APPENDIX B3. LIFE STAGE SPECIFIC PERIODICITY

1. DEVELOPMENT OF TARGET SPECIES PERIODICITIES

The life stage and migration periodicities for target species will be an important consideration for the Study of Fish Passage Feasibility at Watana Dam given the changes in passage facility design constraints, hydrology, Project operations, and other physical processes that would occur over the course of a year. This appendix provides target species periodicities that have been developed as part of the Susitna-Watana licensing studies based on information available to date. Collection of additional information on fish distribution, abundance, and movement patterns in the Susitna Basin will continue in 2013/2014 and may allow for further refinement; the periodicities presented here are a work in progress.

These periodicities are primarily based on studies conducted in the Susitna Basin the 1980s and 2000s, particularly in the in the Middle Segment of the Susitna River (RM 98-184). Some periodicity data are available for the Lower River (RM 0-98), though information for the Upper River (RM 184-248) is sparse. Thus, the periodicities presented here are generally based on information from the Middle River, supplemented with Lower River information as available. In addition, periodicities for certain species/life stages for which Susitna-specific information was lacking were developed using supplementary out-of-basin information (e.g., Morrow 1980).

For each target species, periodicity information is summarized in the following sections and is also displayed in Tables B3-1 through B3-7. Although details regarding the migratory characteristics of each target species are presented in Appendix B4, the information presented below also includes migration timing as it is an important component of life history periodicity. In addition to periodicity, Tables B3-1 through B3-7 also describe the utilization of different habitat types for each species/life stage. This information was included as an indication of the habitat types between which movements may occur.

2. ARCTIC GRAYLING

- Arctic grayling periodicity is shown in Table B3-1.
- Spring spawning migration occurs concurrently with increasing tributary water temperatures during April and May, though movement of some large adults into ice-free tributaries occurred prior to or during ice breakup (Sundet and Wenger 1984; Sundet and Pechek 1985)
- Spawning typically occurs in May and early June but can vary among tributaries (Sundet and Wenger 1984; Sundet and Pechek 1985). Spawning typically occurs in upper extents of clear, non-glacial tributaries soon after ice breakup, though spawning also documented near tributary mouths (Sundet and Wenger 1984). Adult grayling movement and spawn timing differed up to 10 days among Middle River tributaries and up to 20 days between tributaries in the Middle and Lower River due to variable tributary water temperatures (Sundet and Wenger 1984; Sundet and Pechek 1985). These differences suggest that timing in the Upper River may be later assuming colder temperatures.
- During the open water season, many adult grayling either remain within spawning tributaries or move to nearby tributaries to feed during summer (Delaney et al. 1981b;

Delaney et al. 1981c; Schmidt et al. 1983; Sundet and Pechek 1985). Use of tributary mouth, side slough and main channel habitats during the open water season was also documented.

- Adults disperse from tributaries during early August through early October to winter holding habitats (Sundet and Wenger 1984; Sundet and Pechek 1985), with some moving 10 to 35 miles (Sundet and Pechek 1985; Sundet 1986). Winter habitat use in the mainstem Susitna River is poorly understood, but some evidence main channel overwintering exists (Sundet 1986).
- The duration of egg incubation (from fertilization to hatching) is generally from 11 to 21 days, depending on water temperatures (Morrow 1980), suggesting incubation during May and June and fry emergence likely during late May and June.
- Juveniles typically reside in natal tributaries for at least one year, though some age-0+ grayling were observed to move to tributary mouth habitats during late summer (Schmidt et al. 1983).

