spawning.....	140
3.2.4.2.4.1 Main Channel.....	140
3.2.4.2.4.2 Sloughs and Streams.....	141
3.2.5 Coho Salmon.....	144
3.2.5.1 Estuary to Talkeetna.....	144
3.2.5.1.1 Main Channel Escapement.....	144
3.2.5.1.2 Main Channel Spawning.....	152
3.2.5.2 Talkeetna to Upper Devil Canyon.....	152
3.2.5.2.1 Main Channel Escapement.....	152
3.2.5.2.2 Radio Telemetry.....	155
3.2.5.2.3 Lower Devil Canyon Milling.....	161
3.2.5.2.4 Spawning.....	164
3.2.5.2.4.1 Main Channel.....	164
3.2.5.2.4.2 Sloughs and Streams.....	164
3.3 Bering Cisco.....	166
3.3.1 Estuary to Talkeetna.....	166
3.3.1.1 Main Channel Escapement.....	166

(6068)

(# 156)

Estes ✓

	PAGE
3.3.1.2 Main Channel Spawning.....	169
3.3.2 Talkeetna to Upper Devil Canyon.....	171
3.3.2.1 Main Channel Escapement.....	171
3.3.2.2 Main Channel Spawning.....	172
4.0 SUMMARY.....	173
4.1 Eulachon.....	173
4.2 Adult Salmon	174
4.2.1 Chinook Salmon.....	175
4.2.1.1 Estuary to Talkeetna.....	175
4.2.1.1.1 Main Channel Escapement.....	175
4.2.1.1.2 Main Channel Spawning.....	178
4.2.1.2 Talkeetna to Upper Devil Canyon.....	178
4.2.1.2.1 Main Channel Escapement.....	178
4.2.1.2.2 Radio Telemetry.....	182
4.2.1.2.3 Lower Devil Canyon Milling.....	184
4.2.1.2.4 Spawning.....	185
4.2.1.2.4.1 Main Channel.....	185
4.2.1.2.4.2 Sloughs and Streams.....	185
4.2.1.3 Escapement Index Surveys.....	186
4.2.2 Sockeye Salmon.....	187
4.2.2.1 Estuary to Talkeetna.....	187
4.2.2.1.1 Main Channel Escapement	187
4.2.2.1.1.1 First Run.....	187
4.2.2.1.1.2 Second Run.....	188
4.2.2.1.2 Spawning.....	193
4.2.2.1.2.1 Main Channel.....	193
4.2.2.1.2.2 Sloughs and Streams.....	193
4.2.2.1.2.2.1 First Run.....	193
4.2.2.1.2.2.2 Second Run.....	193

(708) (#15b)

	PAGE
4.2.2.2 Talkeetna To Upper Devil Canyon	193
4.2.2.2.1 Main Channel Escapement.....	193
4.2.2.2.1.1 First Run.....	194
4.2.2.2.1.2 Second Run	194
4.2.2.2.2 Lower Devil Canyon Milling.....	197
4.2.2.2.3 Spawning.....	197
4.2.2.2.3.1 Main Channel.....	197
4.2.2.2.3.2 Sloughs and Streams.....	198
4.2.2.2.4 Stock Separation.....	200
4.2.3 Pink Salmon.....	200
4.2.3.1 Estuary to Talkeetna.....	200
4.2.3.1.1 Main Channel Escapement.....	200
4.2.3.1.2 Main Channel Spawning.....	204
4.2.3.2 Talkeetna To Upper Devil Canyon.....	204
4.2.3.2.1 Main Channel Escapement.....	204
4.2.3.2.2 Lower Devil Canyon Milling.....	206
4.2.3.2.3 Spawning.....	206
4.2.3.2.3.1 Main Channel.....	206
4.2.3.2.3.2 Sloughs and Streams.....	207
4.2.4 Chum Salmon.....	209
4.2.4.1 Estuary to Talkeetna.....	209
4.2.4.1.1 Main Channel Escapement.....	209
4.2.4.1.2 Main Channel Spawning.....	212
4.2.4.2 Talkeetna To Upper Devil Canyon	213
4.2.4.2.1 Main Channel Escapement.....	213
4.2.4.2.2 Radio Telemetry.....	215
4.2.4.2.3 Lower Devil Canyon Milling.....	217
4.2.4.2.4 Spawning.....	218
4.2.4.2.4.1 Main Channel.....	218
4.2.4.2.4.2 Sloughs and Streams.....	218
4.2.5 Coho Salmon.....	222

Estes

(#15b)

Estes ✓

	PAGE
4.2.5.1 Estuary to Talkeetna.....	222
4.2.5.1.1 Main Channel Escapement.....	222
4.2.5.1.2 Main Channel Spawning.....	227
4.2.5.2 Talkeetna to Upper Devil Canyon.....	227
4.2.5.2.1 Main Channel Escapement.....	227
4.2.5.2.2 Radio Telemetry.....	230
4.2.5.2.3 Lower Devil Canyon Milling.....	231
4.2.5.2.4 Spawning.....	231
4.2.5.2.4.1 Main Channel.....	231
4.2.5.2.4.2 Sloughs and Streams.....	232
4.3 Bering Cisco.....	233
4.3.1 Estuary to Talkeetna.....	233
4.3.1.1 Main Channel Escapement.....	233
4.3.1.2 Main Channel Spawning.....	236
4.3.2 Talkeetna to Upper Devil Canyon.....	237
4.3.2.1 Main Channel Escapement.....	237
4.3.2.2 Main Channel Spawning.....	237
REFERENCES.....	238

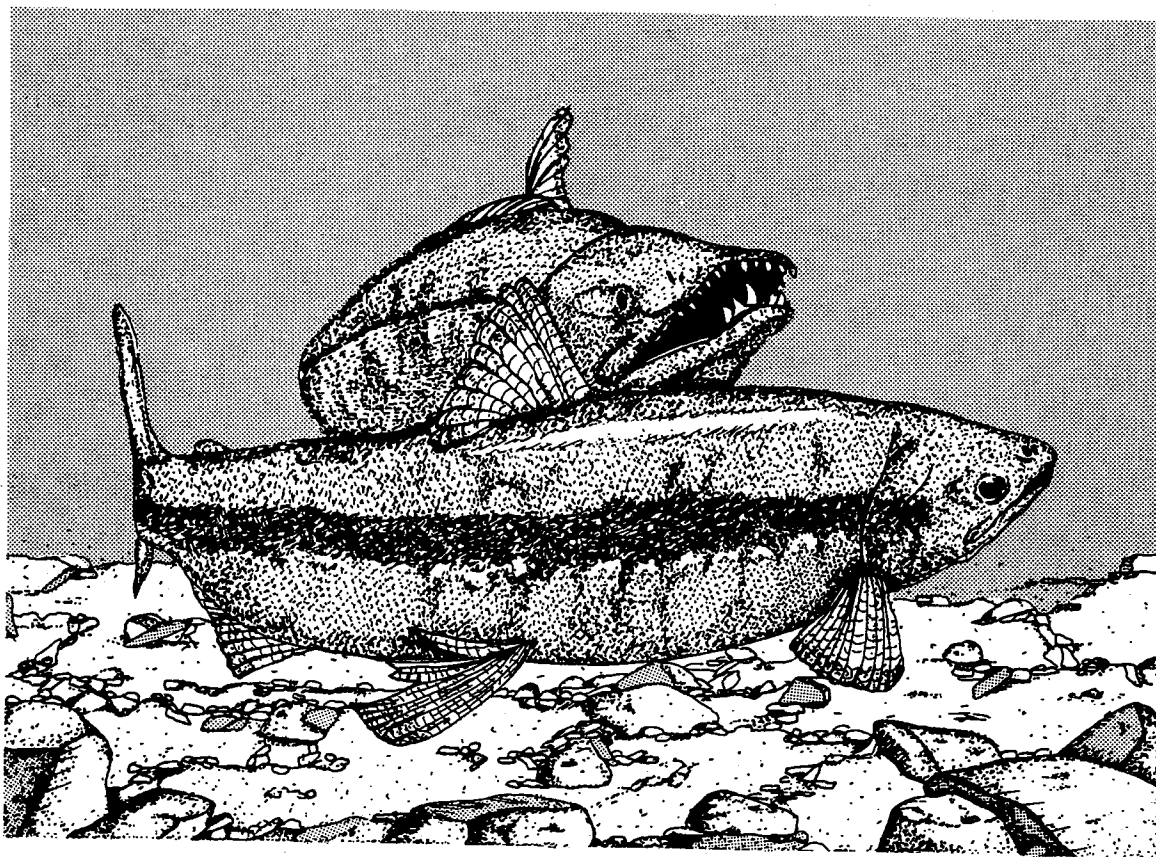
(8-18)

(#15b)

(#15b)

4 of 12

ES 425



SUSITNA HYDRO AQUATIC STUDIES
PHASE II FINAL REPORT

Volume 2. Adult Anadromous
Fish Studies, 1982.

PART B: APPENDICES A-H



(10/11)

#

15c.

APA DDC #589

Estes ✓

(# 15C)

APPENDIX 2-A
SUSITNA AND YENTNA RIVERS
SAMPLING STATIONS

(20811)

Estes ✓

Estes✓

(#150)

APPENDIX 2-B

SONAR

1. FIGURES OF DAILY SIDE SCAN SONAR COUNTS BY SPECIES
2. FIGURE OF CUMULATIVE PERCENT OF SONAR COUNTS BY SPECIES
3. DAILY SONAR COUNTS BY STATION
4. SECTOR DISTRIBUTION OF SONAR COUNTS
5. BOTTOM PROFILES OF 1982 SONAR SITES

(30711)

Estes ✓

(#150)

APPENDIX 2-C
DAILY FISHWHEEL CATCH DATA

(4 of 11)

Estes

(150)

APPENDIX 2-D
LENGTH FREQUENCIES OF
CHINOOK, SOCKEYE, PINK, CHUM AND COHO SALMON
AND
BERING CISCO

(50611)

Estes ✓

(#15C)

APPENDIX 2-E
RADIO TELEMTRY TRACKING REPORTS
FOR CHINOOK, CHUM AND COHO SALMON

(6 of 11)

Estes ✓

(#150)

APPENDIX 2-F
MAINSTEM SPAWNING SURVEYS

1. ELECTROSHOCKING SUMMARY
2. VISUAL AND GILL NET SUMMARY
3. EVALUATION OF TAG LOSS

(7 0 11)

Estes ✓

APPENDIX 2-G

1. SLOUGH AND STREAM LOCATIONS FROM RM 98.6 TO 161.2
2. LOCATION OF CHEECHAKO AND CHINOOK CREEKS
3. MAP OF SLOUGH B
4. MAINSTEM SUSITNA RIVER SPAWNING SITE MAPS
5. ESCAPEMENT SURVEYS OF SLOUGHS AND STREAMS
6. TAGGED/UNTAGGED RATIOS FROM SPAWNING GROUND SURVEYS

(#15C)

(86611)

(#15c)

COMPARISON OF SCALE PATTERNS FROM
SCKEYE SALMON SAMPLED FROM DIFFERENT
STOCKS IN THE SUSITNA RIVER IN 1982

Estes ✓

This report also
produced
- individually
- as part of
doc. 15c

Notes

By
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Glen Oliver
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and
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Alaska Department of Fish and Game
Division of Commercial Fisheries
Statewide Stock Biology Group

January, 1983

(90614)

(#15c)

Estes ✓

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
LIST OF FIGURES	i
LIST OF TABLES	ii
ABSTRACT	v
INTRODUCTION	1
METHODS	2
Sample Collection	2
Age Composition	2
Comparison of Scale Patterns	4
Scale Measurements	4
Classification Matrices	7
RESULTS	8
Age Composition	8
Comparison of Scale Patterns	8
Variable Selection	8
Classification Accuracy	12
DISCUSSION	18
ACKNOWLEDGEMENTS	23
LITERATURE CITED	24

~~WASAN~~

(150)

(10 of 11)

Estes ✓

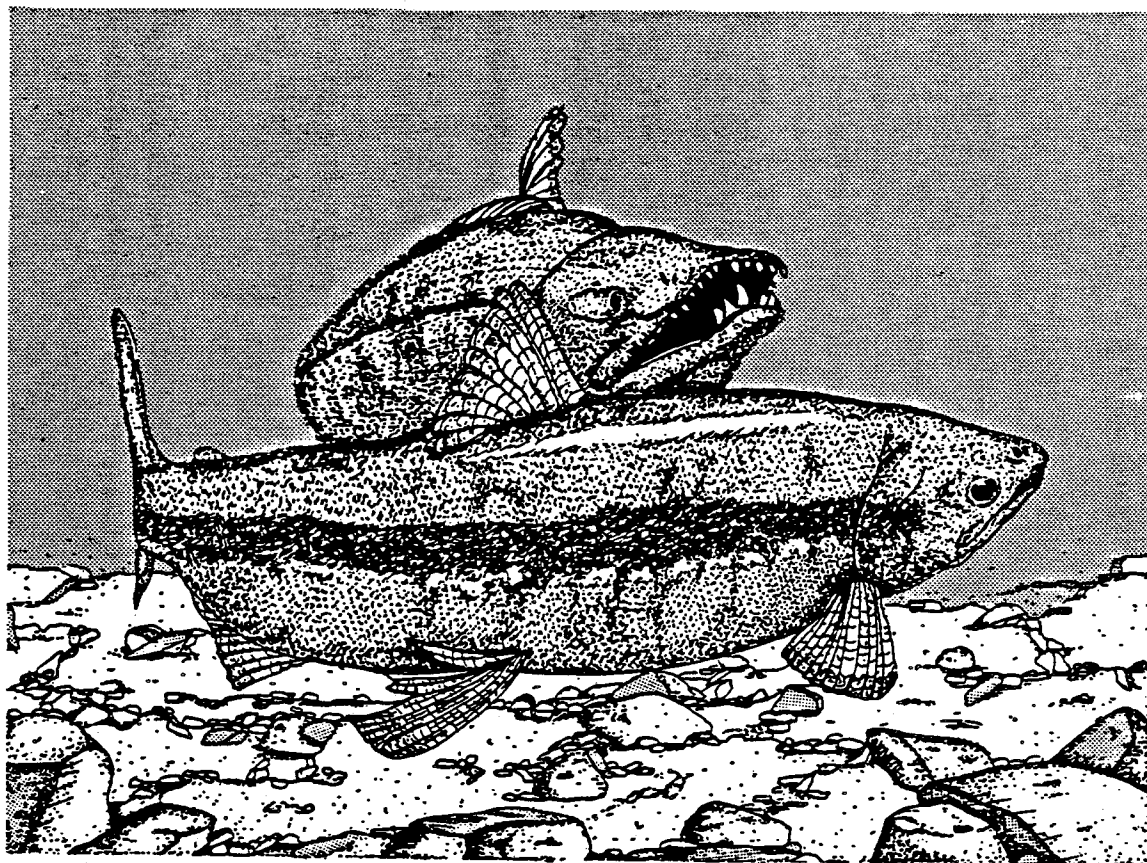
ABSTRACT

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.

(#15C)
(11 of 11)

5 of 12

ESTES



(196)

SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 3. Resident and
Juvenile Anadromous Fish Studies
on the Susitna River
Below Devil Canyon, 1982



15d.

APA Doc #486

Estes ✓

(#15d)

TABLE OF CONTENTS

	Page
PREFACE.....	i
LIST OF FIGURES.....	xv
LIST OF TABLES.....	xx
LIST OF PLATES.....	xxiv
1. OBJECTIVES.....	1
1.1 Distribution and Abundance Studies.....	1
1.2 Emergence and Outmigration Studies.....	3
1.3 Food Habits of Juvenile Salmon	5
2. METHODS.....	7
2.1 Distribution and Abundance Studies.....	7
2.1.1 Boat Electrofishing Studies.....	7
2.1.2 Radiotelemetry Studies.....	11
2.1.3 Designated Fish Habitat Studies.....	16
2.1.3.1 Sampling Sites and Reaches.....	17
2.1.3.2 Hydraulic Zones.....	20
2.1.3.3 Biological Sampling.....	23
2.1.3.4 Winter Season Methods.....	29
2.1.4 Other Methods.....	31
2.2 Emergence and Outmigration Studies.....	31
2.3 Food Habits of Juvenile Salmon.....	37
2.3.1 Field Sampling.....	37
2.3.2 Laboratory Methods.....	43
2.3.3 Analytical Methods.....	46
3. RESULTS.....	47
3.1 Distribution and Abundance Studies.....	47
3.1.1 Resident Fish Species.....	47
3.1.1.1 Rainbow Trout.....	48
Distribution and Relative Abundance..	48
Movement and Migration.....	50
Spawning.....	54

(2086)

Estes ✓

		<u>Page</u>
3.1.1.2	Arctic Grayling.....	55
	Distribution and Relative Abundance..	55
	Movement and Migration.....	58
	Spawning.....	59
3.1.1.3	Burbot.....	59
	Distribution and Relative Abundance..	59
	Movement and Migration.....	61
	Spawning.....	64
3.1.1.4	Round Whitefish.....	65
	Distribution and Relative Abundance..	65
	Movement and Migration.....	68
	Spawning.....	69
3.1.1.5	Humpback Whitefish.....	69
	Distribution and Relative Abundance..	70
	Movement and Migration.....	72
	Spawning.....	72
3.1.1.6	Longnose Sucker.....	73
	Distribution and Relative Abundance..	73
	Movement and Migration.....	75
	Spawning.....	76
3.1.1.7	Dolly Varden.....	77
	Distribution and Relative Abundance..	77
	Movement and Migration.....	80
	Spawning.....	80
3.1.1.8	Threespine Stickleback.....	80
	Distribution and Relative Abundance..	80
	Movement and Migration.....	83
	Spawning.....	83
3.1.1.9	Slimy Sculpin.....	83
	Distribution and Relative Abundance..	83
	Movement and Migration.....	86
	Spawning.....	86
3.1.1.10	Arctic Lamprey.....	87
	Distribution and Relative Abundance..	87
	Movement and Migration.....	87
	Spawning.....	89
3.1.2	Juvenile Anadromous Fish Species.....	89
3.1.2.1	Chinook Salmon.....	89
3.1.2.2	Coho Salmon.....	100
3.1.2.3	Chum Salmon.....	111
3.1.2.4	Sockeye Salmon.....	118
3.1.2.5	Pink Salmon.....	125

Estes ✓

(#15d)
(396)

(#152)

Estes ✓

	Page
3.2 Emergence and Outmigration Studies.....	126
3.2.1 Chinook Salmon.....	127
3.2.2 Coho Salmon.....	137
3.2.3 Chum Salmon.....	147
3.2.4 Sockeye Salmon.....	153
3.2.5 Pink Salmon.....	159
3.3 Food Habits of Juvenile Salmon.....	161
3.3.1 Salmonid Collections.....	161
3.3.2 Important Food Types.....	161
3.3.3 Comparisons Between Species.....	164
3.3.4 Electivity Indices.....	177
3.3.5 Drift Samples Compared to Kick Screen Samples..	177
3.3.6 Comparison of Invertebrate Populations at Different Sites.....	178
4. DISCUSSION AND CONCLUSIONS.....	192
4.1 Distribution and Abundance.....	192
4.1.1 Resident Fish Species.....	192
4.1.1.1 Rainbow Trout.....	192
Distribution and Relative Abundance..	192
Adult Movement and Migration Patterns.....	193
Spawning.....	196
Juvenile Rearing Areas.....	196
4.1.1.2 Arctic Grayling.....	196
Distribution and Relative Abundance..	197
Adult Movement and Migration Patterns.....	200
Spawning.....	203
Juvenile Rearing Areas.....	203
4.1.1.3 Burbot.....	204
Distribution and Relative Abundance..	205
Adult Movement and Migration Patterns.....	205
Spawning.....	207
Juvenile Rearing Areas.....	208
4.1.1.4 Round Whitefish.....	209
Distribution and Relative Abundance..	209
Adult Movement and Migration Patterns.....	213
Spawning.....	214
Juvenile Rearing Areas.....	215

(4 of 6)

Estes ✓

(#152)

(596)

		<u>Page</u>
4.1.1.5	Humpback Whitefish.....	216
	Distribution and Relative Abundance..	216
	Adult Movement and Migration	
	Patterns.....	219
	Spawning.....	220
	Juvenile Rearing Areas.....	221
4.1.1.6	Longnose Sucker.....	222
	Distribution and Relative Abundance..	222
	Adult Movement and Migration	
	Patterns.....	225
	Spawning.....	225
	Juvenile Rearing Areas.....	226
4.1.1.7	Dolly Varden.....	227
	Distribution and Relative Abundance..	228
	Adult Movement and Migration	
	Patterns.....	230
	Spawning.....	231
	Juvenile Rearing Areas.....	232
4.1.1.8	Threespine Stickleback.....	232
	Distribution and Relative Abundance..	232
	Adult Movement and Migration	
	Patterns.....	234
	Spawning.....	234
	Juvenile Rearing Areas.....	235
4.1.1.9	Slimy Sculpin.....	235
	Distribution and Relative Abundance..	236
	Adult Movement and Migration	
	Patterns.....	236
	Spawning.....	236
	Juvenile Rearing Areas.....	237
4.1.1.10	Arctic Lamprey.....	237
4.1.2	Juvenile Anadromous Fish Species.....	238
4.1.2.1	Chinook Salmon.....	238
4.1.2.2	Coho Salmon.....	241
4.1.2.3	Chum Salmon.....	246
4.1.2.4	Sockeye Salmon.....	248
4.2	Emergence and Outmigration.....	253
4.2.1	Chinook Salmon.....	253
4.2.2	Coho Salmon.....	256
4.2.3	Chum Salmon.....	259
4.2.4	Sockeye Salmon.....	260
4.2.5	Pink Salmon.....	262

ESTES ✓

Estes ✓

(#15d)

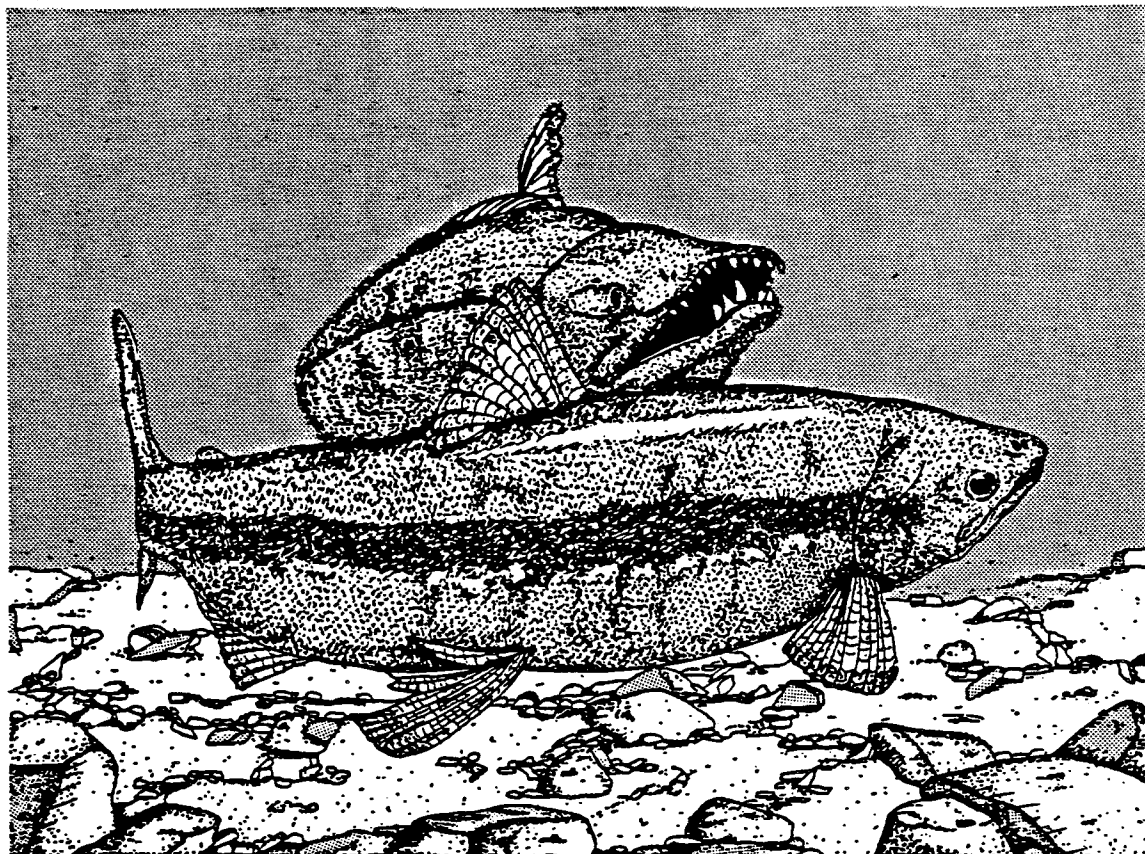
	<u>Page</u>
4.3 Food Habits and Distribution of Food Organisms.....	263
5. CONTRIBUTORS.....	272
6. ACKNOWLEDGEMENTS.....	274
7. LITERATURE CITED.....	275
8. APPENDICES.....	<u>a/</u>

(6 of 6)

a/ Appendices are included under separate binder.

6 of 12

Estes



(1 of 2)

SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 3. Resident and
Juvenile Anadromous Fish Studies
on the Susitna River
Below Devil Canyon, 1982

APPENDICES



15e.

APA DDC #487

8. APPENDICES VOLUME 3

(2862)

TABLE OF CONTENTS

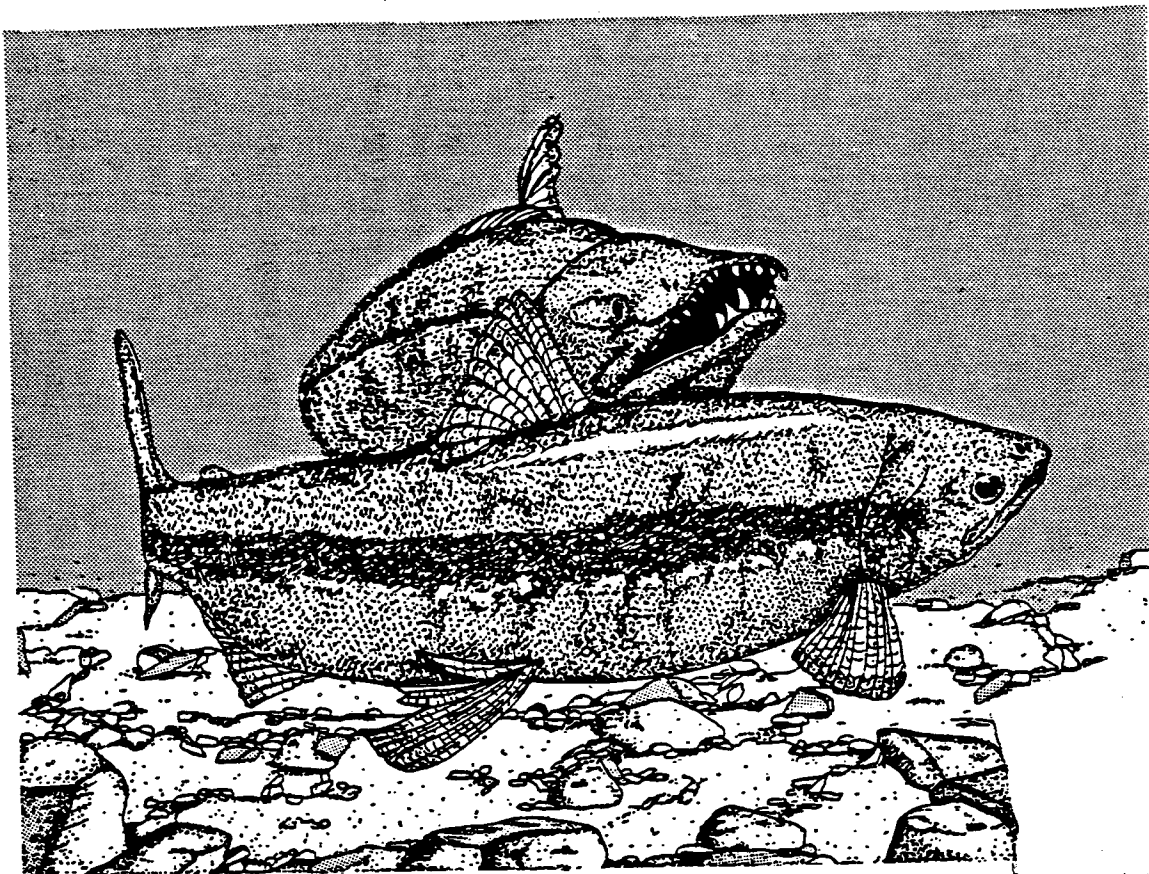
	<u>Page</u>
List of Appendix Figures.....	ii
List of Appendix Tables.....	v
List of Appendix Reports.....	xviii
Appendix A Distribution and Abundance Data.....	A-1
Appendix B Emergence and Outmigration Data.....	B-1
Appendix C Food Habits of Juvenile Salmon Data.....	C-1
Appendix D Upper Indian River and Upper Portage Creek Studies.....	D-1
Appendix E The Effect of Fishing Time on Minnow Trap Catch.....	E-1
Appendix F Downstream Migrant Trap Design, Construction, and Placement.....	F-1
Appendix G Length, Age, and Sex Summaries for Resident Fish.....	G-1
Appendix H Age Class Separation of Juvenile Salmon at DFH Sites.....	H-1

(15e)

Estes ✓

7 of 12

Estes ✓



(1068)

SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 4: Aquatic Habitat and
Instream Flow Studies, 1982.

Parts I and II



15¢

APA Doc #585

TABLE OF CONTENTS

(#15F) (2018)

	<u>Page</u>
PREFACE.....	I
FOREWORD.....	X
LIST OF FIGURES.....	XVIII
LIST OF TABLES.....	XXV
LIST OF PLATES.....	XXVIII
LIST OF APPENDIX FIGURES, TABLES, AND PLATES.....	XXX
CONTRIBUTORS.....	LXXI
ACKNOWLEDGEMENTS.....	LXXIV
MAP LEGEND.....	LXXV

PART 1

1. OBJECTIVES.....	1
2. METHODS.....	5
2.1 Hydrological Investigations.....	5
2.1.1 Stage and Discharge.....	5
2.1.1.1 Stage.....	5
2.1.1.1.1 Mainstem Staff Gage Locations	6
2.1.1.1.2 Non-mainstem Staff Gage Locations.....	10
2.1.1.2 Discharge.....	12
2.1.2 Thalweg Profiles.....	15
2.1.3 Other Hydrological Components	16
2.1.3.1 Backwater Areas.....	16
2.1.3.2 Open Channel.....	19
2.2 Water Quality Investigations.....	20

Estes ✓

(#15 F) (3 of 8)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.2.1 Temperatures.....	20
2.2.1.1 Surface Water Temperature.....	20
2.2.1.1.1 Instantaneous Surface Water Temperature.....	20
2.2.1.1.2 Continuous Surface Water Temperature.....	21
2.2.1.2 Intragravel Water Temperature.....	24
2.2.1.2.1 Instantaneous Intragravel Water Temperature.....	25
2.2.1.2.2 Continuous Intragravel Water Temperature.....	26
2.2.2 Other Basic Field Parameters.....	28
2.2.3 Total Dissolved Gases.....	30
3. RESULTS.....	34
3.1 Hydrological Investigations.....	34
3.1.1 Stage and Discharge.....	34
3.1.1.1 Mainstem Sites Between Talkeetna and Devil Canyon.....	34
3.1.1.2 Sloughs in the Talkeetna to Devil Canyon of the Susitna River.....	36
3.1.1.2.1 Upland Sloughs.....	37
3.1.1.2.2 Side Sloughs.....	43
3.1.1.3 Tributaries Between Talkeetna and Devil Canyon.....	66
3.1.1.4 Mainstem, Sloughs and Tributaries Downstream of Talkeetna.....	79
3.1.1.4.1 Mainstem Sites.....	85
3.1.1.4.2 Tributaries.....	89
3.1.1.4.3 Sloughs.....	100
3.1.1.5 Upstream of Devil Canyon.....	106
3.1.2 Thalweg Profiles.....	106
3.1.3 Other Hydrological Components.....	113

(408) (#)SF

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.1.3.1 Backwater Areas.....	113
3.1.3.2 Open Channels.....	141
3.2 Water Quality Investigations.....	141
3.2.1 Temperature.....	141
3.2.1.1 Mainstem Between Talkeetna and Devil Canyon.....	143
3.2.1.1.1 Surface Water Temperature....	143
3.2.1.1.2 Intragravel Water Temperature	144
3.2.1.2 Sloughs Between Talkeetna and Devil Canyon.....	144
3.2.1.2.1 Surface Water Temperature....	144
3.2.1.2.2 Intragravel Water Temperature	146
3.2.1.3 Tributaries Between Talkeetna and Devil Canyon.....	148
3.2.1.3.1 Surface Water Temperature....	148
3.2.1.3.2 Intragravel Water Temperature	149
3.2.1.4 Mainstem, Sloughs and Tributaries Downstream of Talkeetna.....	150
3.2.1.4.1 Surface Water Temperature....	150
3.2.1.4.2 Intragravel Water Temperature	153
3.2.1.5 Locations Upstream of Devil Canyon.....	153
3.2.1.5.1 Surface Water Temperature....	153
3.2.1.5.2 Intragravel Water Temperature	154
3.2.2 Other Basic Field Parameters.....	154
3.2.2.1 Mainstem and Side Channels Between Talkeetna and Devil Canyon.....	155
3.2.2.2 Sloughs Between Talkeetna and Devil Canyon.....	155
3.2.2.2.1 Upland Sloughs.....	156
3.2.2.2.2 Side Sloughs.....	157
3.2.2.3 Tributaries Between Talkeetna and Devil Canyon.....	161
3.2.2.4 Mainstem and Side Channels Downstream of Talkeetna.....	164

(#15F)

<u>TABLE OF CONTENTS (Continued)</u>	<u>Page</u>
3.2.2.5 Sloughs Downstream of Talkeetna.....	165
3.2.2.6 Tributaries Downstream of Talkeetna.....	167
3.2.2.7 Locations Upstream of Devil Canyon.....	169
3.2.3 Total Dissolved Gases.....	170
4. DISCUSSION.....	175
4.1 Hydrological Investigations.....	175
4.1.1 Stage and Discharge.....	175
4.1.2 Thalweg Profiles.....	180
4.1.3 Other Hydrological Components.....	180
4.1.3.1 Backwater Areas.....	180
4.1.3.2 Open Channels.....	186
4.2 Water Quality Investigations.....	186
4.2.1 Temperature.....	186
4.2.2 Other Basic Field Parameters.....	189
4.2.3 Total Dissolved Gases.....	197

(5 of 8)

ESTES ✓

TABLE OF CONTENTS (Continued)

Page

PART II

1. OBJECTIVES.....	203
1.1 Adult Anadromous Fish Habitat Investigations.....	203
1.1.1 Salmon Habitat.....	204
1.1.1.1 Mainstem.....	204
1.1.1.2 Slough.....	204
1.1.2 Eulachon Habitat.....	205
1.1.3 Bering Cisco Habitat.....	206
1.2 Juvenile Anadromous Fish Habitat Investigations.....	207
1.3 Resident Fish Habitat Investigation.....	208
2. METHODS.....	210
2.1 Adult Anadromous Fish Habitat Investigations.....	210
2.1.1 General Mainstem and Lower River Studies.....	210
2.1.1.1 Mainstem Salmon.....	210
2.1.1.2 Eulachon.....	213
2.1.1.3 Bering Cisco.....	216
2.1.2 General Slough and Tributary Studies.....	218
2.1.3 Specific Slough Studies.....	219
2.1.3.1 Modeling.....	220
2.1.3.2 Habitat Availability and Utilization.....	221
2.1.3.2.1 Availability.....	221
2.1.3.2.2 Utilization.....	222
2.1.3.2.3 Water Quality.....	222
2.2 Juvenile Anadromous Fish Habitat Investigations.....	223
2.3 Resident Fish Habitat Investigations.....	232
2.3.1 Mainstem.....	232
2.3.1.1 Radio Telemetry Studies.....	232
2.3.3.2 Miscellaneous Spawning Fish.....	233
2.3.2 Slough and Tributary.....	233
3. RESULTS.....	234
3.1 Adult Anadromous Fish Habitat Investigations.....	234

TABLE OF CONTENTS (Continued)

Page

3.1.1	Chum Salmon.....	234
3.1.1.1	Mainstem.....	234
3.1.1.2	Slough.....	236
3.1.1.2.1	Modeling.....	236
3.1.1.2.2	Habitat Summaries.....	242
3.1.1.2.3	Water Quality.....	248
3.1.1.2.4	Available and Utilized Habitats.....	259
3.1.1.2.5	General Slough.....	267
3.1.2	Sockeye Salmon.....	267
3.1.3	Pink Salmon.....	268
3.1.4	Coho Salmon.....	268
3.1.5	Chinook Salmon.....	268
3.1.6	Eulachon.....	269
3.1.7	Bering Cisco.....	277
3.2	Juvenile Anadromous Fish Habitat Investigations.....	285
3.3	Resident Fish Habitat Investigations.....	285
3.3.1	Rainbow Trout.....	285
3.3.2	Burbot.....	288
3.3.3	Other.....	288
4.	DISCUSSION.....	292
4.1	Adult Anadromous Fish Habitat Investigations.....	292
4.1.1	Salmon Species	292
4.1.1.1	Mainstem.....	292
4.1.1.2	Slough.....	294
4.1.1.2.1	Spawning Site Selection.....	294
4.1.1.2.2	Timing of Spawning.....	295
4.1.1.2.3	Access.....	301
4.1.1.2.4	Modeling.....	313
4.1.2	Eulachon.....	315
4.1.3	Bering Cisco.....	323
4.2	Juvenile Anadromous Fish Habitat Investigations.....	326
4.2.1	Chum Salmon.....	329
4.2.2	Sockeye Salmon.....	333
4.2.3	Coho Salmon.....	334
4.2.4	Chinook Salmon.....	337

TABLE OF CONTENTS (Continued)

Page

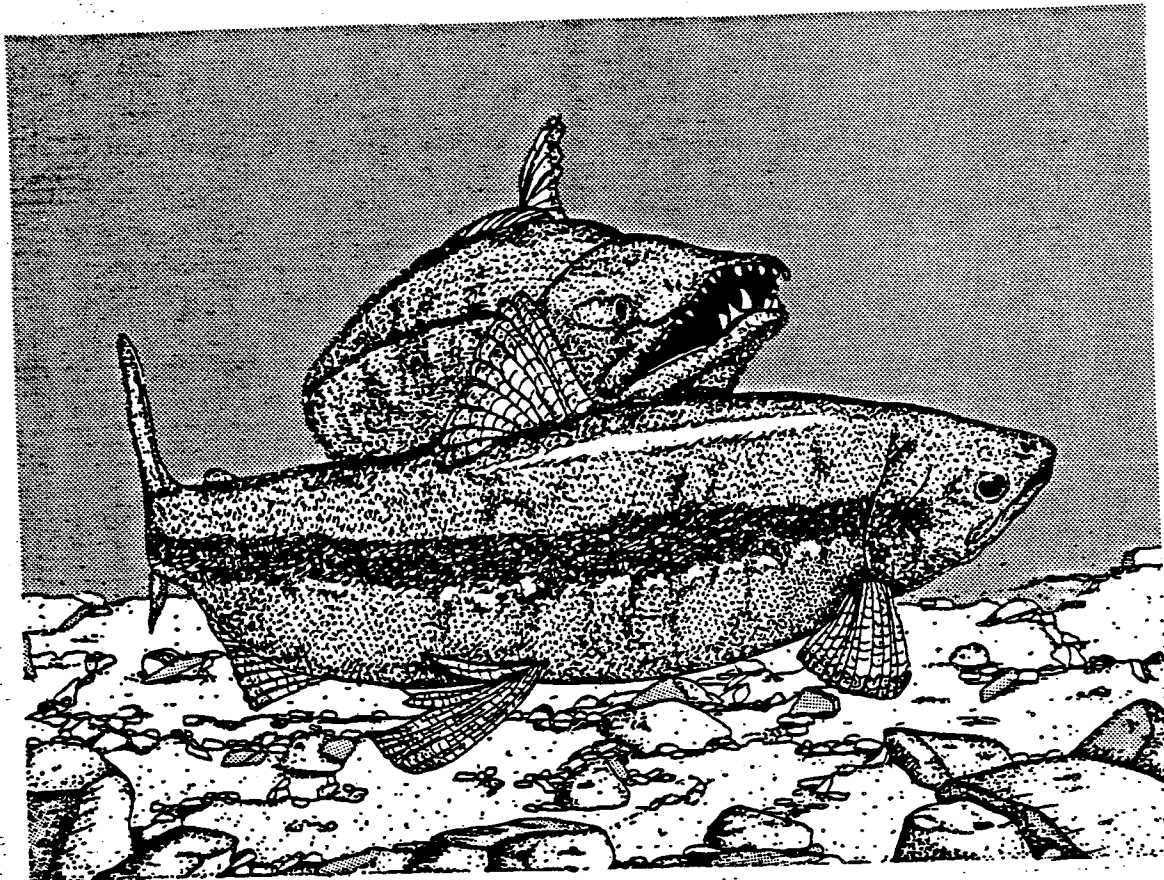
4.3	Resident Fish Habitat Investigations.....	339
4.3.1	Rainbow Trout.....	341
4.3.2	Arctic Grayling.....	345
4.3.3	Burbot.....	348
4.3.4	Round Whitefish.....	351
4.3.5	Humpback Whitefish.....	354
4.3.6	Longnose Sucker.....	356
4.3.7	Other Species.....	358
4.3.7.1	Dolly Varden.....	358
4.3.7.2	Threespine Stickleback.....	359
4.3.7.3	Slimy Sculpin.....	360
4.3.7.4	Arctic Lamprey.....	361
5.	LITERATURE CITED.....	362
6.	APPENDICES	
Appendix A	Stage/Discharge Data.....	4-A-1
Appendix B	Slough Availability and Utilization Data.....	4-B-1
Appendix C	Temperature Data.....	4-C-1
Appendix D	Water Quality Data.....	4-D-1
Appendix E	Survey Data.....	4-E-1
Appendix F	Habitat Location Description and Photos.....	4-F-1
Appendix G	Catch Data.....	4-G-1
Appendix H	CPUE Data.....	4-H-1
Appendix I	Habitat Data.....	4-I-1
Appendix J	Ice-Covered Season (1981-82) Habitat Data.....	4-J-1

ESTES

8 of 12

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SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 4: Aquatic Habitat and
Instream Flow Studies, 1982.

