Susitna-Watana Hydroelectric Project Document
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Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Study of Fish Passage Feasibility at Watana Dam
Study Plan Section 9.11

Initial Study Report
Part A: Sections 1-6, 8-10

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants, Inc.

June 2014

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
BPT	biological performance tool
CEII	Critical Energy Infrastructure Information
FERC	Federal Energy Regulatory Commission
FPTWG	Fish Passage Technical Workgroup
ILP	Integrated Licensing Process
ISR	Initial Study Report
NMFS	NOAA National Marine Fisheries Service
PRM	project river mile
Project	Susitna-Watana Hydroelectric Project
RM	River Mile(s) referencing those of the 1980s Alaska Power Authority Project.
RSP	Revised Study Plan
SPD	study plan determination
TWG	Technical Workgroup
USFWS	United States Fish and Wildlife Service

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed its Revised Study Plan (RSP) with the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (FERC Project No. 14241), which included 58 individual study plans (AEA 2012). Section 9.11 of the RSP described the Study of Fish Passage Feasibility at Watana Dam. This section focuses on conducting a study to develop, to the feasibility level, a fish passage strategy in support of the license application for the proposed Project. RSP Section 9.11 provided goals, objectives, and proposed methods for assessing the feasibility of fish passage at Watana Dam.

On February 1, 2013, FERC staff issued its study plan determination (February 1 SPD) for 44 of the 58 studies, approving 31 studies as filed and 13 with modifications. RSP Section 9.11 was one of the 31 studies approved with no modifications.

On February 21, 2013, the National Marine Fisheries Service (NMFS) filed a notice of study dispute pursuant to section 5.14(a) of the Commission's regulations. This dispute included four elements of RSP Study 9.11.

On April 3, 2013, a dispute resolution panel held the technical conference, which was attended by representatives from NMFS, AEA, the Commission, and other licensing participants. On April 12, 2013, the panel filed its findings with the Commission, and recommended the following modification to RSP Section 9.11:

> *AEA is required to review existing literature relevant to glacial retreat and summarize the understanding of potential future changes in runoff associated with glacier wastage and retreat, as described in RSP section 7.7.4.1. RSP section 9.11.1, General Description of the Proposed Study, is modified to delete the text that reads: "(2) Can the fish passage alternative be constructed and operated while maintaining the original purpose of the project?" The deleted text shall be replaced with the following: "(2) Can the fish passage alternative be constructed and operated while allowing an economically feasible Project?"*

On April 26, 2013, FERC issued a formal study dispute determination and AEA adopted the recommended changes. The RSP and adopted changes were applied in 2013 study efforts as the final study plan (study plan).

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)) This Initial Study Report (ISR) on Fish Passage Feasibility has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP, and as modified by FERC's April 26, 2013 SPD (collectively referred to herein as the "Study Plan")."

2. STUDY OBJECTIVES

The goal of this study is to develop, to the feasibility level, a fish passage strategy in support of the License Application for the proposed Project. The methods section of this report outlines the process that was used during 2013 to achieve this objective. A variety of engineering, biological, sociological, and economic factors will be considered during this process as it continues through 2014. The study will explore various alternatives in support of three basic strategies related to fish passage: (1) proposed Project without fish passage, (2) integration of upstream and downstream passage features into the current Project design, and (3) the retrofit of upstream and downstream fish passage features to a Project designed without passage.

In the context of this study "retrofit" means that fish passage features would be either geographically or temporally independent from the dam design. A retrofitted passage facility may be constructed some distance upstream or downstream from the dam or later in the future after the construction of the dam, and thus is independent of the dam design process. Option 3, the retrofit option, avoids constraints with having the only option of fish passage being part of the dam structure. Thus, the feasibility evaluation can examine a wider spectrum of passage alternatives.

3. STUDY AREA

As described in RSP Section 9.11.3, the study area (Figure 3-1) extends from the confluence with Portage Creek (Project river mile [PRM] 152.3; historic river mile [RM] 148) upstream to the Oshetna River (PRM 235.1; RM 233.4). It is assumed that any potential upstream passage facilities to be considered (e.g., a trap-and-haul facility) would be located in the mainstem upstream of the confluence with Portage Creek.

4. METHODS

This feasibility evaluation includes six tasks needed to determine the technical feasibility of fish passage for the Project. The first four of these tasks were initiated in 2013, and the first three of these were completed during 2013. This study generally follows the guidance provided in the NMFS *Anadromous Salmonid Passage Facility Design* document (NMFS 2011). These tasks are summarized below.

1. Establish a Fish Passage Technical Workgroup (FPTWG) to provide input on the feasibility assessment.
2. Prepare for feasibility study.
3. Conduct site reconnaissance.
4. Develop concepts.
5. Evaluate feasibility of conceptual alternatives.
6. Develop refined passage strategy(ies).

4.1. Task 1: Establish the Fish Passage Technical Workgroup to Provide Input on the Feasibility Assessment.

AEA implemented the methods as described in the Study Plan with no variances.

In cooperation with state and federal agencies and other interested licensing participants, AEA established a FPTWG with representatives from state and federal agencies, and included the contracting of regional experts selected cooperatively by AEA and participating state and federal agencies and other interested licensing participants. This workgroup convened regularly (approximately bi-monthly [once every other month]) from February through September, 2013. Regular meetings and workshops were scheduled for the duration of this study in order to provide input on assessing additional data needs, developing evaluation criteria, and developing conceptual design passage strategies.