3. BURBOT

- Burbot periodicity is shown in Table B3-2.
- During summer, adult burbot movement appears to be infrequent and over short distances (Sundet and Wenger 1984).
- Adult burbot migrate to spawning locations in tributaries, tributary mouths and main channel habitats in the Susitna Basin beginning as early as mid-August and continuing through winter until spawning (Schmidt and Estes 1983; Sundet 1986). Spawning migrations in the Susitna Basin generally range from 5 – 40 miles in length, but have been documented up to 100 miles (Schmidt and Estes 1983).
- Spawning occurs from mid-January to early February (Schmidt and Estes 1983; Sundet and Pechek 1985).
- Post-spawning migrations occur from February through March and are thought to be relatively short (0.5 – 7 miles) (Schmidt and Estes 1983).
- Egg incubation is poorly understood in the Susitna River due to difficulty of sampling ice covered spawning sites during winter (Sundet and Pechek 1985). The duration of egg incubation varies considerably with temperature, ranging from 30 days (at 6°C) to 100 days or more (near 0°C) (Bjorn 1940, MacCrimmon 1959, McPhail and Paragamian 2000). Based on this range, egg incubation is estimated to occur from mid-January through April.
- Upon hatching, burbot fry are small (3-4 mm, total length) and drift passively until swimming ability improves (McPhail and Paragamian 2000). In the Middle and Lower Susitna River, small age-0+ fry (15 mm, total length) were observed in mid-June (Sundet and Pechek 1985).

- Juvenile burbot were infrequently captured in the Susitna Basin (Sundet and Pechek 1985). While they are believed utilize habitats proximal to natal areas, juveniles were primarily captured in downstream migrant traps (Schmidt et al. 1983).

4. CHINOOK SALMON

- Chinook periodicity is shown in Table B3-3.
- The timing of adult Chinook migration and spawning is not well defined in the Upper River because of limited observations. However, active spawning observed in late July in Kosina Creek which suggests that the periods of adult Chinook migration and spawning in this segment may be similar to that described for Chinook in the Middle Susitna River (Buckwalter 2011). If so, the timing and duration of egg incubation and fry emergence would also likely be comparable to the period described for the Middle Segment.
- Chinook fry were documented in Kosina Creek (RM 206.8) in 2003 and 2011 and in the Oshetna River (RM 233.4) in 2003 (Buckwalter 2011). No Chinook salmon were identified in any Upper Segment tributaries sampled during impoundment studies in 1982 (Deadman, Watana, Kosina and Jay Creeks) or in Watana Creek (RM 194.1) or Deadman Creek (RM 186.7) during aerial spawning surveys conducted in 1984 (Sautner and Stratton 1983, Barrett et al. 1985). The periodicity of juvenile Chinook salmon rearing and migration are poorly defined in the Upper Segment due to a paucity of data pertaining to juvenile Chinook presence and movement. It is unclear whether juvenile Chinook captured in 2003 and 2011 in the Upper Segment were age 0+ and/or age 1+ (Buckwalter 2011). Periodicity of juvenile Chinook rearing and migration are considered undefined until additional data are available.
- In the Middle River, Juvenile Chinook salmon exhibited very little freshwater life history diversity during studies conducted in the 1980s. Scale samples from adult Chinook salmon collected at fishwheels indicated that nearly all Chinook salmon that survive to adulthood exhibit a stream-type life history pattern and outmigrate to the ocean as yearlings (ADF&G 1981, ADF&G 1983c, Barrett et al. 1984, Barrett et al. 1985, Thompson et al. 1986). A small percentage of returning adult Chinook salmon outmigrated as fry.
- Roth and Stratton (1985) suggested Chinook salmon juveniles have three patterns of distribution following emergence in tributary streams. One group rears and overwinters in the natal tributary, and then outmigrates at Age 1+. Another group rears in the natal tributary during part of the first summer, migrates to the mainstem for overwintering and additional rearing and eventually outmigration to the ocean, again at Age 1+. The third group migrates to the lower Susitna River as fry. Roth and Stratton (1985) were uncertain what the relative proportion of Chinook production used the three behavior patterns.
- During 1980s studies, the bulk of Chinook salmon fry outmigrated from Indian and Portage creeks by mid-August and redistributed into sloughs and side channels of the Middle Susitna River or migrated to the Lower River (Roth and Stratton 1985, Roth et al. 1986). Outmigrant trapping occurred at Talkeetna Station (RM 103) during open water

periods from 1982 to 1985 and demonstrated Chinook salmon fry were migrating downstream to the Lower Susitna River throughout the time traps were operating (Schmidt et al. 1983, Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986**Error! Reference source not found.**). Based on timing of movements, Roth and Stratton (1986) suggested that some Chinook salmon fry from the Middle Susitna River either overwinter in the Lower Susitna River downstream of Flathorn Station or outmigrate to the ocean as fry, but are unsuccessful, as demonstrated by the low prevalence of Age 0 outmigrant characteristics in adult scales.