Appendices A - C



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APA Doc #586

(#156)

TABLE OF CONTENTS (Continued)

	Page
4.3 Resident Fish Habitat Investigations.....	339
4.3.1 Rainbow Trout.....	341
4.3.2 Arctic Grayling.....	345
4.3.3 Burbot.....	348
4.3.4 Round Whitefish.....	351
4.3.5 Humpback Whitefish.....	354
4.3.6 Longnose Sucker.....	356
4.3.7 Other Species.....	358
4.3.7.1 Bully Varden.....	358
4.3.7.2 Threespine Stickleback.....	359
4.3.7.3 Slimy Sculpin.....	360
4.3.7.4 Arctic Lamprey.....	361
5 LITERATURE CITED.....	362

6. APPENDICES

Appendix A	Stage/Discharge Data.....	4-A-1
Appendix B	Slough Availability and Utilization Data.....	4-B-1
Appendix C	Temperature Data.....	4-C-1
Appendix D	Water Quality Data.....	4-D-1
Appendix E	Survey Data.....	4-E-1
Appendix F	Habitat Location Description and Photos.....	4-F-1
Appendix G	Catch Data.....	4-G-1
Appendix H	CPUE Data.....	4-H-1
Appendix I	Habitat Data.....	4-I-1
Appendix J	Ice-Covered Season (1981-82) Habitat Data.....	4-J-1

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APPENDIX A

STAGE/DISCHARGE DATA

This appendix includes mainstem discharges versus mainstem and slough water surface elevations (pp. 4-A-2 to 4-A-32); cross sectional profiles of sloughs (pp. 4-A-33 to 4-A-51); mainstem, slough, and tributary discharge data (pp. 4-A-52 to 4-A-61), periodic water surface elevations for sloughs (pp. 4-A-62 to 4-A-79); continuous hourly streamflow and surface water temperature records for Indian River and Portage Creek (pp. 4-A-80 to 4-A-177); periodic water surface elevations and measured flow at sloughs and tributaries (pp. 4-A-178 to 4-A-183); and surface areas of aggregate type II hydraulic zones at DFH sites compared with mainstem discharges (pp. 4-A-184 to 4-A-187). These data were collected during the open water season in the study area located within the Cook Inlet to Talkeetna reach of the Susitna River.

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APPENDIX B

SLOUGH AVAILABILITY AND UTILIZATION DATA

This appendix includes depths, velocities, and substrate types for Chum Channel, Rabideux Slough and sloughs 8A, 9 and 21 that were available to (pp. 4-B-2 to 4-B-89) and utilized by (pp. 4-B-90 to 4-B-100) chum, pink and sockeye salmon for spawning at various slough discharges. It also contains a complete summary of instantaneous intragravel and surface water temperature data at redds in sloughs 8A, 9, 11 and 21 (pp. 4-B-92 to 4-B-100). Other temperature data for these sloughs, not included in this appendix, are presented in Appendices C and D. Appendix C includes a complete summary of continuous surface and intragravel water temperatures collected with thermographs and datapods in these and other locations. It also includes the instantaneous temperature data included in this Appendix. Instantaneous surface and intragravel water temperature data collected along transects in Sloughs 8A, 9, 9B, 11 and 21, and at specified locations in sloughs 8A, 9 and 21 are in Appendix D. Mainstem depth and velocity utilization data for eulachon, Bering cisco and chum salmon spawning sites are presented in Appendix F. All of the above data were collected during the open-water season in the study area located within the Cook Inlet to Devil Canyon reach of the Susitna River.

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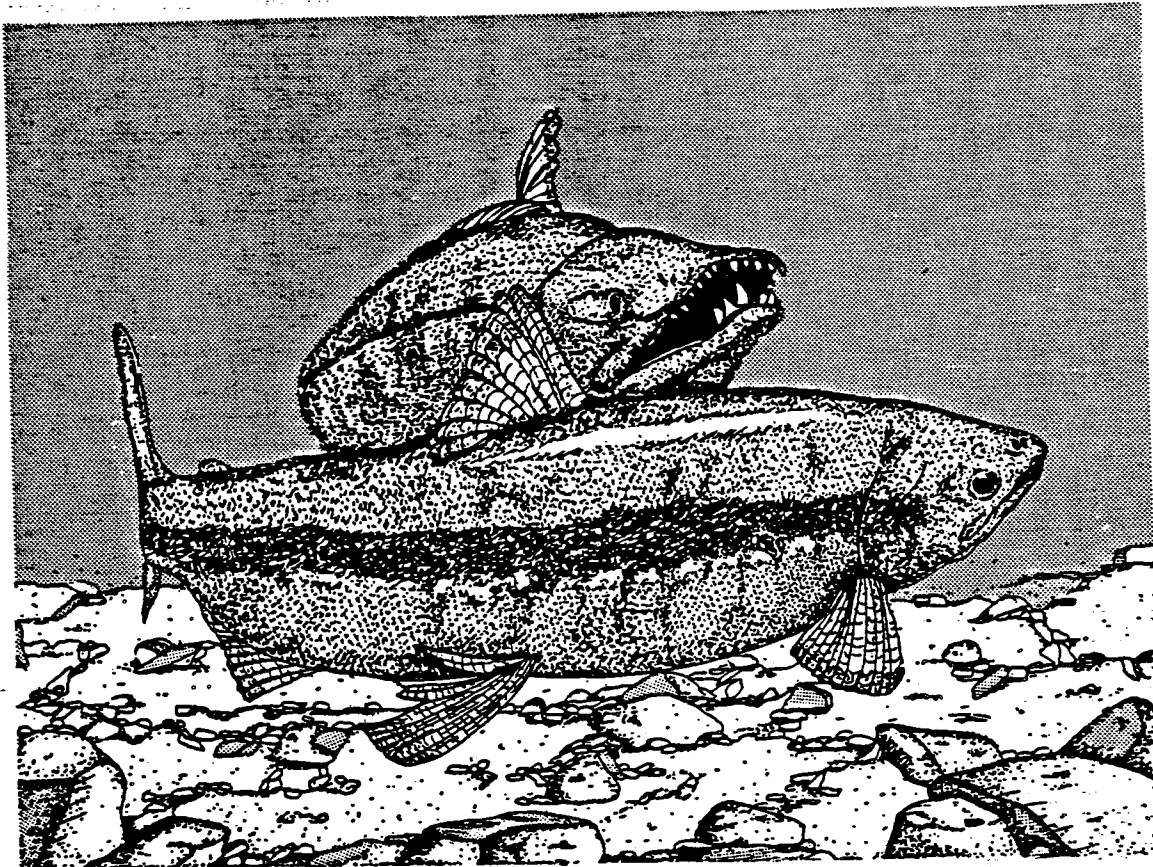
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APPENDIX C

TEMPERATURE DATA (5 of 5)

This appendix includes an index of continuous temperature data collected in the Susitna River basin, 1981-1982, (pp 4-C-2 to 4-C-6); a complete summary of continuous surface water temperatures collected during the open water season in mainstem, sloughs, and tributaries (pp. 4-C-7 to 4-C-94); weekly water temperatures calculated from the mainstem, slough and tributary data (4-C-95 to 4-C-118); continuous intragravel and surface water temperatures collected during the open water season in sloughs (pp. 4-C-119 to 4-C-221); summaries of continuous surface and intragravel water temperatures collected during the ice-covered season in sloughs (pp. 4-C-222 to 4-C-260); weekly water temperatures calculated from the surface and intragravel data (4-C-261 to 4-C-271); and instantaneous intragravel and surface water temperatures in sloughs collected during the open water season at salmon redds (pp. 4-C-272 to 4-C-276). These data were collected during the open water and ice-covered seasons in the study area located within the Cook Inlet to Oshetna reach of the Susitna River. Instantaneous surface water temperature data collected during the ice-covered season, not included in this summary, are located in Appendix J.

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2 of 9

SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 4: Aquatic Habitat and
Instream Flow Studies, 1982.

Appendices D - J



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APA Doc#587

ESTES ✓

TABLE OF CONTENTS (Continued)

	Page
4.3 Resident Fish Habitat Investigations.....	339
4.3.1 Rainbow Trout.....	341
4.3.2 Arctic Grayling.....	345
4.3.3 Burbot.....	348
4.3.4 Round Whitefish.....	351
4.3.5 Humpback Whitefish.....	354
4.3.6 Longnose Sucker.....	356
4.3.7 Other Species.....	358
4.3.7.1 Dolly Varden.....	358
4.3.7.2 Threespine Stickleback.....	359
4.3.7.3 Slimy Sculpin.....	360
4.3.7.4 Arctic Lamprey.....	361
5. LITERATURE CITED.....	362
6. APPENDICES	
Appendix A Stage/Discharge Data.....	4-A-1
Appendix B Slough Availability and Utilization Data.....	4-B-1
Appendix C Temperature Data.....	4-C-1
Appendix D Water Quality Data.....	4-D-1
Appendix E Survey Data.....	4-E-1
Appendix F Habitat Location Description and Photos.....	4-F-1
Appendix G Catch Data.....	4-G-1
Appendix H CPUE Data.....	4-H-1
Appendix I Habitat Data.....	4-I-1
Appendix J Ice-Covered Season (1981-82) Habitat Data.....	4-J-1

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APPENDIX D

WATER QUALITY DATA

This appendix is a complete summary of the dissolved gas data (pp. 4-D-2 to 4-D-43); mainstem and designated fish habitat site water quality data (pp. 4-D-44 to 4-D-68); mainstem and slough provisional water quality data (pp. 4-D-69 to 4-D-84); and instantaneous surface and intragravel water temperature and specific conductance data from sloughs 8A, 9, 9B, 11 and 21 (pp. 4-D-85 to 4-D-96). These data were collected during the open-water season in the study area located within the Cook Inlet to Oshetna River reach of the Susitna River. Ice-covered season water quality data are located in Appendix J. A partial listing of the water quality data collected at Designated Fish Habitat sites, included in this appendix, is presented in Appendix I.

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APPENDIX E
SURVEY DATA

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This appendix includes a complete summary of the headpin and cross sectional elevations obtained at study transects (reported in feet) from five sites during 1982: Chum Channel, Rabideaux Slough, and sloughs 8A, 9, and 21. Cross sections and water surface elevations for these and other locations are illustrated in Appendix A. Thalweg profile data are also presented for sloughs 8A, 9, 11, and 21. Thalweg profiles are illustrated in Volume 4, Part I. These data were collected during the open-water season in the study area located within the Cook Inlet to Devil Canyon reach of the Susitna River.

Tables are ordered by slough with individual tables including: head pin data for each slough, cross sectional data for each transect within each slough (number of transects differed between sloughs), and thalweg elevations. Transects in each slough were oriented perpendicular to the direction of water flow and had limits defined by two head pins located on left and right banks of the slough channel (looking upstream).

Definitions of Terms Used in This Appendix

Table headings for head pin and cross sectional tables are defined as follows:

- 1) Bench Mark is that point in the immediate vicinity of the study site (i.e., head pin, nail in tree base, or ground)

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APPENDIX F

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HABITAT LOCATION DESCRIPTION AND PHOTOS

This appendix includes descriptions, maps, and/or photos of all mainstem, side channel, slough, and tributary study areas. There are two parts: the first describes study areas investigated with regard to spawning adult anadromous fish (pp. 4-F-2 to 4-F-92) and the second describes study areas investigated with regard to juvenile anadromous and resident fish (4-F-93 to 4-F-214). Other descriptions, maps and photographs of these study areas are included in Volume 4, Parts I and II. These data were collected during the open-water season in the study area located within the Cook Inlet to Devil Canyon reach of the Susitna River.

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APPENDIX G

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CATCH DATA

All juvenile anadromous and resident fish catch data (i.e., minnow trap, trotline, beach seine, dip net, backpack electrofishing), except boat electrofishing data, for the 17 Designated Fish Habitat sites by 2-week periods from early June to the end of September 1982 are included in this appendix. Additionally, catch data are included for two sites (Slough 20 and Portage Creek mouth) sampled in early October. These data were collected in the study area located within the Cook Inlet to Devil Canyon reach of the Susitna River.

The catch data are presented by zone and by gear type. Zone codes are defined in Part II, Section 2.2 and gear codes and species codes are defined in the following table.

APPENDIX H

CATCH PER UNIT EFFORT DATA

All juvenile anadromous and resident fish catch per unit effort (CPUE) data (i.e., minnow trap, trotline, beach seine, dip net, backpack electrofishing), except boat electrofishing data, for the 17 Designated Fish Habitat sites by 2-week periods from early June to the end of September 1982 are included in this appendix. Additionally, CPUE data are included for two sites (Slough 20 and Portage Creek mouth) sampled in early October. These data were collected in the study area located within the Cook Inlet to Devil Canyon reach of the Susitna River.

The CPUE data are presented by zone and by gear type. Zone codes are defined in Part II, Section 2.2 and gear codes and species codes are defined in the following tables.

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APPENDIX I

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HABITAT DATA

Water quality and velocity data for the 17 Designated Fish Habitat sites which were collected twice a month on a regularly scheduled basis are included in this appendix. These data are repeated in Appendix D and supplemented with similar data collected on an irregular basis at these sites. The methods describing how these data were obtained and an explanation of the Zone Code are in Part II, Section 2.2 of this volume. These data were collected during the open-water season in the study area located within the Cook Inlet to Devil Canyon reach of the Susitna River.

The data obtained from mixing zones, where tributary, slough or mainstem water mix (zone 3, zone 5, and zone 7), can vary widely, depending on exactly where in the zone the sample was taken.

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APPENDIX J (9669)

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ICE-COVERED SEASON (1981-82) HABITAT DATA

This appendix includes physical and chemical data that were measured instantaneously during the ice-covered season to describe general habitat conditions. Continuous surface and intragravel water temperatures in sloughs are located in Appendix C. These data were collected in the study area located within the Cook Inlet to Oshetna River reach of the Susitna River.

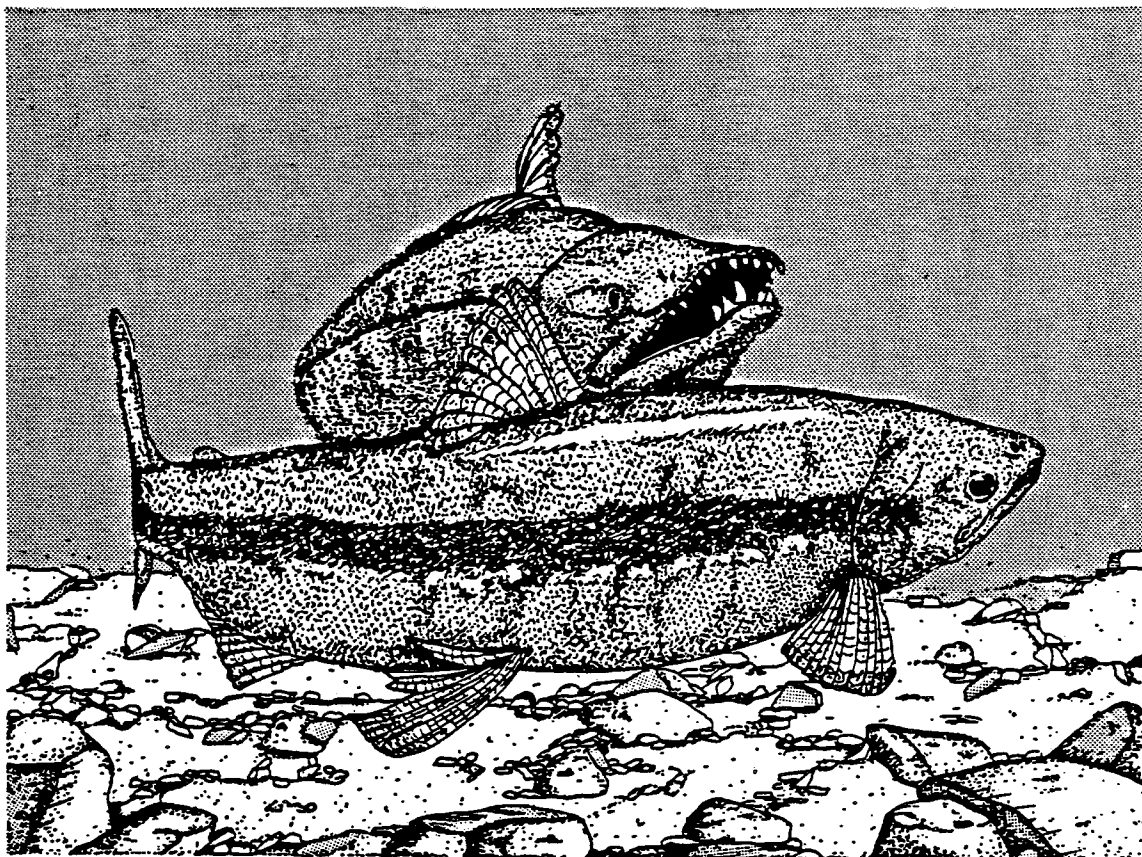
Data were collected at sites previously sampled during the 1981 open-water season and at selected sites in conjunction with radio telemetry studies. Open-water season habitat data are located in Appendices C, D and I.

Variables measured include air temperature, water temperature, pH, dissolved oxygen, specific conductance, turbidity, water depth, and ice thickness. Air temperature was measured with calibrated Brooklyn mercury thermometers. Water temperature, pH, dissolved oxygen, and specific conductance were measured with a Hydrolab Model 4041. Meters were calibrated before and after each field sampling period. Turbidity samples were collected in 250ml polyethylene bottles and stored in a cool, dark location until analyzed.

Analysis was done using a Hach laboratory Model 2100A turbidimeter. Water depth was measured from the bottom of the ice to the substrate. Ice thickness was measured from the top of the ice to the bottom. Surface and intragravel water temperature were monitored continuously at selected sites using Peabody-Ryan thermographs.

10 of 12

ESTES ✓



(1064)

SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 5: Upper Susitna River
Impoundment Studies 1982



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APA Doc #590

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(#151)(284)

TABLE OF CONTENTS

	<u>Page</u>
PREFACE	I
LIST OF FIGURES	XIII
LIST OF TABLES	XVII
LIST OF PLATES	XIX
LIST OF APPENDIX B FIGURES	XX
LIST OF APPENDIX C TABLES	XXI
LIST OF APPENDIX D FIGURES	XXIV
CONTRIBUTORS	XXV
ACKNOWLEDGEMENTS	XXVI
1. INTRODUCTION	1
1.1 General Objectives	1
1.2 Aquatic Habitat Investigations	4
1.3 Resident Fisheries Investigations	5
1.4 Background	6
2. METHODS	8
2.1 General Study Design	8
2.2 Aquatic Habitat Investigations	11
2.2.1 Topographical and General Physical Characteristics of Aquatic Habitats	11
2.2.2 Water Quality	12
2.2.3 Discharge	14
2.2.4 Lake Mapping and Morphometric Data	14
2.3 Resident Fisheries Investigations	16
3. RESULTS	20
3.1 Tributary Habitat and Fisheries Investigations	20
3.1.1 Aquatic Habitat Investigations	20
3.1.1.1 General Stream Descriptions	20
3.1.1.2 Water Quality	44
3.1.1.2.1 Instantaneous Water Quality	44
3.1.1.2.2 Continuous Surface Water Temperature	51

(284)

Estes ✓

(151)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.1.1.3 Discharge	52
3.1.2 Resident Fisheries Investigations	59
3.1.2.1 Arctic Grayling	59
3.1.2.2 Dolly Varden	89
3.2 Mainstem Habitat and Fisheries Investigations	90
3.2.1 Aquatic Habitat Investigations	90
3.2.1.1 General Characteristics of Mainstem Study Area	90
3.2.1.2 Water Quality	92
3.2.1.3 Discharge	94
3.2.1.4 Mainstem Slough Habitats	94
3.2.2 Resident Fisheries Investigations	96
3.2.2.1 Burbot	96
3.2.2.2 Longnose Sucker	100
3.2.2.3 Other Species	106
3.3 Lake Habitat and Fisheries Investigations	108
3.3.1 Aquatic Habitat Investigations	108
3.3.1.1 General Characteristics of Sally Lake ..	108
3.3.1.2 Water Quality	114
3.3.2 Resident Fisheries Investigations	115
3.3.2.1 Lake Trout	115
3.3.2.2 Arctic Grayling	115
4. DISCUSSION	116
4.1 Tributary Habitat and Fisheries Investigations	116
4.1.1 Water Quality	116
4.1.1.1 Instantaneous Water Quality	116
4.1.1.2 Continuous Surface Water Temperature	117
4.1.2 Discharge	118
4.1.3 Stream Gradient	120
4.1.4 Fish Passage Barriers	122
4.1.5 Salmon Spawning Habitat	126
4.1.6 Arctic Grayling Population Estimates	127

(3064)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
4.1.7 Arctic Grayling Spawning and Juveniles	141
4.1.8 Arctic Grayling Migration	142
4.2 Mainstem Habitat and Fisheries Investigations	143
4.2.1 Water Quality	143
4.2.2 Mainstem Slough Habitats	144
4.2.3 Resident Fish Species	145
4.3 Lake Habitat and Fisheries Investigations	146
4.3.1 Resident Fish Species	147
5. LITERATURE CITED	149
6. APPENDICES	5-A-1
Appendix A	5-A-1
Appendix B	5-B-1
Appendix C	5-C-1
Appendix D	5-D-1

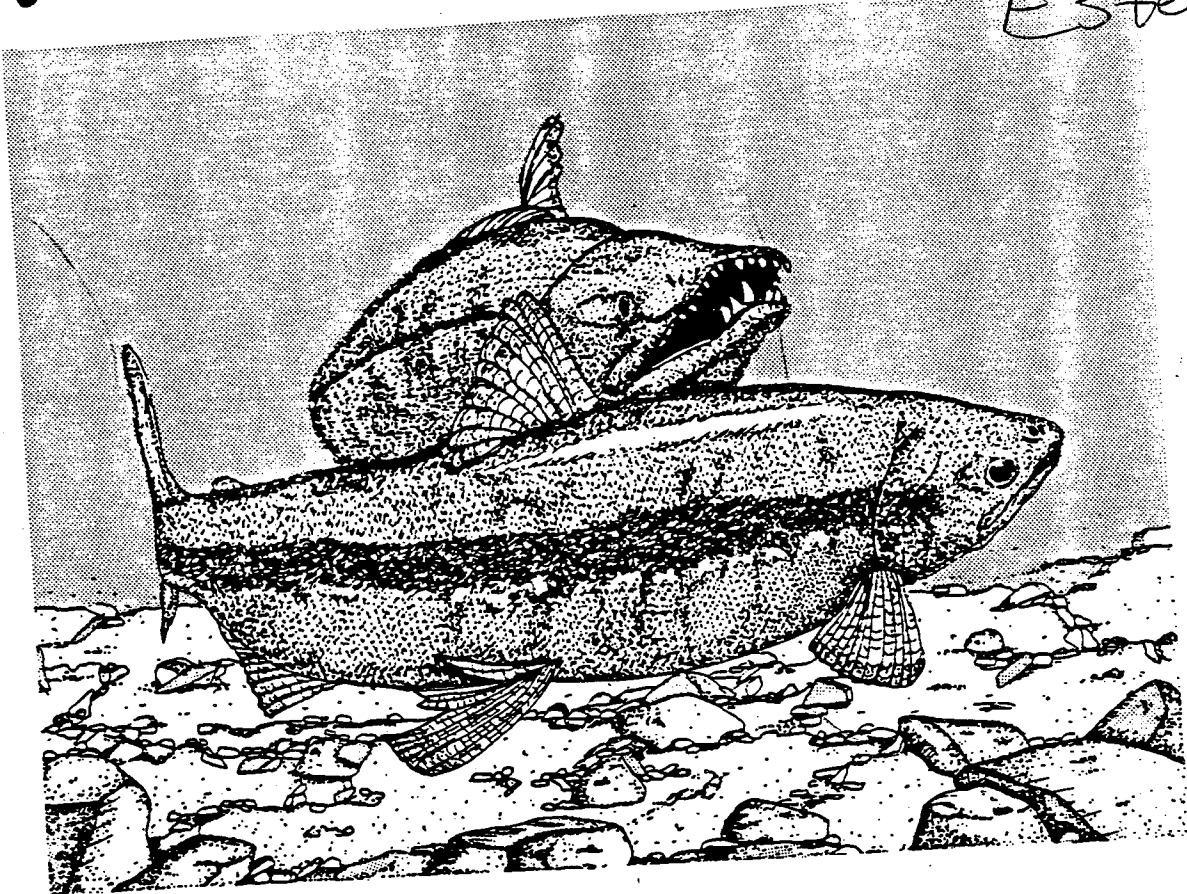
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12 of 12

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(1 of 11)

SUSITNA HYDRO AQUATIC STUDIES
PHASE II REPORT

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



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APA Doc #40

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TABLE OF CONTENTS

	<u>Page</u>
PREFACE.....	i
LIST OF FIGURES.....	xxii
LIST OF TABLES.....	xxiv
1. INTRODUCTION.....	1
1.1 Purpose of report.....	1
1.2 Study objectives.....	2
1.3 Utility of the report in impact analysis and mitigation planning.....	2
2. RESULTS AND DISCUSSION OF THE FISH AND HABITAT STUDIES ON THE SUSITNA RIVER BELOW DEVIL CANYON.....	4
2.1 Chinook salmon.....	4
2.1.1 Adult phase of life cycle.....	4
2.1.1.1 Adult harvest by sport, commercial, and subsistence fisheries.....	6
2.1.1.2 Adult escapement.....	8
2.1.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle (upstream migration, passage, spawning).....	10
2.1.1.3.1 Discharge, water quality, and temperature relation- ships with the adult salmon migration.....	10
2.1.1.3.2 Other factors that influence the spawning success of chinook salmon.....	14
2.1.2 Juvenile rearing and migration phases.....	15
2.1.2.1 Relative abundance of juvenile chinook salmon.....	15

(#162)
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CE ✓

TABLE OF CONTENTS (Continued)

Page

2.1.2.2	Habitat and environmental factors associated with the juvenile phase of the life cycle.....	20
2.1.2.2.1	Physical habitat conditions of rearing juveniles.....	21
-	Discharge (velocity and depth) relationships and their effects on indices of available habitat.....	21
-	Water quality and thermal relationship.....	23
2.1.2.2.2	Timing of outmigration from the tributaries, sloughs, and mainstem and its relationship to environmental changes.....	24
2.1.2.2.3	Food supply for rearing juveniles and its relationship to other parameters and preference dependency of species in the system.....	26
2.1.2.2.4	Other physical and biological constraints.....	27
2.2	Coho salmon.....	28
2.2.1	Adult phase of life cycle.....	28
2.2.1.1	Adult harvest by sport and commercial fisheries.....	28
2.2.1.2	Adult escapement.....	31
2.2.1.3	Habitat and environmental parameters associated with the adult phase of the life cycle.....	31

(#162)
(3 of 11)

CE ✓

TABLE OF CONTENTS (Continued)

Page

2.2.1.3.1	Discharge, water quality, and temperature relationships with the adult salmon migration.....	33
2.2.1.3.2	Other factors that influence the spawning success of coho salmon.....	35
2.2.2	Juvenile rearing and migration phases.....	35
2.2.2.1	Relative abundance of juvenile coho salmon.....	36
2.2.2.2	Habitat and environmental factors associated with the juvenile phase of the life cycle.....	38
2.2.2.2.1	Physical habitat conditions of rearing juveniles.....	39
-	Discharge (velocity and depth) relationships and their effects on indices of available habitat.....	39
-	Water quality and thermal relationships....	40
2.2.2.2.2	Timing of outmigration from the tributaries, sloughs, and mainstem and its relationship to environmental changes.....	41
2.2.2.2.3	Food supply for rearing juveniles and its relationship to other parameters and preference dependency of species in the system.....	42
2.2.2.2.4	Other physical and biological constraints.....	43
2.3	Sockeye salmon.....	44
2.3.1	Adult phase of life cycle.....	44

#16a)
(4 of 11)

CE✓

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.3.1.1 Adult harvest by sport and commercial fisheries.....	44
2.3.1.2 Adult escapement.....	47
2.3.1.3 Habitat and environmental parameters associated with the adult phase of the life cycle (upstream migration, passage and spawning).....	47
2.3.1.3.1 Discharge, water quality, and temperature relationships with adult sockeye salmon migration.....	49
2.3.1.3.2 Substrate type associated with spawning.....	50
2.3.1.3.3 Other physical and biological constraints on spawning success.....	51
2.3.2 Incubation and emergence phase of life cycle....	52
2.3.3 Juvenile rearing and migration phases.....	53
2.3.3.1 Relative abundance of juvenile sockeye salmon.....	53
2.3.3.2 Habitat and environmental factors associated with the juvenile phase of the life cycle.....	56
2.3.3.2.1 Physical habitat conditions of rearing juveniles.....	56
- Discharge (velocity and depth) relationships and their effects on indices of available habitat.....	57
- Water quality and thermal relationship.....	58
2.3.3.2.2 Timing of outmigration from the tributaries, sloughs, and mainstem and its relationship to environmental changes.....	59

(#162)
(50/11)

CE✓

TABLE OF CONTENTS (Continued)

Page

2.3.3.2.3	Food supply for rearing juveniles.....	60
2.3.3.2.4	Predation and cover relationships	60
2.4	Chum salmon.....	61
2.4.1	Adult phase of life cycle.....	61
2.4.1.1	Adult harvest by sport and commercial fisheries.....	61
2.4.1.2	Adult escapement.....	64
2.4.1.3	Habitat and environmental parameters associated with the adult phase of the life cycle (upstream migration, passage and spawning).....	64
2.4.1.3.1	Discharge, water quality, and temperature relationships with the adult chum salmon migration.....	66
2.4.1.3.2	Substrate type associated with spawning.....	68
2.4.1.3.3	Other physical and biological constraints on spawning success	69
2.4.2	Incubation and emergence phase of life cycle.....	69
2.4.3	Juvenile rearing and migration phases.....	70
2.4.3.1	Relative abundance of juvenile chum salmon.....	70
2.4.3.2	Habitat and environmental factors associated with the juvenile phase of the life cycle.....	71
2.4.3.2.1	Physical habitat conditions of rearing juveniles.....	73

(#162)
(6611)

TABLE OF CONTENTS (Continued)

Page

-	Discharge (velocity and depth) relationships and their effects on indices of available habitat.....	73
-	Water quality and thermal relationships....	74
2.4.3.2.2	Timing of outmigration from the tributaries, sloughs, and mainstem and its relationship to environmental changes.....	75
2.4.3.2.3	Food supply for rearing juveniles and its relationship to other parameters and preference dependency of species in the system.....	76
2.4.3.2.4	Predation and cover relationships.....	76
2.5	Pink salmon.....	77
2.5.1	Adult phase of life cycle.....	77
2.5.1.1	Adult harvest by sport and commercial fisheries.....	77
2.5.1.2	Adult escapement.....	80
2.5.1.3	Habitat and environmental parameters associated with the adult phase of the life cycle.....	82
2.5.1.3.1	Discharge, water quality, and temperature relationships with the adult salmon migration.....	82
2.5.2	Incubation and emergence phase of life cycle.....	84
2.5.3	Juvenile rearing and migration phases.....	85

CT ✓

TABLE OF CONTENTS (Continued)

Page

2.5.3.1	Timing of outmigration from the tributaries, sloughs, and mainstem and its relationship to environmental changes.....	85
2.5.3.2	Other physical and biological constraints.....	85
2.6	Rainbow trout.....	87
2.6.1	Adult phase of life cycle.....	87
2.6.1.1	Sport fishery harvest.....	87
2.6.1.2	Adult population indices.....	89
2.6.1.3	Habitat and environmental parameters associated with the adult phase of the live cycle.....	89
2.6.2	Reproductive phase of life cycle and juvenile distribution and abundance.....	91
2.7	Burbot.....	92
2.7.1	Adult phase of life cycle.....	92
2.7.1.1	Sport fishery harvest.....	92
2.7.1.2	Adult population indices.....	92
2.7.1.3	Habitat and environmental parameters associated with the adult phase of the life cycle.....	93
2.7.2	Reproductive phase of life cycle and juvenile distribution.....	94
2.8	The Whitefish - Round and Humpback complex and the anadromous Bering cisco.....	95
2.8.1	Adult phase of life cycle.....	95
2.8.1.1	Sportfishing and other harvests....	95
2.8.1.2	Adult population indices.....	95
2.8.1.2.1	Round whitefish.....	95

(#16a)

(86/11)

CE✓

2.8.1.2.2	Humpback whitefish complex.....	96
2.8.1.2.3	Bering cisco.....	96
2.8.1.3	Habitat and environmental parameters associated with the adult phase of life cycle.....	97
2.8.2	Reproductive phase of the life cycle.....	98
2.8.3	Juvenile rearing and migration.....	99
2.9	Eulachon.....	100
2.9.1	Freshwater reproduction phase of life cycle.....	100
2.9.1.1	Sport fisheries harvest.....	100
2.9.1.2	Adult escapement.....	101
2.9.1.3	Habitat and environmental parameters associated with spawning.....	101
2.9.2	Juvenile emergence, rearing, and migration.....	102
2.10	Miscellaneous game species (Arctic grayling and Dolly Varden)	103
2.10.1	Adult phase of the life cycle.....	103
2.10.1.1	Sport fishery harvest.....	103
2.10.1.2	Adult population indices.....	104
2.10.1.3	Habitat and environmental parameters associated with the adult phase of the life cycle.....	104
2.10.2	Reproductive phase of the life cycle.....	105
2.10.3	Juvenile rearing and migration.....	105
2.11	Other species of the Susitna River drainage.....	107
2.11.1	Threespine stickleback.....	107
2.11.2	Longnose sucker.....	108
2.11.3	Arctic lamprey.....	109

(#16a)

~~2.9.1~~

(9 of 11)

CE ✓

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.11.4 Slimy sculpin.....	110
2.11.5 Other species.....	111
3. THE FISHERIES STUDIES WITHIN THE BOUNDARIES OF THE PROPOSED IMPOUNDMENTS ABOVE DEVIL CANYON.....	112
3.1 The fishery resources of the clear water tributaries of the impoundment zones.....	112
3.1.1 Population estimates or indices of species present within the clear water tributaries...	113
3.1.2 Population dynamics and harvest effects on grayling in the tributaries.....	113
3.1.3 Relationships of growth, population, and production data to general and site specific habitat variables.....	115
3.2 The fisheries resources of the mainstem Susitna within the impoundment zones.....	116
3.3 The fisheries resources of the lakes within the impoundment zone.....	117
4. SUMMARY OF THE INSTREAM FLOW RELATIONSHIPS OF THE FISHERIES RESOURCES DOWNSTREAM OF DEVIL CANYON.....	118
4.1 Introduction.....	118
4.2 Key findings of fisheries studies downstream of Devil Canyon to the Chulitna confluence.....	118
4.2.1 Principal instream habitat types.....	118
4.2.2 Primary species composition and seasonal availability of instream habitat types.....	119
4.2.2.1 Mainstem and side channel habitats.....	119
4.2.2.2 Side slough habitats.....	120
4.2.2.3 Upland slough habitats.....	121
4.2.2.4 Tributary and tributary mouth habitats.....	122
4.2.3 Influence of mainstem discharge and water quality on instream habitat types.....	123

(160)

(10 of 11)

CEV

TABLE OF CONTENTS (Continued)

Page

4.2.3.1	Mainstem and side channel habitats.....	123
4.2.3.2	Side slough habitats.....	125
4.2.3.3	Upland slough habitats.....	127
4.2.3.4	Tributary mouth habitats.....	128
4.3	Key findings of fisheries studies downstream of the Chulitna confluence.....	129
4.3.1	Principal instream habitat types.....	129
4.3.1.1	Mainstem/side channel.....	129
4.3.1.2	Side slough.....	130
4.3.1.3	Upland slough.....	130
4.3.1.4	Tributary.....	131
4.3.1.5	Tributary mouth.....	131
4.3.2	Primary species composition and seasonal availability of instream habitat types.....	132
4.3.2.1	Mainstem/side channel habitats.....	132
4.3.2.2	Side slough habitats.....	133
4.3.2.3	Upland slough habitats.....	133
4.3.2.4	Tributary and tributary mouth habitats.....	134
4.3.3	Influence of mainstem discharge and water quality on instream habitat types.....	134
4.3.3.1	Mainstem/side channel habitats.....	134
4.3.3.2	Side slough habitats.....	135
4.3.3.3	Upland slough habitats.....	135
4.3.3.4	Tributary mouth habitats.....	135
4.4	Limitations of the available data base.....	136
4.4.1	Habitats in the reach downstream of Devil Canyon to the Chulitna confluence.....	136
4.4.2	Habitats in the reach downstream of the Chulitna confluence.....	138
5.	CONTRIBUTORS.....	140
6.	ACKNOWLEDGEMENTS.....	142
7.	LITERATURE CITED.....	143
8.	BIBLIOGRAPHY.....	149
9.	GLOSSARY OF COMMON AND SCIENTIFIC NAMES.....	152

TABLE OF CONTENTS (Continued)

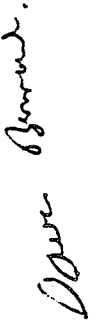
(10/1)

10. APPENDICES^a

Appendix A	Analysis of the species selectivity of fishwheels for the capture of adult salmon in the Susitna River
Appendix B	Timing and passage of adult salmon in the mainstem Susitna River and access into selected sloughs upstream of the Chulitna River confluence
Appendix C	Observations of salmon spawning habitat in selected sloughs of the Susitna River
Appendix D	Modeling of hydraulic conditions and chum salmon spawning habitat in selected Susitna River sloughs
Appendix E	Effects of mainstem Susitna discharge on total wetted and backwater surface area at selected study sites
Appendix F	Influence of habitat parameters on distribution and relative abundance of juvenile salmon and resident species
Appendix G	Use of major habitat types by juvenile salmon and resident species
Appendix H	Habitat relationships of juvenile salmon outmigration
Appendix I	A model of the effect of incremental increase in sport fishing on population structure of Arctic grayling above Devil Canyon
Appendix J	Age-length curves and growth of Arctic grayling and rainbow trout
Appendix K	Evaluation of Arctic grayling spawning and rearing habitat and notes on salmon spawning in the impoundment study area

^a Appendices included under separate binder.

16b.



SUISITNA HYDRO AQUATIC STUDIES PHASE II DATA REPORT

Winter Aquatic Studies
(October, 1982 - May, 1983)



17.

APA Doc #309

TABLE OF CONTENTS

Page

PREFACE	i
LIST OF FIGURES	viii
LIST OF TABLES	xiii
LIST OF PLATES	xv
1.0 INTRODUCTION	1
2.0 CONTINUOUS SURFACE AND INTRAGRAVEL WATER TEMPERATURE STUDY .	3
2.1 Objectives	3
2.2 Methods	5
2.2.1 Instrumentation	5
2.2.2 Site Selection	7
2.3 Results	7
2.4 Discussion	19
3.0 SALMON INCUBATION AND EMERGENCE STUDIES	22
3.1 Objectives	25
3.2 Methods	25
3.2.1 Study sites	27
3.2.2 Sampling techniques for habitat measurements	37
3.2.2.1 Water temperature	37
3.2.2.2 Standpipes	37
3.2.3 Sampling techniques for embryo development study	46
3.3 Results	48
3.3.1 Habitat data	48
3.3.1.1 Temperature	49
3.3.1.2 Dissolved Oxygen	50

Estes ✓

(#17) (3815)

	<u>Page</u>
3.3.1.2 pH	56
3.3.1.4 Specific Conductance	56
3.3.2 Development and emergence data	60
3.3.2.1 Chum salmon	62
3.3.2.2 Sockeye salmon	68
3.4 Discussion	72
3.4.1 Chum salmon	74
3.4.2 Sockeye salmon	76
3.4.3 Conclusions	79
4.0 BURBOT SPAWNING IN THE SUSITNA RIVER BELOW DEVIL CANYON	83
4.1 Objectives	83
4.2 Methods	84
4.2.1 Study site locations	84
4.2.2 Sampling techniques and determination of sexual maturity	87
4.2.3 Habitat measurements	87
4.3 Results	89
4.3.1 Habitat data	89
4.3.2 Sexual development	89
4.3.3 Age, length and sex composition	92
4.4 Discussion	93
4.4.1 Timing and location of spawning	93
4.4.2 Age, length and sex composition	96
4.4.3 Conclusions	98

(#17)(415)

Estes ✓
Page

5.0	WINTER RADIO TELEMETRY INVESTIGATIONS OF RESIDENT FISH	100
5.1	Objectives	100
5.1.1	Radio telemetry studies below Devil Canyon	100
5.1.2	Radio telemetry studies above Devil Canyon	101
5.2	Methods	101
5.2.1	Radio Tags	101
5.2.2	Transmitter implantation	102
5.2.3	Tracking	105
5.2.4	Habitat data collection	106
5.3	Results	107
5.3.1	Rainbow trout below Devil Canyon	107
5.3.2	Burbot below Devil Canyon	111
5.3.3	Arctic grayling above Devil Canyon	112
5.4	Discussion	120
5.4.1	Rainbow trout below Devil Canyon	120
5.4.2	Burbot below Devil Canyon	122
5.4.3	Arctic grayling above Devil Canyon	123
6.0	CONTRIBUTORS	126
7.0	ACKNOWLEDGEMENTS	128
8.0	LITERATURE CITED	129
9.0	APPENDICES	
	Appendix A Continuous surface and intragravel water temperatures	
	Appendix B Intragravel habitat data (standpipes)	

Appendix C Burbot winter catch data and age,
length, and sex data

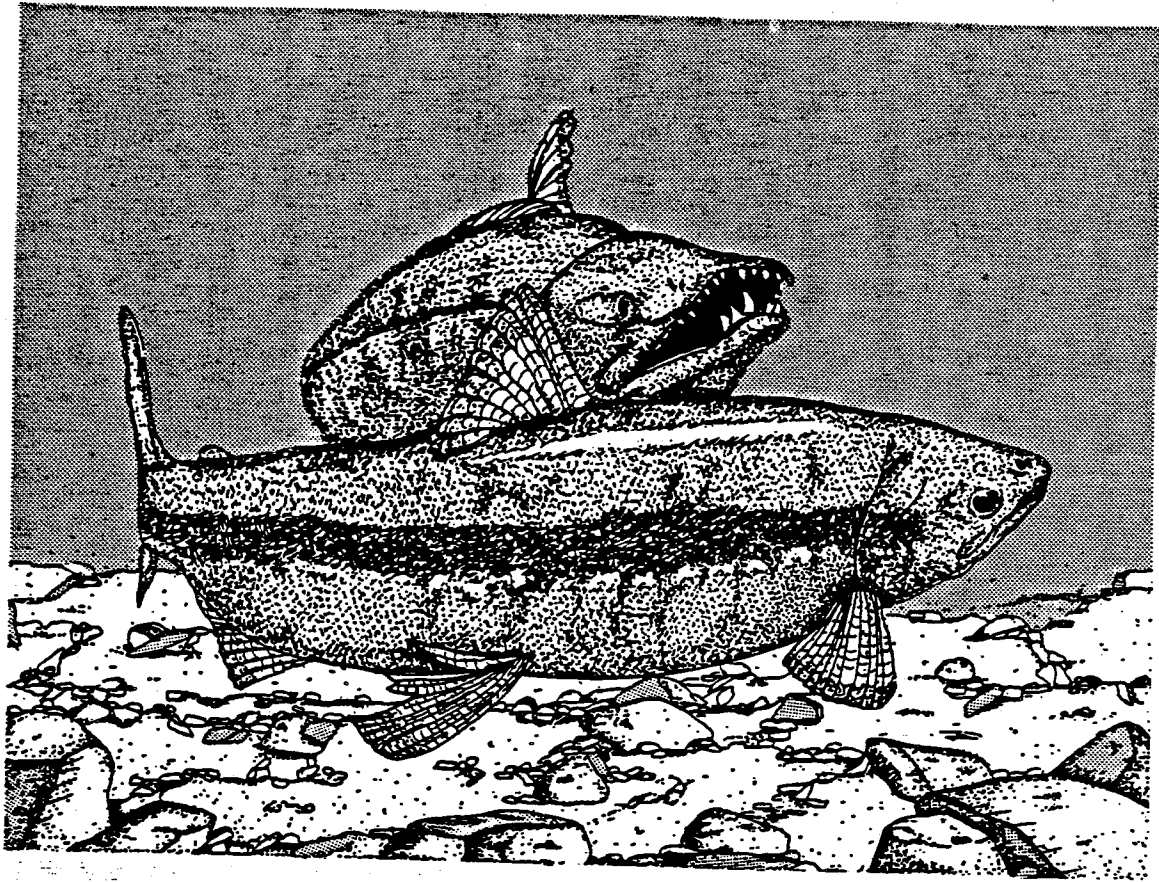
Appendix D Winter radio telemetry data on
burbot, rainbow trout, and
Arctic grayling

(#17)

(5865)

Estes ✓

ESTES ✓



16/11

ADF&G Su Hydro Aquatic Studies
May 1983 - June 1984

Procedures Manual
Final Draft



18a.