The workshops are planned as multi-day meetings where participants will help to develop and refine alternatives as described below. The first of four workshops was completed. The four workshops intend to address the following topics: (1) review of dam design and operational concepts, biological, physical and site specific information, (2) conceptual alternatives brainstorming, (3) critique and refinement of concepts and packaging of conceptual components into alternatives, and (4) alternatives selection, refinement, and costs. The first FPTWG meeting on February 22, 2013 was convened to identify goals, set schedules, establish process, and refine and obtain input on list of information needed for Task 2.

4.2. Task 2: Prepare for Feasibility Study.

AEA implemented the methods as described in the Study Plan with no variances.

Task 2 is focused on technical preparation for the concept development brainstorming session described in Task 4. AEA compiled the existing and salient background information listed below, and the information was disseminated and presented to the FPTWG at the first FPTWG Workshop held on April 9 - 10, 2013. Updates were distributed on September 3, 2013 for the Site Reconnaissance tour held on September 17 – 20, 2013. In addition, AEA prepared workshop materials including a draft passage evaluation and comparison matrix, and will be producing draft evaluation criteria prior to the brainstorming workshop. The review materials and workshop allowed the FPTWG to become familiar with the operational, physical, hydrologic, and biological setting of the Watana Dam. This information will assist the FPTWG during Task 4 in providing input to alternatives identified by AEA that can reasonably and realistically fit within the construct of the proposed Project operations, and that are compatible with hydrological and physical constraints.

Existing data was obtained from the 1980s Susitna studies, ADF&G surveys conducted between 2003 and 2011, AEA survey reports, and engineering documents prepared in 2012 (ADF&G 1984, ADF&G 2003a, ADF&G 2003b, ADF&G 2011, Buckwalter 2011, Delaney et al. 1981, Harza-Ebasco 1985, Thompson et al. 1986). Additional data were developed during the licensing baseline study program in 2013 and these data will also be used to inform development of alternatives and conceptual design. A majority of the following information was compiled to date as part of Task 2, and will be supplemented in the next year of study as more information becomes available and TWG members are able to comment on the initial information (to be distributed prior to the brainstorm workshop).

- Biological
  - List of potential target fish species and life stages that will benefit from passage
  - Species and life stage-specific periodicity
  - Life stage-specific parameters: size, migratory behavior, swimming behavior, swimming ability, and other physical passage constraints
  - Fish relative abundance and distribution upstream and downstream of the proposed Watana Dam site
  - Locations of spawning and rearing habitats
  - Migratory characteristics (seasonal timing, duration) by species and life stage
  - Identification of existing ecological conditions (e.g. presence of predatory and/or invasive species, light, temperature and flow) and how they might be affected by passage facilities
- Physical
  - Topographic survey
  - Water quality and water temperature
  - Hydrologic and hydraulic information (e.g., 5 percent and 95 percent exceedance flows)
  - Ice processes
  - Sedimentation transport processes
  - Geomorphology
- Project Features
  - Project conceptual drawings
  - Project operations (e.g., reservoir storage, powerhouse, and spillway flows)
  - Aerial photos
  - Seasonal flows downstream of the Project (e.g., tailwater rating curves, flow duration curves)
  - Seasonal pool elevation (e.g., forebay rating curves, fluctuations, etc.)
  - Project design components (e.g., dam layout, cross-sections, turbine type, draft tube velocity, sediment capacity, power availability, etc.)
  - Project access or restrictions to access for operations and maintenance

The above information will be used to support the development of a biological performance tool (BPT) as part of Task 4 rather than Task 2, as described in the study plan. In addition, compiling information on migratory behavior, preferably behavior specific to the Susitna River from studies conducted during 2013 (Studies 9.5 Fish Distribution and Abundance in the Upper Susitna River, 9.6 Fish Distribution and Abundance in the Middle and Lower Susitna River, and 9.7 Salmon Escapement), will help identify the type, location, size, and timing of potential upstream and downstream fish passage facility components. Additional information needs may be defined during the compilation.

The deliverables for this task are base drawings; maps; synthesized biological, physical, and site data listed above; and operational protocols necessary to conduct the study.

4.3. Task 3: Conduct Site Reconnaissance.

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.7).

AEA and the FPTWG conducted a site reconnaissance to observe conditions and collect information, as appropriate, for concept development. The visit included an helicopter fly-over of the study area as planned, from the mouth of Portage Creek, over the proposed Watana Dam site at PRM 187.1, as well as tributaries to the proposed reservoir where Chinook salmon have been documented. A summary of the site visit is provided in Section 5.3 below.

4.4. Task 4: Develop Concepts.

AEA initiated implementation of the methods as described in the Study Plan, but varied from the Study Plan in that it did not complete Task 4 in 2013.

Work completed under Task 4 in 2013 included the initial development of the BPT. The BPT was developed using information compiled under Task 2. This tool will be used to qualitatively estimate potential passage success of alternate facilities using concepts to be identified and refined in the feasibility study. Examples of challenging issues that can be addressed with this tool include the influence of reservoir survival on outmigrant success and the effect of facility design flow on fish guidance efficiency. The BPT will present the potential passage success of target life stages and species associated with the alternate passage concepts under consideration. Additional BPT and concept development work will continue in the next year of study.

4.5. Task 5: Evaluate Feasibility of Conceptual Alternatives.

Implementation of Task 5 was initially and is currently scheduled in the next year of study.

4.6. Task 6: Develop Refined Passage Strategy(ies)

Implementation of Task 6 was initially and is currently scheduled in the next year of study.

4.7. Variances

Variances from the Study Plan in 2013 were limited to a schedule modification for Tasks 3 and 4. Task 3 (i.e., site reconnaissance) was initially scheduled for the second quarter of 2013 but was not conducted until the third quarter, in order to target Susitna River low flow time period. Modifications to the schedule occurred in collaboration with the FPTWG.