- The capture of a small number of Age 1+ Chinook salmon juveniles in the Indian River during winter sampling indicated that some Chinook salmon fry remain in natal tributaries throughout their first year of life (Stratton 1986). During 1984, sampling in the Indian River failed to capture any Chinook salmon Age 1+ fish during July, but were successful during May and June, indicating that Age 1+ Chinook salmon juveniles emigrated from tributary streams shortly after ice-out (Roth and Stratton 1985). The cumulative frequency of Age 1+ Chinook salmon juveniles catch at the Talkeetna Station reached 90 percent by early July in 1985 and by late-July at the Flathorn Station (Roth et al. 1986**Error! Reference source not found.**). Consequently, most outmigrating Chinook salmon Age 1+ smolts are generally in estuarine or nearshore waters by mid-summer.

5. DOLLY VARDEN

- Dolly Varden periodicity is shown in Table B3-4.
- Complex and variable life history patterns can be exhibited that include amphidromous, adfluvial, fluvial, and stream resident forms (Morrow 1980). The extent to which each life history pattern is present in the Susitna River is unclear, though adfluvial, fluvial and stream resident populations were apparent during 1980s studies (Sautner and Stratton 1983, Schmidt et al. 1983, Sautner and Stratton 1984). Stream resident populations present in headwater areas of Susitna River tributaries were of substantially smaller size than adfluvial and fluvial populations, though comparison of morphological features among disparately-sized individuals indicated each was of the same species (Sautner and Stratton 1983, Schmidt et al. 1983, Sautner and Stratton 1984).
- Adults primarily reside within tributary habitats during the open water season, though apparent adfluvial populations were observed to use lakes to feed during summer (Sautner and Stratton 1983, Sundet and Wenger 1984, Sautner and Stratton 1984). Movement into tributaries occurred in June and July during 1980s studies, coincident with the timing of upstream spawning migrations of adult Chinook salmon (Delaney et al. 1981b).
- Spawning is believed to occur in the upstream extents of clear tributaries during late September and October based on observations of spawning behavior and ripe adults (Delaney et al. 1981b, Schmidt et al. 1983, Sautner and Stratton 1984).
- Fishwheel capture data at the Talkeetna Station (RM 103) in 1982 and mark-recapture data during 1982-1983 suggest upstream movement of adult Dolly Varden in the main channel in spring and fall, which may represent spring movement to tributary feeding

areas and fall migration to spawning areas (Schmidt et al. 1983, Sundet and Wenger 1984).

- Most adults are believed to migrate downstream from tributaries during September and October to winter holding habitats in the Susitna River main channel, though little is known regarding the timing of such movement or locations of winter rearing (Schmidt et al. 1983, Sundet and Wenger 1984). Adfluvial populations likely utilize lacustrine habitats during winter, though timing of movement from tributaries is not known (Sautner and Stratton 1984).
- Egg incubation and development to hatching varies with temperature, occurs over a period of approximately 130 days at 8.5°C, but may require up to approximately 240 days on the north slope of Alaska (Blackett 1968, Yoshihara 1973, Morrow 1980). After hatching, pre-emergent fry remain in the gravel for 60 – 70 days (Morrow 1980). Based on this information, Dolly Varden egg incubation is estimated to occur from mid-September through late May, and fry emergence likely occurs during April and May.
- Juveniles in the Susitna Basin primarily utilize natal tributaries as summer and winter nursery habitat, though juvenile use of lakes was observed during 1980s studies (Delaney et al. 1981b, Sautner and Stratton 1983, Sautner and Stratton 1984). Little is known regarding possible seasonal differences in juvenile Dolly Varden habitat use because capture rates were generally very low during 1980s studies (Delaney et al. 1981b, Schmidt et al. 1983, Suchanek et al. 1984b). Dolly Varden that use lake habitats are likely part of adfluvial populations that disperse to lakes from natal tributaries (Sautner and Stratton 1984). Few juvenile Dolly Varden were captured in main channel outmigrant traps in 1982 (n=7) and 1983 (n=7) and at tributary mouths in the Susitna River mainstem, suggesting that few juveniles use mainstem habitat (Delaney et al. 1981b, Sundet and Wenger 1984, Schmidt et al. 1983). During winter, it is possible that juvenile Dolly Varden move downstream within natal tributaries, though there is no evidence that juveniles utilize mainstem habitat during winter (Schmidt et al. 1983). In headwater tributaries with adfluvial populations, juvenile Dolly Varden likely use lacustrine habitats during winter (Sautner and Stratton 1984).