APA Doc #885

(#18a)

TABLE OF CONTENTS

Susitna Hydroelectric Aquatic Studies

Adult Anadromous Fisheries Project
Resident and Juvenile Anadromous Fisheries Project
Aquatic Habitat and Instream Flow Project

(28/11)

ADULT ANADROMOUS FISHERIES PROJECT

Page	Contents

1	1.0 INTRODUCTION
2	2.0 EULACHON
2	2.1 Objectives
2	2.2 Technical Procedures
2	2.2.1 Operation Period and Survey Reach
3	2.2.2. Methods
3	2.2.2.1 Estuary Sampling
5	2.2.2.2 Main Channel Sampling
7	2.3 Data Procedures
13	3.0 ADULT SALMON
13	3.1 Objectives
14	3.2 Technical Procedures
14	3.2.1 Main Channel Sampling
14	3.2.1.1 Operation Periods
14	3.2.1.2 Methods
14	3.2.1.2.1 Sonar Name Tag Recapture
21	3.2.1.2.2 Age/Length/Sex Composition Sampling
22	3.2.2 Stream and Slough Surveys
22	3.2.2.1 Operation Period and Survey Reach
22	3.2.2.2 Methods
25	3.2.3 Stream Life
25	3.2.3.1 Operation Period and Survey Reach
25	3.2.3.2 Methods
26	3.3 Data Procedures
26	3.3.1 Side Scan Sonar Operations
26	3.3.1.1 Daily Procedures
30	3.3.2 Tag/Recapture Operations
30	3.3.2.1 Daily Procedures
40	3.3.3 Stream and Slough Survey Operations
40	3.3.4 Stream Life Operations
44	4.0 LITERATURE CITED

Ester ✓

(#182) RESIDENT AND JUVENILE ANADROMOUS FISHERIES PROJECT

Page	Contents
1	1.0 INTRODUCTION
3	2.0 TECHNICAL PROCEDURES
3	2.1 Study Description and Rationale
3	2.1.1 Resident Fish Studies
3	2.1.1.1 Habitat and Population Data
3	2.1.1.1.1 Sub-objectives
3	2.1.1.1.2 Rationale
4	2.1.1.1.3 Field Study Design
9	2.1.2 Juvenile Anadromous Fish Studies
9	2.1.2.1 Abundance, Outmigration, Timing and Survival
9	2.1.2.1.1 Sub-objectives
9	2.1.2.1.2 Rationale
11	2.1.2.1.3 Field Study Design
16	2.1.2.2 Emergence and Development
16	2.1.2.2.1 Sub-objectives
16	2.1.2.2.2 Rationale
17	2.1.2.2.3 Field Study Design
22	2.1.2.3 Rearing Habitat
22	2.1.2.3.1 Sub-objectives
22	2.1.2.3.2 Rationale
23	2.1.2.3.3 Field Study Design
28	2.1.3 Fish and Habitat Surveys Along the Proposed Access/Transmission Corridors
28	2.1.3.1 Sub-objectives
29	2.1.3.2 Rationale
30	2.1.3.3 Field Study Design
33	2.2 Field Data Collection Work Plans
33	2.2.1 Resident Fish Studies
33	2.2.1.1 Methods
33	2.2.1.1.1 Habitat and Relative Abundance
35	2.2.1.1.2 Fish Preference Studies
39	2.2.1.1.3 Population Estimates
41	2.2.1.1.4 Radio Telemetry
42	2.2.1.2 Study Locations
42	2.2.1.2.1 Habitat and Relative Abundance Measurements
42	2.2.1.2.2 Fish Preference Studies
44	2.2.1.2.3 Population Estimates
44	2.2.1.2.4 Radio Telemetry
45	2.2.1.3 Schedule of Activities and Frequency of Sampling
45	2.2.1.3.1 Habitat and Relative Abundance Measurements

estes

102	3.2 Juvenile Anadromous Fish Studies
102	3.2.1 Abundance, Outmigration, Timing and Survival
102	3.2.1.1 Field Data
102	3.2.1.1.1 Coded Wire Tagging
102	3.2.1.1.2 Recovery of Marked and Unmarked Fish
104	3.2.1.2 Data Transfer
104	3.2.1.2.1 Recovery of Marked and Unmarked Fish
104	3.2.1.3 Data Analysis
104	3.2.1.3.1 Coded Wire Tagging
106	3.2.1.3.2 Recovery of Marked and Unmarked Fish
106	3.2.1.3.3 Dye Marking
107	3.2.2 Emergence and Development
107	3.2.2.1 Data Recording
107	3.2.2.2 Data Transfer
108	3.2.2.3 Data Analysis
108	3.2.3 Rearing Habitat Studies
108	3.2.3.1 Field Data
108	3.2.3.1.1 Fish Preference Studies
110	3.2.3.1.2 Fish Habitat Modeling Studies
110	3.2.3.1.3 IFG-4 Modeling Studies
112	3.2.3.2 Data Transfer
112	3.2.3.3 Data Analysis
114	3.3 Fish and Habitat Surveys Along the Proposed Assess/ Transmission Corridor
114	3.3.1 Field Data
114	3.3.1.1 Fish Data Collection
114	3.3.1.2 Aquatic Habitat Data Collection
114	3.3.2 Data Transfer
118	3.3.3 Data Analysis
119	4.0 QUALITY CONTROL
121	5.0 LITERATURE CITED

ESTES ✓

(#18a) AQUATIC HABITAT AND INSTREAM FLOW PROJECT (68/11)

Page	Contents
1	1.0 INTRODUCTION
1	1.1 Background
5	1.2 FY-84 Studies
17	2.0 WORK PLANS
17	2.1 Instream Flow Evaluations
17	2.1.1 Stage Discharge Studies
17	2.1.1.1 Study Approach
17	2.1.1.1.1 Mainstem Habitats
19	2.1.1.1.2 Side Channel, and Side and Upland Slough Habitats
21	2.1.1.1.3 Tributary Habitat
22	2.1.1.2 Site Selection
22	2.1.1.2.1 Mainstem Habitats
22	2.1.1.2.2 Side Channel, and Side and Upland Slough Habitats
24	2.1.1.2.3 Tributary Habitat
27	2.1.1.3 Data Analysis
27	2.1.1.3.1 Mainstem Habitats
27	2.1.1.3.2 Side Channel and Slough Habitats
27	2.1.1.3.3 Tributary Habitat
29	2.1.2 Temperature Studies
29	2.1.2.1 Study Approach
30	2.1.2.2 Site Selection
30	2.1.2.3 Data Analysis
32	2.1.3 Water Quality Studies
32	2.1.3.1 Study Approach
33	2.1.3.2 Site Selection
36	2.1.3.3 Data Analysis
36	2.1.4 Channel Morphology Studies
36	2.1.4.1 Study Approach
36	2.1.4.1.1 Thalweg Studies
37	2.1.4.1.2 Cross Section Studies
38	2.1.4.2 Site Selection
38	2.1.4.2.1 Thalweg Studies
40	2.1.4.2.2 Cross Section Studies
41	2.1.4.3 Data Analysis
41	2.1.4.3.1 Thalweg Studies
42	2.1.4.3.2 Cross Section Studies
44	2.2 Fish Habitat Studies

Estes ✓

44	2.2.1 Timing, Access and Distribution (TAD) Studies
44	2.2.1.1 Study Approach
45	2.2.1.1.1 Timing Studies
45	2.2.1.1.2 Access and Passage Studies
45	2.2.1.1.3 Distribution Studies
46	2.2.1.2 Site Selection
46	2.2.1.3 Data Analysis
46	2.2.1.3.1 Timing Studies
48	2.2.1.3.2 Access and Passage Studies
49	2.2.1.3.3 Distribution Studies
50	2.2.2 Salmon Spawning Habitat Evaluation Studies
52	2.2.2.1 Side Sloughs and Side Channels
53	2.2.2.1.1 Habitat Availability Study
56	2.2.2.1.2 Habitat Utilization Study
59	2.2.2.1.3 Habitat Selectivity Study
60	2.2.2.2 Tributary Mouths
61	2.2.2.2.1 Habitat Availability Study
63	2.2.2.2.2 Habitat Utilization Study
65	2.2.2.3 Tributary Utilization Study
65	2.2.2.3.1 Study Approach
65	2.2.2.3.2 Site Selection
66	2.2.2.3.3 Data Analysis
66	2.2.3 Incubation Studies
66	2.2.3.1 Study Approach
68	2.2.3.2 Site Selection
68	2.2.3.3 Data Analysis
70	2.3 Quality Assurance and Laboratory Operations (QUALO)
71	3.0 TECHNICAL PROCEDURES
71	3.1 Introduction
71	3.2 New FY-84 Procedures
71	3.2.1 Instream Flow Evaluation
71	3.2.1.1 Stage Monitoring Procedures
71	3.2.1.1.1 Staff Gages
73	3.2.1.1.2 Datapod Stage
77	3.2.1.2 Discharge Procedures
79	3.2.1.3 Temperature Procedures
79	3.2.1.3.1 Peabody - Ryan Thermographs
82	3.2.1.3.2 Datapod Temperature Recorders
86	3.2.1.4 Water Quality
86	3.2.1.4.1 Basic Field Parameters
87	3.2.1.4.2 Turbidity
88	3.2.1.5 Channel Morphology
88	3.2.1.5.1 Thalweg Profile Study Procedures

(#18a)

(#182)

(80611)

ix

ESTES ✓

Page Contents

90	3.2.1.5.2	Cross Section Profile Study Procedures
91	3.2.1.5.3	Procedures Used to Determine Breaching Flows
93	3.2.2	Fish Habitat Study Procedures
93	3.2.2.1	Incubation Study
93	3.2.2.1.1	Intragravel Standpipe Water Quality Study Procedures
101	3.2.2.1.2	Embryo Survival Study Procedures
113	3.2.2.2	Substrate Study Procedures
113	3.2.2.2.1	General Substrate Analysis
114	3.2.2.2.2	Intensive Substrate Analysis Procedures
120	3.2.3	Quality Assurance and Laboratory Operations (QUALO)
120	3.2.3.1	Instruments Calibration, Maintenance and Repair Procedures
120	3.2.3.1.1	Instrument Calibration
123	3.2.3.1.2	Equipment Maintenance and Repair
124	3.2.3.2	Data Reduction, Processing and Categorization Procedures
124	3.2.3.2.1	Field Data Reduction and Checking Data Entry
124	3.2.3.2.2	Data Entry
125	3.2.3.2.3	Data Categorization
126	3.2.3.3	Data/Information Requests or Transmittal Procedures
127	4.0	LITERATURE CITED

~~(#182)~~
(#182)

ADULT ANADROMOUS FISHERIES PROJECT

Appendices

1. Sonar Installation and Operation Manual
2. Oscilloscope Operation
3. Fishwheel Operation
4. Fish Tagging
5. Geographic Location Code and General Maps
6. General Equipment, Camp Maintenance and Camp Police
7. Electroshocking Boat Operations

(#182)

Estes ✓

RESIDENT AND JUVENILE ANADROMOUS FISHERIES PROJECT

Appendices

1. Instructions for completing Juvenile Anadromous Habitat Study (JAHS) sampling forms and field data notes.
2. Operational procedures for the Epson HX-20 microcomputer data form program.

(#182) (10 of 11)

CE ✓

(#182)

xxvi

Estes ✓

AQUATIC HABITAT AND INSTREAM FLOW PROJECT

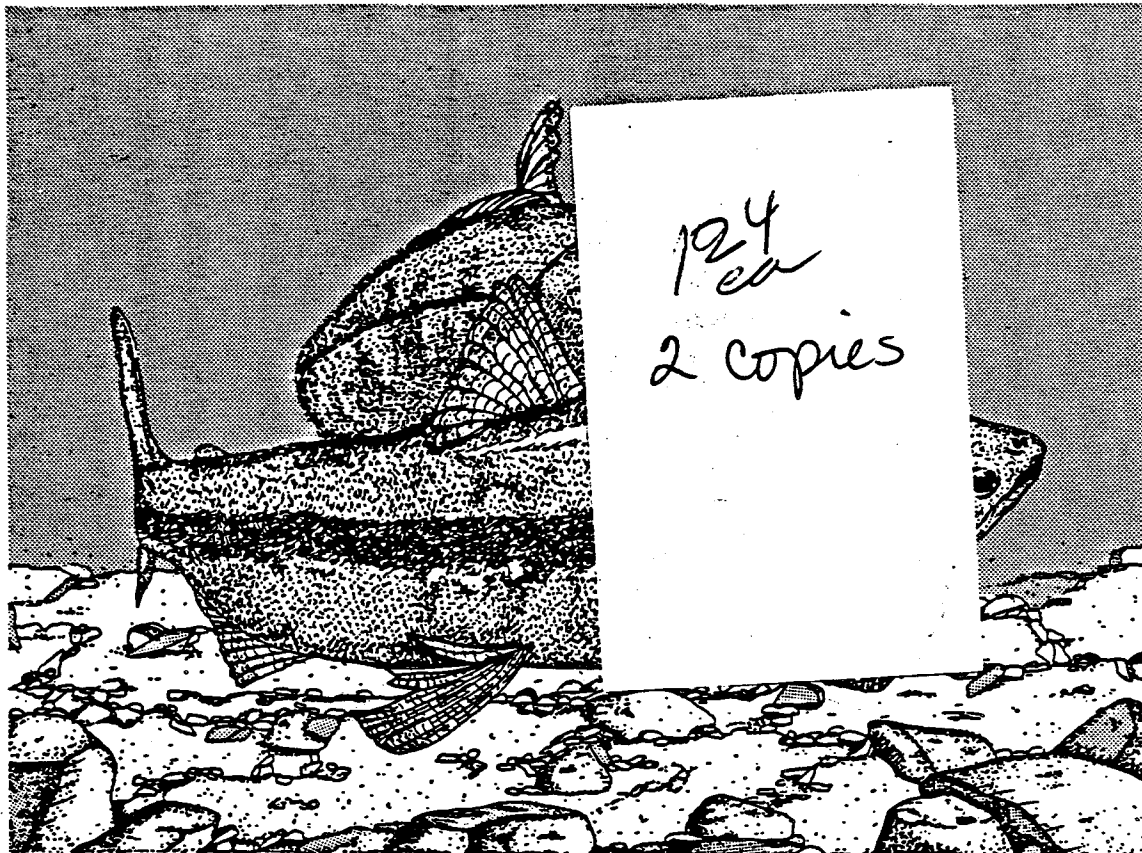
Appendicies

1. Outline describing flow chart for salmon spawning habitat evaluation.
2. Revisions to the operation and maintenance instructions, Hydrolab Digital 4041.

(11 of 11)

27

ESTES



(Part 1)
(1668)

ADF&G Su Hydro Aquatic Studies
May 1983 - June 1984

Procedures Manual
Final Draft

Appendices



18b.

APA Doc #886

CEV ✓

130

(981#)

(1/2)

(1/2)

Sonar Installation and Operation Manual

ADULT ANADROMOUS FISHERIES STUDIES

APPENDIX 1

APPENDIX 2

ADULT ANADROMOUS FISHERIES STUDIES

Oscilloscope Operation

(Part 1)
(3 of 7)

(18b)

CEL ✓

APPENDIX 3

ADULT ANADROMOUS FISHERIES STUDIES

Fishwheel Operation

(Part 1)
(4 of 8)

(#186)

APPENDIX 4

ADULT ANADROMOUS FISHERIES STUDIES

Fish Tagging

(72261)
(5068)

(#186)

CE

APPENDIX 5

ADULT ANADROMOUS FISHERIES STUDIES

Geographic Location Code and General Maps

(p221)
(6 of 8)
(#186)

CE ✓

APPENDIX 6

ADULT ANADROMOUS FISHERIES STUDIES

General Equipment, Camp Maintenance and Camp Policy

(Part 1)
(7668)
(186)

CEV ✓

APPENDIX 7

ADULT ANADROMOUS FISHERIES STUDIES

Electroshocking Boat Operations

(Part 1)
(86-8)
(#186)

CEV ✓

APPENDIX 1

RESIDENT AND JUVENILE ANADROMOUS FISHERIES PROJECT

Instructions for completing Juvenile Anadromous Habitat
Studies (JAHS) sampling forms and field data notes.

(#186)
(Part 2)
(10/3)

CEV ✓

APPENDIX 2

RESIDENT AND JUVENILE ANADROMOUS FISHERIES PROJECT

Operational procedures for the Epson HX-20
microcomputer data form program.

(#186)
(Part 2)
(2 of 3)

CE ✓

Appendix 1

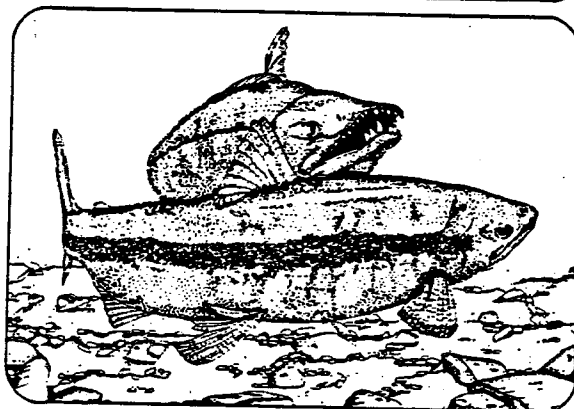
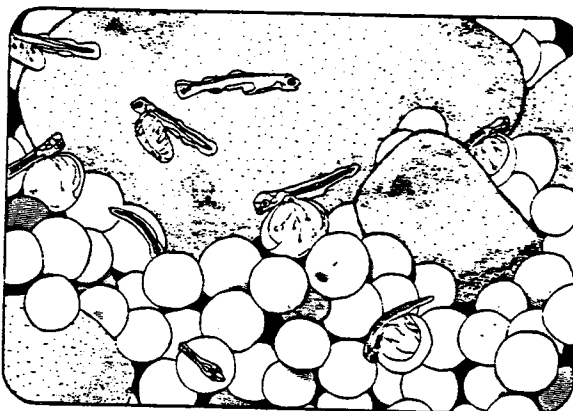
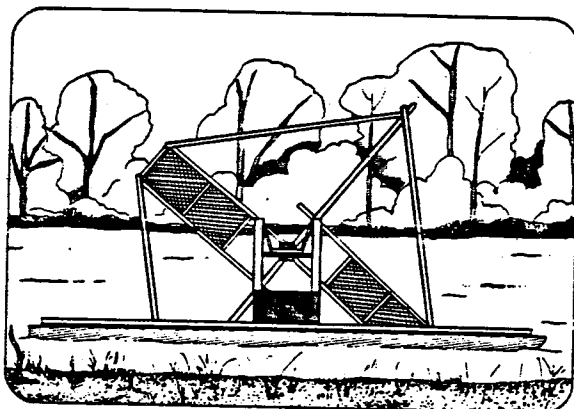
AQUATIC HABITAT AND INSTREAM FLOW PROJECT

Outline describing flow chart for salmon spawning habitat evaluation.

CE

37

Estes



(1064)

1984

ALASKA DEPARTMENT OF FISH AND GAME

SUSITNA HYDRO AQUATIC STUDIES

REPORT NO. 1

2207 Spenard Road

Anchorage, Alaska 99503



#19.

APA Doc #1450

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

CEV

TABLE OF CONTENTS

(#19) (2064)

	PAGE
PREFACE.....	i
TITLES IN THIS SERIES.....	iv
TABLE OF CONTENTS.....	v
LIST OF FIGURES.....	viii
LIST OF TABLES.....	xii
LIST OF PLATES.....	xvii
LIST OF APPENDIX FIGURES.....	xviii
LIST OF APPENDIX TABLES.....	xxii
ACKNOWLEDGEMENTS.....	xxv
1.0 OBJECTIVES.....	1
2.0 METHODS.....	2
2.1 Eulachon.....	2
2.1.1 Intertidal.....	2
2.1.2 Main Channel.....	7
2.2 Adult Salmon.....	8
2.2.1 Main Channel Escapement Monitoring.....	8
2.2.1.1 Sonar Operations.....	10
2.2.1.2 Fishwheel Operations.....	12
2.2.1.3 Tagging Operations.....	13
2.2.1.4 Age, Length and Sex Composition Sampling.....	15
2.2.1.5 Fecundity Sampling.....	16
2.2.2 Spawning Ground and Tag Recovery Surveys.....	18
2.2.2.1 Sloughs and Streams.....	18
2.2.2.1.1 Chinook Salmon Index Surveys.....	19
2.2.2.1.2 Observation Life Surveys.....	20
2.2.2.1.3 Egg Retention Sampling.....	21
2.3 Bering Cisco.....	21
2.4 Data Analysis and Evaluation.....	22
2.4.1 Eulachon.....	22
2.4.2 Salmon Tag and Recapture Escapement Estimates.....	22
2.4.3 Calculation of Main Channel Escapement Timing.....	27
2.4.4 Age Determination.....	27
2.4.5 Slough Escapement.....	28
3.0 RESULTS AND DISCUSSION.....	30
3.1 Eulachon.....	30
3.1.1 Intertidal.....	30
3.1.2 Main Channel.....	41
3.2 Adult Salmon.....	54
3.2.1 Chinook Salmon.....	55
3.2.1.1 Intertidal to Talkeetna.....	55
3.2.1.1.1 Main Channel Escapement Monitoring.....	55
3.2.1.2 Talkeetna to Upper Devil Canyon.....	64

CEU

(#19)

TABLE OF CONTENTS (Continued)

~~(30/4)~~ (30/4)

3.2.1.2.1 Main Channel Escapement Monitoring.....	64
3.2.1.2.2 Spawning Ground Surveys.....	73
3.2.1.2.2.1 Main Channel.....	73
3.2.1.2.2.2 Sloughs and Streams.....	73
3.2.1.3 Escapement Index Surveys.....	75
3.2.2 Sockeye Salmon.....	81
3.2.2.1 Intertidal to Talkeetna.....	81
3.2.2.1.1 Main Channel Escapement Monitoring.....	81
3.2.2.1.1.1 First Run.....	85
3.2.2.1.1.2 Second Run.....	91
3.2.2.1.1.3 Fecundity.....	94
3.2.2.1.2 Spawning Ground Surveys.....	94
3.2.2.1.2.1 Sloughs and Streams.....	94
3.2.2.1.2.1.1 First Run.....	96
3.2.2.1.2.1.2 Second Run.....	96
3.2.2.2 Talkeetna To Upper Devil Canyon	96
3.2.2.2.1 Main Channel Escapement Monitoring.....	96
3.2.2.2.1.1 First Run.....	97
3.2.2.2.1.2 Second Run.....	101
3.2.2.2.2 Spawning Ground Surveys.....	101
3.2.2.2.2.1 Main Channel.....	102
3.2.2.2.2.2 Streams.....	102
3.2.2.2.2.3 Sloughs.....	102
3.2.2.2.2.3.1 Observation Life.....	106
3.2.2.2.2.3.2 Escapement	110
3.2.2.2.2.3.3 Egg Retention.....	112
3.2.3 Pink Salmon.....	112
3.2.3.1 Intertidal to Talkeetna.....	112
3.2.3.1.1 Main Channel Escapement Monitoring.....	116
3.2.3.1.2 Fecundity.....	119
3.2.3.2 Talkeetna To Upper Devil Canyon.....	119
3.2.3.2.1 Main Channel Escapement Monitoring.....	121
3.2.3.2.2 Spawning Ground Surveys.....	121
3.2.3.2.2.1 Main Channel.....	123
3.2.3.2.2.2 Sloughs and Streams.....	125
3.2.4 Chum Salmon.....	125
3.2.4.1 Intertidal to Talkeetna.....	125
3.2.4.1.1 Main Channel Escapement Monitoring.....	133
3.2.4.1.2 Fecundity.....	138
3.2.4.2 Talkeetna To Upper Devil Canyon	138
3.2.4.2.1 Main Channel Escapement Monitoring.....	143
3.2.4.2.2 Spawning Ground Surveys.....	143
3.2.4.2.2.1 Main Channel.....	143
3.2.4.2.2.2 Streams.....	146
3.2.4.2.2.3 Sloughs.....	146
3.2.4.2.2.3.1 Observation Life.....	150
3.2.4.2.2.3.2 Escapement.....	153
3.2.4.2.2.3.3 Egg Retention.....	

CEV

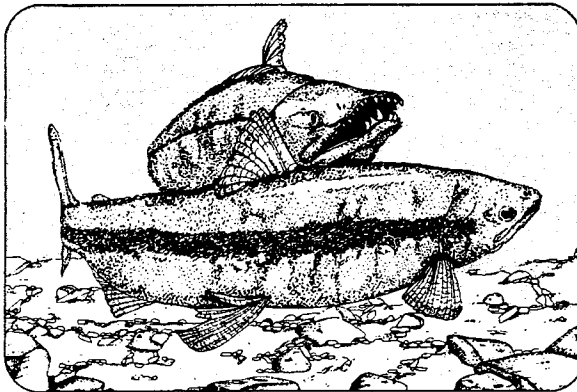
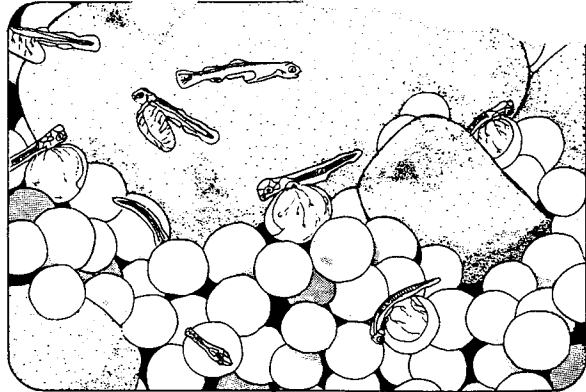
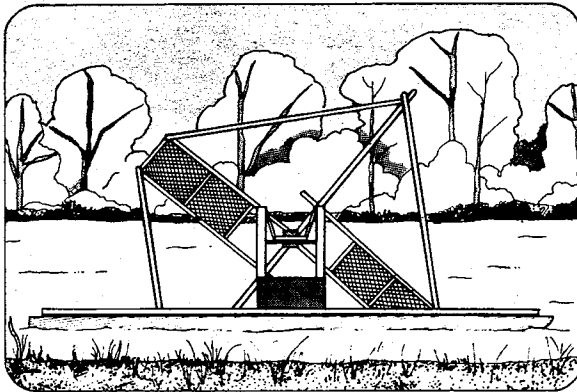
TABLE OF CONTENTS (Continued)

(#19)(4 of 4)

3.2.5 Coho Salmon.....	155
3.2.5.1 Intertidal to Talkeetna.....	155
3.2.5.1.1 Main Channel Escapement Monitoring.....	155
3.2.5.2 Talkeetna to Upper Devil Canyon.....	162
3.2.5.2.1 Main Channel Escapement Monitoring.....	162
3.2.5.2.2 Spawning Ground Surveys.....	167
3.2.5.2.2.1 Main Channel.....	167
3.2.5.2.2.2 Sloughs and Streams.....	167
3.3 Bering Cisco.....	171
3.3.1 Intertidal to Talkeetna.....	171
3.3.1.1 Main Channel Escapement Monitoring.....	171
3.3.2 Talkeetna to Upper Devil Canyon.....	172
3.3.2.1 Main Channel Escapement Monitoring.....	172
4.0 SUMMARY.....	174
4.1 Eulachon.....	174
4.2 Adult Salmon	177
4.2.1 Chinook Salmon.....	177
4.2.1.1 Intertidal to Talkeetna.....	177
4.2.1.2 Talkeetna to Upper Devil Canyon.....	180
4.2.1.3 Escapement Index Surveys.....	183
4.2.2 Sockeye Salmon.....	183
4.2.2.1 First Run.....	183
4.2.2.2 Second Run.....	184
4.2.2.2.1 Intertidal to Talkeetna.....	186
4.2.2.2.2 Talkeetna to Upper Devil Canyon.....	189
4.2.3 Pink Salmon.....	194
4.2.3.1 Intertidal to Talkeetna.....	194
4.2.3.2 Talkeetna To Upper Devil Canyon.....	198
4.2.4 Chum Salmon.....	200
4.2.4.1 Intertidal to Talkeetna.....	202
4.2.4.2 Talkeetna To Upper Devil Canyon	204
4.2.5 Coho Salmon.....	212
4.2.5.1 Intertidal to Talkeetna.....	212
4.2.5.2 Talkeetna to Upper Devil Canyon.....	216
4.3 Bering Cisco.....	218
REFERENCES.....	222

cc✓

4 of Estes



(1 of 23)

REPORT NO. 2

RESIDENT AND JUVENILE ANADROMOUS FISH
INVESTIGATIONS (MAY - OCTOBER 1983)



20.

APA Doc #1784

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

ESTES

CONTENTS OF REPORT NO. 2

(#20)

INTRODUCTION

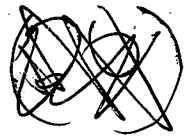
- Part 1. The Outmigration of Juvenile Salmon from the Susitna River above the Chulitna River Confluence.
- Part 2. The Distribution and Relative Abundance of Juvenile Salmon in the Susitna River Drainage Above the Chulitna River Confluence.
- Part 3. Juvenile Salmon Rearing Suitability Criteria.
- Part 4. Juvenile Salmon Rearing Habitat Models.
- Part 5. Resident Fish Distribution and Population Dynamics in the Susitna River Below Devil Canyon.
- Part 6. Resident Fish Habitat Studies.
- Part 7. Modelling of Juvenile and Resident Fish Habitat.

(#20)

(2 of 23)

CEV ✓

(#20)



THE OUTMIGRATION OF JUVENILE SALMON FROM THE
SUSITNA RIVER ABOVE THE CHULITNA RIVER CONFLUENCE

1984 Report No. 2, Part 1

by Kent J. Roth, Daniel C. Gray, and Dana C. Schmidt

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

ABSTRACT

Population estimates of juvenile salmon were obtained by mark-recapture using a unique application of the coded wire tagging technique during 1983. One-half length coded wire tags were used to mark 24,287 post-emergent chum and 17,963 post-emergent sockeye salmon fry at four sloughs and one tributary of the Susitna River between the Chulitna River confluence and Devil Canyon. Tag retention rates averaged 96% and total mortalities caused by the capture and tagging procedure were 1%. Sixty-two coded wire tagged chum salmon fry and 394 tagged sockeye salmon fry were recovered in two downstream migrant traps located in the Susitna River five miles above the Chulitna River confluence. The mark-recapture estimates indicated that 3,322,000 chum salmon fry and 560,000 sockeye salmon fry migrated downstream past the outmigrant traps during 1983. Estimated survival rates between potential egg deposition and outmigration for chum and sockeye salmon fry were 14% and 41%, respectively. The downstream migrant traps collected all five species of Pacific salmon during the open water period. Pink salmon trap catches were highest in early June, and peak outmigration of chum salmon occurred in mid June. Chinook, coho, and sockeye salmon juveniles were collected at the traps throughout the sampling season, with peaks occurring during high mainstem discharge levels in early June, early July, and mid August. The rate of outmigration of chum salmon showed a higher correlation with discharge than that of other species.

(3 of 23)

CE ✓

(# 20)

TABLE OF CONTENTS (4623)

	Page
ABSTRACT.....	i
LIST OF FIGURES.....	iv
LIST OF TABLES.....	v
LIST OF PLATES.....	vi
LIST OF APPENDIX TABLES.....	vii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Study Locations.....	3
2.2 Field Data Collection.....	3
2.2.1 Coded wire tagging.....	3
2.2.2 Downstream migrant traps.....	6
2.2.3 Dye marking.....	8
2.3 Data Recording.....	9
2.3.1 Coded wire tagging.....	9
2.3.2 Downstream migrant traps.....	9
2.3.3 Dye marking.....	9
2.4 Data Analysis.....	9
2.4.1 Population and survival estimates.....	9
2.4.2 Juvenile salmon catch per unit effort.....	11
2.4.3 Relation of outmigration to habitat variables...	12
3.0 RESULTS.....	13
3.1 Coded Wire Tagging and Recovery.....	13
3.2 Population Estimates and Survival Rates of Outmigrants.	13
3.3 Outmigration Rates From Selected Sloughs.....	17
3.4 Juvenile Salmon Catch Per Unit Effort.....	17
3.5 Relation of Outmigration to Habitat Variables	22
3.5.1 Interrelationship of mainstem discharge, temperature and turbidity.....	22
3.5.2 Effects of mainstem discharge on outmigration...	28

(#20)

(5 of 23)

⊖

⊖

	<u>Page</u>
4.0 DISCUSSION.....	33
4.1 Coded Wire Tagging and Recovery.....	33
4.2 Dye Marking and Outmigration Rates.....	34
4.3 Survival of Outmigrants.....	35
4.4 Comparison of Trap Catch Rates.....	36
4.5 Relation of Outmigration to Habitat Variables.....	40
5.0 CONTRIBUTORS.....	42
6.0 ACKNOWLEDGEMENTS.....	43
7.0 LITERATURE CITED.....	44
8.0 APPENDICES	
Appendix A Sampling Selectivity of the Outmigrant Traps.....	49
Appendix B The Schaefer Estimator of Population Size.....	52
Appendix C Comparison of Daily Catch Per Hour Between Outmigrant Trap 1 and Trap 2.....	57

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(6823)

THE DISTRIBUTION AND RELATIVE ABUNDANCE
OF JUVENILE SALMON
IN THE SUSITNA RIVER DRAINAGE
ABOVE THE CHULITNA RIVER CONFLUENCE

1984 Report No. 2, Part 2

by Lawrence J. Dugan, David A. Sterritt, and Michael E. Stratton

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ABSTRACT

The Juvenile Anadromous Habitat Study was undertaken to determine the seasonal distribution and abundance of juvenile salmon by macrohabitat type in the Susitna River drainage between the Chulitna River confluence and Devil Canyon. Thirty-five sites representing four macrohabitat types were sampled from May through September, 1983; limited sampling was conducted in October and November. Side channels and tributaries were found to be important rearing areas for juvenile chinook salmon with tributaries important early in the summer and side channels of the mainstem Susitna increasing in importance as the summer progressed. Coho salmon were most abundant in tributaries and upland sloughs. Natal side sloughs and backwater areas provided rearing areas for chum and sockeye salmon fry. Upland sloughs, the most lake-like environment, had concentrations of sockeye and coho salmon juveniles. Macrohabitat type and time of year were found to be significantly ($p < 0.10$) related to the distribution of all species.

CE✓

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	iv
LIST OF TABLES.....	vi
LIST OF APPENDIX TABLES.....	vi
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Field Sampling Design.....	3
2.1.1 Study site locations and selection criteria.....	3
2.1.2 Field data collection.....	6
2.1.3 Schedule of activities and frequency of sampling..	6
2.2 Data Recording and Analysis.....	8
2.2.1 Macrohabitat use.....	8
2.2.2 Analysis of variance.....	8
3.0 RESULTS.....	10
3.1 Distribution of Juvenile Chinook Salmon.....	10
3.2 Distribution of Juvenile Coho Salmon.....	10
3.3 Distribution of Juvenile Chum Salmon.....	14
3.4 Distribution of Juvenile Sockeye Salmon.....	20
3.5 Analysis of Variance.....	20
4.0 DISCUSSION.....	27
4.1 Limitations of the Data.....	27
4.1.1 Sampling limitations.....	27
4.1.2 Gear efficiency.....	27
4.2 Chinook Salmon.....	28
4.3 Coho Salmon.....	31
4.4 Chum Salmon.....	34

CEV ✓

TABLE OF CONTENTS (Continued)

	<u>Page</u>
4.5 Sockeye Salmon..... (#20)	35
5.0 CONTRIBUTORS.....	38
6.0 ACKNOWLEDGEMENTS.....	39
7.0 LITERATURE CITED.....	40
8.0 APPENDICES	
Appendix A Summary statisitics for transformed catch/cell data.....	43
Appendix B Gear efficiency experiments.....	48

(80/23)

CE ✓

(#20)

JUVENILE SALMON REARING SUITABILITY CRITERIA

1984 Report No. 2, Part 3

by Paul M. Suchanek, Robert P. Marshall, Stephen S. Hale,
and Dana C. Schmidt

Alaska Department of Fish and Game
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2207 Spenard Road
Anchorage, Alaska 99503

(#20)

ABSTRACT

Changes in flow regimes in the Susitna River may affect the habitat used by rearing juvenile salmon. In order to model changes in habitat usability, data were collected for development of suitability criteria for the habitat attributes of cover, velocity, and depth used by juvenile chinook, coho, sockeye, and chum salmon. Representative sites between the Chulitna River confluence and Devil Canyon were sampled for juvenile salmon and habitat attributes were measured. Analysis was primarily univariate and data were pooled over site and season. Turbidity was apparently used by chinook salmon as cover prompting development of suitability criteria for clear (<30 NTU) and turbid (>30 NTU) conditions. Catches were insufficient for analysis of the other species by turbidity level. Suitability criteria for percent cover, cover type, velocity, and depth were developed for all four species of salmon. Composite weighting factors were formulated and correlated or compared with observed fish catch. Limitations of the suitability criteria and possible uses in habitat analysis are discussed.

TABLE OF CONTENTS

Page

ABSTRACT.....	i
LIST OF FIGURES.....	iv
LIST OF TABLES.....	vi
LIST OF APPENDIX TABLES.....	vii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	2
2.1 Study Locations.....	2
2.2 Field Data Collection.....	2
2.2.1 Biological.....	2
2.2.2 Physical.....	4
2.3 Data Analysis.....	4
2.3.1 Cover analysis.....	7
2.3.2 Velocity and depth analysis.....	7
2.3.3 Tests of data fit.....	8
3.0 RESULTS.....	10
3.1 Sampling Effort and Catch.....	10
3.2 Analysis of Chinook and Coho Salmon Distribution in Clear Water Using Electrofishing Data..	14
3.2.1 Cover.....	14
3.2.2 Depth and velocity.....	16
3.3 Analysis of Chinook Salmon Distribution in Turbid Water Using Beach Seine Data.....	19
3.3.1 Cover.....	19
3.3.2 Depth and velocity.....	20
3.4 Analysis of Sockeye and Chum Salmon Distribution Using Pooled Electrofishing and Beach Seine Data.....	20
3.4.1 Cover.....	20
3.4.2 Depth and velocity.....	22
3.5 Tests of Fitted Habitat Criteria to Observed Fish Catches.....	22
3.5.1 Chinook and coho salmon.....	22
3.5.2 Sockeye and chum salmon.....	26

CEV ✓

TABLE OF CONTENTS (Continued)

(#20)

	<u>Page</u>
4.0 DISCUSSION.....	28
4.1 Limitations of the Suitability Criteria.....	28
4.2 Chinook and Coho Salmon.....	29
4.2.1 Chinook salmon.....	29
4.2.2 Coho salmon.....	30
4.3 Sockeye and Chum Salmon.....	31
4.3.1 Sockeye salmon.....	31
4.3.2 Chum salmon.....	32
4.4 Recommended Applications for the Suitability Criteria....	32
5.0 CONTRIBUTORS.....	35
6.0 ACKNOWLEDGEMENTS.....	36
7.0 LITERATURE CITED.....	37
8.0 APPENDICES	
Appendix A Calculations of suitability of cover type for chinook and coho salmon in clear water.....	40
Appendix B Calculations of effect of cover type on distributions of sockeye and chum salmon.....	44
Appendix C Suitability indices for juvenile salmon for cover, velocity, and depth.....	47

(11 of 23)

CEV

(#20)

JUVENILE SALMON REARING HABITAT MODELS

1984 Report No. 2, Part 4

by Robert P. Marshall, Paul M. Suchanek, and Dana C. Schmidt

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
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Anchorage, Alaska 99503

ABSTRACT

The effects of mainstem discharge on rearing habitat of juvenile salmon in the Susitna River reach between the Chulitna River confluence and Devil Canyon were quantified by use of habitat models. Six slough and side channel sites were sampled at four to seven different levels of mainstem discharge during the 1983 open water season. Data were collected on hydraulic characteristics, cover, water quality, water surface area, and fish density. Suitability criteria were integrated with the habitat data to calculate weighting factors for cover and velocity for selected species at each site. These weighting factors, which were calculated for both shoreline and mid-channel areas, were then combined with area to produce weighted usable areas for the site. A habitat index was then calculated for site comparisons. Peaks in habitat indices for chinook salmon occurred when slough or side channel heads were overtopped. Upland slough habitat indices steadily increased with mainstem discharge. Lack of cover may limit juvenile salmon use of many of the sites.

(12 of 23)

JUVENILE SALMON REARING HABITAT MODELS

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	iv
LIST OF TABLES.....	vi
LIST OF PLATES.....	vii
LIST OF APPENDIX TABLES.....	viii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Field Sampling Design.....	3
2.1.1 Study site location and selection criteria...	3
2.1.2 Sampling grid design.....	3
2.1.3 Cell measurements.....	12
2.2 Data Analysis.....	13
2.2.1 Surface areas.....	13
2.2.2 Model.....	16
2.2.3 Model verification.....	18
3.0 RESULTS.....	20
3.1 Surface Areas.....	20
3.2 Side Channel 10A.....	20
3.3 Slough 22.....	20
3.4 Whiskers Creek Slough.....	29
3.5 Slough 8.....	29
3.6 Slough 5.....	29
3.7 Slough 6A.....	35
3.8 Model Verification.....	35

(#20)

(14 of 23)

	<u>Page</u>
4.0 DISCUSSION.....	39
4.1 Chinook Salmon.....	39
4.2 Coho Salmon.....	39
4.3 Sockeye and Chum Salmon.....	42
4.4 Limitations of the Models Regarding Methodology	42
4.5 Model Verification.....	42
5.0 CONTRIBUTORS.....	45
6.0 ACKNOWLEDGEMENTS.....	46
7.0 LITERATURE CITED.....	47
8.0 APPENDICES	
Appendix A Weighted Usable Area and Habitat Indices Tabulated by Site and Species	48

CEV ✓

(#20) (15423)

RESIDENT FISH DISTRIBUTION AND POPULATION DYNAMICS
IN THE SUSITNA RIVER BELOW DEVIL CANYON

1984 Report No. 2, Part 5

by Richard L. Sundet and Mark N. Wenger

Alaska Department of Fish and Game
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Anchorage, Alaska 99503

ABSTRACT

Studies of resident fish during 1983 were concentrated on the reach of the Susitna River between the Chulitna River confluence and Devil Canyon. With the use of radio telemetry and mark and recapture methods, the seasonal distribution of rainbow trout and estimates of local abundance were obtained. Examination of recapture data over the past several years suggests that the rainbow trout population in this reach is probably less than 4,000 fish. Most of the concentrations are in the smaller tributaries, particularly Fourth of July Creek, which also has the only significant amount of successful spawning documented so far in this portion of the Susitna basin. The large tributaries, Portage Creek and Indian River, had comparatively small numbers of rearing rainbow trout. This species spends much of its annual life cycle in the mainstem Susitna near tributary mouth areas or mixing zone confluences of sloughs. Much of the migratory movements during the summer appear to be in response to the influx of adult salmon spawners, whose eggs apparently provide a major source of food. Radio tagged rainbow trout movement data suggests that the mainstem is important for overwintering. Limited data from tagged rainbow trout below the Chulitna River confluence suggests the reach of river between RM 78.0 and Talkeetna may also be an important overwintering area for Talkeetna River stocks as well. Spawning of round whitefish in October and probably burbot in January is directly influenced by mainstem flows. Young age class Arctic grayling and round whitefish appear to reside in the mainstem Susitna, usually near tributary or slough mouths. Nearly all of the spawning and most of the rearing of older age class Arctic grayling occurs in tributaries. Arctic grayling overwinter in the mainstem Susitna. Dolly Varden are rare in this reach of the Susitna. Selected sites have been established that can be used to monitor catch per unit effort of the resident species, and consequently their response to flow regulation of the proposed hydroelectric project.