The Study Plan envisioned completion of Task 4 during 2013. During 2013, AEA work on Task 4 included the initial development of the BPT. In order to allow for further collaboration with the FPTWG and integration of information from other studies, AEA intends to continue additional BPT and concept development in the next year of study. This modification to the schedule will not impact AEA's ability to meet the objectives of the Study Plan.

5. RESULTS

5.1. Fish Passage Technical Working Group

The FPTWG is a subgroup of the Fish and Aquatic TWG and includes representatives from AEA, NMFS, USFWS, ADF&G and their respective contractors. As part of the February 22, 2013 kick-off meeting, participants were solicited for names of any additional passage experts they would like to participate on the Passage TWG. As a result, three experts were added to the FPTWG. A list of FPTWG participants and their roles, as of September 26, 2013, is provided in Table 5.1-1.

5.2. Feasibility Study Preparation

Preparation for the feasibility study involved the compilation of available biological and physical information as well as descriptions of Project features. The FPTWG will be updated with the current status documented through an Information List. The Information List will be treated as a living document along with updates to the relevant information. This information was initially distributed to the FPTWG prior to the Background Information Review workshop (Workshop #1) held on April 9 and 10, 2013. Updates to this information were provided prior to the Site Reconnaissance meeting held on September 18 and 19, 2013, effectively superseding much of the initial information. Additional updates are anticipated as the study progresses. The current lists and available compiled information for biological data and physical, hydrographic, and engineering data needs are provided in Appendix B and Appendix C, respectively.

An important step in the preparation of the feasibility study is identification of potential target species. An initial set of seven potential target species was identified based upon their presence in the Upper Susitna River and a qualitative assessment of three criteria: migratory behavior, relative abundance, and importance to commercial, sport, or subsistence fisheries. Further discussion within the FPTWG expanded the list to include consideration of six additional species not currently known to be present in the Upper Susitna River. In total, the TWG identified 13 target species to potentially consider in the study (Table 5.2-1).

By design, the FPTWG identified a broad set of potential target fish species because of uncertainty regarding the distribution and abundance of some species. Of the identified target species, only Chinook salmon , Arctic grayling, burbot, Dolly Varden, longnose sucker , humpback whitefish, and round whitefish, are known to be present upstream of Devils Canyon (Study 9.5).

5.3. Site Visit

Nearly all members of the FPTWG were able to attend the site reconnaissance trip that was held on September 18, 2013, and a half-day meeting on September 19, 2013 to debrief and prepare for the brainstorm workshop. A site tour via four helicopters was conducted on September 18, 2013. The tour left Talkeetna at 10 am and included a flight upriver through the Project Area depicted on Figure 3-1 to the Oshetna River. The group landed and observed the mouth of the Oshetna River, observed the screw trap and sampling operations in action, and discussed tributary collector options. The group then traveled downriver and landed near the mouth of Kosina

Creek and observed that site. The last stop was at a gravel bar approximately one-half mile upstream of the dam site. At least two of the helicopters flew up the Oshetna River and Kosina Creek to the projected full pool location and beyond, to observe conditions for potential tributary collectors. The group flew back downriver through Devils Canyon, and returned to Talkeetna. Weather was overcast with some rain and snow in the morning, and cleared to overcast with broken clouds in the afternoon, so visibility was generally very good.

A brief meeting was held upon landing to debrief and discuss the overall study plan. This meeting continued on September 19, 2013 to capture comments resulting from the site visit and to discuss steps leading up to the March 18-20, 2014 brainstorming workshop. Summary tables with fish passage information were discussed, and FPTWG input received. A handout with an update of adult Chinook passage through Devils Canyon in 2013 was distributed, and a sample evaluation and comparison matrix for alternative passage concepts was presented. Finally, an updated site plan and Project data was distributed to the FPTWG that was classified as Critical Energy Infrastructure Information (CEII) information.

5.4. Concept Development

Additional work under Task 4 is scheduled for the next year of study. Consequently, there are no Task 4 results to report in the ISR.

5.5. Feasibility Analysis of Conceptual Alternatives

This study component is scheduled for implementation during the next year of study. Consequently, there are no results to report in the ISR.

5.6. Passage Strategy(ies) Development

This study component is scheduled for implementation during the next year of study. Consequently, there are no results to report in the ISR.

6. DISCUSSION

Overall, the status of the Study of Fish Passage Feasibility at Watana Dam is ongoing.

Tasks completed in 2013 include:

- Task 1: Establishment of the Fish Passage Technical Workgroup to provide input on the Feasibility Assessment
- Task 2: Preparation for the Feasibility Study
- Task 3: Site reconnaissance

Although Task 2 has been completed, additional updates to information lists are anticipated as results from other Project studies become available.

Ongoing tasks include:

- Task 4: Concept development

Task 4 work in 2013 included the initial development of the BPT. Additional BPT and concept development will continue in the next year of study.

Tasks to be initiated in the next year of study include:

- Task 5: Feasibility evaluation of conceptual alternatives
- Task 6: Development of refined passage strategy(ies)

As described in RSP Section 9.11, the Fish Passage Feasibility Study will require integration of results from multiple studies. An overview of these studies and their status relative to meeting the objectives of the Fish Passage Feasibility Study are provided below.

The Study of Fish Distribution and Abundance in the Upper Susitna River (Study 9.5), the Study of Fish Distribution and Abundance in the Middle and Lower Susitna River (Study 9.6), the Salmon Escapement Study (Study 9.7), and the Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Study 9.12) will provide baseline biological inputs on migratory timing and behavior as well as distribution of fishes over various life stages in the vicinity of the proposed dam site. These studies are ongoing. Study variances in 2013 are not anticipated to affect the successful completion of the Fish Passage Feasibility Study.

