APPENDIX B4. MIGRATORY CHARACTERISTICS

1. INTRODUCTION

The timing, duration, and routes by which target fish species in the vicinity of the Project may exhibit movements will be important considerations in evaluating the feasibility of fish passage alternatives. To varying degrees, information collected from the Susitna River during the 1980s and in 2012 have allowed the development of periodicity and life history information, which is provided in Appendix B3 in terms by life stage. The following appendix focuses solely on this information as it relates to fish movements, as available. Information on the general migratory routes of target species in the Susitna River is also provided. However, relevant fine-scale movement behavior under post-Project conditions is clearly an unknown. While information may be available from other projects for certain target species, the site-specific nature of hydraulic and bathymetric conditions and their effect on movement behavior limits the utility of such information at this stage. As the feasibility study progresses and passage alternatives are developed, a more targeted review of the literature related to movements of target species in the vicinity of other hydroelectric projects may provide additional relevant information.

2. ARCTIC GRAYLING

2.1. Adult Movements

- Post-spawning migrations to 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)
- During the open water season, many adults 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.

2.2. Juvenile Movements

- 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

3.1. Adult Movements

- 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).

- Post-spawning migrations occur from February through March and are thought to be relatively short (0.5 – 7 miles) (Schmidt and Estes 1983).

3.2. Juvenile Movements

- Upon hatching, burbot fry are small (3-4 mm, total length) and drift passively until swimming ability improves (McPhail and Paragamian 2000).

4. CHINOOK SALMON

4.1. Adult Movements

- 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).
- Adults in the Susitna River begin their upstream migration in late-May to early June (Jennings 1985). Although a few Chinook salmon may pass Susitna Station (HRM 26.7) as late as mid-August, nearly all Chinook salmon (95 percent) have passed the station by the first week of July (Jennings 1985). Peak run timing is generally later at Talkeetna Station (HRM 103) compared to Sunshine Station. However, peak run timing at Curry Station appears to be similar or earlier than at Talkeetna Station, suggesting that upriver fish (i.e., Chinook salmon bound primarily for Indian and Portage creeks) enter and migrate during the early portion of the overall Chinook salmon migration period in the Susitna River Basin.

4.2. Juvenile Movements

- The timing of juvenile migration is poorly defined in the Upper River due to limited information. It is unclear whether juvenile Chinook captured in 2003 and 2011 in the Upper River were age 0+ and/or age 1+ (Buckwalter 2011). Periodicity of juvenile Chinook rearing and migration are considered undefined until additional data are available.
- 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.
- 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 at Talkeetna Station (RM 103) indicated that 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.**). 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.

- Some Chinook salmon fry remain in natal tributaries throughout their first year of life (Stratton 1986). Age 1+ juveniles are thought to emigrate 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

5.1. Adult Movements

- 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).
- 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).
- Fishwheel capture data at the Talkeetna Station (RM 103) in 1982 and mark-recapture data during 1982-1983 suggest upstream movement of adults 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).

5.2. Juvenile Movements

- Little is known regarding possible seasonal movements of juveniles because capture rates were generally very low during 1980s studies (Delaney et al. 1981b, Schmidt et al. 1983, Suchanek et al. 1984b). Juveniles primarily remain in 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). During winter, it is possible that juveniles 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, juveniles likely move to lacustrine habitats during winter (Sautner and Stratton 1984).

6. HUMPBACK WHITEFISH

6.1. Adult Movements

- Movements in the Upper River are essentially unknown due to low capture rates.
- In the Middle and Lower River, a portion of the population may move to estuarine or marine habitats for a portion of their lifespan, although most appear to exhibit a riverine life history pattern based on analysis of adult scale patterns (Sundet and Wenger 1984, Sundet and Pechek 1985).
- Adults 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).
- Movements associated with overwintering in the Middle and Lower River is largely unknown due to low winter capture rates (Schmidt et al. 1983).

6.2. Juvenile Movements

- 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 River and 5% in the Middle River were believed to use estuarine areas during the first two years of life (Sundet and Pechek 1985).

7. LONGNOSE SUCKER

7.1. Adult Movements

- Adults in the Susitna Basin are thought to exhibit some movement associated with spawning in mainstem and tributary mouth habitats during May and early June, though the extent of this migration is unclear (Schmidt et al. 1983). An additional spawning

period may occur in the late summer during October and/or November (Schmidt et al. 1983, Sundet and Wenger 1984).

- Following spring spawning, some adults appeared to move upstream to summer feeding habitats and return downstream to winter holding areas (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). 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 River, 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 (Schmidt and Bingham 1983, Schmidt et al. 1983).

7.2. Juvenile Movements

- Juvenile longnose sucker fry typically drift from natal sites following emergence to summer nursery areas (Morrow 1980), a strategy apparently exhibited in the Susitna River; 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 River occurred throughout the open water period in 1982 and 1983, and exhibited a bi-modal peak during June and during late August and September (Schmidt et al. 1983, Sundet and Wenger 1984, Sundet and Pechek 1985).

8. ROUND WHITEFISH

8.1. Adult Movements

- 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).
- Tributary sampling indicated that many large adult round whitefish moved upstream into large clear tributaries in the Middle River in June and returned downstream to mainstem areas in August and September (Schmidt et al. 1983, Sundet and Wenger 1984).
- 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).
- 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).

8.2. Juvenile Movements

- Age-0+ juveniles are thought to remain near natal sites, though a portion in the Middle River migrate downstream (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).
- 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.

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.

Jennings, T.R. 1985. Fish Resources and Habitats in the Middle Susitna River. Woodward-Clyde Consultants and Entrix. Final Report to Alaska Power Authority. 175 pp.

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.

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.

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.

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 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. 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., 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 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.

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.

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.