(16623)
TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	v
LIST OF TABLES.....	vi
LIST OF PLATES.....	vii
LIST OF APPENDIX FIGURES.....	viii
LIST OF APPENDIX TABLES.....	xi
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Study Locations.....	3
2.1.1 Relative abundance measurements.....	3
2.1.2 Population estimates.....	3
2.1.3 Radio telemetry.....	3
2.2 Data Collection.....	6
2.2.1 Relative abundance.....	6
2.2.2 Population estimates.....	8
2.2.3 Radio telemetry.....	9
2.2.3.1 Equipment.....	9
2.2.3.2 Transmitter implantation.....	9
2.2.3.3 Tracking.....	10
2.3 Data Recording and Analysis.....	13
3.0 RESULTS.....	14
3.1 Rainbow Trout.....	14
3.1.1 Distribution and relative abundance.....	14
3.1.2 Movement and migration.....	14
3.1.3 Population estimates.....	18
3.2 Burbot.....	18
3.2.1 Distribution and relative abundance.....	18
3.2.2 Movement and migration.....	20
3.2.3 Population estimates.....	20

(#20)

(17 of 23)

	Page
3.3 Arctic Grayling.....	20
3.3.1 Distribution and relative abundance.....	20
3.3.2 Movement and migration.....	20
3.4 Round Whitefish.....	23
3.4.1 Distribution and relative abundance.....	23
3.4.2 Movement and migration.....	23
3.5 Humpback Whitefish.....	25
3.5.1 Distribution and relative abundance.....	25
3.5.2 Movement and migration.....	25
3.6 Longnose Sucker.....	25
3.6.1 Distribution and relative abundance.....	25
3.6.2 Movement and migration.....	27
3.7 Other Species.....	27
3.7.1 Dolly Varden.....	27
3.7.2 Threespine stickleback.....	27
3.7.3 Arctic lamprey.....	27
4.0 DISCUSSION.....	28
4.1 Rainbow Trout.....	28
4.2 Burbot.....	32
4.3 Arctic Grayling.....	34
4.4 Round Whitefish.....	36
4.5 Humpback Whitefish.....	38
4.6 Longnose Sucker.....	40
4.7 Other Species.....	41
4.7.1 Dolly Varden.....	41
4.7.2 Threespine stickleback.....	41
4.7.3 Arctic lamprey.....	42
5.0 CONTRIBUTORS.....	43
6.0 ACKNOWLEDGEMENTS.....	44
7.0 LITERATURE CITED.....	45

CE ✓

(20)

(180/23)

Page

8.0 APPENDICES

Appendix A	Gear efficiency and selectivity and tag retention efficiency.....	49
Appendix B	Radio tagged fish movement data	62
Appendix C	Population and biological characteristics.....	65
Appendix D	Population estimates.....	94

CE ✓

(19 of 23)

RESIDENT FISH HABITAT STUDIES

1984 Report No. 2, Part 6

by Paul M. Suchanek, Richard L. Sundet and Mark N. Wenger

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503

ABSTRACT

The macrohabitat distribution and microhabitat suitability for rainbow trout, Arctic grayling, round whitefish, and longnose suckers in the Susitna River drainage between the Chulitna River confluence and Devil Canyon were evaluated using electrofishing, beach seine, and hook and line catch data and habitat data collected at radio telemetry relocation sites (rainbow trout and burbot) and spawning sites (round whitefish).

Turbidity had important effects on distribution of both adult and juvenile resident fish. Longnose suckers and juvenile round whitefish were found in highest numbers in turbid water. Adult rainbow trout, Arctic grayling, and round whitefish found clear water more suitable, but used turbidity for cover. Suitability criteria for velocity, depth, and object cover were fit to the distribution of resident fish. The location of radio tagged rainbow trout among macrohabitat types varied greatly by season.

CE ✓

(#20)

TABLE OF CONTENTS

(20 of 23)

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	iv
LIST OF TABLES.....	v
LIST OF APPENDIX TABLES.....	v
1.0 INTRODUCTION.....	1
2.0 METHODS.....	2
2.1 Study Locations.....	2
2.1.1 Macrohabitat studies.....	2
2.1.2 Microhabitat studies.....	2
2.2 Field Data Collection.....	5
2.2.1 Biological.....	5
2.2.2 Habitat.....	5
2.3 Data Analysis.....	8
2.3.1 Macrohabitat studies.....	8
2.3.2 Microhabitat studies.....	8
2.3.2.1 Adult resident fish.....	8
2.3.2.2 Juvenile resident fish.....	10
3.0 RESULTS.....	12
3.1 Macrohabitat Distribution.....	12
3.1.1 Adult resident fish.....	12
3.1.2 Juvenile resident fish.....	12
3.2 Microhabitat Suitability.....	17
3.2.1 Adult resident fish.....	17
3.2.1.1 Rainbow trout.....	17
3.2.1.2 Arctic grayling.....	23
3.2.1.3 Round whitefish.....	23
3.2.1.4 Longnose suckers.....	23
3.2.1.5 Burbot.....	23
3.2.2 Juvenile resident fish.....	27

CE✓

(#20)

(21 of 23)

	<u>Page</u>
4.0 DISCUSSION.....	29
4.1 Adult Resident Fish.....	29
4.2 Juvenile Resident Fish.....	30
5.0 CONTRIBUTORS.....	32
6.0 ACKNOWLEDGEMENTS.....	33
7.0 LITERATURE CITED.....	34
8.0 APPENDICES	
Appendix A Suitability indices for resident species for cover, velocity, and depth.....	36
Appendix B Round whitefish spawning micro- habitat data.....	38

CEL ✓

(20)

(22 of 23)

MODELLING OF JUVENILE SALMON AND
RESIDENT FISH HABITAT

Report Series No. 2, Part 7

by Stephen S. Hale, Paul M. Suchanek, and Dana C. Schmidt

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Susitna Hydro Aquatic Studies
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ABSTRACT

Output from the Instream Flow Group hydraulic models of rearing habitat for juvenile salmon and resident species at seven sites in the Chulitna River confluence to Devil Canyon reach of the Susitna River leads to similar conclusions as those drawn from a habitat model developed by the Susitna Hydro Aquatic Studies group for six additional sites. Overtopping of side slough heads by mainstem discharge causes abrupt changes in rearing habitat which are of positive benefit for some species/life stages and negative for others. Rearing habitat for chinook salmon at the study sites is greatest when the head of the site is slightly overtopped, thus providing turbid water for cover and moderate water velocities. The portions of this reach which are directly influenced by the mainstem provide only limited rearing habitat for coho and sockeye salmon during the open water season, but are likely to be of major importance for all overwintering species. Resident species are associated with levels of turbidity, velocity, and food supply and in general are not abundant in side sloughs when the head is closed unless a tributary is present.

(#20) (238/23) TABLE OF CONTENTS

Estes ✓

ABSTRACT.....	Page 1
LIST OF FIGURES.....	iii
LIST OF TABLES.....	v
1.0 INTRODUCTION.....	1
2.0 METHODS.....	2
2.1 Study Locations.....	2
2.2 Physical Habitat Modelling.....	5
2.2.1 Instream Flow Group (IFG) PHABSIM Models.....	5
2.2.2 RJ Habitat Model (RJHAB).....	5
2.3 Suitability Criteria.....	6
2.4 Weighted Usable Area Projections.....	6
2.5 Model Verification.....	9
3.0 RESULTS.....	10
3.1 IFG Weighted Usable Area.....	10
3.1.1 Chinook salmon.....	10
3.1.2 Chum and sockeye salmon.....	17
3.1.3 Resident species.....	17
3.2 IFG Model Verification.....	22
3.3 Habitat Indices.....	22
3.3.1 Juvenile salmon.....	31
3.3.2 Resident species.....	31
4.0 DISCUSSION.....	35
4.1 Limitations of the Data.....	35
4.2 Comparison of IFG Models with RJHAB.....	36
4.2.1 Model characteristics.....	36
4.2.2 Model output.....	39
4.3 Summary of Seasonal Habitat Projections for Rearing Salmon and Resident Fish.....	41
5.0 CONTRIBUTORS.....	45
6.0 ACKNOWLEDGEMENTS.....	46
7.0 LITERATURE CITED.....	47

Estes ✓

Intro (p1062)

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(see 21a-j)

SEE #21a + 21j

(p1012)

#21.

CONTENTS OF REPORT NO. 3

Part One

Chapter

- 1 Stage and Discharge Investigations. 21-A
- 2 Channel Geometry Investigations. 21-B
- 3 Continuous Water Temperature Investigations. 21-C
- 4 Water Quality Investigations. 21-D

Part Two

Chapter

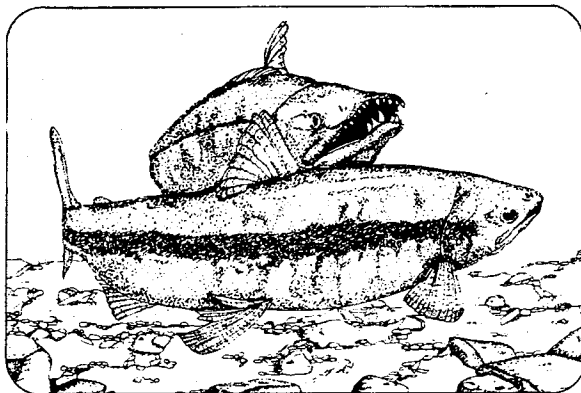
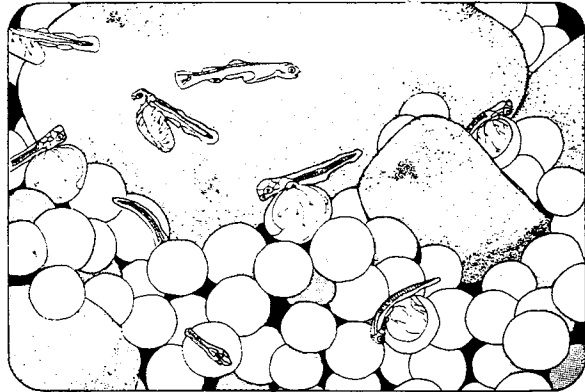
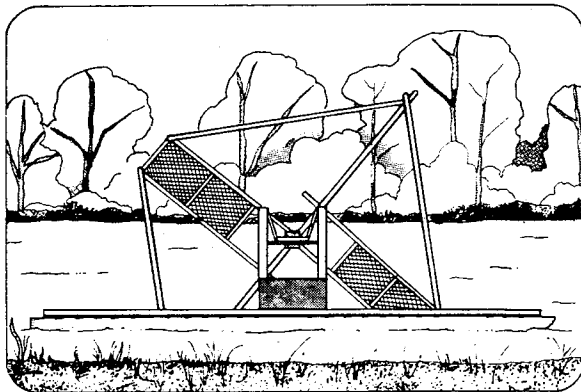
- 5 Eulachon Spawning in the Lower Susitna River. 21-E
- 6 An Evaluation of Passage Conditions for Adult Salmon in Sloughs and Side Channels of the Middle Susitna River. 21-F
63. 7 An Evaluation of Chum and Sockeye Salmon Spawning Habitat in Sloughs and Side Channels of the Middle Susitna River. 21-G
- 8 An Evaluation of Salmon Spawning Habitat in Selected Tributary Mouth Habitats of the Middle Susitna River. 21-H
- 9 Habitat Suitability Criteria for Chinook, Coho, and Pink Salmon Spawning. 21-I
- 10 The Effectiveness of Infrared Thermal Imagery Techniques for Detecting Upwelling Groundwater. 21-J

Questions concerning this and prior reports should be directed to:

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ESTES

(169)

REPORT NO. 3

AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)

Chapter 1: Stage and Discharge Investigations



21a.

APA Doc # 1930

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

CEL

STAGE AND DISCHARGE INVESTIGATIONS

1984 Report No. 3, Chapter 1

by Tim Quane, Pat Morrow, and Tommy Withrow

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
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ABSTRACT

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, streamflow, 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 groundwater 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 streamflow 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.

(3069)

TABLE OF CONTENTS

(#212)

	<u>Page</u>
ABSTRACT	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	ix
LIST OF TABLES.....	xiv
LIST OF APPENDIX FIGURES.....	xvii
LIST OF APPENDIX TABLES.....	xxiii
1.0 INTRODUCTION	1
1.1 Background.....	1
1.2 Objectives.....	3
1.2.1 Mainstem Habitats.....	3
1.2.2 Side Channel, Side Slough and Upland Slough Habitats.....	3
1.2.3 Tributary Habitats.....	4
2.0 METHODS.....	5
2.1 Site Selection.....	5
2.1.1 Mainstem Habitats.....	5
2.1.2 Side Channel, Side Slough and Upland Slough Habitats.....	5
2.1.3 Tributary Habitats.....	11
2.2 Field Data Collection.....	11
2.2.1 Stage.....	11
2.2.2 Discharge Procedures.....	13
2.3 Analytical Approach.....	13
2.3.1 Mainstem Habitats.....	13
2.3.2 Side Channel, Side Slough and Upland Slough Habitats.....	13
2.3.3 Tributary Habitats.....	13

CEV ✓

(#21a)

TABLE OF CONTENTS (Cont.)

(4 of 9)

	<u>Page</u>
3.0 RESULTS.....	14
3.1 Mainstem Habitats.....	14
3.2 Side Channels.....	14
3.2.1 Mainstem 2 Side Channel (RM 114.4).....	17
3.2.1.1 Site Description.....	17
3.2.1.2 General Results.....	18
3.2.1.3 Stage/Discharge Relationship.....	18
3.2.1.4 Mainstem Controlling and Breaching Discharge.....	18
3.2.1.5 Backwater.....	18
3.2.2 Side Channel 10 (RM 133.8).....	25
3.2.2.1 Site Description.....	25
3.2.2.2 General Results.....	25
3.2.2.3 Stage/Discharge Relationship.....	25
3.2.2.4 Mainstem Controlling and Breaching Discharges.....	25
3.2.2.5 Backwater.....	30
3.2.3 Lower Side Channel 11 (RM 134.6).....	30
3.2.3.1 Site Description.....	30
3.2.3.2 General Results.....	30
3.2.3.3 Stage/Discharge Relationship.....	30
3.2.3.4 Mainstem Controlling and Breaching Discharges.....	34
3.2.3.5 Backwater.....	34
3.2.4 Upper Side Channel 11 (RM 136.2).....	34
3.2.4.1 Site Description.....	34

CEV

TABLE OF CONTENTS (Cont.)

	<u>Page</u>
3.2.4.2 General Results.....	34
3.2.4.3 Stage/Discharge Relationship.....	34
3.2.4.4 Mainstem Controlling and Breaching Discharges.....	38
3.2.4.5 Backwater.....	38
3.2.5 Side Channel 21 (RM 141.2).....	38
3.2.5.1 Site Description.....	38
3.2.5.2 General Results.....	38
3.2.5.3 Stage/Discharge Relationship.....	43
3.2.5.4 Mainstem Controlling and Breaching Discharges.....	43
3.2.5.5 Backwater.....	43
3.3 Side Sloughs.....	43
3.3.1 Whiskers Side Slough (RM 101.2).....	48
3.3.1.1 Site Description.....	48
3.3.1.2 General Results.....	48
3.3.1.3 Stage/Discharge Relationship.....	48
3.3.1.4 Mainstem Controlling and Breaching Discharges.....	48
3.3.1.5 Backwater.....	52
3.3.2 Side Slough 8 (RM 133.6).....	52
3.3.2.1 Site Description.....	52
3.3.2.2 General Results.....	52
3.3.2.3 Stage/Discharge Relationship.....	52
3.3.2.4 Mainstem Controlling and Breaching Discharges.....	52
3.3.2.5 Backwater.....	57

CEU

(#21a)

(6 of 9)

TABLE OF CONTENTS (Cont.)

	<u>Page</u>
3.3.3 Side Slough 8A (RM 125.3).....	57
3.3.3.1 Site Description.....	57
3.3.3.2 General Results.....	57
3.3.3.3 Stage/Discharge Relationship.....	57
3.3.3.4 Mainstem Controlling and Breaching Discharges.....	63
3.3.3.5 Backwater.....	63
3.3.4 Side Slough 9 (RM 128.3).....	63
3.3.4.1 Site Description.....	63
3.3.4.2 General Results.....	63
3.3.4.3 Stage/Discharge Relationship.....	68
3.3.4.4 Mainstem Controlling and Breaching Discharges.....	68
3.3.4.5 Backwater.....	68
3.3.5 Side Slough 11 (RM 135.7).....	68
3.3.5.1 Site Description.....	68
3.3.5.2 General Results.....	72
3.3.5.3 Stage/Discharge Relationship.....	72
3.3.5.4 Mainstem Controlling and Breaching Discharges.....	72
3.3.5.5 Backwater.....	72
3.3.6 Side Slough 16B (RM 137.8).....	72
3.3.6.1 Site Description.....	72
3.3.6.2 General Results.....	75
3.3.6.3 Stage/Discharge Relationship.....	75
3.3.6.4 Mainstem Controlling and Breaching Discharges.....	75

CE ✓

(7 of 9)

(#21a)

TABLE OF CONTENTS (Cont.)

	Page
3.3.6.5 Backwater.....	75
3.3.7 Side Slough 20 (RM 140.2).....	75
3.3.7.1 Site Description.....	75
3.3.7.2 General Results.....	80
3.3.7.3 Stage/Discharge Relationship.....	80
3.3.7.4 Mainstem Controlling and Breaching Discharges.....	80
3.3.7.5 Backwater.....	80
3.3.8 Side Slough 21 (RM 141.8).....	80
3.3.8.1 Site Description.....	80
3.3.8.2 General Results.....	85
3.3.8.3 Stage/Discharge Relationship.....	85
3.3.8.4 Mainstem Controlling and Breaching Discharges.....	85
3.3.8.5 Backwater.....	85
3.3.9 Side Slough 22 (RM 144.2).....	90
3.3.9.1 Site Description.....	90
3.3.9.2 General Results.....	90
3.3.9.3 Stage/Discharge Relationship.....	90
3.3.9.4 Mainstem Controlling and Breaching Discharges.....	90
3.3.9.5 Backwater.....	90
3.4 Upland Sloughs.....	95
3.4.1 Upland Slough 6A (RM 112.3).....	95
3.4.1.1 Site Description.....	95
3.4.1.2 General Results.....	95
3.4.1.3 Stage/Discharge Relationship.....	95

CEV

TABLE OF CONTENTS (Cont.)

	<u>Page</u>
3.4.1.4 Backwater.....	95
3.4.2 Upland Slough 19 (RM 140.0).....	98
3.4.2.1 Site Description.....	98
3.4.2.2 General Results.....	98
3.4.2.3 Stage/Discharge Relationship.....	98
3.4.2.4 Backwater.....	98
3.5 Tributaries.....	98
3.5.1 Whiskers Creek (RM 101.4).....	101
3.5.1.1 Site Description.....	101
3.5.1.2 General Results.....	101
3.5.1.3 Stage/Discharge Relationship.....	101
3.5.2 Lane Creek (RM 113.6).....	101
3.5.2.1 Site Description.....	101
3.5.2.2 General Results.....	101
3.5.2.3 Stage/Discharge Relationship.....	105
3.5.3 Fourth of July Creek (RM 131.1).....	105
3.5.3.1 Site Description.....	105
3.5.3.2 General Results.....	105
3.5.3.3 Stage/Discharge Relationship.....	105
3.5.4 Waterfall Creek (RM 140.1).....	105
3.5.4.1 Site Description.....	105
3.5.4.2 General Results.....	105
3.5.4.3 Stage/Discharge Relationship.....	110
3.5.5 Unnamed Tributary at Side Slough 20 (RM 140.1)....	110
3.5.5.1 Site Description.....	110

CEV ✓

(212)

(9869)

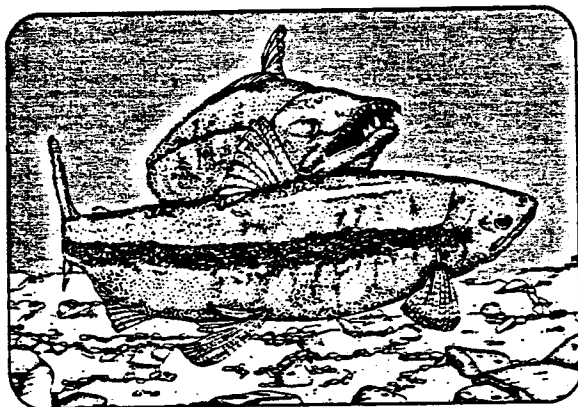
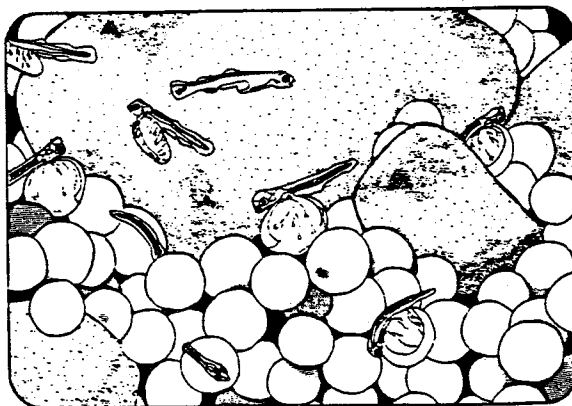
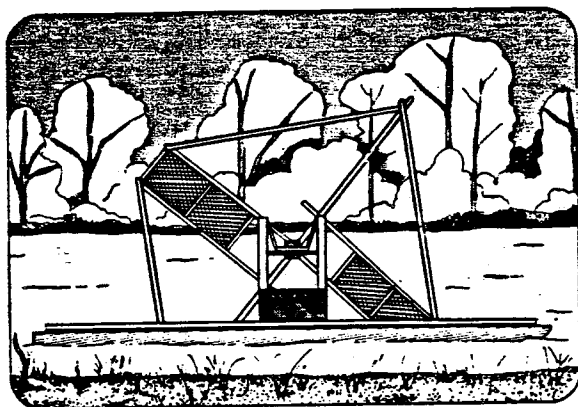
TABLE OF CONTENTS (Cont.)

	<u>Page</u>
3.5.5.2 General Results.....	110
3.5.5.3 Stage/Discharge Relationship.....	110
3.5.6 Gold Creek (RM 136.8).....	110
3.5.6.1 Site Description.....	110
3.5.6.2 General Results.....	110
3.5.6.3 Stage/Discharge Relationship.....	114
3.5.7 Indian River (RM 138.6).....	114
3.5.7.1 Site Description.....	114
3.5.7.2 General Results.....	114
3.5.7.3 Stage/Discharge Relationship.....	114
3.5.8 Portage Creek (RM 148.8).....	120
3.5.8.1 Site Description.....	120
3.5.8.2 General Results.....	120
3.5.8.3 Stage/Discharge Relationship.....	120
4.0 DISCUSSION.....	124
5.0 CONTRIBUTORS.....	129
6.0 ACKNOWLEDGEMENTS.....	130
7.0 LITERATURE CITED.....	131
8.0 GLOSSARY.....	132

CE ✓

606

ESTES ✓



(18/4)

REPORT NO. 3

AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)

Chapter 2: Channel Geometry Investigations



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21b.

APA Doc #1931

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

Channel Geometry Investigations
of the Susitna River Basin

(#216)

1984 Report No. 3, Chapter 2

by: Tim Quane, Isaac Queral, Theresa Keklak, and Don Seagren,

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
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Anchorage, Alaska 99503

ABSTRACT

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 channel 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 hydro-electric development on the Susitna River.

(2 of 4)

CE✓

TABLE OF CONTENTS

(3014)

(#216)

	<u>Page</u>
ABSTRACT	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	iv
LIST OF TABLES.....	viii
LIST OF APPENDIX TABLES.....	x
1.0 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Objectives.....	1
1.2.1 Thalweg Profile Study.....	1
1.2.2 Cross Sectional Profile Studies.....	1
2.0 METHODS.....	3
2.1 Site Selection.....	3
2.1.1 Thalweg Profile Surveys.....	3
2.1.2 Cross Sectional Profile Surveys.....	3
2.2 Field Data Collection.....	3
2.2.1 Thalweg Data Collection Procedures.....	3
2.2.2 Cross Sectional Data Collection Procedures.....	3
2.3 Analytical Approach.....	7
2.3.1 Thalweg Profile Study Analysis.....	7
2.3.2 Cross Sectional Profile Study Analysis.	7
3.0 RESULTS.....	9
3.1 Side Channel Habitats	9
3.1.1 Mainstem 2 Side Channel (RM 114.4).....	9
3.1.2 Side Channel 10 (RM 133.8).....	9
3.1.3 Upper Side Channel 11 (RM 136.2).....	14

CEV ✓

(444)

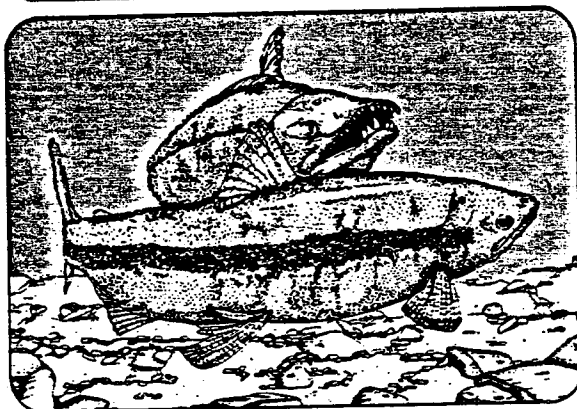
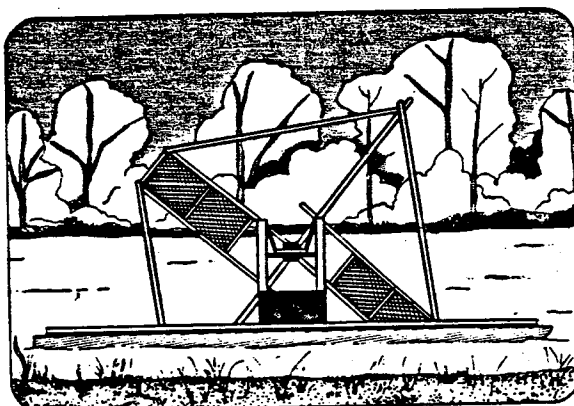
(#216)

3.1.4	Side Channel 21 (RM 140.6).....	21
3.2	Side Slough Habitats.....	21
3.2.1	Whiskers Creek Side Slough (RM 101.2).....	21
3.2.2	Side Slough 8 (RM 113.6).....	25
3.2.3	Side Slough 8A (RM 126.2).....	25
3.2.4	Side Slough 9 (RM 128.3).....	32
3.2.5	Side Slough 9A (RM 133.2).....	32
3.2.6	Side Slough 11 (RM 135.7).....	40
3.2.7	Side Sloughs 16/16B (RM 137.7).....	40
3.2.8	Side Slough 20 (RM 140.2).....	46
3.2.9	Side Slough 21 (RM 141.8).....	46
3.2.10	Side Slough 22 (RM 144.2).....	53
3.3	Upland Slough Habitats.....	53
3.3.1	Upland Slough 6A (RM 112.3).....	59
3.3.2	Upland Slough 10 (RM 133.8).....	59
3.3.3	Upland Slough 19 (RM 140.0).....	64
3.4	Tributary Habitats.....	64
3.4.1	Fourth of July Creek (RM 131.1).....	64
3.4.2	Gold Creek (RM 136.8).....	64
3.4.3	Indian River (RM 138.6).....	64
3.4.4	Portage Creek (RM 148.8).....	71
3.5	General Results.....	71
4.0	DISCUSSION.....	75
5.0	GLOSSARY.....	76
6.0	CONTRIBUTORS.....	79
7.0	ACKNOWLEDGEMENTS.....	80
8.0	LITERATURE CITED.....	81
9.0	APPENDICES.....	82

CE✓

706

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REPORT NO. 3

AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)

Chapter 3: Continuous Water Temperature Investigations



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APA Doc# 1932

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

(H21c)

Continuous Water Temperature Investigations

1984 Report No. 3, Chapter 3

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Susitna Hydro Aquatic Studies
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ABSTRACT

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 Su 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 was 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 from 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 Sloughs 9 and 21. Intragravel temperatures recorded in side channels and side sloughs were influenced by groundwater 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 a fish and fish habitats and to calibrate or validate various temperature models.

i

(2069)

CEV ✓

(#21c)

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	ix
LIST OF TABLES.....	xix
1.0 INTRODUCTION.....	1
1.1 Background.....	1
1.2 FY84 Objectives.....	1
1.2.1 Mainstem Habitats.....	1
1.2.2 Side Channel Habitats.....	1
1.2.3 Side and Upland Slough Habitats.....	2
1.2.4 Tributary Habitats.....	2
2.0 METHODS.....	3
2.1 Site Selection.....	3
2.1.1 Mainstem Habitats.....	3
2.1.2 Side Channel Habitats.....	3
2.1.3 Side and Upland Slough Habitats.....	3
2.1.4 Tributary Habitats.....	3
2.2 Field Data Collection.....	3
2.2.1 Peabody Ryan Temperature Recorders (Thermographs).....	7
2.2.2 Omnidata Temperature Recorders (Datapods).....	7
2.2.3 Advantages and Disadvantages of the Instrumentation.....	8
2.3 Analytical Approach.....	8
2.3.1 Peabody Ryan Temperature Recorders (Thermographs).....	8
2.3.2 Omnidata Temperature Recorders (Datapods).....	9

(349)

CEV ✓

(#21C) (4/8/9)

	<u>Page</u>
3.0 RESULTS.....	10
3.1 Mainstem Habitats.....	10
3.1.1 Lower Reach (Estuary, RM 0.0 to Parks Highway Bridge, RM 83.9).....	10
3.1.1.1 Estuary (RM 4.5) to Mainstem above the Yentna (RM 29.5).....	10
3.1.1.2 Above the Deshka River (RM 41.1) to Parks Highway Bridge (RM 83.9).....	13
3.1.2 Middle Reach (Parks Highway Bridge, RM 83.9 to Devil Canyon, RM 150.0).....	13
3.1.2.1 Parks Highway Bridge (RM 83.9) to Talkeetna Fishwheel Camp (RM 103.0).....	13
3.1.2.2 Talkeetna Fishwheel Camp (RM 103.0), Curry Fishwheel Camp (RM 120.7), Above Gold Creek (RM 136.8), and Devil Canyon (RM 150.0).....	16
3.1.2.3 Curry Fishwheel Camp (RM 120.7), at Gold Creek Bridge (RM 136.6) (site of old USGS recorder), Above Gold Creek (RM 136.8).....	16
3.1.2.4 Talkeetna Fishwheel Camp (RM 103.0), Curry Fishwheel Camp (RM 120.7), Below Gold Creek (RM 135.8), and Above Gold Creek (RM 136.8).....	20
3.1.2.5 LRX 9 (RM 103.2), LRX 29 (RM 126.1), LRX 57 (RM 142.3).....	20
3.1.2.5.1 Surface water temperature at LRX 9 (RM 103.2), LRX 29 (RM 126.1), and LRX 57 (RM 142.3).....	20
3.1.2.5.2 Intragravel water temperatures at LRX 9 (RM 103.2), LRX 29 (RM 126.1), and LRX 57 (RM 142.3).....	24
3.1.2.5.3 Intragravel and surface water temperature at LRX 9 (RM 103.2), LRX 29 (RM 126.1), and LRX 57 (RM 142.3).....	24

✓

(# 21c)

	<u>Page</u>
3.1.2.5.4 Intragravel versus surface water temperature at LRX 9 (RM 103.2).....	24
3.1.2.5.5 Intragravel versus surface water temperature at LRX 29 (RM 126.1).....	28
3.1.2.5.6 Intragravel versus surface water temperature at LRX 57 (RM 142.3).....	28
3.1.2.6 LRX 9 (RM 103.2) and Talkeetna Fishwheel Camp (RM 103.0).....	28
3.1.3 Upper Reach (Devil Canyon, RM 150.0 to above the Oshetna River, RM 235.7).....	28
3.1.4 Susitna River (Parks Highway Bridge, RM 89.3 to above the Oshetna River, RM 235.7).....	32
3.2 Side Channel Habitats.....	32
3.2.1 Side Channel 10 (RM 133.9).....	36
3.2.2 Upper Side Channel 11 - Sites 1 and 2 (RM 136.3).....	36
3.2.3 Side Channel 21 - Sites 1 and 2 (RM 141.0).....	36
3.3 Side and Upland Slough Habitats.....	41
3.3.1 Side Slough 8A (RM 125.6).....	41
3.3.1.1 Lower Side Slough 8A - Sites 2 and 3 (RM 125.6).....	41
3.3.1.2 Upper Side Slough 8A (RM 126.6).....	41
3.3.1.3 Lower Side Slough 8A (RM 125.6) versus Upper Side Slough 8A (RM 126.6).....	45
3.3.2 Side Slough 9 (RM 128.6).....	45
3.3.3 Side Slough 9 Incubation Site (RM 128.3).....	45
3.3.4 Upland Slough 10 - Northeast and Northwest Channels (RM 134.0).....	45
3.3.5 Side Slough 11 (RM 135.7).....	48

(549)

CE✓

(#21C)

	<u>Page</u>
3.3.6 Upland Slough 19 (RM 140.0).....	48
3.3.7 Side Slough 21 (RM 141.8).....	48
3.3.7.1 Lower Side Slough 21 (RM 141.8).....	48
3.3.7.2 Upper Side Slough 21 (RM 142.0).....	48
3.3.7.3 Lower Side Slough 21 (RM 141.8) versus Upper Side Slough 21 (RM 142.0).....	54
3.4 Tributary Habitats.....	54
3.4.1 Tributaries Below Talkeetna.....	54
3.4.1.1 Yentna River (RM 28.0, TRM 4.0).....	54
3.4.2 Tributaries Between Talkeetna and Devil Canyon..	58
3.4.2.1 Talkeetna River (RM 97.2, TRM 1.5).....	58
3.4.2.2 Chulitna River (RM 98.6, TRM 0.6, 2.4, 4.4).....	58
3.4.2.3 Fourth of July Creek (RM 131.1, TRM 0.0).....	58
3.4.2.4 Gold Creek (RM 136.7, TRM 0.2).....	63
3.4.2.5 Indian River (RM 138.6, TRM 1.0).....	63
3.4.2.6 Portage Creek (RM 148.8, TRM 0.2).....	63
3.4.2.7 Comparison of Gold Creek, Indian River and Portage Creek.....	63
3.4.3 Tributaries above Devil Canyon.....	63
3.4.3.1 Tsusena Creek (RM 181.8, TRM 0.1).....	63
3.4.3.2 Deadman Creek (RM 186.7, TRM 0.1).....	75
3.4.3.3 Watana Creek (RM 194.1, TRM 0.1).....	75
3.4.3.4 Kosina Creek (RM 206.8, TRM 0.1).....	75
3.4.3.5 Goose Creek (RM 231.1, TRM 0.1).....	75
3.4.3.6 Oshetna River (RM 233.4, TRM 0.1).....	75

(5 of 9)

CEV

(#21c)

	<u>Page</u>
3.5 Interhabitat Relationships.....	75
3.5.1 Mainstem habitats versus tributary habitats.....	75
3.5.1.1 A comparison of surface water temperatures recorded in the Yentna River and in the Mainstem Susitna River.....	75
3.5.1.2 A comparison of surface water temperatures recorded in the Chulitna and Talkeetna Rivers to mainstem Susitna River surface water temperatures.....	76
3.5.1.3 A comparison of intragravel water temperatures recorded at Fourth of July Creek and in the clearwater plume of Four of July Creek to mainstem Susitna River intragravel temperatures.....	76
3.5.1.4 A comparison of surface water temperatures recorded in Gold Creek to mainstem Susitna River surface water temperatures.....	79
3.5.1.5 A comparison of Indian River surface water temperatures to surface water temperatures recorded in the mainstem Susitna River.....	79
3.5.1.6 A comparison of Portage Creek surface water temperatures to surface water temperatures recorded in the mainstem Susitna River.....	83
3.5.1.7 Mainstem Susitna River and Tributaries above Devil Canyon.....	83
3.5.2 Mainstem Susitna River and Side Channels.....	83
3.5.2.1 Side Channel 10 (RM 134.0) and Mainstem Susitna River above Gold Creek (RM 136.8)	83
3.5.2.2 Upper Side Channel 11 (RM 136.3) and Mainstem Susitna River Above Gold Creek (RM 136.8).....	86

(7069)

(7069)

CE✓

(#21C)

(8 of 9)

	<u>Page</u>
3.5.2.3 Side Channel 21 (RM 141.0) and Mainstem Susitna River at LRX 57 (RM 142.3).....	86
3.5.3 Mainstem Susitna River and Sloughs.....	89
3.5.3.1 Lower Side Slough 8A (RM 125.6) and Mainstem Susitna River at LRX 29 (RM 126.1).....	89
3.5.3.2 Upper Side Slough 8A (RM 126.6) and Mainstem Susitna River at LRX 29 (RM 126.1).....	89
3.5.3.3 Slough 9 (RM 128.6) and Mainstem Susitna River at LRX 29 (RM 126.1).....	89
3.5.3.4 Slough 11 (RM 135.7) and Mainstem Susitna River at LRX 29 (RM 126.1).....	93
3.5.3.5 Slough 19 (RM 140.0) and Mainstem Susitna River at LRX 57 (RM 142.3).....	93
3.5.3.6 Side Slough 21 (RM 141.8) and Mainstem Susitna River at LRX 57 (RM 142.3).....	93
3.5.4 Susitna River Side Channels and Sloughs.....	98
3.5.4.1 Upper Side Channel 11 (RM 136.3) and Slough 11 (RM 135.7).....	98
3.5.4.2 Side Channel 21 (RM 141.0), Lower Slough 21 (RM 141.8), and Upper Slough 21 (RM 142.0).....	98
4.0 DISCUSSION.....	102
4.1 Mainstem Habitats.....	102
4.1.1 Lower Reach (Estuary, RM 0.0 - Parks Highway Bridge, RM 83.9).....	102
4.1.2 Middle Reach (Parks Highway Bridge, RM 83.9 - Devil Canyon, RM 250.0).....	102
4.1.3 Upper Reach (Devil Canyon, RM 150.0 - Above the Oshetna River (RM 234.9, 235.7).....	103
4.2 Side Channel and Side Slough Habitats.....	104
4.3 Upland Slough Habitats.....	105
4.4 Tributary Habitats.....	105

CEV ✓

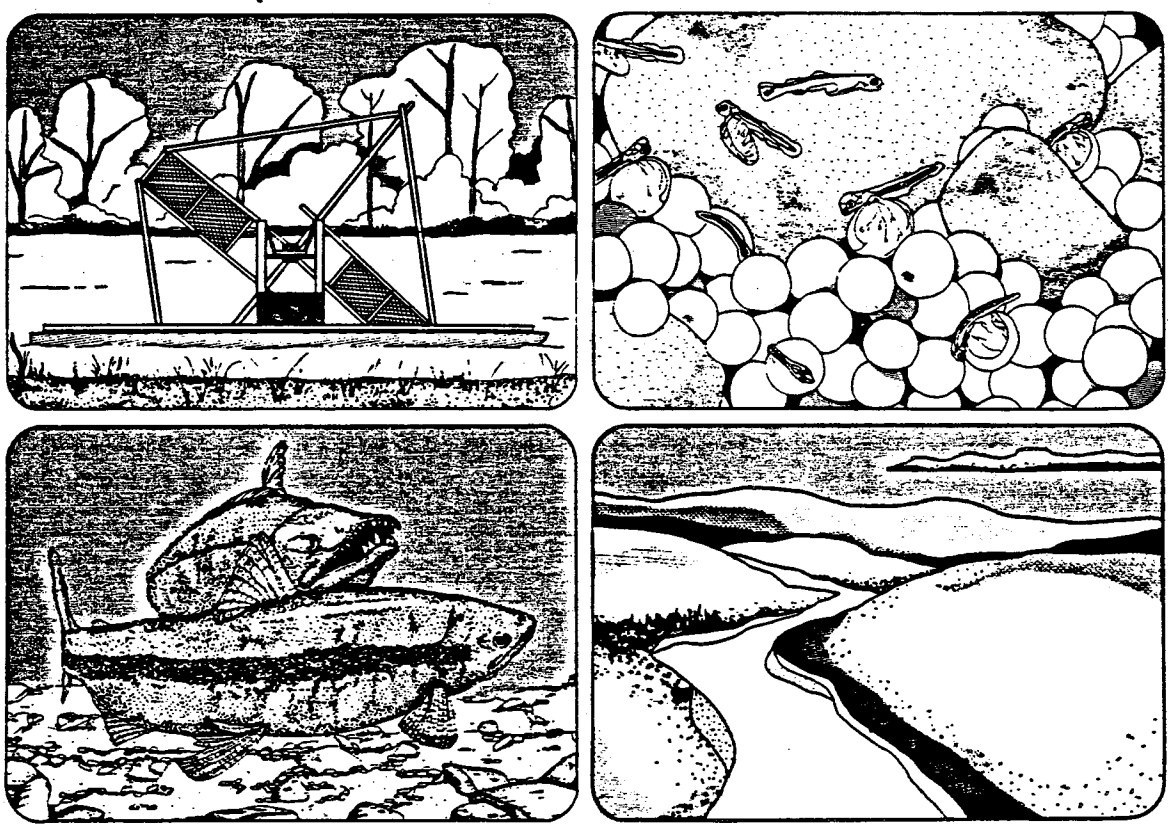
(#21C)

5.0 GLOSSARY.....	107
6.0 CONTRIBUTORS.....	110
7.0 ACKNOWLEDGEMENTS.....	111
8.0 LITERATURE CITED.....	112
9.0 APPENDIX.....	3-A-1

(9 of 9)

180f

Estes)



(1 of 4)

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REPORT NO. 3
AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)
Chapter 4: Water Quality Investigations



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APA Doc # 1933

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

Water Quality Investigations

1984 Report No. 3, Chapter 4

by: Gene Sandone and Tim Quane

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Anchorage, Alaska 99503

ABSTRACT

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 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.

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 the 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 channel 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 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

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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.