The Future Watana Reservoir Fish Community and Risk of Entrainment Study (Study 9.10) will interrelate by providing biological information on the anticipated reservoir fish assemblage and entrainment risk. This study is currently scheduled for initiation in the next year of study. This delay in study initiation is not anticipated to affect the successful completion of the Fish Passage Feasibility Study.

The Geology and Soils Study (Study 4.5), Water Quality studies (Studies 5.5, 5.6, and 5.7), the Ice Processes in the Susitna River Study (Study 7.6),and the Geomorphology Study (Study 6.5) will provide input related to hydraulics, sediment transport, and other physical processes for the Study of Fish Passage Feasibility at Watana Dam. These studies are ongoing. Study variances in 2013 are not anticipated to affect the successful completion of the Fish Passage Feasibility Study.

7. COMPLETING THE STUDY

[Section 7 appears in the Part C section of this ISR.]

8. LITERATURE CITED

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9. TABLES

Table 5.1-1. Fish Passage TWG members as of September 26, 2013.

Name	Company	Role
Betsy McGregor	AEA	Environmental Manager.
Dana Postlewait	R2	Study Lead
MaryLou Keefe	R2	Aquatics Lead
Dan Turner	R2	Lead R2 Engineer
Tim Sullivan	R2	Lead Biologist
Dennis Dorratcague	MWH	Lead MWH Engineer
Dana Schmidt	Golder	expert advisor, biologist
Chick Sweeney	Alden	expert advisor, engineer
Al Giorgi	BioAnalysts	expert advisor, biologist
Ed Meyer	NMFS	Agency Representative
Sue Walker	NMFS	Agency Representative
Stormy Haught	ADF&G	Agency Representative
Phil Brna	USFWS	Agency Representative
Jeff Davis	ARRI	Biologist under contract to Services
Ed Zapel	NHC	Engineer under contract to Services
Graham Hill	NHC	Engineer under contract to Services

Table 5.2-1. List of preliminary target fish species for the Fish Passage Feasibility Study. The list includes additional target species identified during FPTWG discussions.

Species	Latin Name	Documented in Upper River Basin	Migratory Potential	Relative Abundance[3]	Harvest Importance	Target Species
Chinook Salmon	*Oncorhynchus tshawytscha*	Yes	High	Low	High	✓
Chum Salmon	*Oncorhynchus keta*	No	Included based on TWG discussion			✓
Coho Salmon	*Oncorhynchus kisutch*	No	Included based on TWG discussion			✓
Sockeye Salmon	*Oncorhynchus nerka*	No	Included based on TWG discussion			✓
Arctic Grayling	*Thymallus arcticus*	Yes	Moderate	High	High	✓
Burbot	*Lota lota*	Yes	Moderate	Low	High	✓
Dolly Varden	*Salvelinus malma*	Yes	Moderate	High	High	✓
Lamprey, Arctic	*Thymallus arcticus*	No	Included based on TWG discussion			✓
Longnose Sucker	*Catostomus catostomus*	Yes	Moderate	Moderate	None	✓
Sculpin[1]	*Cottus spp.*	Yes	Low	High	None	
Trout, Lake	*Salvelinus namaycush*	Yes	Low	Low	High	
Trout, Rainbow Trout/ Steelhead	*Oncorhynchus mykiss*	No	Included based on TWG discussion			✓
Whitefish, Bering Cisco	*Coregonus laurettae*	No	Included based on TWG discussion			✓
Whitefish, Humpback[2]	*Coregonus pidschian*	Yes	Moderate	Low	Moderate	✓
Whitefish, Round	*Prosopium cylindraceum*	Yes	Moderate	Moderate	Moderate	✓

Notes:

1 Sculpin species were generally not differentiated in the field. In addition to slimy sculpin *(Cottus cognatus)*, species may include others belonging to the *Cottus* genus.

2 Whitefish species that were not identifiable to species by physical characteristics in the field were called humpback by default. This group may have included lake *(Coregonus clupeaformis)* or Alaska *(Coregonus nelsonii)* whitefish.