6. HUMPBACK WHITEFISH

- Humpback whitefish periodicity is shown in Table B3-5.
- Humpback whitefish populations in Alaska are typically anadromous, though the marine distribution and the distance individuals disperse from natal rivers is not well known (Morrow 1980). In the Susitna River, a portion of the population may utilize estuarine or marine habitats for a portion of their lifespan, while most humpback whitefish appear to exhibit a riverine life history pattern based on analysis of adult scale patterns (Sundet and Wenger 1984, Sundet and Pechek 1985). High growth rates during the first two years of life, which may indicate estuarine feeding, were apparent in approximately 20% of adult humpback whitefish captured at Lower River fishwheel traps (Flathorn Station [RM 22], Yentna River Station [Yentna RM 4]) and about 5% of adults captured at the Talkeetna Station (RM 103) fishwheel in the Middle Segment (Sundet and Pechek 1985).

- Adult humpback whitefish exhibited higher relative use of tributary and slough habitats for holding and feeding in summer relative to mainstem areas during studies conducted in the Middle and Lower River during 1981-1983 (Sundet and Wenger 1984). Just one adult humpback whitefish was captured in the Upper River during 1980s studies at a tributary mouth (Sautner and Stratton 1983). Adult humpback whitefish generally exhibit little movement during summer except for spawning migrations, which occur in an upstream direction from July through September in the Susitna River; peak movement occurs during August (Morrow 1980, Schmidt et al. 1983, Sundet and Wenger 1984).
- Spawning is not well-documented but is believed to occur during October in tributaries of the Susitna River, based on high capture of adults in tributaries during fall (Sundet and Pechek 1985).
- Alaskan humpback whitefish populations utilize estuarine habitat during winter (Morrow 1980), though in the Susitna River overwinter habitat for adult humpback whitefish is largely unknown due to low winter capture rates (Schmidt et al. 1983). Humpback whitefish in the Middle Segment were believed to remain in that segment during winter (Sundet and Pechek 1985).
- Incubation and development timing of humpback whitefish eggs is not well known, though it is presumed that hatching occurs in late winter and spring (Morrow 1980). Based on this limited information, the period of humpback whitefish egg incubation is assumed to occur in the Susitna Basin from the start of spawning in early October through June.
- Emergence of humpback whitefish fry started prior to June during 1980s studies based on outmigrant trap capture records (Schmidt et al. 1983, Sundet and Wenger 1984) and is therefore estimated to occur from early May through late June.
- Juvenile humpback whitefish rearing was believed to primarily occur in the Lower Susitna River during the 1980s, though specific nursery habitat use was not well defined due to low and infrequent capture (Schmidt et al. 1983, Sundet and Wenger 1984). Most capture of juvenile humpback whitefish during the 1980s studies occurred at outmigrant traps. Downstream migration of juvenile humpback whitefish was observed to occur from June through October at the Talkeetna Station (RM 103) outmigrant trap, with peak movement during July and early August (Schmidt et al. 1983, Sundet and Wenger 1984). Approximately 20% of juvenile humpback whitefish in the Lower Segment and 5% in the Middle Segment were believed to use estuarine areas during the first two years of life (Sundet and Pechek 1985).