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TABLE OF CONTENTS

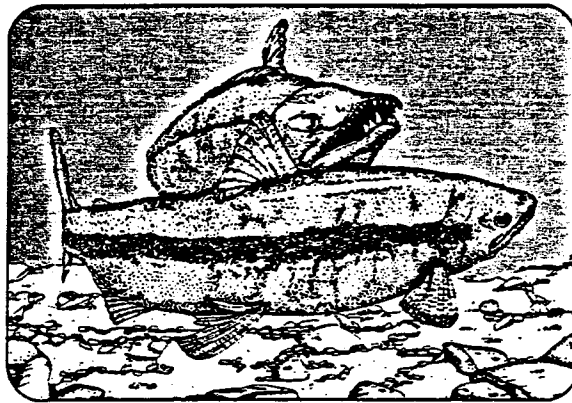
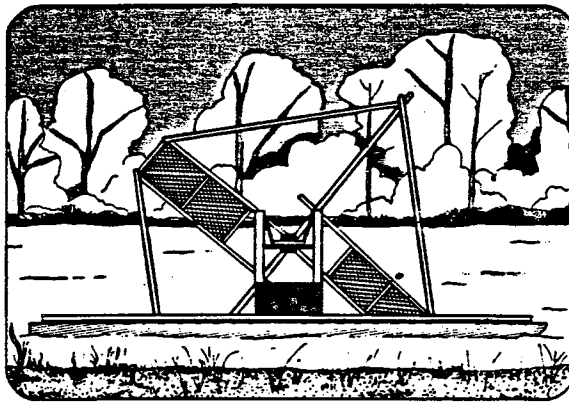
	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	iii
LIST OF FIGURES.....	iv
LIST OF TABLES.....	v
LIST OF APPENDIX TABLES.....	vi
1.0 INTRODUCTION.....	1
1.1 Introduction.....	1
1.2 Objectives.....	1
1.2.1 Mainstem Habitats.....	1
1.2.2 Side Channel and Upland and Side Slough Habitats.....	1
1.2.3 Tributary Habitats.....	2
2.0 METHODS.....	3
2.1 Site Selection.....	3
2.1.1 Mainstem Habitats.....	3
2.1.2 Side Channel and Side and Upland Slough Habitats.....	3
2.1.3 Tributary Habitats.....	3
2.2 Field Data Collection.....	3
2.3 Analytical Approach.....	7
3.0 RESULTS.....	8
3.1 Mainstem Habitats.....	8
3.2 Side Channels and Side and Upland Slough Habitats.....	8
3.3 Tributary Habitats.....	18
4.0 DISCUSSION.....	19
5.0 GLOSSARY.....	24
6.0 CONTRIBUTORS.....	28
7.0 ACKNOWLEDGEMENTS.....	29
8.0 LITERATURE CITED.....	30
9.0 APPENDICES.....	4-A-1

(#014)

CEV

24

ESTES



(193)

REPORT NO. 3

**AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)**

**Chapter 5: Eulachon Spawning Habitat in
the Lower Susitna River**



21e.

APA Doc #1934

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

(# 21 e)

EULACHON SPAWNING
HABITAT IN THE LOWER SUSITNA RIVER.

1984 Report No. 3, Chapter 5

By: Douglas Vincent-Lang
and
Isaac Queral

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ABSTRACT

Eulachon [Thaleichthys pacificus (Richardson)] are an anadromous member of the smelt family. Studies to determine naturally occurring hydraulic and temperature relationships to eulachon immigration 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 1982 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 definite 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.

(243)

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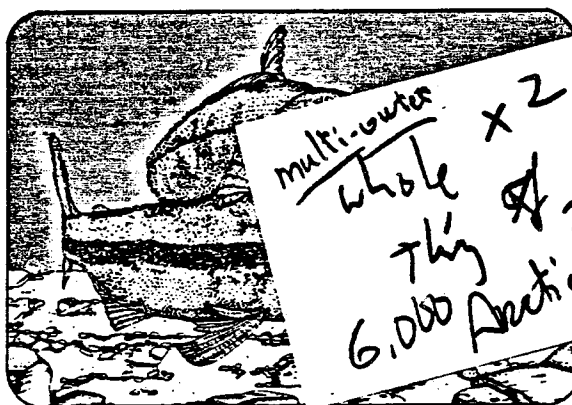
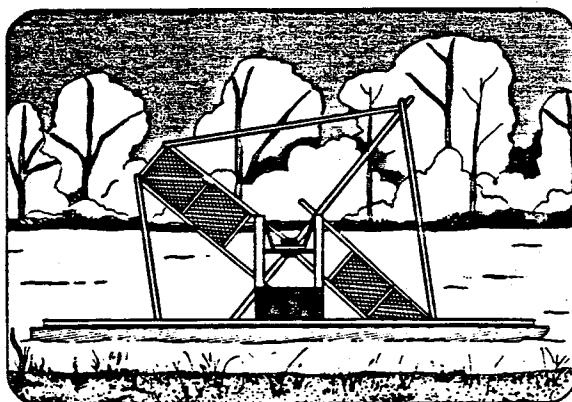
TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	iii
LIST OF APPENDIX FIGURES.....	v
LIST OF TABLES.....	viii
1.0 INTRODUCTION.....	5-1
2.0 METHODS.....	5-3
3.0 RESULTS.....	5-7
4.0 DISCUSSION.....	5-26
5.0 CONTRIBUTORS.....	5-30
6.0 ACKNOWLEDGEMENTS.....	5-31
7.0 LITERATURE CITED.....	5-32
8.0 APPENDIX A.....	5-33

(36/3)

104

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(1065)

REPORT NO. 3

AQUATIC HABITAT AND INSTREAM FLOW INVESTIGATIONS (MAY-OCTOBER 1983)

Chapter 8: An Evaluation of Passage Conditions for
Adult Salmon in Sloughs and Side Channels
of the Middle Susitna River



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APA Dbc#1935

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

(#217)

AN EVALUATION OF PASSAGE CONDITIONS FOR ADULT SALMON
IN SLOUGHS AND SIDE CHANNELS OF THE MIDDLE SUSITNA RIVER

1984 Report, Chapter 6

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ABSTRACT

An interim evaluation of passage conditions for adult Pacific salmon 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 FY85. 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 effects 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.

(2065)

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(#21F)

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	iii
LIST OF FIGURES.....	vi
LIST OF APPENDIX FIGURES.....	viii
LIST OF TABLES.....	xiii
1.0 INTRODUCTION.....	6-1
1.1 Background.....	6-1
1.2 Objective.....	6-5
2.0 METHODS.....	6-6
2.1 Site Selection.....	6-6
2.2 Timing and Distribution of Salmon	6-6
2.2.1 Mainstem Sites.....	6-6
2.2.2 Slough and Side Channel Sites.....	6-7
2.3 Passage of Salmon.....	6-7
2.3.1 Field Methods.....	6-8
2.3.1.1 Thalweg Surveys.....	6-8
2.3.1.2 Cross Sectional Profiles.....	6-8
2.3.1.3 Stage and Flow Measurements.....	6-10
2.3.2 Analytical Methods.....	6-10
2.3.2.1 Definitions of Fish Passage Criteria.....	6-10
2.3.2.2 Identification of Passage Reaches.....	6-16
2.3.2.3 Evaluation of Passage Reaches.....	6-17
2.3.2.3.1 Breaching.....	6-17
2.3.2.3.2 Backwater.....	6-17
2.3.2.3.3 Local Flow.....	6-21

(30/5)

CEV ✓

(# 21f)

Page

3.0 RESULTS

3.1 Timing and Distribution of Salmon.....	6-27
3.1.1 Mainstem Sites.....	6-27
3.1.2 Slough and Side Channel Sites.....	6-27
3.2 Passage of Salmon.....	6-27
3.2.1 Breaching and Backwater Discharges.....	6-38
3.2.2 Local Flow.....	6-38

4.0 DISCUSSION..... 6-45

4.1 Assumptions and Limitations of Analyses.....	6-45
4.1.1 Passage Criteria Assumptions and Limitations.....	6-45
4.1.2 Analytical Assumptions and Limitations.....	6-46
4.2 Timing.....	6-47
4.3 Passage Conditions at Study Sites.....	6-47
4.3.1 Slough Sites.....	6-47
4.3.1.1 Whiskers Creek Slough.....	6-47
4.3.1.2 Slough 8A.....	6-48
4.3.1.3 Slough 9.....	6-48
4.3.1.4 Slough 9A.....	6-49
4.3.1.5 Slough 11.....	6-50
4.3.1.6 Slough 20.....	6-50
4.3.1.7 Slough 21.....	6-51
4.3.1.8 Slough 22.....	6-52
4.3.2 Side Channel Sites.....	6-53
4.3.2.1 Mainstem 2 Side Channel.....	6-53
4.3.2.2 Side Channel 10.....	6-53
4.3.2.3 Upper Side Channel 11.....	6-54
4.3.2.4 Side Channel 21.....	6-54

4.4 Previous Studies: Comparison of Results..... 6-55

5.0 SUMMARY AND CONCLUSIONS..... 6-59

5.1 Summary.....	6-59
5.1.1 Mainstem Influence.....	6-59
5.1.2 Local Flow Influence.....	6-59
5.2 Conclusions.....	6-60
5.2.1 Timing and Distribution of Salmon.....	6-60
5.2.2 Passage of Salmon.....	6-60

CEV ✓

(#21f)

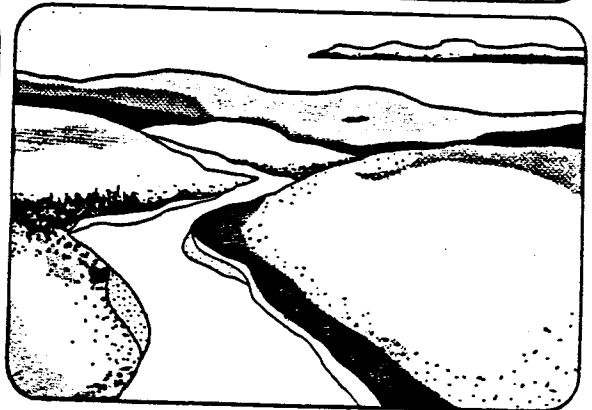
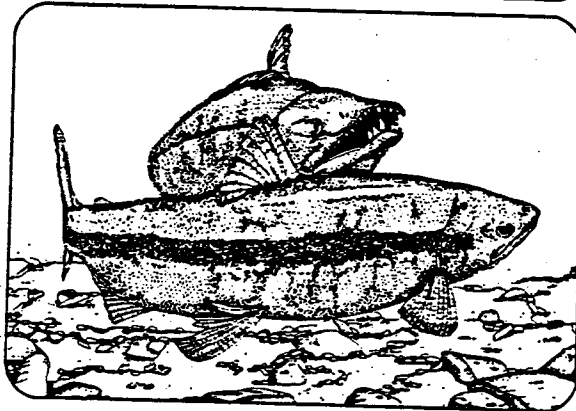
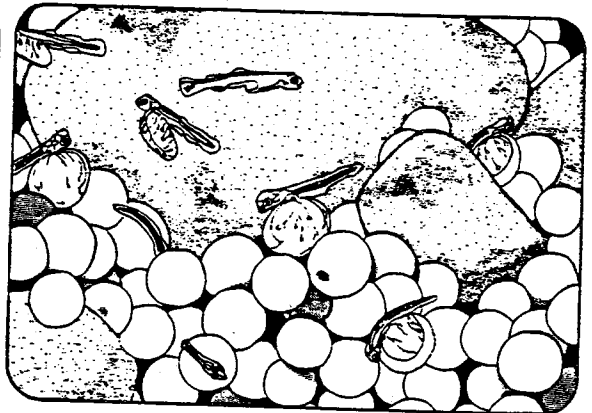
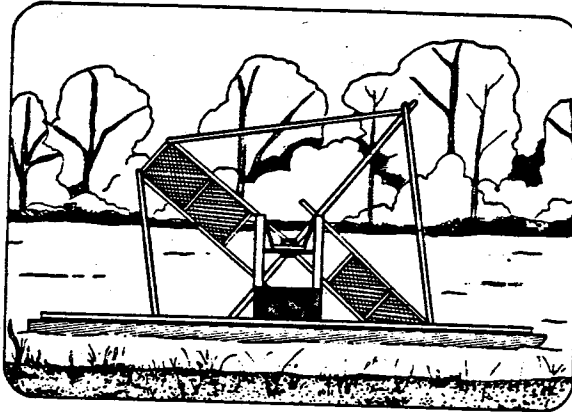
	<u>Page</u>
6.0 GLOSSARY.....	6-62
7.0 CONTRIBUTORS.....	6-66
8.0 ACKNOWLEDGEMENTS.....	6-68
9.0 LITERATURE CITED.....	6-69
10.0 APPENDICES.....	6-71
Appendix A. Site Descriptions.....	6-A-1
Appendix B. Supplement to Methods of Local Flow Analysis.....	6-B-1
Appendix C. Timing Plots.....	6-C-1
Appendix D. Salmon Spawning Distribution Maps.....	6-D-1
Appendix E. Thalweg Profiles of Sloughs and Side Channels....	6-E-1

(5015)

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18 of

Estes



(18 of 7)

REPORT NO. 3

**AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)**

**Chapter 7: An Evaluation of Chum and Sockeye
Salmon Spawning Habitat in Sloughs and
Side Channels of the Middle Susitna River**



21g.

APA Doc #1936

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

(#219)

AN EVALUATION OF CHUM AND SOCKEYE
SALMON SPAWNING HABITAT IN SLOUGHS AND
SIDE CHANNELS OF THE MIDDLE SUSITNA RIVER

1984 Report No. 3, Chapter 7

By:

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ABSTRACT

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 and sockeye salmon spawning habitat usability. Based in available field data, 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.

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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 overtime 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.

(3067)

(#219)

TABLE OF CONTENTS

	<u>Page</u>
PREFACE.....(4067)	
ABSTRACT.....	i
TABLE OF CONTENTS.....	iii
LIST OF FIGURES.....	vii
LIST OF APPENDIX FIGURES.....	xvi
LIST OF TABLES.....	xviii
LIST OF APPENDIX TABLES.....	xxi
LIST OF PLATES.....	xv
FOREWARD.....	7-F-1
1.0 GENERAL INFORMATION.....	7-1-1
1.1 Background and Objectives.....	7-1-1
1.2 Study Approach.....	7-1-3
1.3 Previous Studies.....	7-1-4
2.0 STUDY SITE SELECTION.....	7-2-1
2.1 Study Site Selection Concepts.....	7-2-1
2.2 Study Site Selection.....	7-2-1
2.2.1 Slough Study Sites.....	7-2-1
2.2.2 Side Channel Study Sites.....	7-2-6
2.3 Study Site Descriptions.....	7-2-7
3.0 HYDRAULIC SIMULATION MODELS.....	7-3-1
3.1 Introduction.....	7-3-1
3.2 Methods.....	7-3-1
3.2.1 Analytical Approach.....	7-3-1
3.2.2 General Techniques for Data Collection.....	7-3-3
3.2.3 General Techniques for Calibration.....	7-3-5
3.2.4 General Techniques for Verification.....	7-3-6
3.3 Results.....	7-3-9
3.3.1 Slough 8A.....	7-3-9
3.3.1.1 Site Description.....	7-3-9
3.3.1.2 Data Collected.....	7-3-9
3.3.1.3 Calibration.....	7-3-13
3.3.1.4 Verification.....	7-3-13
3.3.1.5 Application.....	7-3-18

CE ✓

TABLE OF CONTENTS (continued)

(219)

(507)

	Page
3.3.2 Slough 9.....	7-3-20
3.3.2.1 Site Description.....	7-3-20
3.3.2.2 Data Collected.....	7-3-20
3.3.2.3 Calibration.....	7-3-21
3.3.2.4 Verification.....	7-3-26
3.3.2.5 Application.....	7-3-30
3.3.3 Slough 21.....	7-3-30
3.3.3.1 Site Description.....	7-3-30
3.3.3.2 Data Collected.....	7-3-32
3.3.3.3 Calibration.....	7-3-32
3.3.3.4 Verification.....	7-3-37
3.3.3.5 Application.....	7-3-37
3.3.4 Side Channel 10.....	7-3-40
3.3.4.1 Site Description.....	7-3-40
3.3.4.2 Data Collected.....	7-3-40
3.3.4.3 Calibration.....	7-3-42
3.3.4.4 Verification.....	7-3-42
3.3.4.5 Application.....	7-3-47
3.3.5 Lower Side Channel 11.....	7-3-47
3.3.5.1 Site Description.....	7-3-47
3.3.5.2 Data Collected.....	7-3-47
3.3.5.3 Calibration.....	7-3-49
3.3.5.4 Verification.....	7-3-51
3.3.5.5 Application.....	7-3-51
3.3.6 Upper Side Channel 11.....	7-3-55
3.3.6.1 Site Description.....	7-3-55
3.3.6.2 Data Collected.....	7-3-55
3.3.6.3 Calibration.....	7-3-57
3.3.6.4 Verification.....	7-3-57
3.3.6.5 Application.....	7-3-62
3.3.7 Side Channel 21.....	7-3-62
3.3.7.1 Site Description.....	7-3-62
3.3.7.2 Data Collected.....	7-3-62
3.3.7.3 Calibration.....	7-3-64
3.3.7.4 Verification.....	7-3-67
3.3.7.5 Application.....	7-3-73
3.4 Discussion.....	7-3-73
4.0 FISH HABITAT CRITERIA ANALYSIS.....	7-4-1
4.1 Introduction.....	7-4-1
4.2 Methods.....	7-4-1
4.2.1 Site Selection.....	7-4-1
4.2.2 Field Data Collection.....	7-4-2
4.2.3 Analytical Approach.....	7-4-4
4.3 Results.....	7-4-14
4.3.1 Chum Salmon.....	7-4-14
4.3.1.1 Depth Spawning Suitability	
Criteria.....	7-4-16
4.3.1.2 Velocity Spawning Suitability	
Criteria.....	7-4-21
4.3.1.3 Substrate Spawning Suitability	
Criteria.....	7-4-28

TABLE OF CONTENTS (continued)

	Page
4.3.1.4 Upwelling Spawning Suitability Criteria.....	7-4-32
4.3.1.5 Combined Substrate/Upwelling Spawning Suitability Criteria.....	7-4-32
4.3.1.6 Statistical Independence of Habitat Variables Evaluated.....	7-4-32
4.3.2 Sockeye Salmon.....	7-4-32
4.3.2.1 Depth Spawning Suitability Criteria...	7-4-32
4.3.2.2 Velocity Spawning Suitability Criteria.....	7-4-37
4.3.2.3 Substrate Spawning Suitability Criteria.....	7-4-44
4.2.3.4 Upwelling Spawning Suitability Criteria.....	7-4-48
4.2.3.5 Combined Substrate/Upwelling Spawning Suitability Criteria	7-4-50
4.2.3.6 Statistical Independence of Habitat... Variables Evaluated.....	7-4-50
4.4 Discussion.....	7-4-50
4.4.1 Assumptions and Limitations of the Data Base...	7-4-50
4.4.2 Suitability Criteria.....	7-4-55
4.4.2.1 Chum Salmon.....	7-4-55
4.4.2.2 Sockeye Salmon.....	7-4-56
4.4.3 Recommended Applications and Limitations of the Suitability Criteria.....	7-4-56
5.0 SPAWNING HABITAT PROJECTIONS.....	7-5-1
5.1 Introduction.....	7-5-1
5.2 Methods.....	7-5-1
5.2.1 Analytical Approach and Methodology.....	7-5-1
5.2.2 Model Validation.....	7-5-4
5.3 Results.....	7-5-7
5.3.1 Weighted Usable Area Projections.....	7-5-7
5.3.1.1 Chum Salmon.....	7-5-7
5.3.1.2 Sockeye Salmon.....	7-5-14
5.3.2 Model Validation.....	7-5-26
5.4 Discussion.....	7-5-45
5.4.1 Assumptions used in the Application of the Habitat Simulation Models	7-5-45
5.4.2 Weighted Usable Area Projections.....	7-5-47
5.4.3 Recommended Applications and Limitations of the Data.....	7-5-48
6.0 SUMMARY	7-6-1
7.0 GLOSSARY.....	7-7-1
8.0 CONTRIBUTORS.....	7-8-1
9.0 ACKNOWLEDGEMENTS.....	7-9-1

CEV ✓

(#219)

TABLE OF CONTENTS (continued)

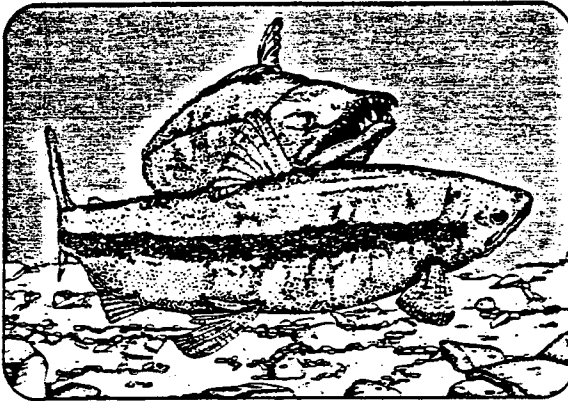
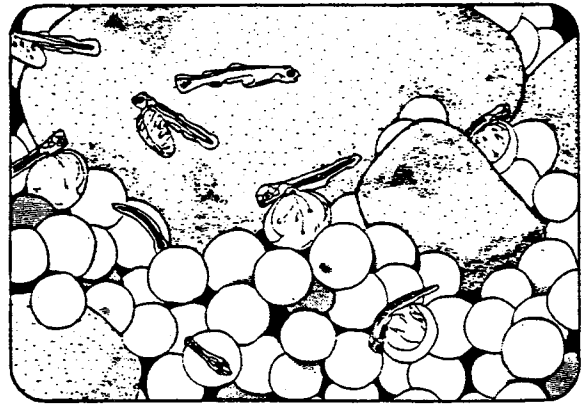
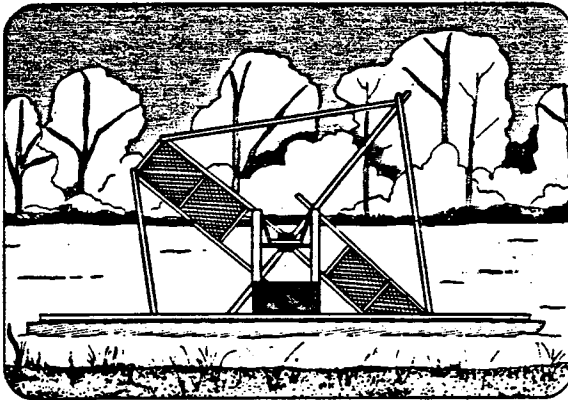
10.0 LITERATURE CITED.....	7-10-1
11.0 APPENDICES.....	7-11-1
Appendix 7-A: Calibration Data and Scatter Plots for Hydraulic Simulation Models	7-A-1
Appendix 7-B: Salmon Spawning Utilization Data.....	7-B-1
Appendix 7-C: Summary of Statistics and Tests for Various.. Groupings of Chum and Sockeye Salmon..... Utilization Histograms.....	7-C-1
Appendix 7-D: Weighted Usable Area Projection Data.....	7-D-1
Appendix 7-E: Flow Chart and Outline of Salmon Habitat..... Analysis.....	7-E-1

(7 of 7)

CEV ✓

124

ESTES



(1083)

REPORT NO. 3

**AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)**

**Chapter 8: Evaluations of Chum Salmon Spawning Habitat
in Selected Tributary Mouth Habitats
of the Middle Susitna River**



21h.

APA Doc #1937

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

(2063)

(#21h)

EVALUATIONS OF CHUM SALMON-SPAWNING HABITAT IN SELECTED TRIBUTARY-MOUTH
HABITATS OF THE MIDDLE SUSITNA RIVER

1984 Report No. 3, Chapter 8

By: Gene Sandone, Doug Vincent-Lang, and Andrew Hoffmann

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ABSTRACT

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 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 in 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.

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TABLE OF CONTENTS

(3063)

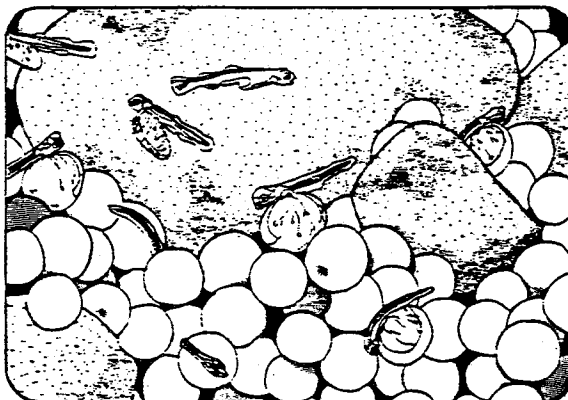
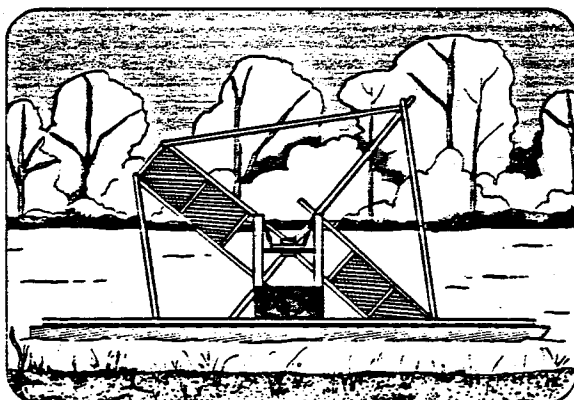
(#21h)

	<u>PAGE</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	iii
LIST OF TABLES.....	vii
1.0 INTRODUCTION.....	8-1
2.0 METHODS.....	8-3
2.1 Site Selection.....	8-3
2.2 Available Habitat.....	8-9
2.3 Usable Habitat.....	8-11
2.4 Utilized Habitat.....	8-14
3.0 RESULTS.....	8-15
3.1 Available Habitat.....	8-15
3.2 Usable Habitat.....	8-31
3.3 Utilized Habitat.....	8-48
4.0 DISCUSSION.....	8-56
4.1 Tributary Mouth Chum Salmon Spawning Habitat.....	8-56
4.2 Limitations of the Data.....	8-59
5.0 GLOSSARY.....	8-63
6.0 CONTRIBUTORS.....	8-65
7.0 ACKNOWLEDGEMENTS.....	8-66
8.0 LITERATURE CITED.....	8-67

CEV ✓

134

Estes



(1 of 3)

REPORT NO. 3

**AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)**

**Chapter 9: Habitat Suitability Criteria for Chinook,
Coho, and Pink Salmon Spawning
in Tributaries of the Middle Susitna River**



21i.

APA Doc # 1938

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

(#211)
(2 of 3)

HABITAT SUITABILITY CRITERIA FOR
CHINOOK, COHO, AND PINK SALMON SPAWNING
IN TRIBUTARIES OF THE MIDDLE SUSITNA RIVER

1984 Report No. 3, Chapter 9

By

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ABSTRACT

Utilization data for the habitat variables of depth, velocity, and substrate composition were collected at chinook salmon spawning sites in selected tributaries of the middle reach of the Susitna River. These data were modified using statistical methods and the professional judgments 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 ft; mean water column velocities ranging from 0.3 to 4.5 ft/sec; and, substrates ranging from small gravels to cobbles are suitable for chinook salmon spawning in these habitats. Suitability criteria were also developed for coho and pink salmon spawning in tributaries of the middle Susitna River based on literature information as modified using the professional judgments of project biologists familiar with Susitna River coho and pink salmon stocks. These criteria show that depths ranging from 0.3 to 4.0 ft; mean water column velocities ranging from 0.1 to 5.0 ft/sec; 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 ft; mean water column velocities from 0.1 to 4.0 ft/sec; 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.

(#211)
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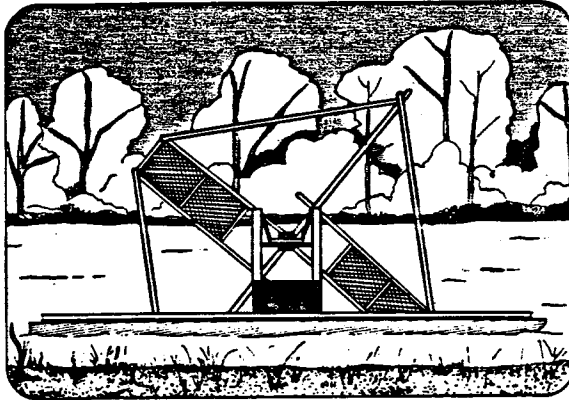
TABLE OF CONTENTS

	Page
ABSTRACT.....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	iii
LIST OF TABLES.....	iv
LIST OF APPENDIX TABLES.....	v
1.0 INTRODUCTION.....	9-1
2.0 METHODS.....	9-2
2.1 Site Selection.....	9-2
2.2 Field Data Collection.....	9-2
2.3 Analytic Approach.....	9-2
3.0 RESULTS.....	9-15
3.1 Chinook Salmon.....	9-15
3.1.1 Depth Spawning Suitability Criteria.....	9-15
3.1.2 Velocity Spawning Suitability Criteria.....	9-21
3.1.3 Substrate Spawning Suitability Criteria.....	9-21
3.1.4 Independence of Habitat Variables Evaluated....	9-27
3.2 Pink Salmon.....	9-27
3.3 Coho Salmon.....	9-36
4.0 DISCUSSION.....	9-40
4.1 Assumption and Limitations of the Data Base.....	9-40
4.2 Suitability Criteria.....	9-41
4.2.1 Chinook Salmon.....	9-41
4.2.2 Pink and Coho Salmon.....	9-42
4.3 Recommended Applications and Limitations of the Suitability Criteria.....	9-42
5.0 GLOSSARY.....	9-44
6.0 CONTRIBUTORS.....	9-48
7.0 ACKNOWLEDGEMENTS.....	9-49
8.0 LITERATURE CITED.....	9-50
9.0 APPENDICES.....	9-52
Appendix 9-A: Chinook Salmon Spawning Habitat Utilization Data.....	9-A-1
Appendix 9-B: Chinook Salmon Utilization Statistics.....	9-B-1

CE ✓

141

Estes



REPORT NO. 3

AQUATIC HABITAT AND INSTREAM FLOW
INVESTIGATIONS (MAY-OCTOBER 1983)

Chapter 10: Evaluations of the Effectiveness of
Applying Infrared Thermal Imagery
Techniques to Detect Upwelling Groundwater

(16/3)



21j.

APA Doc #1939

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

(#215)

EVALUATIONS OF THE EFFECTIVENESS OF APPLYING INFRARED THERMAL IMAGERY
TECHNIQUES TO DETECT UPWELLING GROUNDWATER

1984 Report No. 3, Chapter 10

By:
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and
Christopher Estes

(2013)

Alaska Department of Fish and Game
Susitna Hydro Aquatic Studies
Anchorage, Alaska 99503

ABSTRACT

Studies by the Alaska Department of Fish and Game Susitna Hydroelectric Aquatic Studies Team suggest that upwelling groundwater is one of the principal variables influencing the suitability of habitat for chum 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 groundwater 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 groundwater 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.

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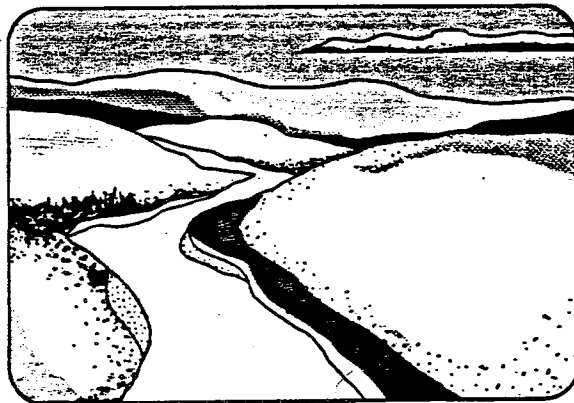
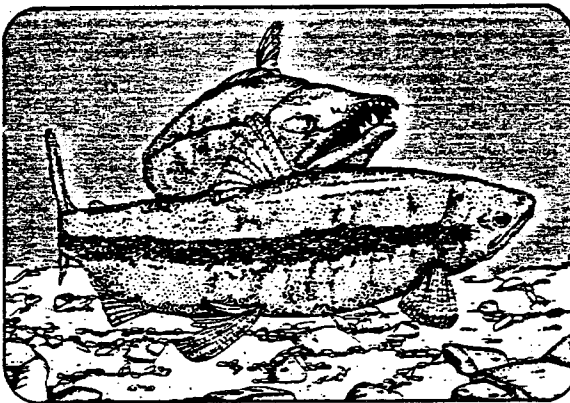
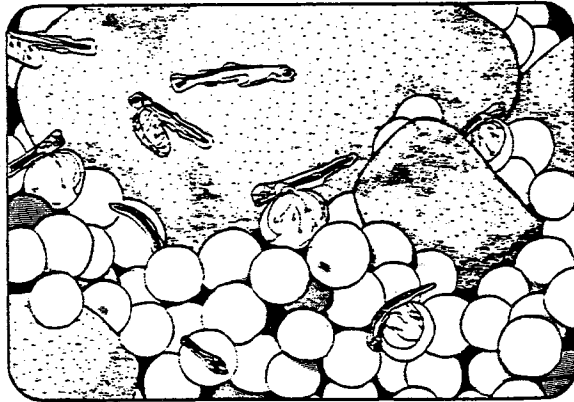
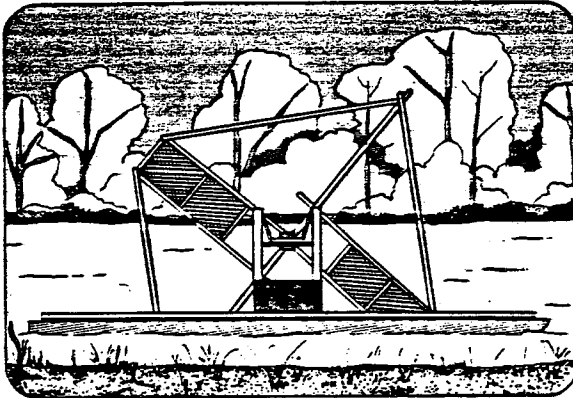
TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	iii
LIST OF TABLES.....	iv
LIST OF PLATES.....	v
1.0 INTRODUCTION.....	10-1
2.0 METHODS.....	10-6
2.1 Site Selection.....	10-6
2.2 Analytical Approach and Field Data Collection.....	10-6
3.0 RESULTS.....	10-12
4.0 DISCUSSION.....	10-20
5.0 GLOSSARY.....	10-22
6.0 CONTRIBUTORS.....	10-23
7.0 ACKNOWLEDGEMENTS.....	10-24
8.0 LITERATURE CITED.....	10-25

(30/3)

ESTES

Report 4 2 parts



(169)

REPORT NO. 4

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



22.

APA Doc #2049

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

CONTENTS OF REPORT NO. 4

(#22)

INTRODUCTION

- Part 1. Access and Transmission Corridor Studies.
- Part 2. Population Dynamics of Arctic Grayling in the Upper Susitna Basin.

(206^a)

CE✓

ACCESS AND TRANSMISSION CORRIDOR STUDIES

(#22)

1984 Report No. 4, Part 1

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(3069)

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ABSTRACT

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

CE ✓

(#22)

(4069)

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	i
LIST OF FIGURES	vi
LIST OF TABLES	viii
LIST OF PLATES	x
1.0 INTRODUCTION	1
1.1 Objectives	1
1.2 Background	3
2.0 METHODS	7
2.1 Selection and Description of Study Locations	7
2.1.1 Streams	7
2.1.2 Lakes	13
2.2 Field Data Collection	13
2.2.1 Biological data	13
Streams	13
Lakes	14
2.2.2 Habitat data	15
Streams	15
Lakes	15
2.3 Data Recording and Analysis	17
3.0 RESULTS	18
3.1 Access Corridor Stream Crossing Studies	18
3.1.1 Lily Creek drainage	24
Stream 1	24
Stream 2 (Lily Creek)	24
3.1.2 Seattle Creek drainage	26
Stream 3 (Seattle Creek)	26
Stream 4	26
Stream 5	26

CE ✓

(#22)

(50/9)

	Page
3.1.3 Brushkana Creek drainage	28
Stream 6	28
Stream 7	28
Stream 8 (Brushkana Creek)	30
Stream 9	30
Stream 10	32
Stream 11	32
3.1.4 Deadman Creek drainage	32
Stream 12 (Deadman Creek)	34
Streams 13 and 14	34
Stream 15	36
Stream 16	36
Stream 17	36
Stream 18	36
Stream 19	38
Streams 20, 21 and 22	38
3.1.5 Tsusena Creek drainage	40
Stream 23 (Tsusena Creek)	40
3.1.6 Swimming Bear Creek drainage	40
Stream 24	41
Stream 25	41
Streams 26 and 27	41
Streams 28 and 29	41
Stream 30	44
Stream 31	44
3.1.7 Devil Creek drainage	44
Stream 32	44
Stream 33	46
Stream 34 (Devil Creek)	46
Streams 35 and 36	46
3.1.8 Jack Long Creek drainage	49
Stream 37	49
Stream 38	49
Stream 39	50
3.1.9 Additional streams	50
Stream 40	50
Stream 41 (Waterfall Creek)	50
Stream 42 (Gold Creek)	51

CE✓

(60/9) (#22)

	Page
3.2 Transmission Corridor Stream Crossing Studies	51
3.3 Deadman Creek Reach Studies	51
3.3.1 Arctic grayling	53
Distribution and relative abundance	53
Age-length composition	53
Population estimates	60
Radio telemetry	60
3.3.2 Lake trout	60
3.3.3 Other species	60
3.4 Selected Lake Studies	60
3.5 Deadman Lake Studies	62
3.5.1 Lake trout	62
Distribution and relative abundance	62
Age-length composition	67
Population estimates	67
3.5.2 Humpback whitefish	67
Distribution and relative abundance	67
Age-length composition	67
Population estimates	69
3.5.3 Round whitefish	69
Distribution and relative abundance	69
Age-length composition	69
3.5.4 Arctic grayling	69
Distribution and relative abundance	69
Age-length composition	69
3.5.5 Other species	70
4.0 DISCUSSION	71
4.1 Access Corridor Stream Crossing Studies	71
4.1.1 Arctic grayling.	72
4.1.2 Dolly Varden	73
4.2 Transmission Corridor Stream Crossing Studies	74
4.3 Deadman Creek Studies	74

CE✓

(7069)

(#22)

Page

4.3.1 Arctic grayling population estimates	74
4.3.2 Arctic grayling age-length composition	75
4.3.3 Arctic grayling radio telemetry.	78
4.4 Selected Lake Studies	79
4.5 Deadman Lake Studies	81
4.5.1 Lake trout	81
4.5.2 Humpback whitefish	81
4.5.3 Round whitefish	82
4.5.4 Arctic grayling	82
4.5.5 Other species	83
5.0 CONTRIBUTORS	84
6.0 ACKNOWLEDGEMENTS	85
7.0 LITERATURE CITED	86

CE✓

POPULATION DYNAMICS OF ARCTIC GRAYLING

IN THE UPPER SUSITNA BASIN

1984 Report No. 4, Part 2

by Dana C. Schmidt and Mike E. Stratton

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Susitna Hydro Aquatic Studies
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ABSTRACT

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

TABLE OF CONTENTS

(#22)

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	iii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	2
2.1 Study Locations.....	2
2.2 Fish Data Collection.....	2
2.3 Data Analysis.....	2
3.0 RESULTS.....	5
3.1 Population Dynamics of Arctic Grayling.....	5
3.2 Sport Fishing Harvest Model.....	10
4.0 DISCUSSION.....	16
5.0 CONTRIBUTORS.....	19
6.0 ACKNOWLEDGEMENTS.....	20
7.0 LITERATURE CITED.....	21
8.0 APPENDICES	
Appendix A. Equations Used to Model Population Changes.....	23

(909)

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Adult Ombudsman Studies
Procedure Manual
(May 84-Apr 85) draft

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- 23 Alaska Department of Fish and Game (ADF&G). 1985. Adult Anadromous Studies Procedures Manual (June 1984 - June 1985). Draft. Susitna Hydro Aquatic Studies Program. Alaska Department of Fish and Game, Anchorage, Alaska (Unpublished report). APA Document #2748.

Technical procedures and data procedures used by Adult Anadromous Studies personnel during the period June 1984 - June 1985 of the Susitna Hydro Aquatic Studies Program are detailed.

An Adult Anadromous Studies procedures manual was not actually produced. Instead objectives and procedures for the period June 1984 - June 1985 were extracted from Barrett, et al, 1985, ADF&G Susitna Hydro Aquatic Studies Report No. 6; APA Document #2748, RTS #29.

(242)

December 1984
Alaska Power Authority
Susitna Hydroelectric Project

(10/5)

Resident and Juvenile Anadromous Studies
Procedures Manual Draft

(May 1984 - April 1985)

24.