3 Reflects relative abundance in the Upper River Basin based on best available information.

10. FIGURES

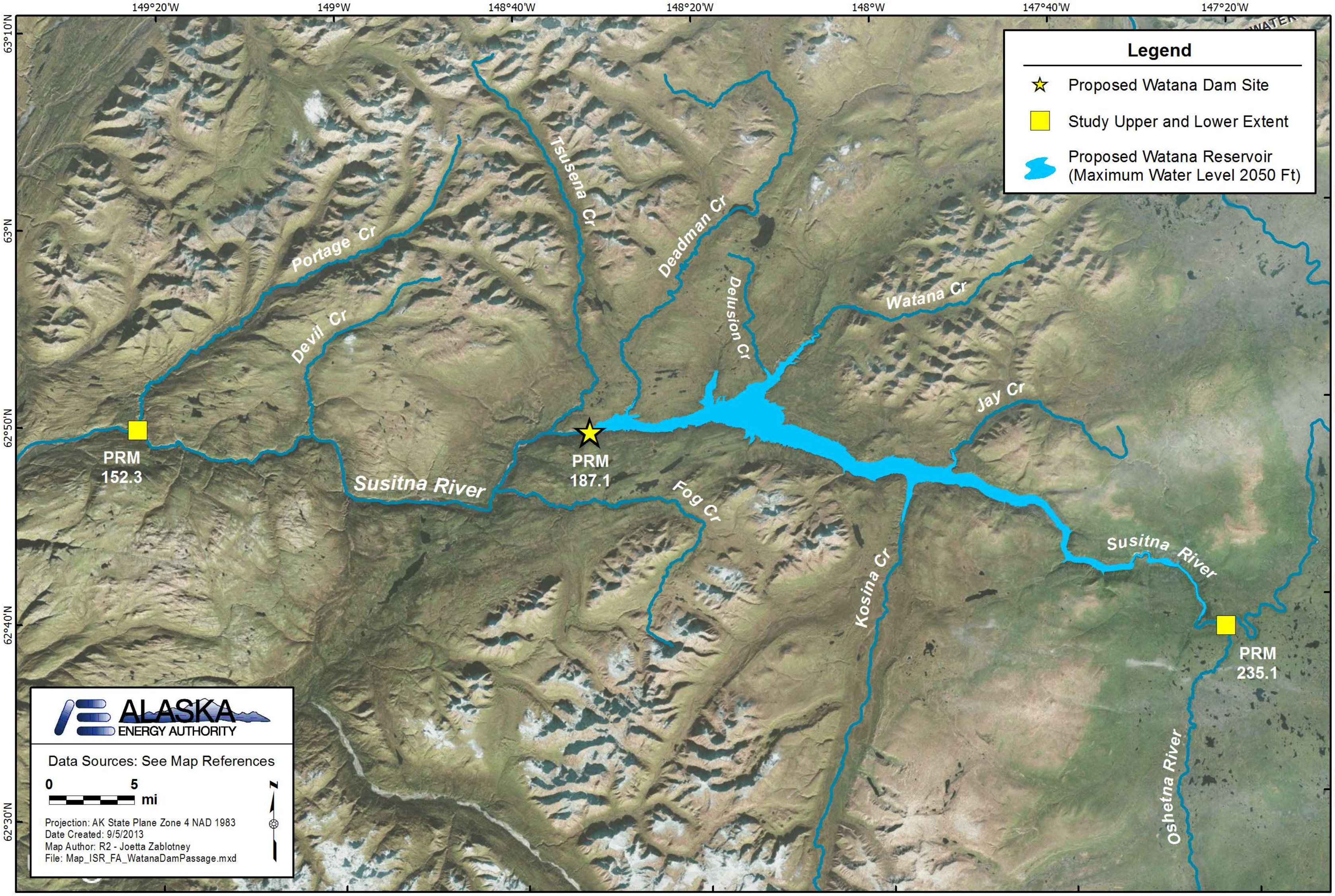

Figure 3-1. Study area for Fish Passage Feasibility, from the confluence with Portage Creek (PRM 152.3) upstream to the Oshetna River (PRM 235.1)

PART A - APPENDIX A: FISH PASSAGE TECHNICAL WORKING GROUP CONSULTATION RECORD

Table A1. Summary of consultation for the Study of Fish Passage Feasibility at Watana Dam (RSP Section 9.11).

Date	Agency/Organization Consulted	Summary of Contact
2/22/2013	Fish Passage TWG	Kickoff Meeting[1]
2/26/2013	ADF&G	MaryLouise Keefe (R2) contacted Stormy Haught (ADF&G) by telephone about ADF&G attendance at FPTWG meetings
3/13/2013	NMFS	Dana Postlewait (R2) contacted Ed Meyer (NMFS) by telephone about a preliminary list of experts to consider for fish passage brainstorm session
3/20/2013	Fish Passage TWG	Update Web Teleconference[1]
4/9/2013	Fish Passage TWG	Workshop #1[1]
5/21/2013	Fish Passage TWG	Update Web Teleconference[1]
6/24/2013	Fish and Aquatic TWG	Quarterly Meeting – Updated FATWG with the progress of Study 9.11
7/9/2013	Fish Passage TWG	Update Web Teleconference[1]
9/17/2013 to 9/19/2013	Fish Passage TWG	Site Visit

1. Meeting notes attached as part of appendix.

SUSITNA-WATANA HYDRO

Agenda and Schedule
Fish Passage
Technical Workgroup Meeting
February 22, 2013

LOCATION:	**MWH office Conference Room** **806 SW Broadway, Suite 200** **Portland, OR**
TIME:	**9:00 am – 2:00 pm AKST (<u>10:00 am – 3:00 pm PST</u>)**
SUBJECT:	**Kick-off meeting to review study plan, set protocols, refine information needs, and review meeting schedules**
ATENDEES:	**Betsy McGregor** AEA, **Wayne Dyok** AEA, **MaryLouise Keefe** R2, **Dana Postlewait** R2, **Dan Turner** R2, **Dennis Dorratcague** MWH, **Kirby Gilbert** MWH, **Steve Padula** McMillen, **Leslie Jensen** ARRI, **Matt Love** Van Ness Feldman, **Marie Steele** OPMP, **Ed Meyer** NMFS, **Sue Walker** NMFS, **Jeff Davis** ARRI, **Graham Hill** NHC, , **Ed Zapel** NHC, **Bryan Carey** AEA
ON PHONE:	**Brian Bjorkquist** State of Alaska, **Stormy Haught** ADF&G, **Kathryn Toews** McMillen, **Greg Auble** USGS

The purpose of today's meeting is to kick off the efforts of the fish passage TWG. The main goal is to achieve agreement on the work approach and to address the desired content of acceptable work products. Although presentations will be displayed, the intended approach for today's meeting is interactive with input desired from all attendees.