7. LONGNOSE SUCKER

- Longnose sucker periodicity is shown in Table B3-6.
- Adult longnose suckers in the Susitna Basin spawn in mainstem and tributary mouth habitats during May and early June, similar to other Alaskan sucker populations (Morrow 1980, Schmidt et al. 1983). An additional spawning period may occur in the late summer during October and/or November based on observed concentrations of adults with well-developed eggs and nuptial tubercles during September in suitable spawning habitats,

though spawning during this time has not been verified (Schmidt et al. 1983, Sundet and Wenger 1984). Morrow (1980) reports that longnose sucker spawning typically occurs at water temperatures above 5°C.

- Following spring spawning, a portion of longnose suckers in the Susitna River appeared to move upstream to summer feeding habitats and return downstream to winter holding areas, based on 1980s mark-recapture data (Sundet and Wenger 1984, Sundet and Pechek 1985). Spring upstream movement of adult suckers primarily occurred during June and July, while the timing of downstream fall movement was less defined (Schmidt et al. 1983, Sundet and Wenger 1984). Many suckers tagged during 1980s studies moved little during summer, similar to summer movement behavior of other sucker populations (Morrow 1980, Sundet and Wenger 1984, Sundet and Pechek 1985). Adult suckers were most commonly captured at tributary and slough sites, though use of mainstem habitat was greater in the Middle Segment relative to that of the Lower Segment (Schmidt et al. 1983, Sundet and Wenger 1984, Sundet and Pechek 1985). High capture rates of adults in tributaries and sloughs in August and September may indicate opportunistic feeding on salmon eggs during this time (Sundet and Wenger 1984). In the Upper Segment, only sub-adult suckers were captured in mainstem habitats, while larger adults were captured at the mouths of suspected spawning tributaries (Sautner and Stratton 1983). Habitat utilization by adult longnose suckers during winter in the Susitna River is not well known, though winter holding is believed to occur in the mainstem and the only winter capture of a longnose sucker occurred in side channel habitat (Schmidt and Bingham 1983, Schmidt et al. 1983).
- Incubation and development of longnose sucker eggs in the Susitna River has not been documented, however, general incubation time required from fertilization to hatching is one to two weeks and newly hatched fry may remain in the gravel for an additional two weeks prior to emerging (Morrow 1980). Timing of longnose sucker egg incubation is estimated to occur from early May to mid-July based on this information. Fry emergence likely occurs during June and early July.
- Juvenile longnose sucker fry typically drift from natal sites following emergence to summer nursery areas (Morrow 1980). Suckers in the Susitna River appear to exhibit this early life history strategy, though it is not clear to what extent such dispersal occurs based on low catch at outmigrant traps at Talkeetna Station (RM 103) (Schmidt et al. 1983). Age-0+ downstream movement in the Middle Segment occurred throughout the open water period in 1982 and 1983, and exhibited a bi-modal peak during June and during late August and September, based on outmigrant traps in the Susitna River main channel and Deshka River (Schmidt et al. 1983, Sundet and Wenger 1984, Sundet and Pechek 1985). Summer nursery habitats used by juvenile longnose in the Susitna River during the 1980s were side channels, upland sloughs, side sloughs and to a lesser extent, tributary mouths (Schmidt et al. 1983, Sundet and Wenger 1984). Winter habitat use by juvenile suckers is not known (Schmidt et al. 1983). Shallow depth, low water velocity and turbidity or structural (i.e., aquatic or overhead vegetation) cover are considered important characteristics for juvenile longnose nursery habitat (Suchanek et al. 1984b).