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APA Doc #3014

TABLE OF CONTENTS

Page

1.0 INTRODUCTION

2.0 TECHNICAL PROCEDURES

2.1 Study Description and Rationale

2.1.1 Resident and Juvenile Anadromous Fish Studies

2.1.1.1 Sub-Objectives

2.1.1.2 Rationale

2.1.1.3 Field Study Design

2.1.2 Juvenile Outmigration Studies

2.1.2.1 Juvenile Outmigration Studies of the Middle Susitna River

2.1.2.1.1 Sub-Objectives

2.1.2.1.2 Rationale

2.1.2.1.3 Field Study Design

2.1.2.2 Juvenile Outmigration Studies of the Lower Susitna River

2.1.2.2.1 Sub-Objectives

2.1.2.2.2 Rationale

2.1.2.2.3 Field Study Design

2.1.3 Winter Studies of Resident and Juvenile Anadromous Fish

2.1.3.1 Sub-Objectives

2.1.3.2 Rationale

2.1.3.3 Field Study Design

2.2 Field Data Collection Work Plan

2.2.1 Resident and Juvenile Anadromous Fish Studies

2.2.1.1 Resident Fish Studies

2.2.1.1.1 Methods

Habitat and Relative Abundance
Radio Telemetry

2.2.1.1.2 Study Locations

2.2.1.1.3 Schedule of Activities and Frequency of Sampling

2.2.1.2 Juvenile Anadromous Fish Studies

2.2.1.2.1 Methods

Resident Juvenile Habitat (RJHAB) Model Sites

(#24)

(2 of 5)

CEV

Instream Flow Incremental Methodology (IFIM) Sites
Opportunistic Sites

2.2.1.2.2 Study Locations

(# 24)

2.2.1.2.3 Schedule of Activities and Frequency of Sampling

2.2.2 Juvenile Outmigration Studies

2.2.2.1 Juvenile Outmigration Studies of the Middle River

2.2.2.1.1 Methods

Coded Wire Tagging
Talkeetna Stationary Outmigrant Traps
Cold Branding

2.2.2.1.2 Study Locations

(30/5)

Coded Wire Tagging
Talkeetna Stationary Outmigrant Traps
Cold Branding

2.2.2.1.3 Schedule of Activities and Frequency of Sampling

Coded Wire Tagging
Talkeetna Stationary Outmigrant Traps
Cold Branding

2.2.2.2 Juvenile Outmigration Studies of the Lower River

2.2.2.2.1 Methods

Flathorn Stationary Outmigrant Trap
Flathorn Mobile Outmigrant Trap
Deshka River Fyke Net Weir/Minnow Trapping
Talkeetna River Beach Seining

2.2.2.2.2 Study Locations

Flathorn Stationary Outmigrant Traps
Flathorn Mobile Outmigrant trap
Deshka River Fyke Net Weir/Minnow Trapping
Talkeetna River Beach Seining

2.2.2.2.3 Schedule of Activities and Frequency of Sampling

Flathorn Stationary Outmigrant Traps
Flathorn Mobile Outmigrant trap
Deshka River Fyke Net Weir/Minnow Trapping
Talkeetna River Beach Seining

2.2.3 Winter Studies of Resident and Juvenile Anadromous Fish

CEV

2.2.3.1 Resident Fish Studies

2.2.3.1.1 Methods

2.2.3.1.2 Study Locations

2.2.3.1.3 Schedule of Activities and Frequency of Sampling

2.2.3.2 Juvenile Anadromous Fish Studies

2.2.3.2.1 Methods

2.2.3.2.2 Study Locations

2.2.3.2.3 Schedule of Activities and Frequency of Sampling

3.0 DATA PROCEDURES

3.1 Resident and Juvenile Anadromous Fish Studies

3.1.1 Resident Fish Studies

3.1.1.1 Field Data

Habitat and Relative Abundance
Radio Telemetry

3.1.1.2 Data Transfer

3.1.1.3 Data Analysis

3.1.2 Juvenile Anadromous Fish Studies

3.1.2.1 Field Data

Coded Wire Tagging
Talkeetna Stationary Outmigrant Traps
Cold Branding

3.1.2.2 Data Transfer

Talkeetna Stationary Outmigrant Traps
Cold Branding

3.1.2.3 Data Analysis

Coded Wire Tagging
Talkeetna Stationary Outmigrant Traps
Cold Branding

3.2 Juvenile Outmigration Studies

3.2.1 Juvenile Outmigration Studies of the Middle River

(#24)

(4 of 5)

CEC ✓

3.2.1.1 Field Data

Coded Wire Tagging
Talkeetna Stationary Outmigrant Traps
Cold Branding

(#24)

3.2.1.2 Data Transfer

Talkeetna Outmigrant Trap
Cold Branding

(5 of 5)

3.2.1.3 Data Analysis

Coded Wire Tagging
Talkeetna Stationary Outmigrant Traps
Cold Branding

3.2.2 Juvenile Outmigration Studies of the Lower River

3.2.2.1 Field Data

Flathorn Stationary Outmigrant Trap
Flathorn Mobile Outmigrant Trap
Deshka River Fyke Net Weir/Minnow Trapping
Talkeetna River Beach Seining

3.2.2.2 Data Transfer

Flathorn Outmigrant Traps
Deshka River Fyke Net Weir/Minnow Trapping

3.2.2.3 Data Analysis

Flathorn Outmigrant Traps
Deshka River Fyke Net Weir/Minnow Trapping
Talkeetna River Beach Seining

3.3 Winter Studies of Resident and Juvenile Anadromous Fish

3.3.1 Resident Fish Studies

3.3.2 Juvenile Anadromous Fish Studies

3.3.2.1 Field Data

3.3.2.2 Data Transfer

3.3.2.3 Data Analysis

4.0 QUALITY CONTROL

5.0 LITERATURE CITED

CE ✓

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Acoustic Habitat & Instream Flow Studies
Procedures Manual

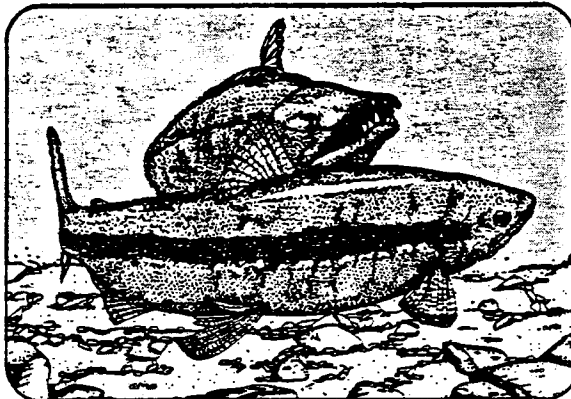
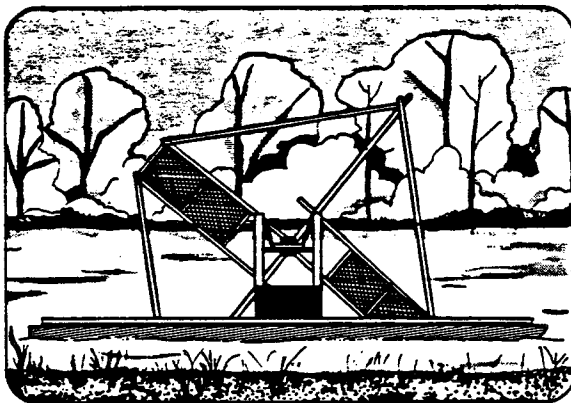
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TASK 32 SUPPORT TECHNICAL REPORT

CONTINUOUS WATER TEMPERATURE INVESTIGATIONS

by: Theresa Keklak and Timothy Quane



(10/3)

25.

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

TABLE OF CONTENTS

(#25)

	<u>Page</u>
TABLE OF CONTENTS.....	i
LIST OF TABLES.....	iii
LIST OF FIGURES.....	xi
1.0 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Objectives.....	1
2.0 METHODS.....	2
2.1 Site Selection.....	2
2.2 Field Data Collection.....	2
2.2.1 Peabody Ryan Temperature Recorder.....	2
2.2.2 Omnidata Temperature Recorder (Datapods).....	5
2.3 Data Analysis.....	6
2.3.1 Peabody Ryan Temperature Recorder (Thermographs).	6
2.3.2 Omnidata Temperature Recorder (Datapods).....	7
3.0 RESULTS.....	7
3.1 Table 2 - Susitna River index of temperatures recorded in mainstem and tributary habitats during the 1984 open water season.....	8
3.2 Tables 3 to 22 - Daily and monthly minimum, mean and maximum temperatures recorded at mainstem Susitna River sites during the 1984 open water season.....	13
3.3 Tables 23 to 36 - Daily and monthly minimum, mean and maximum temperatures recorded at tributary sites during the 1984 open water season.....	105
3.4 Tables 37 to 56 - Water year weeeekly minimum, mean, and maximum temperatures recorded at mainstem Susitna River sites during the 1984 open water season.....	173

(20/3)

CE ✓

TABLE OF CONTENTS (cont.)

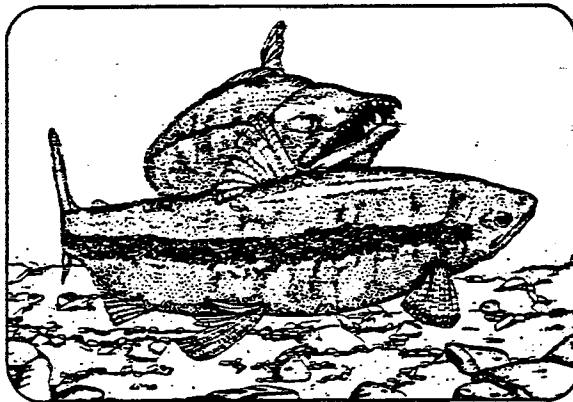
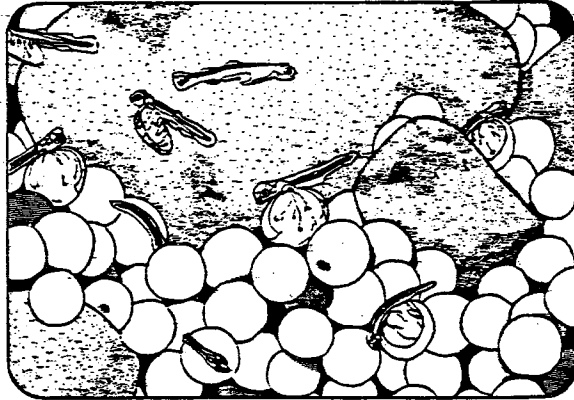
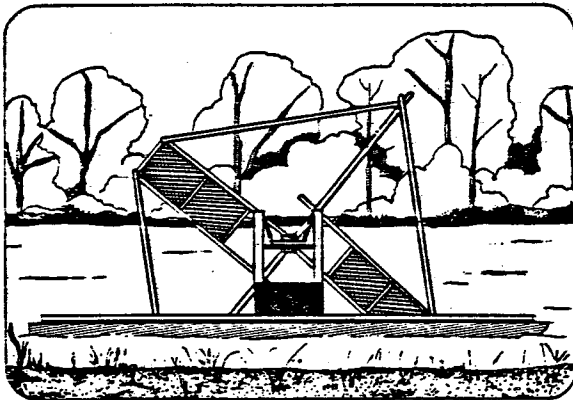
(#25)

3.5	Tables 57 to 70 - Water year weeeekly minimum, mean, and maximum temperatures recorded at tributary sites during the 1984 open water season.....	194
3.6	Table 71 - Water temperature profiles of continuous temperature monitoring sites located in the Susitna River Basin during the 1984 open water season.....	209
3.7	Figures 2 to 16 - Mean daily temperatures recorded at Mainstem Susitna River sites during the 1984 open water season.....	213
3.8	Figures 17 to 28 - Mean daily temperatures recorded at tributary sites suring the 1984 open water season....	229
3.9	Figures 29 to 45 - Site maps depicting locations of study areas in mainstem and tributary habitats during the 1984 open water season.....	242
	LITERATURE CITED.....	265

(3 of 3)

CE✓

ESTES



REPORT NO. 5

WINTER AQUATIC INVESTIGATIONS
(SEPTEMBER 1983-MAY 1984)

Volume 1: An Evaluation of the Incubation
Life-Phase of Chum Salmon in the
Middle Susitna River, Alaska



26a.

APA Doc#2658

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

(#26a)

WINTER AQUATIC INVESTIGATIONS:

SEPTEMBER, 1983 - MAY, 1984

REPORT NUMBER 5

VOLUME 1

AN EVALUATION OF THE INCUBATION LIFE-PHASE OF CHUM SALMON
IN THE MIDDLE SUSITNA RIVER, ALASKA

By:

(2016)

Leonard J. Vining,
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1985

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ABSTRACT

An evaluation of the pattern of survival and development of chum 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 (WVBs) 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% 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.

(# 262)

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% of the total number of WVBs 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 ($p < 0.05$). 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 WVBs. Although there was no significant correlation, the percent survival of embryos decreased to zero when the percent of fines exceeded 18%.

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% 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% 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 temperature 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.

(306)

CEV ✓

(# 26a)

TABLE OF CONTENTS

<u>VOLUME 1</u>	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	iii
LIST OF FIGURES.....	vi
LIST OF APPENDIX FIGURES.....	xiii
LIST OF TABLES.....	xvi
LIST OF APPENDIX TABLES.....	xvii
LIST OF PLATES.....	xviii
1.0 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Objectives.....	5
2.0 METHODS.....	7
2.1 Selection of Study Sites.....	7
2.2 Procedures for Evaluating Physical and Chemical Variables.....	10
2.2.1 Physical Variables.....	14
2.2.1.1 Water Temperature.....	14
2.2.1.2 Substrate Composition.....	14
2.2.1.3 Water Depth and Velocity.....	16
2.2.1.4 Turbidity.....	16
2.2.2 Chemical Variables.....	16
2.2.2.1 Dissolved Oxygen.....	16
2.2.2.2 pH.....	18
2.2.2.3 Conductivity.....	18
2.3 Salmon Embryo Development and Survival.....	18
2.3.1 Whitlock-Vibert Incubation Boxes.....	18
2.3.2 Analysis of Development and Survival of Embryos.....	21

(4 of 6)

CEL ✓

(#262)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.3.2.1 Embryonic Development.....	21
2.3.2.2 Embryonic Survival.....	29
2.3.2.2.1 Handling Mortality.....	30
2.3.2.2.2 Flatworms.....	30
2.4 Interpretation of Figures.....	30
3.0 RESULTS.....	33
3.1 Comparison of Physical and Chemical Characteristics of Study Sites and Habitat Types.....	33
3.1.1 Physical Characteristics.....	33
3.1.1.1 Water Temperature.....	33
3.1.1.1.1 Instantaneous Intragravel Water Temperatures.....	33
3.1.1.1.2 Comparison of Instantaneous Surface and Intragravel Water Temperatures.....	33
3.1.1.1.3 Continuous Intragravel Water Temperatures..	41
3.1.1.2 Substrate Composition.....	41
3.1.2 Chemical Characteristics.....	58
3.1.2.1 Dissolved Oxygen.....	58
3.1.2.2 pH.....	58
3.1.2.3 Conductivity.....	70
3.2 Comparison of Embryo Survival and Development at Study Sites and Habitat Types.....	70
3.2.1 Embryo Survival.....	78
3.2.1.1 Accumulation of Fine Substrate Particles.....	78
3.2.1.2 Survival Estimates.....	78
3.2.2 Embryo Development.....	83
3.3 Effects of Physical, Chemical and Biological Habitat Variables on Embryo Survival at Study Sites and Habitats.....	85
3.3.1 Physical Variables.....	85
3.3.2 Chemical Variables.....	89
3.3.3 Biological Variables.....	95

(50/6)

CE✓

TABLE OF CONTENTS (Continued)

(# 26a)

	<u>Page</u>
4.0 DISCUSSION.....	96
4.1 Assumptions and Limitations.....	96
4.2 Physical, Chemical, and Biological Habitat Conditions Associated with Chum Salmon Development and Survival.....	99
4.2.1 Upwelling.....	99
4.2.2 Dewatering and Freezing.....	100
4.2.3 Substrate.....	101
4.2.4 Water Temperature.....	105
4.2.5 Dissolved Oxygen.....	110
4.2.6 pH.....	111
4.2.7 Conductivity.....	114
4.2.8 Turbidity.....	115
4.2.9 Flatworms.....	115
4.3 Conclusions/Recommendations.....	116
4.3.1 Conclusions.....	116
4.3.2 Recommendations.....	118
5.0 CONTRIBUTORS.....	120
6.0 ACKNOWLEDGEMENTS.....	121
7.0 LITERATURE CITED.....	122
8.0 APPENDICES.....	131
Appendix A. Embryo Development and Survival Data.....	A-1
Appendix B. Study Site Maps.....	B-1
Appendix C. Water Quality Data.....	C-1
Appendix D. Substrate Data.....	D-1
Appendix E. Additional Habitat Data.....	E-1

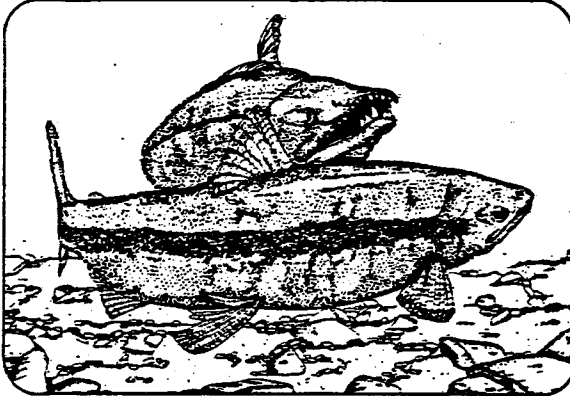
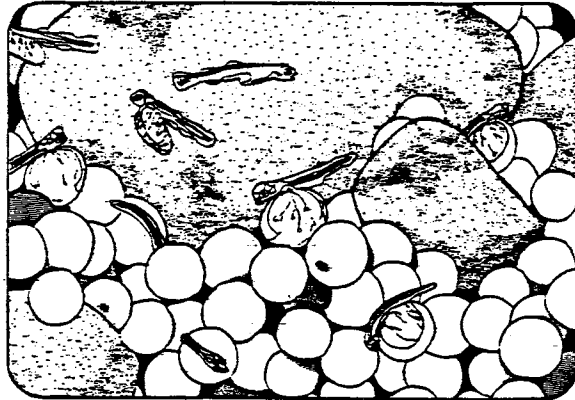
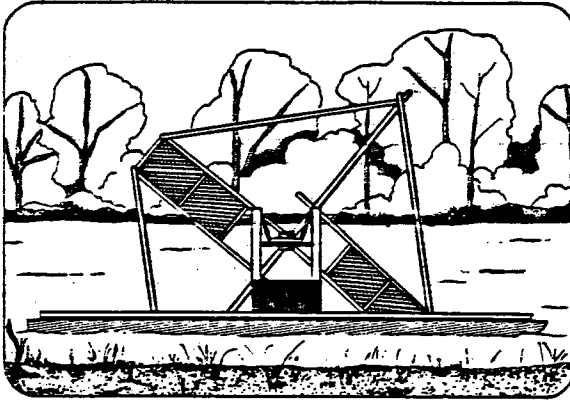
VOLUME 2

Appendix F. Winter Temperature Data

(6 of 6)

CEV ✓

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REPORT NO. 5

**WINTER AQUATIC INVESTIGATIONS
(SEPTEMBER 1983-MAY 1984)**

Volume 2: Appendix F

Winter Temperature Data



(1075)

26b.

APA Doc#2659

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

(#26b)

Appendix F: Winter Temperature Data

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Appendix F is presented in standard report format including an introduction section, an objectives section, a methods section, a results section, and a discussion section. This format was selected to increase the usability of the information for purposes other than those related to salmon incubation. The appendix is limited to a summarization and review of the temperature data. Subsequent analyses are addressed in the body of this report and in other reports.

(2 of 5)

CEV ✓

TABLE OF CONTENTS

(#26b)

	<u>Page</u>
TABLE OF CONTENTS.....	i
LIST OF APPENDIX FIGURES.....	iv
LIST OF APPENDIX TABLES.....	ix
1.0 INTRODUCTION.....	F-1
1.1 Background.....	F-1
1.2 Objectives.....	F-1
2.0 METHODS.....	F-2
2.1 Site Selection.....	F-2
2.1.1 Mainstem Temperature Evaluation.....	F-2
2.1.2 Chum Salmon Spawning/Incubation Temperature Evaluation.....	F-2
2.1.3 Preliminary Mitigation Evaluation.....	F-2
2.2 Field Data Collection.....	F-2
2.2.1 Peabody-Ryan Temperature Recorders (Thermographs).....	F-6
2.2.2 Omnidata Temperature Recorders (Datapods).....	F-6
2.3 Data Analysis.....	F-7
2.3.1 Peabody-Ryan Temperature Recorders (Thermographs).....	F-7
2.3.2 Omnidata Temperature Recorders (Datapods).....	F-7
3.0 RESULTS.....	F-9
3.1 Mainstem Temperature Evaluation.....	F-9
3.1.1 LRX 9 - Sites 1 and 2 (RM 103.2) and Site 3 (RM 103.5)..	F-9
3.1.2 LRX 29 (RM 126.1).....	F-11
3.1.3 LRX 57 (RM 142.3).....	F-11
3.2 Chum Salmon Spawning/Incubation Temperature Evaluation.....	F-14
3.2.1 Mainstem Habitats.....	F-14

(3 of 5)

CE✓

TABLE OF CONTENTS (Continued)

(# 266)
Page

3.2.1.1 Mainstem Susitna River at RM 136.1.....	F-14
3.2.2 Side Channel Habitats.....	F-14
3.2.2.1 Side Channel 10 (RM 134.0).....	F-14
3.2.2.2 Upper Side Channel 11 (RM 136.3).....	F-16
3.2.2.3 Side Channel 21 (RM 141.0).....	F-20
3.2.3 Slough Habitats.....	F-24
3.2.3.1 Slough 8A.....	F-24
3.2.3.1.1 Lower Slough 8A (RM 125.6).....	F-27
3.2.3.1.2 Upper Slough 8A (RM 126.6).....	F-27
3.2.3.1.3 Upper Slough 8A and Lower Slough 8A.....	F-30
3.2.3.2 Slough 9 (RM 128.6).....	F-30
3.2.3.3 Slough 10.....	F-30
3.2.3.3.1 Slough 10 Northeast Channel (RM 134.0).....	F-30
3.2.3.3.2 Slough 10 Northwest Channel (RM 134.0).....	F-34
3.2.3.3.3 Slough 10 Northeast and Slough 10 Northwest.....	F-34
3.2.3.4 Slough 11 (RM 135.7).....	F-34
3.2.3.5 Slough 21.....	F-38
3.2.3.5.1 Lower Slough 21 (RM 141.8).....	F-38
3.2.3.5.2 Upper Slough 21 (RM 142.0).....	F-38
3.2.3.5.3 Upper Slough 21 and Lower Slough 21.....	F-38
3.2.4 Tributary Habitats.....	F-42
3.2.4.1 Fourth of July Creek (RM 131.1; TRM 0.0).....	F-42
3.2.4.2 Indian River (RM 138.6; TRM 0.2).....	F-42
3.3 Preliminary Mitigation Evaluation.....	F-46
3.3.1 Deadhorse Creek (RM 120.9; TRM 1.0).....	F-46
3.4 Habitat Relationships.....	F-46

(4 of 5)

CEV

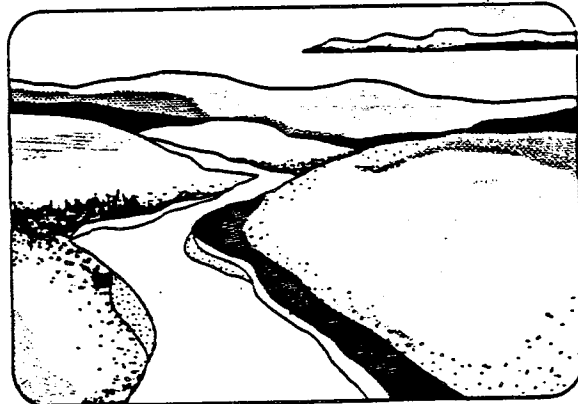
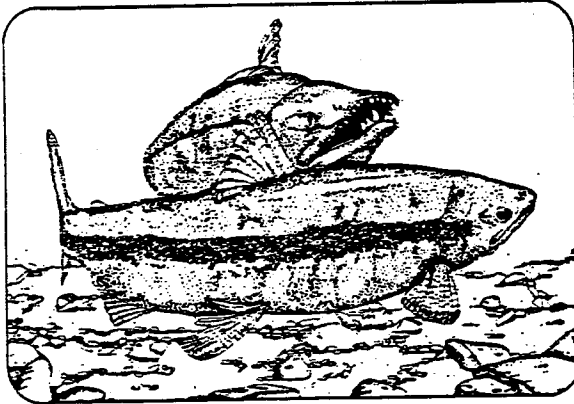
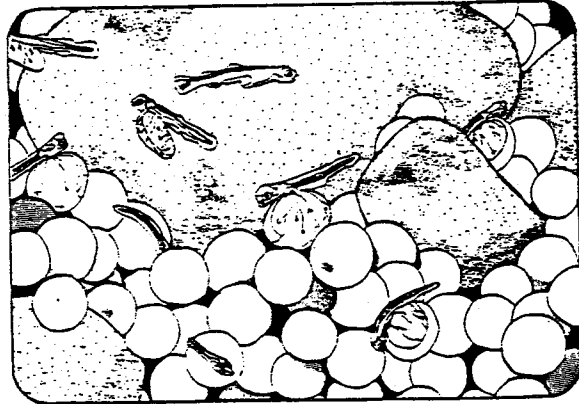
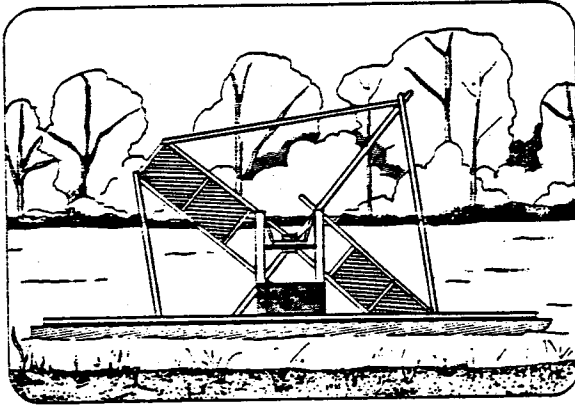
(# 26b)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.4.1 Mainstem Habitat Relationships.....	F-46
3.4.1.1 Surface Water Temperatures at LRX 9 (RM 103.2, RM 103.5), LRX 29 (RM 126.1) and LRX 57 (RM 142.3).....	F-46
3.4.1.2 Intragravel Water Temperatures at LRX 9 (103.2 RM 103.5), LRX 29 (RM 126.1), and LRX 57 (RM 142.3).....	F-49
3.4.2 Side Channel Habitat Relationships.....	F-49
3.4.2.1 Surface Water Temperatures at Side Channels 10 (RM 134.0), Upper 11 (RM 136.3), and 21 (RM 141.0)..	F-49
3.4.2.2 Intragravel Water Temperatures at Side Channels 10 (RM 134.0), Upper 11 (RM 136.3), and 21 (RM 141.0)..	F-49
3.4.3 Slough Habitat Relationships.....	F-53
3.4.3.1 Surface Water Temperatures at Side Sloughs 8A (RM 126.6), 9 (RM 128.6), 11 (RM 135.7), and 21 (RM 142.0).....	F-53
3.4.3.2 Intragravel Water Temperatures at Side Sloughs 8A (RM 126.6), 9 (RM 128.6), 11 (RM 135.7), and 21 (RM 142.0).....	F-53
3.4.4 Interhabitat Relationships.....	F-56
3.4.4.1 Slough 8A (RM 125.6, 126.6) and Susitna River at LRX 29 (RM 126.1).....	F-56
3.4.4.2 Upper Side Channel 11 (RM 136.3) and Slough 11 (RM 135.7).....	F-56
3.4.4.3 Slough 21 (RM 141.8, RM 142.0), Side Channel 21 (RM 141.0), and Susitna River at LRX 57 (RM 142.3).....	F-56
4.0 DISCUSSION.....	F-64
4.1 Mainstem Temperature Evaluation.....	F-64
4.2 Chum Spawning/Incubation Temperature Evaluation.....	F-65
4.3 Preliminary Mitigation Evaluation.....	F-67
5.0 LITERATURE CITED.....	F-320
6.0 CONTRIBUTORS.....	F-321

(5015)

ESTES



(16/4)

TASK 36 SUPPORT TECHNICAL REPORT

**HYDROLOGICAL INVESTIGATIONS AT SELECTED
LOWER SUSITNA RIVER STUDY SITES**

by: Tim Quane, Pat Morrow, and Isaac Queral
Aquatic Habitat and Instream Flow Project



#27.

APA Doc #2704

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

(#27)

TABLE OF CONTENTS

	<u>Page</u>
1.0 OBJECTIVES OF STUDY.....	1
2.0 METHODS.....	2
2.1 Site Selection.....	2
2.2 Field Data Collection.....	2
2.2.1 Stage.....	4
2.2.2 Streamflow.....	4
2.2.3 Channel Geometry.....	5
2.2.3.1 Thalweg Profile.....	5
2.2.2.2 Cross Section Profile.....	6
2.3 Data Analysis.....	6
2.3.1 Stage and Streamflow.....	6
2.3.2 Initial Breaching and Controlling Discharges.....	8
2.3.2.1 Initial Breaching Discharges.....	8
2.3.2.2 Controlling Breaching Discharge.....	8
2.3.3 Backwater.....	9
2.3.4 Channel Geometry.....	10
2.3.4.1 Thalweg Profile.....	10
2.3.4.2 Cross Section Profile.....	11
3.0 RESULTS.....	12
3.1 Island Side Channel (RM 63.3).....	12
3.1.1 Site Description.....	12
3.1.2 Stage/Discharge Relationship.....	15
3.1.3 Mainstem Controlling and Breaching Discharges.....	20
3.1.4 Channel Geometry.....	23
3.1.4.1 Thalweg Profile.....	23
3.1.4.2 Cross Section Profile.....	25
3.1.5 Backwater.....	25
3.2 Mainstem West Bank Side Channel (RM 74.4).....	27
3.2.1 Site Description.....	27
3.2.2 Stage/Discharge Relationship.....	30
3.2.3 Mainstem Controlling and Breaching Discharges.....	33
3.2.4 Channel Geometry.....	35

20/4

CEV ✓

(#27)

TABLE OF CONTENTS (Continued)

	Page
3.2.4.1 Thalweg Profile.....	35
3.2.4.2 Cross Section Profile.....	36
3.2.5 Backwater.....	36
3.3 Circular Side Channel (RM 75.3).....	39
3.3.1 Site Description.....	39
3.3.2 Stage/Discharge Relationship.....	41
3.3.3 Mainstem Controlling and Breaching Discharges.....	41
3.3.4 Channel Geometry.....	48
3.3.4.1 Thalweg Profile.....	48
3.3.4.2 Cross Section Profile.....	48
3.3.5 Backwater.....	48
3.4 Sauna Side Channel (RM 79.8).....	51
3.4.1 Site Description.....	51
3.4.2 Stage/Discharge Relationship.....	52
3.4.3 Mainstem Controlling and Breaching Discharges.....	57
3.4.4 Channel Geometry.....	58
3.4.4.1 Thalweg Profile.....	58
3.4.4.2 Cross Section Profile.....	58
3.4.5 Backwater.....	60
3.5 Sunset Side Channel (RM 86.9).....	60
3.5.1 Site Description.....	60
3.5.2 Stage/Discharge Relationship.....	67
3.5.3 Mainstem Controlling and Breaching Discharges.....	67
3.5.4 Channel Geometry.....	69
3.5.4.1 Thalweg Profile.....	69
3.5.4.2 Cross Section Profile.....	69
3.5.5 Backwater.....	69
3.6 Trapper Creek Side Channel (RM 91.6).....	72
3.6.1 Site Description.....	72
3.6.2 Stage/Discharge Relationship.....	75
3.6.3 Mainstem Controlling and Breaching Discharges.....	78
3.6.4 Channel Geometry.....	80

(30 of 4)

CE ✓

TABLE OF CONTENTS (Continued)

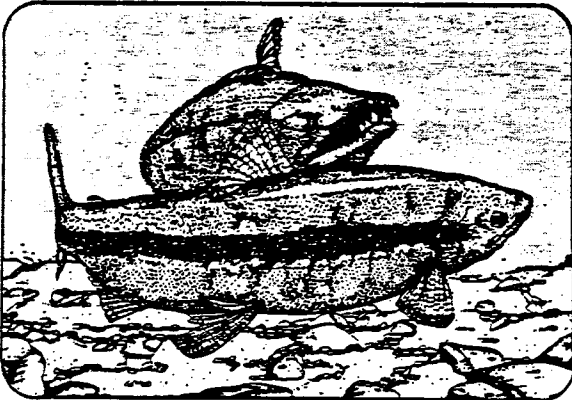
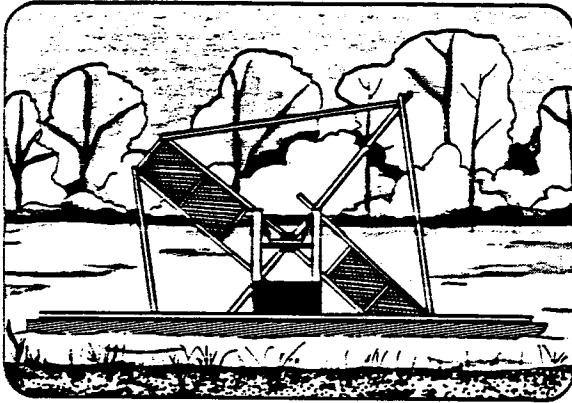
(#27)

	<u>Page</u>
3.6.4.1 Thalweg Profile.....	80
3.6.4.2 Cross Section Profile.....	80
3.6.5 Backwater.....	81
4.0 SUMMARY.....	84
5.0 GLOSSARY.....	91
6.0 CONTRIBUTORS.....	96
7.0 ACKNOWLEDGEMENTS.....	97
8.0 LITERATURE CITED.....	98
9.0 ATTACHMENTS.....	

(40/4)

CE ✓

ESTES



(1687)

TASK 14 SUPPORT TECHNICAL REPORT

**HYDROLOGICAL INVESTIGATIONS AT SELECTED
LOWER SUSITNA RIVER STUDY SITES**

by: Timothy Quane, Patrick Morrow, and Isaac Queral
Aquatic Habitat and Instream Flow Project



#28.

APA Doc #2736

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

(# 28)

TABLE OF CONTENTS

	<u>Page</u>
TABLE OF CONTENTS.....	i
LIST OF FIGURES.....	vii
LIST OF TABLES.....	xiii
LIST OF ATTACHMENT FIGURES.....	xiv
LIST OF ATTACHMENT TABLES.....	xxiii
 1.0 OBJECTIVES OF STUDY.....	 1
 2.0 METHODS.....	 2
2.1 Site Selection.....	2
2.2 Field Data Collection.....	2
2.2.1 Stage.....	2
2.2.2 Streamflow.....	5
2.2.3 Channel Geometry.....	5
2.2.3.1 Thalweg Profile.....	5
2.2.3.2 Cross Section Profile.....	6
2.3 Data Analysis.....	7
2.3.1 Stage and Streamflow.....	7
2.3.2 Initial Breaching and Controlling Discharges.....	8
2.3.2.1 Initial Breaching Discharge.....	8
2.3.2.2 Controlling Breaching Discharge.....	9
2.3.3 Backwater.....	10
2.3.4 Channel Geometry.....	10
2.3.4.1 Thalweg Profile.....	11
2.3.4.2 Cross Section Profile.....	11
 3.0 RESULTS.....	 13
3.1 Hooligan Side Channel (RM 35.2).....	13
3.1.1 Site Description.....	13
3.1.2 Stage/Discharge Relationship.....	16
3.1.3 Mainstem Breaching and Controlling Discharges.....	16
3.1.4 Channel Geometry.....	24

(26/7)

CEV ✓

TABLE OF CONTENTS (Continued)

(# 28) Page

3.1.4.1 Thalweg Profile.....	24
3.1.4.2 Cross Section Profile.....	24
3.1.5 Backwater.....	25
3.2 Eagle's Nest Side Channel (RM 36.2).....	25
3.2.1 Site Description.....	25
3.2.2 Stage/Discharge Relationship.....	27
3.2.3 Mainstem Breaching and Controlling Discharges.....	27
3.2.4 Channel Geometry.....	28
3.2.4.1 Thalweg Profile.....	28
3.2.4.2 Cross Section Profile.....	29
3.2.5 Backwater.....	29
3.3 Kroto Slough Head (RM 36.3).....	29
3.3.1 Site Description.....	29
3.3.2 Stage/Discharge Relationship.....	31
3.3.3 Mainstem Breaching and Controlling Discharges.....	33
3.3.4 Channel Geometry.....	36
3.3.4.1 Thalweg Profile.....	36
3.3.4.2 Cross Section Profile.....	38
3.3.5 Backwater.....	38
3.4 Rolly Creek (RM 39.0).....	38
3.4.1 Site Description.....	38
3.4.2 Stage/Discharge Relationship.....	39
3.4.3 Channel Geometry.....	39
3.4.3.1 Thalweg Profile.....	39
3.4.3.2 Cross Section Profile.....	42
3.4.4 Backwater.....	42
3.5 Bear Bait Side Channel (RM 42.9).....	43
3.5.1 Site Description.....	43
3.5.2 Stage/Discharge Relationship.....	43
3.5.3 Mainstem Breaching and Controlling Discharges.....	46
3.5.4 Channel Geometry.....	49
3.5.4.1 Thalweg Profile.....	49
3.5.4.2 Cross Section Profile.....	50

(367)

CEV ✓

(#28)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.5.5 Backwater.....	50
3.6 Last Chance Side Channel (RM 44.4).....	50
3.6.1 Site Description.....	50
3.6.2 Stage/Discharge Relationship.....	51
3.6.3 Mainstem Breaching and Controlling Discharges.....	54
3.6.4 Channel Geometry.....	57
3.6.4.1 Thalweg Profile.....	57
3.6.4.2 Cross Section Profile.....	58
3.6.5 Backwater.....	58
3.7 Rustic Wilderness Side Channel (RM 59.5).....	59
3.7.1 Site Description.....	59
3.7.2 Stage/Discharge Relationship.....	59
3.7.3 Mainstem Breaching and Controlling Discharges.....	62
3.7.4 Channel Geometry.....	65
3.7.4.1 Thalweg Profile.....	65
3.7.4.2 Cross Section Profile.....	65
3.7.5 Backwater.....	66
3.8 Caswell Creek (RM 63.0).....	66
3.8.1 Site Description.....	66
3.8.2 Stage/Discharge Relationship.....	69
3.8.3 Channel Geometry.....	69
3.8.3.1 Thalweg Profile.....	69
3.8.3.2 Cross Section Profile.....	70
3.8.4 Backwater.....	70
3.9 Island Side Channel (RM 63.2).....	70
3.9.1 Site Description.....	70
3.9.2 Stage/Discharge Relationship.....	71
3.9.3 Mainstem Breaching and Controlling Discharges.....	73
3.9.4 Channel Geometry.....	80
3.9.4.1 Thalweg Profile.....	80
3.9.4.2 Cross Section Profile.....	80
3.9.5 Backwater.....	80

(4 of 7)

CEV ✓

TABLE OF CONTENTS (Continued)

(#28)

	<u>Page</u>
3.10 Mainstem West Bank Side Channel (RM 74.4).....	82
3.10.1 Site Description.....	82
3.10.2 Stage/Discharge Relationship.....	84
3.10.3 Mainstem Breaching and Controlling Discharges.....	86
3.10.4 Channel Geometry.....	90
3.10.4.1 Thalweg Profile.....	90
3.10.4.2 Cross Section Profile.....	91
3.10.5 Backwater.....	91
3.11 Goose 2 Side Channel (RM 74.8).....	94
3.11.1 Site Description.....	94
3.11.2 Stage/Discharge Relationship.....	97
3.11.3 Mainstem Breaching and Controlling Discharges.....	97
3.11.4 Channel Geometry.....	100
3.11.4.1 Thalweg Profile.....	100
3.11.4.2 Cross Section Profile.....	102
3.11.5 Backwater.....	102
3.12 Circular Side Channel (RM 75.3).....	103
3.12.1 Site Description.....	103
3.12.2 Stage/Discharge Relationship.....	105
3.12.3 Mainstem Breaching and Controlling Discharges.....	105
3.12.4 Channel Geometry.....	112
3.12.4.1 Thalweg Profile.....	112
3.12.4.2 Cross Section Profile.....	112
3.12.5 Backwater.....	112
3.13 Sauna Side Channel (RM 79.8).....	115
3.13.1 Site Description.....	115
3.13.2 Stage/Discharge Relationship.....	117
3.13.3 Mainstem Breaching and Controlling Discharges.....	121
3.13.4 Channel Geometry.....	123
3.13.4.1 Thalweg Profile.....	123
3.13.4.2 Cross Section Profile.....	123
3.13.5 Backwater.....	124

(5867)

CEV ✓

TABLE OF CONTENTS (Continued)

Page

3.14 Sucker Side Channel (RM 84.5).....	124
3.14.1 Site Description.....	124
3.14.2 Stage/Discharge Relationship.....	126
3.14.3 Mainstem Breaching and Controlling Discharges.....	129
3.14.4 Channel Geometry.....	134
3.14.4.1 Thalweg Profile.....	134
3.14.4.2 Cross Section Profile.....	137
3.14.5 Backwater.....	137
3.15 Beaver Dam Slough and Side Channel (RM 86.3).....	137
3.15.1 Site Description.....	137
3.15.2 Stage/Discharge Relationship.....	138
3.15.3 Mainstem Breaching and Controlling Discharges.....	141
3.15.4 Channel Geometry.....	144
3.15.4.1 Thalweg Profile.....	144
3.15.4.2 Cross Section Profile.....	146
3.15.5 Backwater.....	146
3.16 Sunset Side Channel (RM 86.9).....	147
3.16.1 Site Description.....	147
3.16.2 Stage/Discharge Relationship.....	150
3.16.3 Mainstem Breaching and Controlling Discharges.....	150
3.16.4 Channel Geometry.....	153
3.16.4.1 Thalweg Profile.....	153
3.16.4.2 Cross Section Profile.....	155
3.16.5 Backwater.....	155
3.17 Sunrise Side Channel (RM 87.0).....	155
3.17.1 Site Description.....	155
3.17.2 Stage/Discharge Relationship.....	158
3.17.3 Mainstem Breaching and Controlling Discharges.....	160
3.17.4 Channel Geometry.....	163
3.17.4.1 Thalweg Profile.....	163
3.17.4.2 Cross Section Profile.....	163
3.17.5 Backwater.....	165

TABLE OF CONTENTS (Continued)

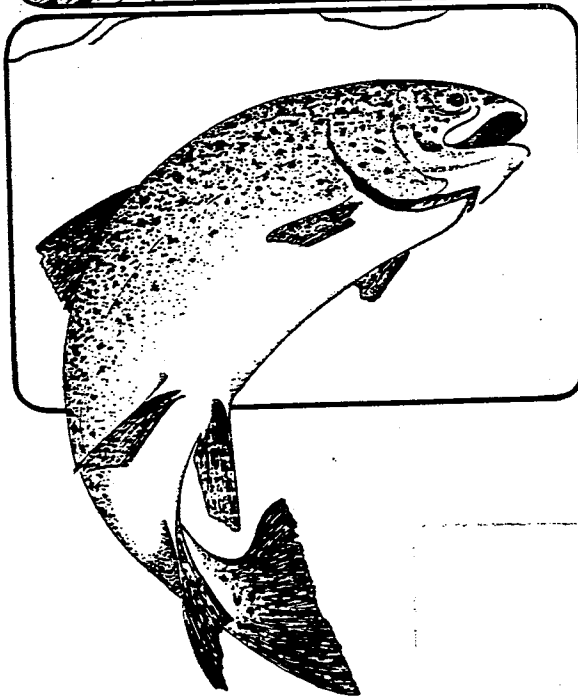
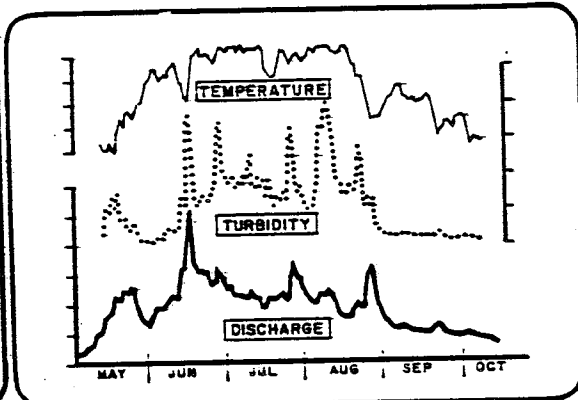
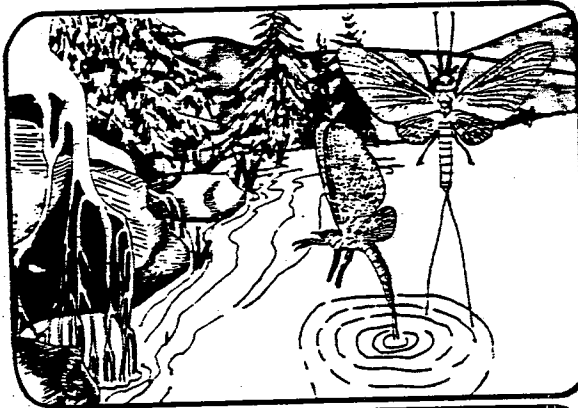
(#28)

	<u>Page</u>
3.18 Birch Creek Slough (RM 88.4).....	165
3.18.1 Site Description.....	165
3.18.2 Stage/Discharge Relationship.....	167
3.18.3 Mainstem Breaching and Controlling Discharges.....	170
3.18.4 Channel Geometry.....	171
3.18.4.1 Thalweg Profile.....	171
3.18.4.2 Cross Section Profile.....	171
3.18.5 Backwater.....	171
3.19 Trapper Creek Side Channel (RM 91.6).....	172
3.19.1 Site Description.....	172
3.19.2 Stage/Discharge Relationship.....	174
3.19.3 Mainstem Breaching and Controlling Discharges.....	178
3.19.4 Channel Geometry.....	180
3.19.4.1 Thalweg Profile.....	180
3.19.4.2 Cross Section Profile.....	180
3.19.5 Backwater.....	181
4.0 SUMMARY.....	184
5.0 GLOSSARY.....	192
6.0 CONTRIBUTORS.....	197
7.0 ACKNOWLEDGEMENTS.....	198
8.0 LITERATURE CITED.....	199
9.0 ATTACHMENTS	

(7067)

CEV

ESTES



REPORT NO. 6

ADULT SALMON INVESTIGATIONS
MAY - OCTOBER 1984

(1 of 4)

#29.