MaryLouise Keefe discussed the study goals of the Fish Passage Study as explained in the RSP Section 9.11.1. The primary goal is to develop a passage strategy to support the ILP. The secondary goal is to understand, from an engineering perspective, the feasibility of fish passage. Sue Walker asked for the original stated purpose of the proposed Susitna-Watana Project. Wayne Dyok noted that this is explained in the PAD and includes meeting Alaska's state energy demands, to achieve 50% renewable energy goal by 2025, and fulfilling AEA's obligations under Senate Bill 42. Sue Walker asked that the Project purpose be included in the Fish Passage Study. Wayne Dyok agreed to make these changes.

Ed Meyer asked about the protocol for meeting notes at the Fish Passage meetings. Steve Padula said that notes will be posted according to the Project's communication protocol, with a goal of within 2 weeks after the meeting.

The following engineers introduced themselves and provided a brief overview of their relative experience:

- Dennis Dorratcague (MWH) was involved in his first fish passage project in 1979. Most of his experience is in the Pacific Northwest and California.

- Dana Postlewait (R2) was involved in his first fish passage project in 1991. He has experience in the Pacific Northwest, Idaho, California, and Canada.
- Dan Turner (R2) is a civil engineer with about 20 years of fish passage experience, including many projects involved with FERC licensing.
- Ed Meyer (NMFS) is a civil engineer with specialization in hydrology. He has international experience and primarily works on relatively large hydro projects.
- Ed Zaple (NHC) worked on his first fish passage project in 1987. He has experience in California, the Pacific Northwest, the mid-West, and Canada.
- Graham Hill (NHC) has much experience in natural channel bypasses to about 80-90 feet in height.

Sue Walker asked how much of Dennis Dorratcague, Dana Postlewait and Dan Turner's experience is with new dams. Most, if not all, of their major work has been related to retrofitting to existing dam structures.

Sue Walker informed the attendees that NMFS had filed a study dispute with FERC on three studies, including fish passage, the previous day. She warned that changes in the fish passage study plan may be requested. Steve Padula acknowledged this and said any required changes would be addressed when necessary, but for now the TWG process must follow the current Revised Study Plan (RSP).

To ensure that everyone had a complete understanding of the study plan, Dana Postlewait reviewed the Fish Passage RSP study goals and tasks (available under the study plan tab on the Project website http://www.susitna-watanahydro.org/study-plan/). The intended work product of the TWG's efforts is information on passage alternatives that can be utilized when decisions are being made regarding the feasibility of fish passage. The process throughout the study will be documented so decisions and how they are made will be recorded.

Clarification was made regarding the third study goal in RSP Section 9.11.1. It was clarified that "retrofit" includes a fish passage structure that is either geographically or temporally independent of the dam design. A retrofitted passage facility may be constructed some distance upstream or downstream from the dam or later in the future after the construction of the dam, and thus is independent of the dam design process. Jeff Davis questioned the importance of the third goal in this study. MaryLouise Keefe explained that the three specified goals were created as result of a conversation with licensing participants in September 2012. Dennis Dorratcague explained that the retrofit option avoids constraints with having the only option of fish passage being part of the dam structure. The language in the study report will be elaborated on to further define the full intent of "retrofit". Sue Walker added that NMFS may reserve the request to require fish passage at a later date.

The Fish Passage TWG is considered a subgroup of the Fish and Aquatic TWG. For efficiency and practicality, the TWG will consist only of fish passage experts. They will develop information and present it to the larger workgroup. Sue Walker requested that meeting notifications include USFWS representatives so that the opportunity for their involvement is assured. The TWG Workshop #2 will be a "brainstorming session". This may include experts outside of the current participants. The attendees are asked to compile a list of experts that they would like to involve in the brainstorming session. The logistics of the brainstorming session are currently uncertain because many people may be in Seattle/Portland and many may be in Alaska. The idea of using videoconferencing was mentioned, as well as holding multiple brainstorming sessions.

Dana Postlewait explained that fish passage structures are unique compared with other engineering structures. There are so many driving factors related to biology that it is not as simple as “does it work” or “does it not” (such as a bridge). The involvement of experienced experts is necessary to create an acceptable work product.

Dana Postlewait mentioned that 6-8 weeks between each workshop would be ideal. If they were scheduled too close together there would not be enough data finalized to present at each meeting. He said that materials will be posted 2 weeks before each meeting, and during those 2 weeks, more revisions may be made. A tentative schedule (Attachment A) was provided and confirmation of the dates was discussed. Steve Padula said that the closer dates needed to be finalized. The later dates can remain tentative and at later meetings they can be confirmed. Sue Walker noted that the proposed March 20 date is 2 days after comments are due to FERC on the 14 outstanding study plans, and commenters may not be prepared for the fish passage meeting.

Marie Steele suggested using a Gantt chart and creating a standing agenda item to update the chart at every meeting.

Other possible participants to include in the fish passage TWG were discussed. Sue Walker will contact EPA to confirm if it would like a representative present. Either Stormy Haught or Joe Klein will likely represent ADF&G. Sue Walker asked for clarification on FERC’s involvement in the Fish Passage TWG efforts. Wayne Dyok agreed to follow up with FERC.

One component of Task 2 of the RSP is a spreadsheet based biological performance tool. This tool will be used to identify pros and cons related to fish passage alternatives, allowing the team to narrow down the list of alternatives. It will also be used to identify data gaps. Many attendees, including Ed Meyer, have used the biological performance tool on other projects. An example of this tool will be distributed before the brainstorm session. Per Jeff Davis’ request, an example from other projects will be provided to allow for a better understanding of what to expect. MaryLouise Keefe explained that this tool can be created with data pulled from other projects. It identifies issues associated with alternatives from a biological perspective. Ed Meyers added that the spreadsheet can also be used to compare / rank one alternative to another qualitatively. The data compilation, also a part of Task 2 will be completed before site reconnaissance (TWG #4) so the participants can use the time in the field efficiently with an understanding of hydrological, ecological, and biological implications of various alternatives.