8. ROUND WHITEFISH

- Round whitefish periodicity is shown in Table B3-7.
- Adults in the Susitna River Basin predominantly used tributary, tributary mouth and sloughs for feeding and holding habitat during the open water season during the 1980s (Sautner and Stratton 1983, Schmidt et al. 1983, Sundet and Wenger 1984, Sundet and Pechek 1985).
- Tributary sampling indicated that many large adult round whitefish moved upstream into large clear tributaries in the Middle Segment in June and returned downstream to mainstem areas in August and September (Schmidt et al. 1983, Sundet and Wenger 1984).
- During tag-recapture studies in the 1980s, most recaptured adult round whitefish exhibited little movement, though approximately 20% of recovered fish in 1983 and 1984 had moved an average of 18.5 and 16 miles in the respective years (Sundet and Wenger 1984, Sundet and Pechek 1985). Maximum observed movement of tagged round whitefish was 55.7 miles based on 1983 recapture data and 69.5 miles based on 1984 tag recaptures (Sundet and Wenger 1984, Sundet and Pechek 1985). Movement was typically downstream during summer and upstream in fall (Sundet and Wenger 1984).
- In late summer, adult round whitefish migrate upstream and downstream from summer feeding habitats to spawning areas located in main channel and tributary mouth habitats, though large schools observed at the mouths of Portage Creek (RM 148.8) and Indian River (RM 138.6) may indicate tributary spawning (Schmidt et al. 1983, Sundet and Wenger 1984).
- Based on fishwheel capture in 1982 and 1983, upstream spawning migration in the main channel of the Middle Segment occurred during late August and September (Schmidt et al. 1983, Sundet and Wenger 1984). Round whitefish spawning in the Susitna Basin was believed to occur during October (Sundet and Wenger 1984, Sundet and Pechek 1985).
- After spawning, it is believed that adult round whitefish utilized mainstem areas to hold for winter, but little is known regarding winter behavior and habitat use (Sundet and Pechek 1985).
- The duration of round whitefish egg incubation and timing of fry emergence in the Susitna River is not well defined by 1980s studies. Development and incubation time for round whitefish eggs has been observed to take approximately 140 days at 2.2° C, though duration can vary with water temperature and other variables (Normandeau 1969, Morrow 1980). Based on this basic incubation period and the timing of earliest age-0+ round whitefish capture in late May and June, incubation is estimated to occur from October through June and emergence likely occurs in May and June (Schmidt et al. 1983).
- Age-0+ juvenile round whitefish are believed to utilize nursery habitats proximal to where hatching and emergence occurs, though a portion of the Middle Segment population migrated downstream in each year of 1982 and 1983 (Schmidt et al. 1983, Sundet and Wenger 1984). Downstream movement of juvenile round whitefish at the Talkeetna Station (RM 103) outmigrant trap occurred throughout the trap operational

period in each year, from late May through September, and peaked in late June and July (Schmidt et al. 1983, Sundet and Wenger 1984).

- Following downstream movement, primary habitats used by juvenile round whitefish in the Middle and Lower segments were side slough, upland slough and turbid main channel and side channel areas (Schmidt et al. 1983, Sundet and Wenger 1984). In the Upper Segment, juvenile round whitefish were captured at tributary mouths and slough habitats (Sautner and Stratton 1983). Juvenile round whitefish may utilize turbid mainstem areas for cover (Suchanek et al. 1984b). Little is known regarding juvenile round whitefish habitat use during the winter, but based on spring capture locations during the 1980s, it was presumed that winter nursery habitats were proximal to summer habitats (Sundet and Pechek 1985).

9. REFERENCES

ADF&G (Alaska Department of Fish and Game). 1981. Adult Anadromous Fisheries Project ADF&G/Su Hydro 1981. Phase I Final Draft Report, Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 467 pp. APA Document # 324.

ADF&G (Alaska Department of Fish and Game). 1983c. Susitna Hydro Aquatic Studies Phase II Report Volume I: Summarization of Volumes 2, 3, 4; Parts I and II, and 5. Prepared for Alaska Power Authority, Anchorage, Alaska. 146 pp. APA Document # 96.

Barrett, B. M., F. M. Thompson and S. N. Wick. 1984. Adult anadromous fish investigations: May - October, 1983. Report No. 1, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for the Alaska Power Authority, Anchorage, Alaska. 430 pp. APA Document # 1450.

Barrett, B. M., F. M. Thompson and S. N. Wick. 1985. Adult salmon investigations: May - October, 1984. Report No. 6, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for the Alaska Power Authority, Anchorage, Alaska. 528 pp. APA Document # 2748.

Bjorn, E. E. 1940. Preliminary observations and experimental study of the ling, *Lota maculosa* (LeSueur), in Wyoming. Transactions of the American Fisheries Society 69: 192-196.

Blackett, R. F. 1962. Some phases of the life history of the Alaskan blackfish, *Dallia pectoralis*. Copeia 1962: 124-130.