APA Doc #2748



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

TABLE OF CONTENTS

(#29)

	<u>Page</u>
PREFACE.....	i
TABLE OF CONTENTS.....	iii
LIST OF TABLES.....	vi
LIST OF FIGURES.....	xiii
LIST OF APPENDIX TABLES.....	xix
LIST OF APPENDIX FIGURES.....	xxii
1.0 OBJECTIVES.....	1
2.0 METHODS.....	2
2.1 Main Channel Escapement Monitoring.....	2
2.2 Spawning Ground and Tag Recovery Surveys.....	5
2.2.1 Lower Reach.....	5
2.2.2 Middle Reach.....	6
2.3 Data Analysis.....	7
2.3.1 Escapement Monitoring by SSS Counter.....	7
2.3.2 Tag and Recapture Estimates.....	7
2.3.3 Escapement Timing.....	7
2.3.4 Age Samples.....	7
2.3.5 Slough Escapements.....	7
3.0 RESULTS AND DISCUSSION.....	9
3.1 Chinook Salmon.....	9
3.1.1 Lower Reach.....	9
3.1.1.1 Main Channel Escapements.....	9
3.1.1.2 Spawning Areas.....	14
3.1.2 Middle Reach.....	18
3.1.2.1 Main Channel Escapements.....	18
3.1.2.2 Spawning Areas.....	22
3.1.3 Escapement Index Surveys.....	25

(2014)

CE ✓

(#29)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.2 Sockeye Salmon.....	25
3.2.1 First-Run.....	25
3.2.1.1 Lower Reach.....	30
3.2.1.1.1 Main Channel Escapements.....	30
3.2.1.1.2 Spawning Areas.....	31
3.2.2 Second-Run.....	37
3.2.2.1 Lower Reach.....	37
3.2.2.1.1 Main Channel Escapements.....	37
3.2.2.1.2 Spawning Areas.....	46
3.2.2.2 Middle Reach.....	46
3.2.2.2.1 Main Channel Escapements.....	46
3.2.2.2.2 Spawning Areas.....	48
3.3 Pink Salmon.....	56
3.3.1 Lower Reach.....	56
3.3.1.1 Main Channel Escapements.....	56
3.3.1.2 Spawning Areas.....	63
3.3.2 Middle Reach.....	63
3.3.2.1 Main Channel Escapements.....	63
3.3.2.2 Spawning Areas.....	65
3.4 Chum Salmon.....	70
3.4.1 Lower Reach.....	70
3.4.1.1 Main Channel Escapements.....	70
3.4.1.2 Spawning Areas.....	76
3.4.2 Middle Reach.....	81
3.4.2.1 Main Channel Escapements.....	81
3.4.2.2 Spawning Areas.....	83
3.5 Coho Salmon.....	94
3.5.1 Lower Reach.....	94
3.5.1.1 Main Channel Escapements.....	94
3.5.1.2 Spawning Areas.....	105

(3064)

CEV ✓

(#29)

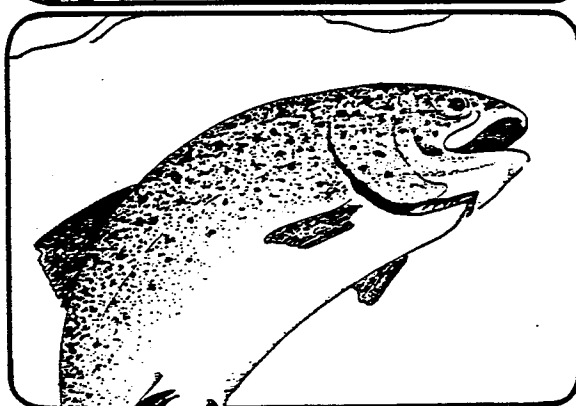
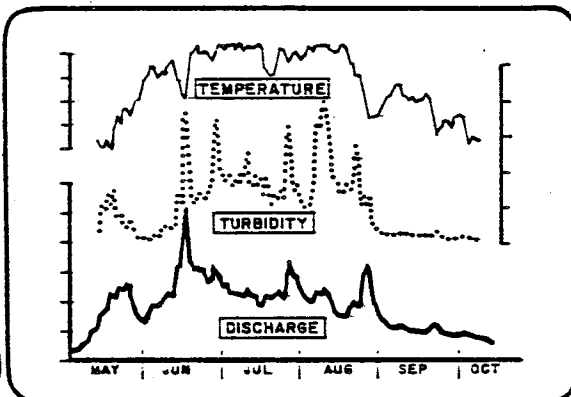
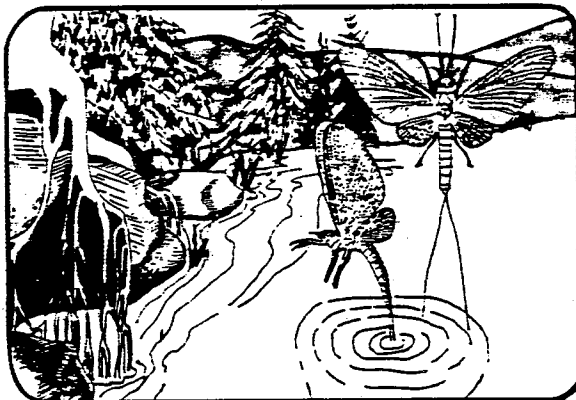
TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.5.2 Middle Reach.....	105
3.5.2.1 Main Channel Escapements.....	105
3.5.2.2 Spawning Areas.....	108
4.0 SUMMARY.....	111
4.1 Chinook Salmon.....	113
4.2 Sockeye Salmon.....	117
4.2.1 First-Run.....	117
4.2.2 Second-Run.....	121
4.3 Pink Salmon.....	128
4.4 Chum Salmon.....	134
4.5 Coho Salmon.....	145
REFERENCES.....	154
ACKNOWLEDGEMENTS.....	157
APPENDICES	
APPENDIX 1. Adult Salmon Lower River Susitna River Sampling Surveys.....	A1
APPENDIX 2. Susitna and Yentna Rivers - Sampling Locations.....	A124
APPENDIX 3. Daily Fishwheel Catch Data and Migrational Rate Histograms.....	A130
APPENDIX 4. Daily Yentna Station Sonar Counts and Cumulative Percent Sonar Counts by Species.....	A209
APPENDIX 5. Length Frequencies of Chinook, Sockeye, Pink, Chum, and Coho Salmon.....	A229
APPENDIX 6. Spawning Data.....	A255

494

CEV ✓

ESTES



REPORT NO. 7

RESIDENT AND JUVENILE ANADROMOUS FISH
INVESTIGATIONS (MAY - OCTOBER 1984)

PARTS 1 AND 2 AND 3

(10615)



#30a.

part 1+2

APA Doc #2836

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

See #30 b part 3

(# 30a)

CONTENTS OF REPORT NO. 7

- Part 1. The Migration and Growth of Juvenile Salmon in the Susitna River. 30a.
- Part 2. The Relative Abundance, Distribution, and Instream Flow Relationships of Juvenile Salmon in the Lower Susitna River. 30a
- Part 3. Resident Fish Distribution and Life History in the Susitna River below Devil Canyon. 30b.

(2 of 15)

CE ✓

THE MIGRATION AND GROWTH OF JUVENILE SALMON
IN THE SUSITNA RIVER

(#30a)

Report No. 7, Part 1

by Kent J. Roth and Michael E. Stratton

(30615)

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Susitna River Aquatic Studies Program
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ABSTRACT

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 (river mile 103.0) for the past three years. The data from 1982 and 1983 have shown that a substantial number of chinook, coho, and sockeye 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 was demonstrated by their growth and by analysis of stomach contents.

(4 of 15)

(#30a)

TABLE OF CONTENTS

	Page
ABSTRACT.....	i
LIST OF FIGURES.....	vi
LIST OF TABLES.....	xii
LIST OF APPENDIX TABLES.....	xiii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Study Locations.....	3
2.1.1 Flathorn Station.....	3
2.1.2 Deshka River.....	3
2.1.3 Talkeetna River.....	3
2.1.4 Talkeetna Station.....	3
2.1.5 Coded wire tagging.....	3
2.1.6 Cold branding.....	10
2.2 Field Data Collection and Recording.....	11
2.2.1 Flathorn Station outmigrant traps.....	11
2.2.2 Deshka River outmigrant weir.....	11
2.2.3 Talkeetna River beach seining.....	12
2.2.4 Talkeetna Station outmigrant traps.....	12
2.2.5 Coded wire tagging.....	12
2.2.6 Cold branding.....	13
2.3 Data Analysis.....	14
2.3.1 Juvenile salmon catch per unit effort.....	14
2.3.2 Population and survival estimates.....	16
2.3.3 Time series analysis.....	16
3.0 RESULTS.....	17
3.1 Chinook Salmon.....	17
3.1.1 Catch per unit effort.....	17
3.1.1.1 Age 0+.....	17
3.1.1.2 Age 1+.....	19
3.1.2 Growth.....	27
3.1.2.1 Age 0+.....	27
3.1.2.2 Age 1+.....	27

TABLE OF CONTENTS (Continued)

(6 of 15)

(#30 a)

	Page
3.1.3 Cold branding.....	27
3.1.4 Population estimates.....	31
3.2 Coho Salmon.....	35
3.2.1 Catch per unit effort.....	35
3.2.1.1 Age 0+.....	35
3.2.1.2 Age 1+ and older.....	39
3.2.2 Growth.....	39
3.2.2.1 Age 0+.....	39
3.2.2.2 Age 1+ and older.....	44
3.2.3 Cold branding.....	44
3.2.4 Population estimates.....	44
3.3 Sockeye Salmon.....	44
3.3.1 Catch per unit effort.....	44
3.3.1.1 Age 0+.....	47
3.3.1.2 Age 1+.....	47
3.3.2 Growth.....	54
3.3.3 Coded wire tagging and recovery.....	54
3.3.4 Population estimates and survival rates of outmigrants.....	60
3.4 Chum Salmon.....	60
3.4.1 Catch per unit effort.....	60
3.4.2 Growth.....	64
3.4.3 Coded wire tagging and recovery.....	64
3.4.4 Population estimates and survival rates of outmigrants.....	64
3.5 Pink Salmon.....	67
3.6 Descriptive Statistics for Catch and Environmental Variables.....	67
4.0 DISCUSSION.....	74
4.1 Chinook Salmon.....	74
4.1.1 Outmigration.....	74
4.1.2 Freshwater life history.....	74
4.1.3 Estimates of population size and residence time.....	78
4.1.4 Growth.....	79

CEV

TABLE OF CONTENTS (Continued)

(7 of 15) (#30a)

	<u>Page</u>
4.2 Coho Salmon.....	79
4.2.1 Outmigration.....	79
4.2.2 Freshwater life history.....	83
4.2.3 Growth.....	83
4.3 Sockeye Salmon.....	88
4.3.1 Outmigration.....	88
4.3.2 Freshwater life history.....	88
4.3.3 Estimates of population size and survival.....	91
4.3.4 Growth.....	92
4.4 Chum Salmon.....	96
4.4.1 Outmigration.....	96
4.4.2 Freshwater life history.....	96
4.4.3 Estimates of population size and survival.....	96
4.4.4 Growth.....	96
4.5 Pink Salmon.....	99
4.5.1 Outmigration.....	99
4.5.2 Freshwater life history.....	99
5.0 CONTRIBUTORS.....	101
6.0 ACKNOWLEDGEMENTS.....	103
7.0 LITERATURE CITED.....	104
8.0 APPENDICES	
Appendix A Juvenile Salmon Catch and Length Data, 1984	
Appendix B The Schaefer Estimate of Population Size	
Appendix C Time Series Analysis of Discharge, Turbidity, and Juvenile Salmon Outmigration in the Susitna River, Alaska	

TIME SERIES ANALYSIS OF DISCHARGE, TURBIDITY, AND JUVENILE
SALMON OUTMIGRATION IN THE SUSITNA RIVER, ALASKA

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(#30 a)

ABSTRACT

(8615)

During the three years of study of juvenile salmon outmigration from the middle reach of the Susitna River, a correspondence has been noted between the peaks of river discharge and the peaks of outmigration. Further investigation of the relationship of outmigration to discharge was required because two large hydroelectric dams have been proposed for a region above the salmon rearing areas. These dams will markedly change the downstream discharge and turbidity regimes, factors which influence not only salmon outmigration, but almost all fish species and life stages including juvenile salmon rearing. Box-Jenkins models were developed for the 1983 and 1984 time series of river discharge, turbidity, and chinook and sockeye salmon fry outmigration rates in order to better understand the forces that shape the series and to statistically describe the natural conditions as a baseline against which future changes can be measured. The time series examined were described by relatively simple models, using mostly first-order autoregressive terms. About 85% of the variance in turbidity for one day was explained by the value for turbidity of the previous day. This figure was 44% for chinook salmon outmigration and 43% for sockeye salmon outmigration, the lower numbers indicating the effect of behavioral decisions on biological time series. Although the form of the time series plots of discharge and chinook salmon outmigration was different between the two years, the underlying stochastic processes which generated these series were the same. Bivariate transfer function models were constructed for turbidity and salmon outmigration rates which explain present values of these variables in terms of their own past values as well as past values of discharge.

CE✓

(302)

TABLE OF CONTENTS

(9615)

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	iii
1.0 INTRODUCTION.....	1
1.1 Time Series Analysis.....	4
1.2 Applications of Time Series Analysis.....	5
1.3 Objectives.....	5
2.0 METHODS.....	7
2.1 The Data.....	7
2.2 Identification and Estimation of Time Series Models.....	7
2.3 Transfer Function Models.....	10
3.0 RESULTS.....	11
3.1 Univariate Model for Mean Daily Discharge.....	11
3.2 Univariate Model for Turbidity.....	17
3.3 Univariate Model for Age 0+ Chinook Salmon Outmigration.....	22
3.4 Univariate Model for Age 0+ Sockeye Salmon Outmigration.....	31
3.5 Discharge - Turbidity Transfer Function Model.....	31
3.6 Discharge - Chinook Transfer Function Model.....	35
3.7 Discharge - Sockeye Transfer Function Model.....	37
4.0 DISCUSSION.....	40
5.0 ACKNOWLEDGEMENTS.....	44
6.0 LITERATURE CITED.....	45
7.0 BOX-JENKINS ARIMA AND TRANSFER FUNCTION MODELS.....	50

CE✓

THE RELATIVE ABUNDANCE, DISTRIBUTION, AND INSTREAM
FLOW RELATIONSHIPS OF JUVENILE SALMON
IN THE LOWER SUSITNA RIVER

(302)

Report No. 7, Part 2

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(10 of 15)

ABSTRACT

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, chum, and sockeye 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.

CE✓

TABLE OF CONTENTS

(11 of 15) (#302)

	Page
ABSTRACT.....	i
LIST OF FIGURES.....	iv
LIST OF TABLES.....	viii
LIST OF APPENDIX FIGURES.....	ix
LIST OF APPENDIX TABLES.....	xv
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Field Sampling Design.....	3
2.1.1 Study locations and selection criteria.....	3
2.1.2 Field data collection.....	5
2.1.2.1 Resident Juvenile Habitat (RJHAB) model sites.....	5
2.1.2.2 Instream Flow Incremental Methodology (IFIM) sites..	9
2.1.2.3 Opportunistic sites.....	9
2.1.3 Schedule of activities and frequency of sampling.....	10
2.2 Data Analysis.....	10
2.2.1 Physical data.....	10
2.2.2 Abundance and distribution.....	11
2.2.3 Habitat modelling of rearing salmon.....	11
2.2.3.1 Suitability criteria development.....	11
2.2.3.2 Instream Flow Incremental Methodology (IFIM) models.	11
2.2.3.3 Resident Juvenile Habitat (RJHAB) models.....	12
2.2.3.4 Model verification.....	14
3.0 RESULTS.....	15
3.1 Seasonal, Spatial, and Discharge Related Variations in Habitat.....	15
3.1.1 Macrohabitat type classifications of study sites.....	15
3.1.2 Chulitna and Talkeetna River plume influences on turbidity of side channels.....	19
3.1.3 Physical responses of sampling sites to mainstem discharge variations.....	19
3.1.3.1 Area.....	19
3.1.3.2 Cover.....	21

CEV ✓

(#302)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.2 Distribution and Abundance of Juvenile Salmon.....	25
3.2.1 Chinook salmon.....	25
3.2.2 Coho salmon.....	25
3.2.3 Chum salmon.....	28
3.2.4 Sockeye salmon.....	28
3.3 Habitat Modelling of Rearing Juvenile Salmon.....	33
3.3.1 Chinook salmon.....	39
3.3.2 Coho salmon.....	42
3.3.3 Chum salmon.....	48
3.3.4 Sockeye salmon.....	54
4.0 DISCUSSION.....	64
4.1 Chinook Salmon.....	64
4.2 Coho Salmon.....	65
4.3 Chum Salmon.....	67
4.4 Sockeye Salmon.....	68
5.0 CONTRIBUTORS.....	70
6.0 ACKNOWLEDGEMENTS.....	72
7.0 LITERATURE CITED.....	73
8.0 APPENDICES	
Appendix A Lower Susitna River Juvenile Salmon Rearing Suitability Criteria	
Appendix B Modelled Site Turbidities, Juvenile Salmon Catches, Areas, Weighted Usable Areas, and Habitat Indices	
Appendix C Comparison of the IFIM and RJHAB Modelling Techniques at Two Selected Sites	
Appendix D Hydraulic Models for Use in Assessing the Rearing Habitat of Juvenile Salmon in Six Side Channels of the Lower Susitna River	

(120/15)

CE✓

APPENDIX D

(#302)

HYDRAULIC MODELS FOR USE IN ASSESSING THE REARING
HABITAT OF JUVENILE SALMON IN SIX SIDE
CHANNELS OF THE LOWER SUSITNA RIVER

(130615)

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ABSTRACT

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 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 70,000 cfs 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.

✓

TABLE OF CONTENTS

(14 of 15)

(#302)

	Page
ABSTRACT.....	D-i
TABLE OF CONTENTS.....	D-ii
LIST OF APPENDIX FIGURES.....	D-iv
LIST OF APPENDIX TABLES.....	D-viii
INTRODUCTION.....	D-1
METHODS.....	D-1
Analytical Approach.....	D-1
Study Site Selection.....	D-3
General Techniques for Data Collection.....	D-4
General Techniques for Calibration.....	D-7
General Techniques for Verification.....	D-10
RESULTS.....	D-10
Island Side Channel.....	D-13
Site Description.....	D-13
Calibration.....	D-19
Verification.....	D-19
Application.....	D-25
Mainstem West Bank Side Channel.....	D-26
Site Description.....	D-26
Calibration.....	D-32
Verification.....	D-35
Application.....	D-35
Circular Side Channel.....	D-39
Site Description.....	D-39
Calibration.....	D-39
Verification.....	D-46
Application.....	D-49

CE✓

TABLE OF CONTENTS (Continued)

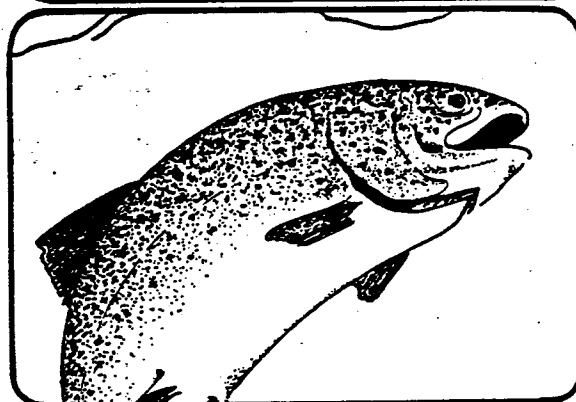
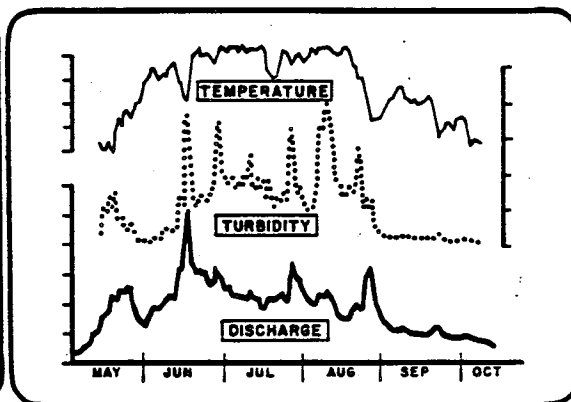
(#302)

	<u>Page</u>
Sauna Side Channel.....	D-51
Site Description.....	D-51
Calibration.....	D-51
Verification.....	D-60
Application.....	D-62
Sunset Side Channel.....	D-64
Site Description.....	D-64
Calibration.....	D-70
Verification.....	D-74
Application.....	D-74
Trapper Creek Side Channel.....	D-77
Site Description.....	D-77
Calibration.....	D-77
Verification.....	D-83
Application.....	D-87
SUMMARY.....	D-87
ACKNOWLEDGEMENTS.....	D-88
LITERATURE CITED.....	D-89

(15 of 15)

CE✓

ESTES



REPORT NO. 7

RESIDENT AND JUVENILE ANADROMOUS FISH
INVESTIGATIONS (MAY - OCTOBER 1984)

PART 3

(1065)

#30b.

APA Doc #2837



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

RESIDENT FISH DISTRIBUTION AND
LIFE HISTORY IN THE
SUSITNA RIVER BELOW DEVIL CANYON

(# 306)

Report No. 7, Part 3

by Richard L. Sundet and Stuart D. Pechek

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(265)

ABSTRACT

Studies of resident fish were conducted in both the lower (below Chulitna River confluence) and middle (Devil Canyon to Chulitna River confluence) 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, 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 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 are anadromous, and that rainbow trout and Arctic grayling outmigrate from most east side tributaries in September. Lower river studies also found that burbot move into the Deshka River in mid-September.

TABLE OF CONTENTS

(# 306)

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	v
LIST OF TABLES.....	vii
LIST OF PLATES.....	viii
LIST OF APPENDIX FIGURES.....	ix
LIST OF APPENDIX TABLES.....	xi
1.0 INTRODUCTION.....	1
2.0 METHODS.....	2
2.1 Study Locations.....	2
2.1.1 Relative abundance.....	2
2.1.2 Population estimates.....	4
2.1.3 Radio telemetry.....	4
2.2 Data Collection.....	4
2.2.1 Relative abundance.....	4
2.2.2 Population estimates.....	7
2.2.3 Radio telemetry.....	7
Equipment.....	7
Transmitter implantation.....	9
Tracking.....	11
3.0 RESULTS.....	12
3.1 Distribution and Relative Abundance of Resident Fish on the Lower Susitna River.....	12
3.1.1 Rainbow trout.....	12
3.1.2 Burbot.....	12
3.1.3 Arctic grayling.....	12
3.1.4 Round whitefish.....	13
3.1.5 Humpback whitefish.....	13
3.1.6 Longnose suckers.....	14

(305)

CE✓

TABLE OF CONTENTS (Continued)

(#306)

Page

3.1.7	Other species.....	14
	Dolly Varden.....	14
	Northern pike.....	15
	Threespine stickleback.....	15
	Ninespine stickleback.....	15
	Arctic lamprey.....	
3.2	Resident Fish Index Site Monitoring on the Middle Susitna River.....	16
3.2.1	Tributary mouth sites.....	16
3.2.2	Slough sites.....	16
3.2.3	Mainstem sites.....	16
3.3	Radio Telemetry Studies of Selected Resident Fish on the Middle Susitna River.....	18
3.3.1	Rainbow trout.....	18
3.3.2	Burbot.....	26
3.3.3	Arctic grayling.....	28
3.4	Other Resident Fish Studies on the Middle River.....	28
3.4.1	Lake surveys.....	28
3.4.2	Tag-and-recapture studies.....	28
	Rainbow trout.....	28
	Burbot.....	30
	Arctic grayling.....	30
	Round whitefish.....	30
	Humpback whitefish.....	30
	Longnose suckers.....	30
	Dolly Varden.....	31
4.0	DISCUSSION.....	32
4.1	Lower Susitna River.....	32
4.1.1	Rainbow trout.....	32
4.1.2	Burbot.....	32
4.1.3	Arctic grayling.....	33
4.1.4	Round whitefish.....	34
4.1.5	Humpback whitefish.....	35
4.1.6	Longnose suckers.....	35
4.1.7	Other species.....	35
	Dolly Varden.....	35
	Northern pike.....	35
	Threespine stickleback.....	36
	Ninespine stickleback.....	36
	Arctic lamprey.....	36

(405)

CE ✓

TABLE OF CONTENTS (Continued)

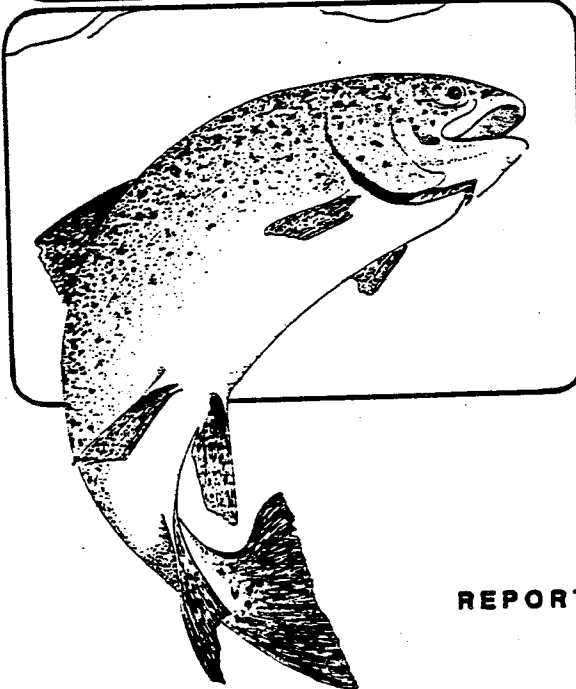
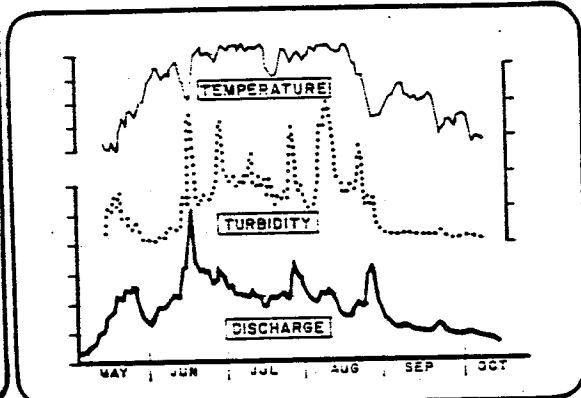
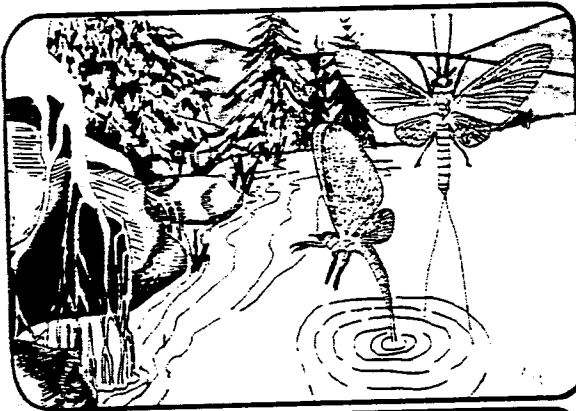
(#306)

	<u>Page</u>
4.2 Middle Susitna River.....	37
4.2.1 Rainbow trout.....	37
4.2.2 Burbot.....	42
4.2.3 Arctic grayling.....	43
4.2.4 Round whitefish.....	44
4.2.5 Humpback whitefish.....	45
4.2.6 Longnose suckers.....	45
4.2.7 Other species.....	45
Dolly Varden.....	45
Lake trout.....	46
Threespine stickleback.....	46
5.0 CONTRIBUTORS.....	47
6.0 ACKNOWLEDGEMENTS.....	48
7.0 LITERATURE CITED.....	49
8.0 APPENDICES	
Appendix A - Floy anchor tag retention rates	
Appendix B - Radio tagged fish tagging and habitat data	
Appendix C - Population and biological characteristics	
Appendix D - Population estimates	
Appendix E - Middle river index site catch data and descriptions, and spawning rainbow trout habitat data	

(5065)

CE✓

ESTES



REPORT NO. 8

Availability of Invertebrate Food Sources
for Rearing Juvenile Chinook Salmon
in Turbid Susitna River Habitats

(1066)

#31.

APA Doc #2846



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

(# 31)

AVAILABILITY OF INVERTEBRATE FOOD SOURCES

FOR REARING JUVENILE CHINOOK SALMON

IN TURBID SUSITNA RIVER HABITATS

1985 Report Number 8

by

Tim F. Hansen and J. Craig Richards

(266)

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ABSTRACT

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 salmon were also sampled using electro-fishing techniques to correlate the available food sources with that 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 the density of organisms. Water velocities less than 0.4 ft/sec 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 ft/sec and 2.6 ft/sec 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.

(30/6)

(#31)

CE ✓

TABLE OF CONTENTS

(#31)

(4066)

	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	iii
LIST OF FIGURES.....	vi
LIST OF APPENDIX FIGURES.....	ix
LIST OF TABLES.....	x
LIST OF APPENDIX TABLES.....	xii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	5
2.1 Field Sampling.....	5
2.1.1 Study Site Selection.....	5
2.1.2 Invertebrate Drift.....	5
2.1.3 Benthic Invertebrates.....	12
2.1.4 Juvenile Chinook Salmon.....	12
2.1.5 Turbidity.....	14
2.2 Laboratory Analysis.....	14
2.2.1 Sample Handling and Storage.....	14
2.2.2 Invertebrate Identification and Enumeration.....	14
2.3 Data Analysis.....	15
2.3.1 Invertebrate Drift.....	15
2.3.2 Benthic Invertebrates.....	16
2.3.2.1 Standing Crop Estimation.....	16
2.3.2.2 Suitability Criteria Development.....	17
2.3.2.3 Weighted Usable Area.....	21
2.3.3 Invertebrate Larval Development.....	22
2.3.4 Juvenile Chinook Salmon.....	22
3.0 RESULTS.....	23
3.1 Invertebrate Drift.....	23
3.1 Benthic Invertebrates.....	28
3.2.1 Benthic Habitat Suitability Criteria.....	30

CEV ✓

TABLE OF CONTENTS (Continued)

(506) (#31)

	Page
3.2.1.1 Depth.....	30
3.2.1.2 Velocity.....	45
3.2.1.3 Substrate.....	46
3.2.2 Benthic Weighted Usable Area Projections.....	47
3.3 Invertebrate Larval Development.....	52
3.4 Juvenile Chinook Salmon Diet.....	52
3.5 Turbidity at Study Sites and Mainstem Susitna River.....	52
4.0 DISCUSSION.....	57
4.1 Available Food Sources for Juvenile Chinook Salmon in Side Channels and Side Sloughs.....	57
4.2 Effects of Flow on the Distribution and Abundance of Benthic Invertebrates in Side Channels and Side Sloughs.....	59
4.2.1 Habitat Suitability.....	59
4.2.2 Weighted Usable Area.....	60
4.3 Utilization of Available Food by Juvenile Chinook Salmon in Side Channels and Side Sloughs.....	62
4.4 Conclusions and Future Research.....	63
5.0 CONTRIBUTORS.....	66
6.0 ACKNOWLEDGEMENTS.....	67
7.0 LITERATURE CITED.....	68
8.0 APPENDICES.....	73
Appendix A Study Site Hydrographs, Rating Curves, and Discharge Data.....	A-1
Appendix B Benthic and Drift Invertebrate Data.....	B-1
Appendix C Results of the Multiple Regression Analysis of Drift Data.....	C-1

CEV

(#31)

TABLE OF CONTENTS (Continued)

	<u>Page</u>
Appendix D Formula for Calculating the Shannon-Weaver Diversity Index and Eveness Index.....	D-1
Appendix E Juvenile Chinook Salmon Stomach Content Data.....	E-1
Appendix F Weighted Usable Area Projection Data.....	F-1
Appendix G Water Turbidity Data.....	G-1

(68/6)

CE ✓

ESTES

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

REPORT NO. 9

SUMMARY OF SALMON FISHERY DATA FOR
SELECTED MIDDLE SUSITNA RIVER SITES

by: Andrew G. Hoffmann
Aquatic Habitat and Instream Flow Project

(1 of 3)

#32.

APA Doc #2749

Prepared for:
ALASKA POWER AUTHORITY
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(#32)

ABSTRACT

The fishery data collected by the ADF&G 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.

(283)

CE✓

(#32)

TABLE OF CONTENTS

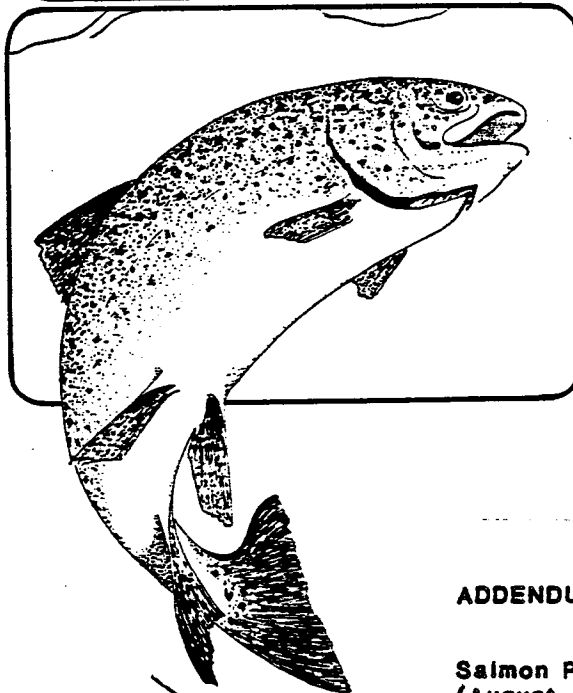
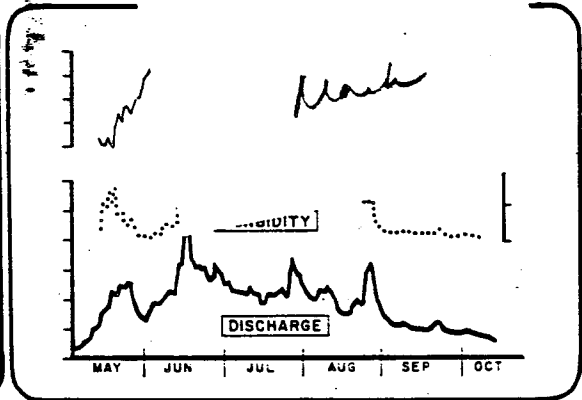
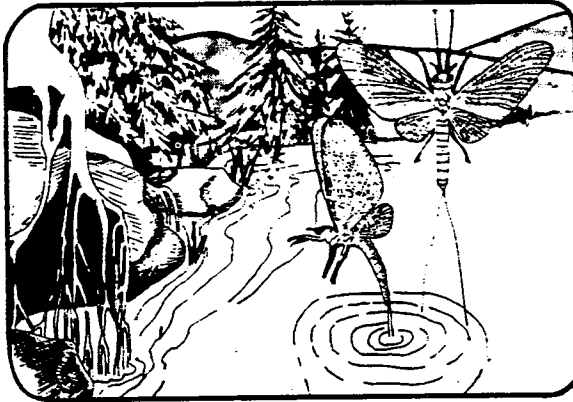
	<u>Page</u>
PREFACE	i
ABSTRACT	i
ACKNOWLEDGEMENTS	ii
TABLE OF CONTENTS	ii
LIST OF TABLES	iii
LIST OF APPENDIX TABLES	v
LIST OF PLATES	x
INTRODUCTION	1
RESULTS	2
Recon sites	4
Non-recon sites	78
LITERATURE CITED	89
APPENDIX A	A-1
APPENDIX B	B-1
APPENDIX C	C-2
APPENDIX D	D-1

(30/3)

CEV ✓

ESTES

Thanks!



ADDENDUM TO REPORT NO. 3, CH. 6

Salmon Passage Validation Studies
(August -October 1984)

(195)

#33.

APA Doc# 2854



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

ADDENDUM TO ALASKA DEPARTMENT OF FISH AND GAME

REPORT NO. 3, CHAPTER 6:
SALMON PASSAGE VALIDATION STUDIES

AUGUST - OCTOBER, 1984

(#33)

By:

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and
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4794 Business Park Boulevard
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1985

ABSTRACT

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 reevaluate 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

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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 movement in selected slough and side channel habitats.

The salmon passage criteria previously presented in Sautner et al. (1984) were reevaluated 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 reevaluation 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.

(#33) (30/5)

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TABLE OF CONTENTS

(4065)

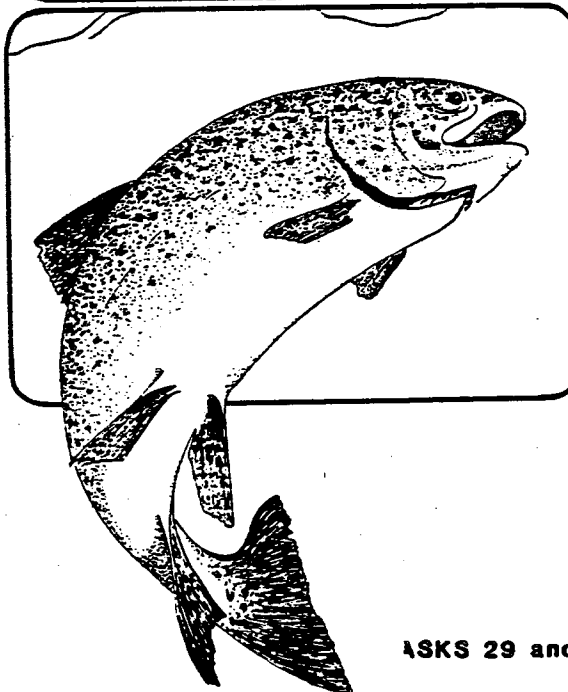
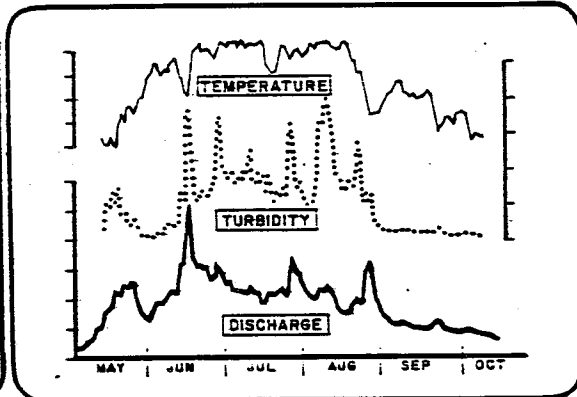
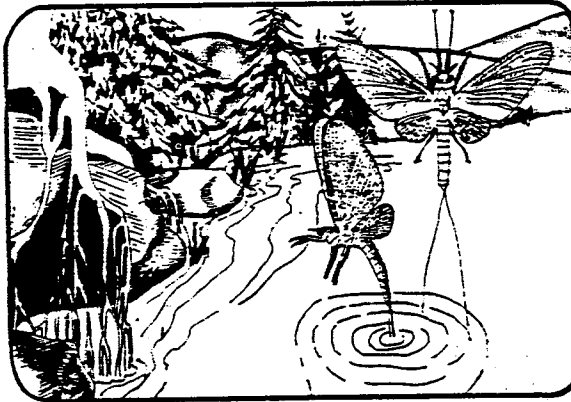
(#33)

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	v
LIST OF TABLES.....	vi
LIST OF APPENDIX FIGURES.....	viii
LIST OF APPENDIX TABLES.....	xv
 1.0 INTRODUCTION.....	 1
1.1 Background.....	1
1.2 Objectives.....	3
 2.0 METHODS.....	 4
2.1 Site Selection.....	4
2.2 Field Methods.....	4
2.2.1 Determination of Salmon Passage Criteria.....	4
2.2.2 Identification of Passage Reaches.....	6
2.2.3 Physical Habitat Variables Used to Evaluate Passage Reach Conditions.....	7
2.3 Analytical Methods.....	10
2.3.1 Salmon Passage Criteria.....	10
2.3.2 Passage Reach Evaluations.....	11
2.3.2.1 Verification of Passage Reaches.....	12
2.3.2.2 Breaching Analysis.....	12
2.3.2.3 Backwater Analysis.....	13
2.3.2.4 Local Flow Analysis.....	13
 3.0 RESULTS.....	 17
3.1 Salmon Passage Criteria.....	17
3.2 Passage Reach Evaluations.....	25
3.2.1 Breaching and Backwater Analyses.....	25
3.2.2 Local Flow Analysis.....	25

TABLE OF CONTENTS (Continued)

	<u>Page</u>
4.0 DISCUSSION.....	39
4.1 Salmon Passage Criteria.....	39
4.2 Passage Reach Evaluations.....	41
4.2.1 Mainstem Breaching.....	41
4.2.2 Mainstem Backwater.....	42
4.2.3 Local Flow.....	44
4.3 Influence of Mainstem Discharge on Local Flows.....	47
4.4 Conclusions/Recommendations.....	48
5.0 CONTRIBUTORS.....	53
6.0 ACKNOWLEDGEMENTS.....	54
7.0 LITERATURE CITED.....	55
8.0 APPENDICES.....	57
Appendix A. Supplement to Local Flow Methods.....	A-1
Appendix B. Passage Reach Distribution Maps.....	B-1
Appendix C. Thalweg Profiles of Passage Study Sites.....	C-1
Appendix D. Cross Sectional Data.....	D-1
Appendix E. Stage and Discharge Data.....	E-1

ESTES



ASKS 29 and 37 SUPPORT TECHNICAL REPORT

CONTINUOUS WATER TEMPERATURE INVESTIGATIONS

by Theresa Keklak and Tommy Withrow

(1042)



#34.