Dana explained that he will condense information for the workshops to avoid overloading attendees with details and risk running out of time to make decisions. Marie Steele would like all of the 1980s data to be provided to the TWG in order to allow members to confirm AEA’s approach based on 1980s data. MaryLouise Keefe said that the synthesis of 1980s fish data will be posted by March 1, 2013. Jeff Davis mentioned that he has performed a synthesis as well and asks that any assumptions and uncertainties related to the use of 1980s data be identified. MaryLouise Keefe said that when historic data are presented, uncertainties should be given so that everyone understands the limitations. Dennis added that these limitations are essential to understand when evaluating data used in the biological performance tool.

Sue Walker asked how biological data gaps will be addressed. Dennis mentioned that there are many other studies on the biological aspects of the area. The Fish Passage Study will identify needs and if there are gaps identified that will affect the fish passage feasibility analysis, more data will be collected.

A check-in TWG meeting will occur on March 20, 2013 as a 1-hour long teleconference. The purpose of this meeting is to have everyone understand the status of today's action items and for the TWG members to present any comments or questions. It was agreed that the fish passage team will digest any provided materials prior to the meeting.

MaryLouise Keefe presented a data request table, explaining the engineering and biological data needs, and said that it will be updated and distributed at least 2 weeks before Workshop #1 in April. The licensing participants can present their edits at the meeting.

Dennis discussed Task 3 of the RSP (site reconnaissance), which is currently scheduled to take place on June 19, 2013. Wayne Dyok asked if the videography provides enough detail and questioned the need for a site visit. The group felt that it would be useful because NHC and others have not been to the dam site. This will be a 2-day trip, 1 day on a helicopter tour and 1 day for debriefing. It was noted that restrictions are in place through August 15 for nesting eagles and other raptors and vegetation clearing is not allowed through July 15. Dennis mentioned that the participants need information and understanding of Task 2 and all interim consultation so they can apply this information in the field. Visiting the site and envisioning the application of alternatives are very helpful in supporting later decisions. Sue Walker mentioned the extensive logistics that need to be arranged before a site visit, such as refueling and landing locations. Wayne Dyok said that a logistics coordinator has been hired and will be starting with AEA soon to coordinate these efforts. The date for the site visit was pushed back into July 2013 in anticipation of better conditions along the river.

Dana explained Task 4 as the development of passage concepts. This consists of a 2-3 day interactive workshop beginning with a day of systematically going through ideas to create a list for further development. The second day would consist of a brainstorming session. Ed Meyer said that if outside resources are included in the brainstorming, half of the first day would be used getting everyone up-to-date with the study/Project status so they can suggest approaches. MaryLouise Keefe asked about the advantage of having a large meeting vs. a small meeting. Ed explained that larger groups provide more perspectives and experience. Sue Walker liked the idea of including outside resources and having a larger brainstorming session. Dan said that logistics need to be considered immediately if outside resources are being invited. The attendees need to be identified and location of the meeting needs to be confirmed. Because any new experts will not be fully informed about the Project, Wayne Dyok suggested having them attend (by phone if needed) at the informational workshop. AEA's Fish Passage Consultants will compile a list of prospective attendees and distribute it for the group's review. AEA will still need to determine if additional experts will be brought into the process.

Task 5 includes creating an evaluation matrix to establish and weight criteria. This is a result of the brainstorming session (Task 4). The matrix is a comparison tool used in evaluating options. Dennis presented an example of this matrix. Weights are assigned to each criterion as a group effort. Once alternatives are established based on these criteria, the participants apply "grades" and these are compared. Dana mentioned that there are generally several cycles of refining the matrix as more information becomes available and is discussed. Sue Walker asked if a narrative is provided to define the grades as well as to explain the disagreements and agreements. Dana confirmed that such a narrative is provided.

Dana presented a sample report and explained that all consultation is applied to and included in the report. He presented sample drawings of fish passage structures from multiple perspectives to express the level of detail to anticipate in the fish passage final work product. Alternatives are narrowed down while considering many aspects such as feasibility, risks, cost, and stability.

The chart listing the data needs for this fish passage study was discussed (**Attachment B**). MaryLouise Keefe explained that other resources will be engaged to complete the table and it will be distributed for comment. She continued by explaining each item and asking for feedback. Once the data needs are confirmed, AEA and its contractors will collect all data available and identify the data gaps. These gaps will influence plans for 2013 and 2014 studies.

Jeff Davis requested that, rather than providing a list of target migratory species at the dam site, AEA provide a list of all species and life stages in the Susitna River and indicate which ones were considered not to pass through the dam site (not part of the fish passage study) and rationale for not including them. MaryLouise Keefe agreed to provide this list. Sue Walker requested that all salmon species, except pink, be added to the target species list.

MaryLouise Keefe added that, for the species chosen, a periodicity chart will be provided. This chart will be based on life stage information, behavioral information, migratory/habitat information, abundance and distribution information both upstream and downstream of the dam site, known spawning and rearing habitat, and ecological conditions. Jeff Davis requested that discrepancies be provided when an inference is being made. MaryLouise Keefe agreed to do so.

Sue Walker asked how the predatory invasive species will be evaluated. Betsy McGregor explained that in addition to the stream surveys, ponds and lakes to be inundated will be sampled to determine fish species, such as lake trout, that need to be evaluated. Ed Zapel said we should be aware of changes in the trophic structure that may occur due to the likelihood of lake trout moving into the reservoir and decreased turbidity in the reservoir. Sue Walker mentioned the loss of salmon spawning habitat in the reservoir due to inundation. She noted the possibility of salmon moving upstream of the reservoir if spawning habitat is available. Sue Walker mentioned a FRED study in the 80s that may have useful habitat measures of the area.