Buckwalter, J.D. 2011. Synopsis of ADF&G's Upper Susitna Drainage Fish Inventory, August 2011. Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, Alaska. 27 pp.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K. Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P Suchanek, R. Sundet, and M. Stratton. 1981b. Resident fish investigation on the Lower Susitna River. Phase I Final Draft Report, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 311 pp. APA Document # 318.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K. Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P Suchanek, R. Sundet, and M. Stratton. 1981c. Resident fish investigation on the Upper Susitna River. Phase I Final Draft Report, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 157 pp. APA Document # 316.

MacCrimmon, H. R. 1971. Observations on spawning of burbot in Lake Simcoe, Ontario. Journal of Wildlife Management 23(4): 447-449.

McPhail, J. D., and V. L. Paragamian. 2000. Burbot biology and life history. Pages 10-23 in Paragamian, V. L. and D. W. Willis, eds., Burbot: Biology, ecology, and management. Publication 1. Fisheries Management Section, American Fisheries Society, Spokane, Washington.

Morrow, J. E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage, Alaska. 248 pp.

Normandeau, D. A. 1969. Life history and ecology of the round whitefish, Prosopium *cylindraceum* (Pallas), of Newfound Lake, Bristol, New Hampshire. Transactions of the American Fisheries Society 98: 7-13.

Roth, K. J. and M. E. Stratton. 1985. The migration and growth of juvenile salmon in Susitna River, 1985. Pages 6-207 in Schmidt, D., S. Hale, and D. Crawford, eds., Resident and juvenile anadromous fish investigations (May - October 1984). Report No. 7, Alaska Department of Fish and Game Susitna Aquatic Studies Program. Prepared for the Alaska Power Authority, Anchorage, Alaska. APA Document # 2836.

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. Pages 9-73 in Schmidt, D. C., S. S. Hale, D. L. Crawford, and P. M. Suchanek, eds., Resident and juvenile anadromous fish investigations (May - October 1983). Report No. 2, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. APA Document # 1784.

Roth, K. J., D. C. Gray, J. W. Anderson, A. C. Blaney, J. P. McDonell. 1986. The migration and growth of juvenile salmon in Susitna River, 1985. Susitna Aquatic Studies Program Report No. 14, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 130 pp. APA Document # 3413.

Sautner, J., and M. Stratton. 1983. Upper Susitna River impoundment studies, 1982. Volume 5, Phase II Basic Data Report, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 220 pp. APA Document # 590.

Sautner, J., and M. Stratton. 1984. Access and transmission corridor studies. Pages 7-89 in Schmidt, D., C. Estes, D. Crawford and D. Vincent-Lang, eds., Access and transmission corridor aquatic investigations, May - August 1983. Report No. 4, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. APA Document # 2049.

Schmidt, D. and C. Estes. 1983. Winter aquatic studies (October 1982 - May 1983). Phase II Data Report, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 269 pp. APA Document # 397.

Schmidt, D., and A. Bingham. 1983. Synopsis of the 1982 Aquatic Studies and Analysis of Fish and Habitat Relationships. Phase II Report, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 185 pp + appendices. APA Document #s 40a_ver2 (main report), 40 (appendices).

Schmidt, D., S. Hale, D. Crawford, and P. Suchanek. 1983. Resident and juvenile anadromous fish studies on the Susitna River below Devil Canyon, 1982. Volume 3, Phase II Basic Data Report, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 303 pp + appendices. APA Documents #s 486, 487.

Stratton, M.E. 1986. Summary of juvenile Chinook and coho salmon winter studies in the Middle Susitna River, 1984-1985. Report No. 11, Part 2, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 148 pp. APA Document # 3063.

Suchanek, P.M., R. L. Sundet and M. N. Wenger. 1984a. Resident fish habitat studies. Pages 360-404 in Schmidt, D.C., S.S. Hale, D.L. Crawford, and P.M. Suchanek, eds., Resident and juvenile anadromous fish investigations (May - October 1983). Report No. 2, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. APA Document # 1784.