APA Doc #2867

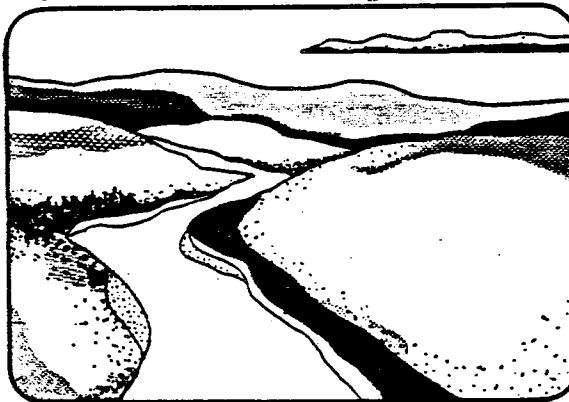
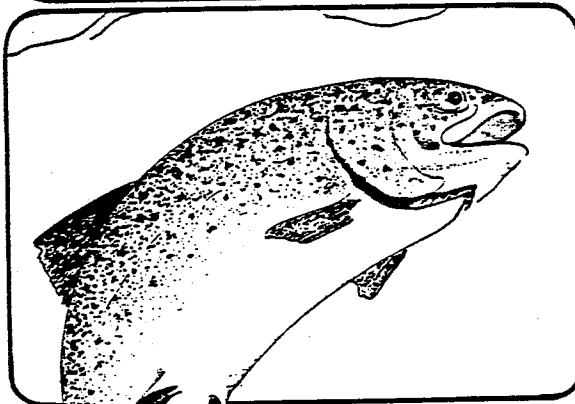
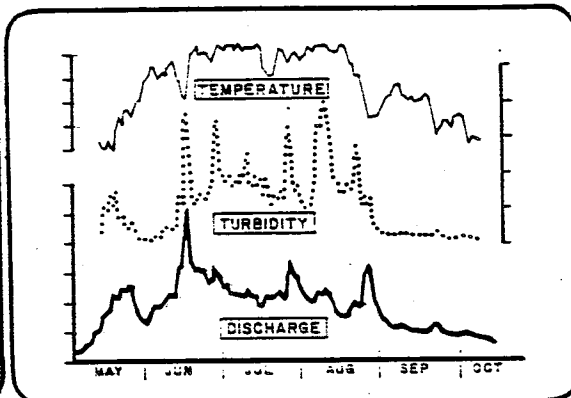
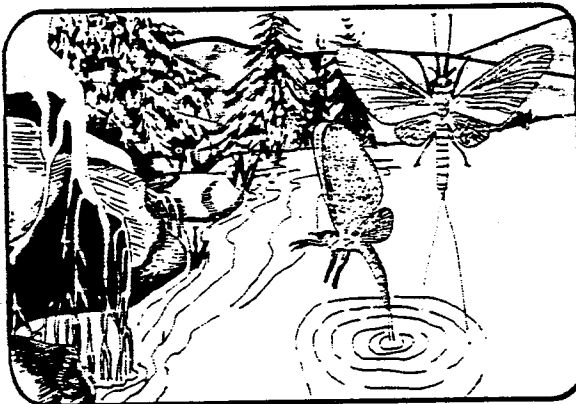
ALASKA DEPARTMENT OF FISH AND GAME
SUSITNA HYDRO AQUATIC STUDIES REPORT SERIES

TABLE OF CONTENTS

Page

TABLE OF CONTENTS.....	i
LIST OF APPENDIX TABLES.....	ii
LIST OF APPENDIX FIGURES.....	v
1.0 OBJECTIVES.....	1
2.0 METHODS.....	2
2.1 Site Selection.....	2
2.1.1 Task 29 Sites.....	2
2.1.2 Task 37 Sites.....	2
2.2 Field Data Collection.....	2
2.3 Data Analysis.....	6
3.0 DATA SUMMARY.....	10
3.1 Task 29 Sites.....	10
3.1.1 Lane Creek (RM 113.6, TRM 0.1).....	10
3.1.2 Fourth of July Creek (RM 131.1, TRM 0.2).....	10
3.1.3 Indian River - Site 3 (RM 131.1, TRM 0.2).....	13
3.1.4 Indian River - Site 4 (RM 131.1, TRM 0.2).....	13
3.1.5 Mainstem 2 Side Channel (RM 115.0).....	13
3.1.6 Side Channel at RM 117.9.....	16
3.1.7 Side Channel at RM 129.8.....	16
3.1.8 Side Channel at RM 131.3.....	19
3.1.9 Upper Side Channel 11 (RM 136.0).....	19
3.1.10 Upper Side Channel 21 (RM 141.6).....	23
3.1.11 Susitna River at RM 118.9.....	23
3.1.12 Susitna River at RM 127.1.....	23
3.1.13 Susitna River at RM 132.9.....	27
3.1.14 Susitna River at RM 137.5.....	27
3.1.15 Susitna River at RM 139.0.....	29
3.1.15.1 Susitna River at RM 139.0, Site 1.....	29
3.1.15.2 Susitna River at RM 139.0, Site 2.....	32
3.2 Task 37 Sites.....	32
3.2.1 Bushrod Slough (RM 117.9).....	32
3.2.2 Curry Slough (RM 119.7).....	34
3.2.3 Slough 10 (RM 133.8).....	34
3.2.3.1 Slough 10 Northeast Channel (RM 133.8).....	37
3.2.3.2 Slough 10 Northwest Channel (RM 133.8).....	37
4.0 CONTRIBUTORS.....	180

ESTES



REPORT NO. 10

PRELIMINARY EVALUATIONS OF
POTENTIAL FISH MITIGATION SITES
IN THE MIDDLE SUSITNA RIVER

(1065)

#35.

APA Doc #2908



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

PRELIMINARY EVALUATIONS OF POTENTIAL FISH MITIGATION SITES

IN THE MIDDLE SUSITNA RIVER

Report No. 10

(# 35)

by Donald R. Seagren and Robert G. Wilkey

(2565)

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ABSTRACT

Development of the Susitna Hydroelectric Project is expected to alter the natural seasonal flow regime of the Susitna River downstream of Devil Canyon (RM 152.0). Changes in the natural flow regime of the Susitna River may impact salmon spawning and incubation habitat in the middle reach of the river from Talkeetna (RM 98.0) to Devil Canyon (RM 152.0). This study was conducted by the Alaska Department of Fish and Game during 1984 and 1985 to evaluate potential slough and side channel sites that may be used to mitigate for adverse impacts to salmon spawning and incubation habitat resulting from operation of the hydroelectric project. These evaluations focused on habitat modification as a mitigation alternative to improve fish passage, upwelling, and substrate conditions. Forty-four potential fish mitigation sites were identified during the open-water portion of this study. Of these 44 sites, 23 were side slough habitats, 16 were upland slough habitats, and 5 were side channel habitats. From the initial 44 sites, three representative sites were selected for more detailed evaluations of habitat modification alternatives during the ice-covered season. Baseline information on surface and intragravel water quality, substrate conditions, upwelling sources, and fish passage restrictions were collected during the open-water season. The ice-covered studies evaluated incubation conditions (water quality and substrate) and specific habitat modification techniques which may be applicable for mitigation purposes. Recommendations for specific sites which generally appear to be most suitable for mitigation are presented in the discussion. However, the selection of these sites was based on field observations and limited data, therefore a more detailed evaluation should be conducted to determine if these sites are the most practical sites for mitigation purposes. This study only evaluates the mitigation potential of sites under current habitat conditions and any changes to the habitat that may take place in the future may necessitate a reevaluation of these sites.

CEV ✓

(#35)

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES.....	v
LIST OF TABLES.....	viii
LIST OF APPENDIX FIGURES.....	ix
LIST OF APPENDIX TABLES.....	xvii
1.0 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Objectives.....	3
2.0 METHODS.....	6
2.1 Open-Water Studies.....	6
2.1.1 Site Selection.....	6
2.1.2 Surface Water Quality and Intragravel Water Temperature.....	6
2.1.3 General Substrate Evaluations.....	14
2.1.4 Upwelling and Bank Seepage.....	15
2.1.5 Evaluations of Passage Restrictions.....	15
2.2 Ice-Covered Studies.....	15
2.2.1 Site Selection.....	15
2.2.2 Surface and Intragravel Water Quality.....	16
2.2.3 Freeze Core Substrate Analysis.....	17
2.2.4 Upwelling and Bank Seepage.....	21
2.3 Interpretation of Figures.....	21

Table of Contents (Continued)

(#35) (4065)

	Page
3.0 RESULTS.....	23
3.1 Open-Water Studies.....	23
3.1.1 Instantaneous Surface Water Quality and Intragravel Water Temperatures.....	23
3.1.2 General Substrate Evaluations.....	23
3.1.3 Upwelling and Bank Seepage.....	23
3.1.4 Evaluations of Fish Passage Restrictions.....	28
3.1.5 Salmon Spawning Utilization.....	29
3.2 Ice-Covered Studies.....	30
3.2.1 Physical Characteristics.....	30
3.2.1.1 Water Temperature.....	30
3.2.1.1.1 Instantaneous Surface and Intragravel Water Temperatures.....	31
3.2.1.1.2 Continuous Surface and Intragravel Water Temperature.....	31
3.2.1.2 Freeze Core Substrate Analysis.....	31
3.2.1.3 Upwelling and Bank Seepage.....	40
3.2.2 Chemical Characteristics.....	40
3.2.2.1 Dissolved Oxygen.....	40
3.2.2.2 pH.....	41
3.2.2.3 Conductivity.....	41
4.0 DISCUSSION.....	54
4.1 General Evaluations of Potential Mitigation Sites at Side Slough, Upland Slough and Side Channel Habitats.....	54
4.1.1 Side Channel Habitats.....	54
4.1.2 Upland Slough Habitats.....	54
4.1.3 Side Slough Habitats.....	55
4.2 Opening of Beaver Dams to Improve Fish Passage Conditions.....	56
4.3 Identification of Habitat Modification Techniques at Selected Slough Sites.....	56
4.3.1 Bushrod Slough.....	57
4.3.2 Curry Slough.....	58
4.3.3 Slough 10.....	59

CE ✓

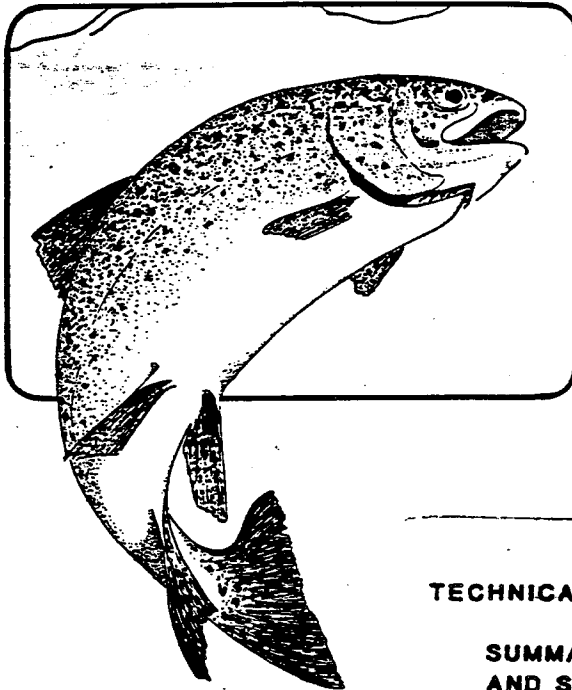
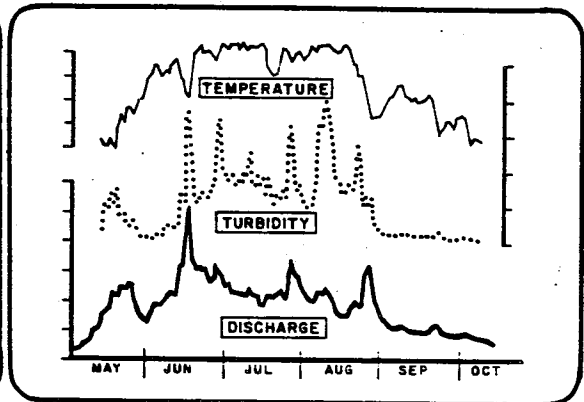
TABLE OF CONTENTS (Continued)

(#35) (5065)

	<u>Page</u>
4.4 Conclusions/Recommendations.....	60
5.0 CONTRIBUTORS.....	62
6.0 ACKNOWLEDGEMENTS.....	63
7.0 LITERATURE CITED.....	64
8.0 APPENDICES.....	70
Appendix A. Site Descriptions and Site Maps.....	A-1
Appendix B. General Surface Water Quality and Intragravel Water Temperature Data.....	B-1
Appendix C. Salmon Spawning Distribution Data.....	C-1
Appendix D. Selected Physical and Chemical Requirements for Various Life Stages of Salmon Species.....	D-1
Appendix E. Winter Water Quality Data.....	E-1
Appendix F. Freeze Core Substrate Data.....	F-1

CE ✓

ESTES



TECHNICAL DATA REPORT NO. 12

SUMMARY OF WATER TEMPERATURE
AND SUBSTRATE DATA FROM SELECTED
SALMON SPAWNING AND GROUNDWATER
UPWELLING SITES IN THE MIDDLE
SUSITNA RIVER.

(1 of 4)

#36.

APA Doc # 2913



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

(# 36)

SUMMARY OF WATER TEMPERATURE AND SUBSTRATE DATA
FROM SELECTED SALMON SPAWNING AND GROUNDWATER
UPWELLING SITES IN THE MIDDLE
SUSITNA RIVER

Technical Data Report No. 12

(20/4)

by
Donald R. Seagren
and
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Susitna River Aquatic Studies Program
620 East 10th Avenue, Suite 302
Anchorage, Alaska 99501

December 1985

CEV ✓

TABLE OF CONTENTS

	<u>Page</u>
LIST OF FIGURES.....	ix
LIST OF TABLES.....	xii
LIST OF APPENDIX FIGURES.....	xiii
LIST OF APPENDIX TABLES.....	xvi
1.0 INTRODUCTION.....	1
2.0 METHODS.....	2
2.1 Open-Water Studies.....	2
2.1.1 Site Selection.....	2
2.1.2 Instantaneous Surface and Intragravel Water Temperature.....	10
2.1.3 General Substrate Evaluations.....	10
2.1.4 Groundwater Upwelling and Bank Seepage.....	11
2.2 Ice-Covered Studies.....	11
2.2.1 Site Selection.....	11
2.2.2 Continuous Surface and Intragravel Water Temperature....	12
2.2.3 Freeze Core Substrate Evaluations.....	12
2.3 Interpretation of Figures.....	16
3.0 DATA SUMMARY.....	17
3.1 Open-Water Studies.....	17
3.1.1 Instantaneous Surface and Intragravel Water Temperature.....	17
3.1.2 General Substrate Evaluations.....	17
3.1.3 Groundwater Upwelling and Bank Seepage.....	24
3.2 Ice-Covered Studies.....	24
3.2.1 Continuous Surface and Intragravel Water Temperature.....	24
3.2.2 Freeze Core Substrate Evaluations.....	33
4.0 CONTRIBUTORS.....	41
5.0 ACKNOWLEDGEMENTS.....	42

CEV ✓

TABLE OF CONTENTS (Continued)

(#36)

Page

6.0 LITERATURE CITED.....	43
7.0 APPENDICES.....	47
Appendix A. Salmon Spawning Utilization Data of Mainstem and Side Channel Habitats in the Middle Susitna River, 1981-1984.....	A-1
Appendix B. Site Descriptions at Continuous Water Temperature Monitoring Locations, Ice- Covered Studies, 1984-1985.....	B-1

(484)

ESTES

LOWER SUSITNA RIVER PRELIMINARY
CHUM SALMON SPAWNING HABITAT
ASSESSMENT

Draft Technical Memorandum

by

Jeff Bigler
Kim Levesque

1985

(10/3)

ALASKA DEPARTMENT OF FISH AND GAME

Susitna Hydro Aquatic Studies
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Anchorage, Alaska 99501

37.

TABLE OF CONTENTS

Page

LIST OF FIGURES.....	iii
LIST OF TABLES.....	vii
LIST OF PLATES.....	x
INTRODUCTION.....	1
Background.....	1
Objectives.....	1
Habitat Data.....	1
Biological Data.....	1
METHODS.....	4
Habitat Data.....	4
Temperatures.....	4
Water Surface Elevations.....	4
Substrate.....	6
Biological Data.....	6
Chum Salmon Spawning Surveys.....	6
Chum Salmon Spawning WUA.....	6
Egg Survival and Development.....	12
Outmigration Occurrence.....	12
DATA SUMMARY.....	14
Habitat Data.....	14
Temperature.....	14
Upper Trapper Side Channel.....	14
Lower Trapper Side Channel.....	14
Upper Sunset Side Channel.....	14
Lower Sunset Side Channel.....	37
Upper Circular Side Channel.....	37
Lower Circular Side Channel.....	37
Water Surface Elevations.....	59
Trapper Side Channel.....	59
Sunset Side Channel.....	59
Circular Side Channel.....	59

CE ✓

TABLE OF CONTENTS (Continued)

(#37)

	Page
Substrate.....	64
Upper Trapper Side Channel.....	64
Lower Trapper Side Channel.....	64
Sunset Side Channel.....	64
Circular Side Channel.....	64
Biological Data.....	64
Chum Salmon Spawning Surveys.....	64
Chum Salmon Spawning WUA.....	104
Mainstem West Bank Side Channel.....	104
Circular Side Channel.....	104
Sunset Side Channel.....	104
Trapper Side Channel.....	120
Egg Survival and Development.....	120
Upper Trapper Side Channel.....	120
Lower Trapper Side Channel.....	120
Sunset Side Channel.....	120
Circular Side Channel.....	123
Birch Camp Mainstem.....	123
Outmigration.....	123
Trapper Side Channel.....	123
Sunset Side Channel.....	123
Circular Side Channel.....	123
CONCLUSIONS.....	125
RECOMMENDATIONS FOR FUTURE STUDIES.....	127
LITERATURE CITED.....	128
CONTRIBUTORS.....	129

(30/3)

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(# 37a)

SUSITNA PROJECT REVIEW
Division of Commercial Fisheries
Central Region
October 2 - 4, 1985

See also RTS Files

I 800, 200, 400 (1)(2)

for draft FY86

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I 800, 100, 200(4)

(10/3)

ADFG 37a

REVIEWERS GUIDE

(#37a)

Your participation in the Susitna Project Review is sincerely appreciated. As a reviewer, your comments and recommendations will assist the Commercial Fisheries Division develop and refine future fisheries study plans for the Susitna River.

The Division presently has two primary management goals for the Susitna. The first goal is "TO ENSURE THAT OPTIMUM ("ADEQUATE") SPAWNING ESCAPEMENTS ARE MAINTAINED FOR SUSITNA RIVER SALMON STOCKS." The second primary goal addresses monitoring potential changes resulting from the construction and operation of the Susitna Hydroelectric Project on fish populations and their habitats. More specifically the goal is "TO DESCRIBE THE NATURAL PRE-PROJECT VARIATIONS IN FISH POPULATIONS AND THEIR HABITATS AT A LEVEL OF RELIABILITY NECESSARY TO DETECT AND EXPLAIN POSSIBLE FUTURE CHANGES CAUSED BY THE HYDRO-ELECTRIC DEVELOPMENT".

Given the reality of shrinking budgets and rapidly increased resource demands, we must carefully assess our fisheries projects to ensure 1) technical merit 2) cost effectiveness, and 3) relevance to primary management goals. In this regard, please attempt to use the following list of questions as an outline to structure your comments and recommendations.

1. Do the objectives of this project appear to adequately address the Division's primary goals? How might project objectives be modified to more clearly address our goals?
2. If you believe that technical difficulties associated with this project may exist; what are they and how might they be remedied?
3. Could our sampling programs be modified to reduce project costs without unreasonably sacrificing technical quality.
4. What priority would you give this project in terms of meeting the Division's primary goals?

20/3

(#37a)

Table of Contents
Susitna Project Review
October 2 - 4, 1985

A. Background Information

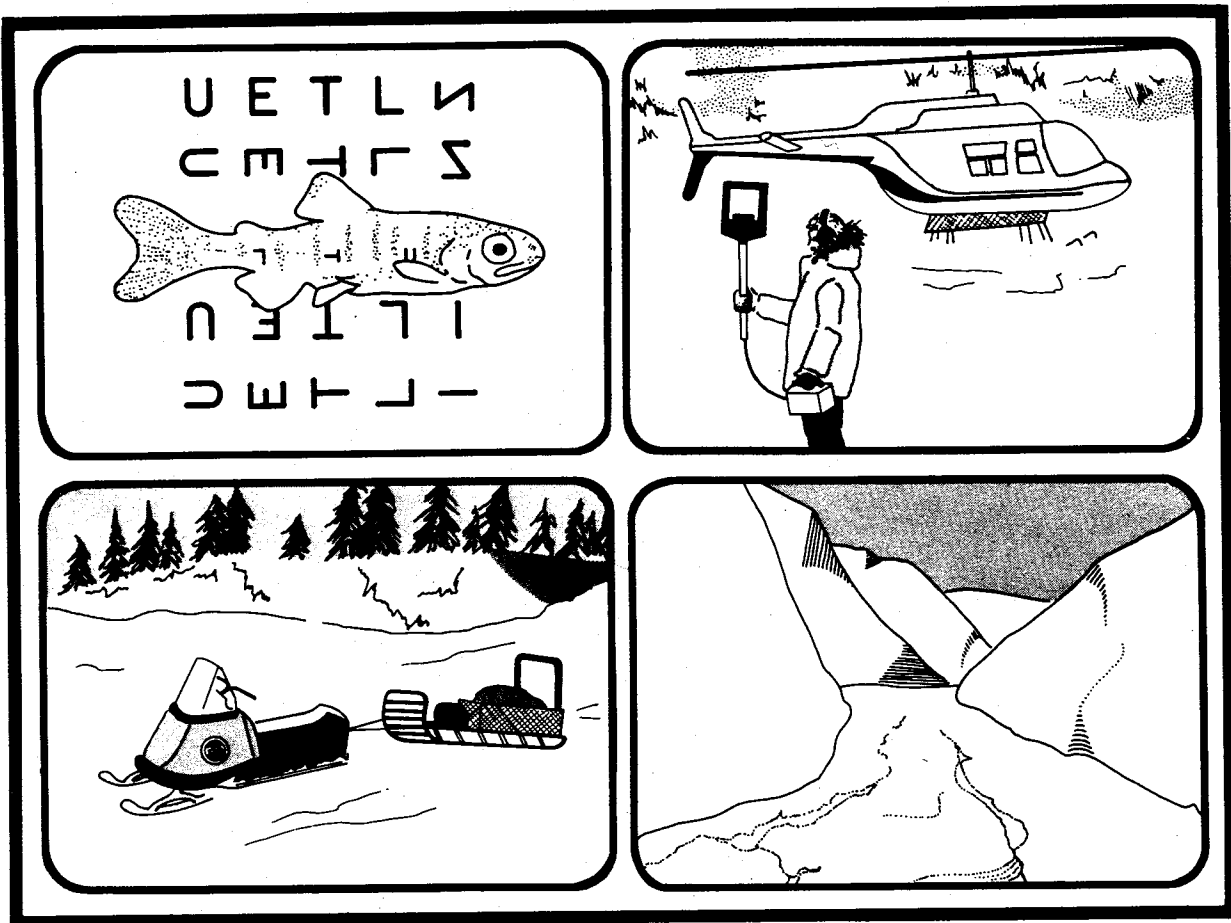
1. Correspondence
2. White Paper
3. 1979 Plan of Study

B. Project Description

1. Lower River Salmon Escapement
2. Middle River Salmon Escapement
3. Middle River Outmigrant Evaluation
4. Lower River Spawning Habitat Evaluation
5. Middle River Resident Fish Study
6. Aquatic Habitat Monitoring
7. Long Term Monitoring Strategies

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REPORT NO. 11

WINTER STUDIES OF RESIDENT AND JUVENILE
ANADROMOUS FISH (OCTOBER 1984 - MAY 1985)

PART 1

(10/4)

38a.

APA Doc# 3062



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

WINTER RESIDENT FISH DISTRIBUTION AND HABITAT STUDIES
CONDUCTED IN THE SUSITNA RIVER BELOW DEVIL CANYON, 1984-85

Report No. 11, Part 1

By Richard L. Sundet

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ABSTRACT

Studies of selected resident fish species were conducted in both the lower (below the Chulitna River confluence) and middle (between the Chulitna River confluence and Devil Canyon) Susitna River during the winter of 1984-85. These studies present distribution and habitat data collected from resident fish which were radio tagged in the spring and fall of 1984. Additional studies were done on the lower Susitna River to document the timing and locations of spawning burbot. Findings from radio telemetry studies indicate that middle river rainbow trout overwintered in the mainstem Susitna River, whereas lower river rainbow trout usually overwintered in side channels. Most rainbow trout overwintered from 0.0 to 4.0 miles below the mouth of the tributary they were tagged at. Rainbow trout in both reaches of river overwintered in areas of low to moderate water velocities (0.0-2.5 fps) and in areas with surface ice. No rainbow trout overwintered in areas that had anchor ice. Middle river rainbow trout were found in slightly deeper waters than lower river rainbow trout. Several middle river rainbow trout overwintered close to each other suggesting that this species congregate during the winter or that overwintering habitat is limited, resulting in cohabitation. Two pronounced winter movements were recorded for rainbow trout in both reaches of river: one between mid-September and mid-October, and one between mid-December and mid-January. Most rainbow trout begin to migrate from the mainstem to tributaries during breakup in May. Lower river burbot spawned between late January and early February. Four spawning sites at the Deshka River were documented. Several radio tagged burbot probably spawned in the mainstem Susitna River between RM 13.0 and RM 92.0. Burbot showed both a pre- and post-spawning migration of up to 20 miles. Monitoring data suggest some middle river Arctic grayling overwinter in the mainstem at RM 147.0, near Portage Creek (RM 148.8), while other stocks migrate 40.0 miles downriver to overwinter in the mainstem Susitna River near Talkeetna.

TABLE OF CONTENTS

(3014)

(#38a)

	<u>Page</u>
ABSTRACT.....	i
LIST OF FIGURES.....	iv
LIST OF TABLES.....	vi
LIST OF APPENDIX TABLES.....	vii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Study Locations.....	3
2.1.1 Radio telemetry.....	3
2.1.2 Burbot spawning.....	3
2.2 Data Collection.....	5
2.2.1 Radio telemetry.....	5
Equipment.....	5
Transmitter implantation.....	6
Tracking.....	6
2.2.2 Burbot spawning.....	7
3.0 RESULTS.....	8
3.1 Lower Susitna River.....	8
3.1.1 Rainbow trout.....	8
3.1.2 Burbot.....	10
Biological characteristics: sexual development, age, length, and sex composition.....	16
3.2 Middle Susitna River.....	16
3.2.1 Rainbow trout.....	16
3.2.2 Arctic grayling.....	25

CE✓

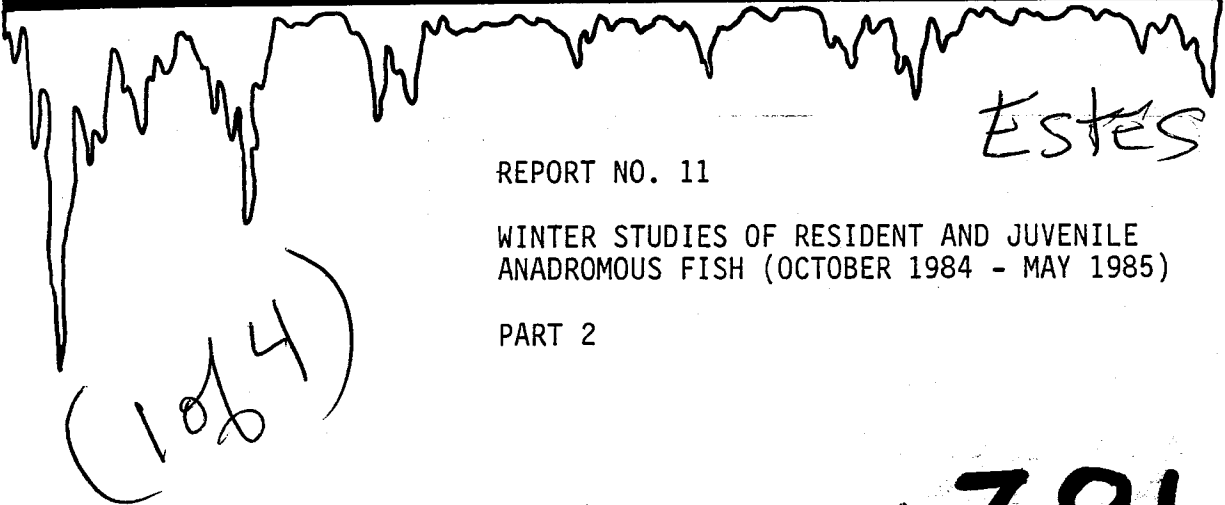
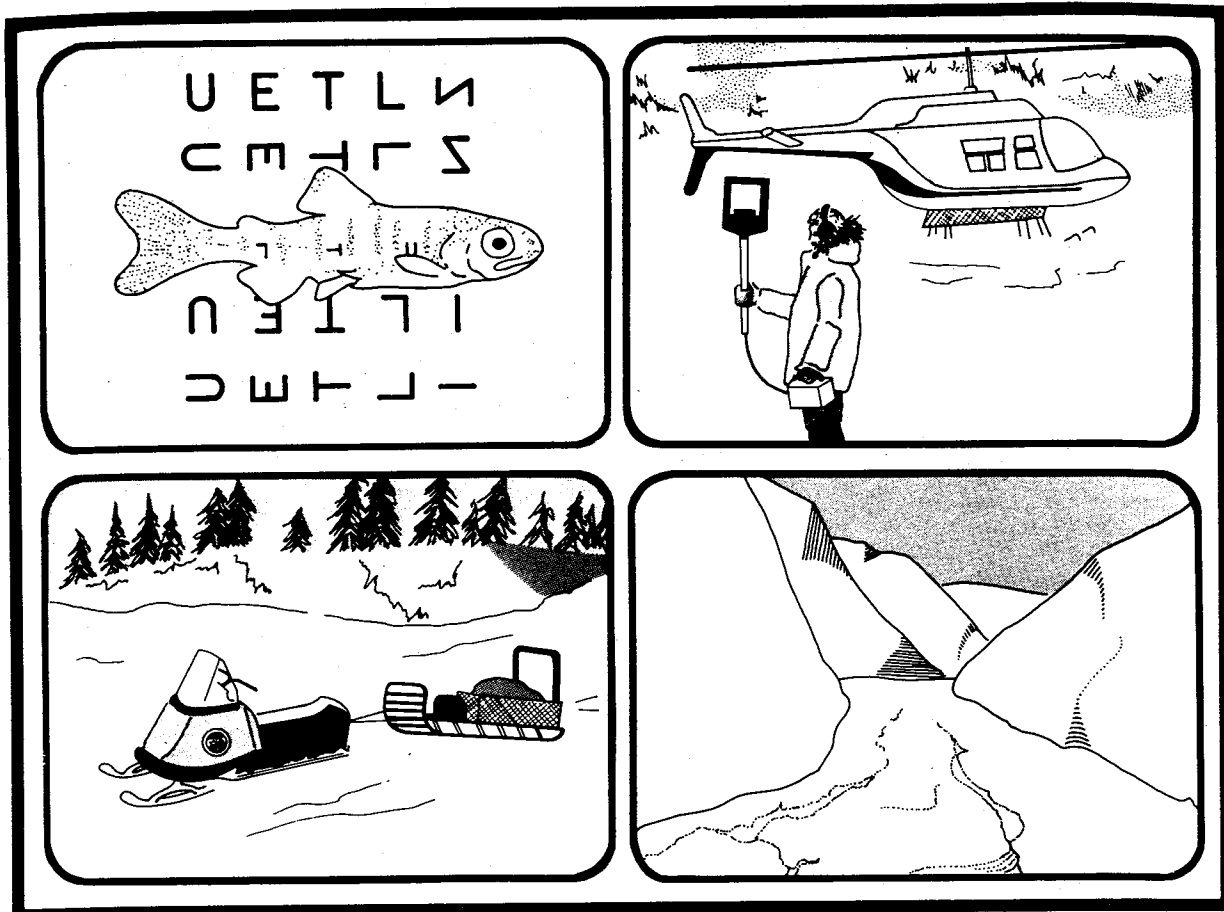
TABLE OF CONTENTS (Continued)

(#38a)

	<u>Page</u>
4.0 DISCUSSION.....	27
4.1 Lower Susitna River.....	29
4.1.1 Rainbow trout.....	29
4.1.2 Burbot.....	33
4.2 Middle Susitna River.....	38
4.2.1 Rainbow trout.....	38
4.2.2 Arctic grayling.....	40
5.0 CONTRIBUTORS.....	43
6.0 ACKNOWLEDGEMENTS.....	44
7.0 LITERATURE CITED.....	45
8.0 APPENDICES.....	49
Appendix A - Radio tagged fish tagging and habitat data.....	A-1
Appendix B - Burbot biological characteristics and resident fish catch data.....	B-1

(40/4)

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REPORT NO. 11

WINTER STUDIES OF RESIDENT AND JUVENILE
ANADROMOUS FISH (OCTOBER 1984 - MAY 1985)

PART 2

#38b.

APA Doc #3063



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

~~P-3063-48-3863?~~

(#386)
(2064)

SUMMARY OF JUVENILE CHINOOK AND COHO SALMON
WINTER STUDIES IN THE MIDDLE SUSITNA RIVER, 1984-85

Report No. 11, Part 2

by Michael E. Stratton

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April 1986

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TABLE OF CONTENTS

(# 38b)

	<u>Page</u>
LIST OF FIGURES.....	xiii
LIST OF TABLES.....	xv
LIST OF APPENDIX TABLES.....	xvii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Study Locations.....	3
2.2 Field Data Collection and Recording.....	3
2.3 Data Analysis.....	11
3.0 RESULTS.....	13
3.1 Biological Data.....	13
3.1.1 Chinook Salmon.....	13
3.1.1.1 Distribution and relative abundance.....	13
3.1.1.2 Length.....	18
3.1.1.3 Movement.....	20
3.1.1.4 Population estimate data.....	25
3.1.2 Coho Salmon.....	25
3.1.2.1 Distribution and relative abundance.....	25
3.1.2.2 Length.....	31
3.1.2.3 Movement.....	31
3.1.2.4 Population estimate data.....	31
3.2 Habitat Data.....	35
4.0 DISCUSSION.....	41
4.1 Chinook Salmon.....	41
4.2 Coho Salmon.....	45
4.3 Habitat Data.....	46

(3064)

CE ✓

TABLE OF CONTENTS (Continued)

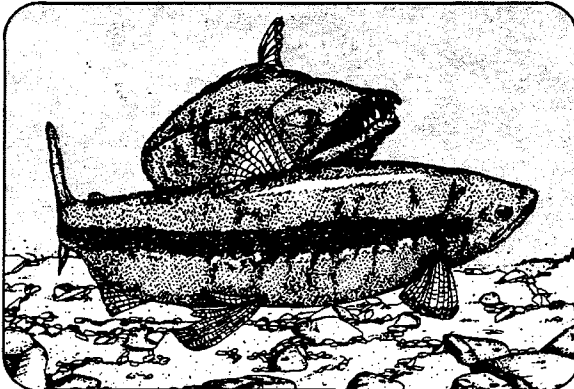
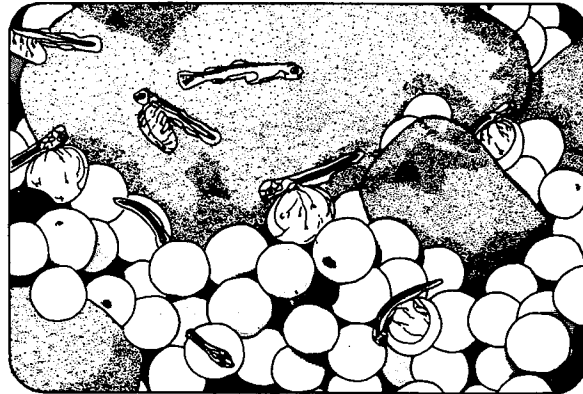
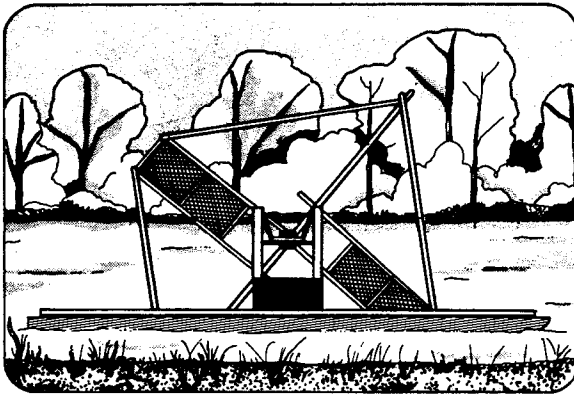
(# 386)

	<u>Page</u>
5.0 CONTRIBUTORS.....	49
6.0 ACKNOWLEDGEMENTS.....	51
7.0 LITERATURE CITED.....	53
8.0 APPENDICIES.....	59
Appendix A - Juvenile chinook and juvenile coho salmon catch data by site and month, winter 1984-85.....	A-1
Appendix B - Creation of tag-recapture data files which can be used in the POPAN-2 computer model to generate population estimates of juvenile chinook salmon at selected winter rearing sites in the middle Susitna River.....	B-1
Appendix C - Ice thickness data, winter 1984-85.....	C-1
Appendix D - Field observations on predation and food availability.....	D-1

(4664)

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(10/4)

Report No. 13

Adult Salmon Investigations:
May - October 1985

DRAFT



#39.

APA Doc #3412

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

(#39)

ADULT SALMON INVESTIGATIONS:

MAY - OCTOBER 1985

(28/4)

Technical Data Report No. 13

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April 1986

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TABLE OF CONTENTS

(#39)

	<u>Page</u>
TABLE OF CONTENTS.....	iv
LIST OF FIGURES.....	vi
LIST OF TABLES.....	x
LIST OF APPENDIX FIGURES.....	xiii
LIST OF APPENDIX TABLES.....	xiv
 1.0 INTRODUCTION AND OBJECTIVES.....	 1
 2.0 METHODS.....	 2
2.1 Main Channel Escapement Monitoring.....	2
2.2 Spawning Ground Surveys.....	4
2.3 Data Analysis.....	5
2.3.1 Escapement Estimates.....	5
2.3.2 Escapement Timing.....	7
2.3.3 Slough Escapements.....	7
 3.0 RESULTS AND DISCUSSION.....	 8
3.1 Chinook Salmon.....	8
3.1.1 Main Channel Escapements.....	8
3.1.2 Fecundity.....	14
3.1.3 Spawning Areas.....	17
3.2 Sockeye Salmon.....	17
3.2.1 First-Run.....	17
3.2.1.1 Main Channel Escapements.....	17
3.2.1.2 Spawning Areas.....	22
3.2.2 Second-Run.....	22
3.2.2.1 Main Channel Escapements.....	22
3.2.2.2 Spawning Areas.....	32

(38/4)

CEV ✓

TABLE OF CONTENTS (Continued)

(#39)

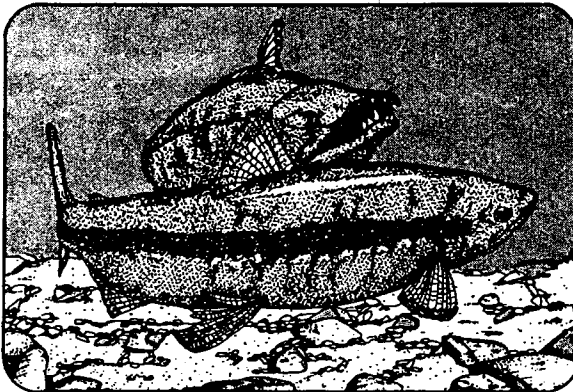
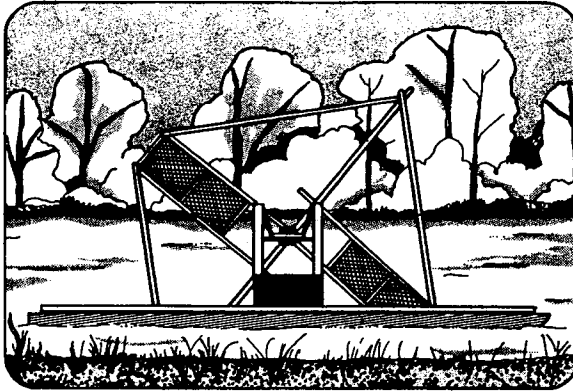
Page

3.3	Pink Salmon.....	33
3.3.1	Main Channel Escapements.....	33
3.3.2	Spawning Areas.....	43
3.4	Chum Salmon.....	47
3.4.1	Main Channel Escapements.....	47
3.4.2	Spawning Areas.....	51
3.5	Coho Salmon.....	59
3.5.1	Main Channel Escapements.....	59
3.5.2	Fecundity.....	66
3.5.3	Spawning Areas.....	66
4.0	ACKNOWLEDGEMENTS.....	71
5.0	LITERATURE CITED.....	72
6.0	APPENDICES.....	74
Appendix 1.	Susitna River Drainage Salmon Escapement Data Summary, 1951-1984 (Volume II).....	A-1
Appendix 2.	Fishwheel Daily and Cumulative Catches, by Station.....	A-173
Appendix 3.	Escapement and Tag Recovery Surveys.....	A-194
Appendix 4.	Station Locations and Middle River Survey Areas.....	A-245
Appendix 5.	Migrational Timing Based on Cumulative Fishwheel Catch Weighted by CPUE.....	A-253

(40/4)

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ESTES



(1984)

Report No. 14

The Migration and Growth of Juvenile
Salmon in the Susitna River, 1985.

Authors: Kent J. Roth
Danial C. Gray



#40.

APA Doc #3413

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

(#40)

(26/4)

ALASKA DEPARTMENT OF FISH AND GAME
SUSITNA RIVER AQUATIC STUDIES PROGRAM

Report No. 14

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Salmon in the Susitna River, 1985.

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June 1986

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(#40)

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS.....	i
LIST OF FIGURES.....	iv
LIST OF APPENDIX FIGURES.....	vii
LIST OF TABLES.....	xi
LIST OF APPENDIX TABLES.....	xii
1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
2.1 Study Locations.....	3
2.1.1 Stationary traps.....	3
2.1.2 Mobile trap.....	3
2.1.3 Coded wire tagging.....	3
2.1.4 Cold branding.....	3
2.2 Field Data Collection and Recording.....	7
2.2.1 Stationary traps.....	7
2.2.1.1 Flathorn Station.....	7
2.2.1.2 Talkeetna Station.....	8
2.2.2 Mobile trap.....	8
2.2.3 Coded wire tagging.....	9
2.2.4 Cold branding.....	9
2.3 Data Analysis.....	10
2.3.1 Juvenile salmon catch per unit effort.....	10
2.3.2 Population estimates.....	11
3.0 RESULTS AND DISCUSSION.....	12
3.1 Chinook Salmon.....	12
3.1.1 Catch per unit effort.....	12
3.1.1.1 Age 0+.....	12
3.1.1.2 Age 1+.....	19

(30/4)

CE ✓

TABLE OF CONTENTS (Continued)

PAGE

3.1.2	Size.....	19
3.1.2.1	Age 0+.....	19
3.1.2.2	Age 1+.....	23
3.1.3	Mark-and-recapture.....	23
3.1.3.1	Spatial and temporal distribution.....	23
3.2	Coho Salmon.....	26
3.2.1	Catch per unit effort.....	26
3.2.1.1	Age 0+.....	26
3.2.1.2	Age 1+ and 2+.....	33
3.2.2	Size.....	36
3.2.2.1	Age 0+.....	36
3.2.2.2	Age 1+ and 2+.....	36
3.2.3	Mark-and-recapture.....	36
3.2.3.1	Spatial and temporal distribution.....	36
3.3	Sockeye Salmon.....	39
3.3.1	Catch per unit effort.....	39
3.3.1.1	Age 0+.....	39
3.3.1.2	Age 1+.....	41
3.3.2	Size.....	45
3.3.2.1	Age 0+.....	45
3.3.2.2	Age 1+.....	45
3.3.3	Mark-and-recapture.....	45
3.3.4	Population estimates.....	47
3.4	Chum Salmon.....	47
3.4.1	Catch per unit effort.....	47
3.4.2	Size.....	49
3.4.3	Mark-and-recapture.....	49
3.4.4	Population estimates.....	51

TABLE OF CONTENTS (Continued)

	<u>PAGE</u>
3.5 Pink Salmon.....	51
3.5.1 Catch per unit effort.....	51
3.5.2 Size.....	51
4.0 CONTRIBUTORS.....	54
5.0 ACKNOWLEDGEMENTS.....	55
6.0 LITERATURE CITED.....	56
7.0 APPENDICES.....	58
Appendix A - Discharge, Temperature, and Turbidity for Talkeetna and Flathorn Stations, 1985.....	A-1
Appendix B - Brand Symbols, Release Dates, and the Number of Fish Branded by Species and Collection Site in the Middle Reach of the Susitna River During the Cold-Branding Program, 1984-1985.....	B-1
Appendix C - Chum and Sockeye Salmon Cold- Branding Experiment.....	C-1
Appendix D - Flathorn Station Juvenile Salmon Catch Data, 1985.....	D-1
Appendix E - Length and Weight Relationship Data for Juvenile Salmon, 1985.....	E-1