Sundet, R. L. 1986. Winter resident fish distribution and habitat studies conducted in the Susitna River below Devil Canyon, 1984-1985. Report No. 11, Part 1, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 80 pp. APA Document # 3062.

Sundet, R. L., and M. N. Wenger. 1984. Resident fish distribution and population dynamics in the Susitna River below Devil Canyon. Pages 250-358 in Schmidt, D.C., S.S. Hale, D.L. Crawford, and P.M. Suchanek, eds., Resident and juvenile anadromous fish investigations (May - October 1983). Report No. 2, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. APA Document # 1784.

Sundet, R. L., and S. D. Pechek. 1985. Resident fish distribution and life history in the Susitna River below Devil Canyon. Part 3 (97 pages) in Schmidt, D. C., S. S. Hale, and D. L. Crawford, eds., Resident and juvenile anadromous fish investigations (May - October 1984). Report No. 7, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. APA Document # 2837.

Thompson, F. M., S. N. Wick, and B. L. Stratton. 1986. Adult salmon investigations, May – October 1985. Report No. 13, Volume 1, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 173 pp. APA Document # 3412.

Yoshihara, H. T. 1973. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Progress Report, 1972-1973, Project F-9-5, Study G-III-A. 14: 1-63.

10. TABLES

Table B3-1. Periodicity of Arctic grayling utilization among macro-habitat types in the Susitna River by life history stage. Shaded areas indicate timing of utilization by macro-habitat type and dark gray areas represent areas and timing of peak use.

Life Stage	Habitat Type: Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Holding																		
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Juvenile Rearing																		

Table B3-2. Periodicity of burbot utilization among macro-habitat types in the Susitna River by life history stage. Shaded areas indicate timing of utilization by macro-habitat type and dark gray areas represent areas and timing of peak use.

Life Stage	Habitat Type: Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Holding																		
Adult Migration																		
Spawning																		
Incubation																		
Juvenile Migration																		
Juvenile Rearing																		

Table B3-3. Periodicity of Chinook salmon utilization among macro-habitat types in the Middle River (RM 184 - 98.5) by life history stage. In the Upper Segment (RM 248 – RM 184), adult Chinook are believed to exhibit similar habitat use to that shown for the Middle Segment, while juvenile Chinook rearing and migration timing in this segment is not known. Shaded areas indicate timing of utilization by macro-habitat type and dark gray areas represent areas and timing of peak use.

Life Stage	Habitat Type: Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Age 0+ Rearing																		
Age 0+ Migration																		
Age 1+ Rearing																		
Age 1+ Migration																		

Table B3-4. Periodicity of Dolly Varden in the Susitna River by life history stage and habitat type. Shaded areas represent utilization of habitat types and temporal periods and dark gray areas indicate peak use.

Life Stage	Habitat Type						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary												
Adult Holding																		
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Juvenile Rearing																		

Table B3-5. Periodicity of humpback whitefish utilization among macro-habitat types in the Susitna River by life history stage. Shaded areas indicate timing of utilization by macro-habitat type and dark gray areas represent areas and timing of peak use.

Life Stage	Habitat Type: Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Holding																		
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Juvenile Migration																		
Juvenile Rearing[1]																		

Notes:

1 A portion of juvenile humpback whitefish may utilize estuarine habitats to rear during the first two years of life.

Table B3-6. Periodicity of longnose sucker in the Susitna River by life history stage and habitat type. Shaded areas represent utilization of habitat types and temporal periods and dark gray areas indicate peak use.

Life Stage	Habitat Type: Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Holding																		
Adult Migration																		
Spawning[1]																		
Incubation																		
Fry Emergence																		
Juvenile Migration																		
Juvenile Rearing																		

Notes:

1 Longnose sucker typically spawn in spring, however, a second unconfirmed spawn period may occur during the late summer in October or November.

Table B3-7. Periodicity of round whitefish utilization among macro-habitat types in the Susitna River by life history stage. Shaded areas indicate timing of utilization by macro-habitat type and dark gray areas represent areas and timing of peak use.

Life Stage	Habitat Type						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary												
Adult Holding																		
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Juvenile Migration																		
Juvenile Rearing																		