Jeff Davis asked if effects on migration will be studied, such as ice on the reservoir and up tributaries. MaryLouise Keefe said that this might be an additional data need and inquired where these data could be collected. She said that today's focus is to see what data need to be collected. A placeholder was added for this reservoir ice topic. How to obtain such data will be discussed later. Steve Padula said that the data needs should be established first. Then, at the first workshop in April, the list will be narrowed to items relevant to the study and items identified for which data cannot be collected. MaryLouise Keefe requested that additional items be provided ASAP. If additional items are provided via email, Betsy McGregor, Wayne Dyok and Sue Walker need to be CCed. Jeff Davis requested that information on the distribution of spawning and rearing habitats after inundation be added to the list. Clarification will be added to the "floating debris" item.

PROTOCOL

Protocols, as discussed in the PAD, will be applied to fish passage, unless the participants agree on fish-passage-specific protocol.

A meeting notice will be posted at http://www.susitna-watanahydro.org 30 days prior to the meeting date. MaryLouise Keefe explained that the goal is to provide meeting dates as soon as possible to allow for accommodations to be made. Sue Walker added that the lack of State-approved overtime should be considered.

Meeting materials will be posted 2 weeks prior to the meeting date.

Draft meeting notes will be posted 2 weeks after the meeting has taken place. They are considered "draft" for 2 weeks and participants may provide edits within that time. A standing agenda item will be included for each fish passage meeting to discuss any concerns with the notes from the previous meeting. Sue Walker voiced concern about the level of detail in the meeting notes. Attendees agreed that future meeting notes should include decisions made, "parking lot" items, and action items. Wayne Dyok mentioned that if someone wants to ensure that something is included in the notes, they should request that the item be captured in the notes.

Sue Walker requested that a neutral facilitator be present for each meeting. Wayne Dyok asked if there were any concerns about having Steve Padula as the facilitator. There were no objections, although it was noted that a request could be made in the future to change the facilitator. Throughout the meetings, the facilitator will write all action items, "parking lot" items, and decisions on an easel to ensure a full understanding of these items.

MaryLouise Keefe asked where the future fish passage meetings will be held. Betsy McGregor mentioned that AEA prefers that as many meetings as possible be held in Alaska. Wayne Dyok and Betsy McGregor will speak with Sara Fisher-Goad regarding acceptable locations for the fish passage workshops and TWG meetings. Seattle or Oregon would be preferred by most attendees because they are located in those areas. It was mentioned that conference centers located at the airports may be a possibility. Betsy McGregor also proposed rotating the meeting location.

Confirmed representatives to be part of the fish passage technical team include: Ed Meyer (NMFS), Graham Hill (NHC), Ed Zapel (NHC), Jeff Davis (ARRI), Dana Postlewait (R2), Dan Turner (R2), Dennis Dorratcague (MWH), Tim Sullivan (R2), MaryLouise Keefe (R2), Betsy McGregor (AEA), and Bryan Carey (AEA). Attendees need to be confirmed. The outstanding confirmations include whether Stormy Haught or Joe Klein will represent ADF&G (Stormy Haught will find out), and if there will be a USFWS staff representative (Sue Walker will find out). Will EPA contribute a staff representative (Sue Walker will find out)?

Betsy McGregor requested that all fish passage email communications between contractor groups CC her. Ed Meyer and Sue Walker should be CCed as well.

MaryLouise Keefe asked if anyone has a conflict with the workshop scheduled on April 9 and 10. Steve Padula will be unable to attend as facilitator for this session. MaryLouise Keefe will confirm with Michael Barclay so he can present video taken on the Upper River. The ice study had also taken video in 2012. This will be available on AEA's website before the April 9 and 10 meeting. A 10:00 a.m. time was agreed upon for the March 20 meeting. Wednesdays at 10:00 a.m. was established as the default day and time for all fish passage meetings. Also, at all meetings, WebEx will be available.

The May 22 TWG meeting (#3) was rescheduled to take place on May 21 starting at 10:00 a.m.

The June 19 meeting was rescheduled to a date during the week of July 8 (TBD).

The July 23 Workshop (#2) meeting was rescheduled for 2 days during the week of August 19. This is the brainstorming session with possible additional attendees from outside organizations. Once their availability is known, a date will be chosen.

MaryLouise Keefe will provide a Gantt chart of meeting dates at the April meeting, and attendees can provide feedback.

Marie Steele mentioned that the multiple layers on DNR's GIS files are not available. Betsy McGregor went online to view the available data. She mentioned that only final data are presented so people can expect to see data after QA/QC review has taken place. Betsy McGregor added that DNR staff members are in transition and this may be cause for delay in data posting.

Action Item	Date	Responsibility
Identify Strategy Statement (e.g., Senate Bill; PAD)	3/8/13	AEA
Clarify meaning of “retrofit” with space/time components	3/8/13	R2
Propose meeting and workshop locations	3/8/13	AEA
Data needs table: Input from TWG on list of items	3/8/13	All participants
Add changes in spawning and rearing habitat in proposed inundation zone to data needs table	3/8/13	R2
Include discrepancies in data to information table	3/8/13	R2
Produce/distribute communications protocol from PAD (cc: Betsy, Ed, Sue)	3/8/13	McMillen
Standing agenda item for agendas – review and approve previous meeting notes and future meeting schedule	NA	NA
Meeting protocol – summarize action items, decisions, parking lot items	NA	NA
Follow-up with others re: future participation in TWG; FERC (AEA), EPA (Sue W.), NGOs (AEA), ADF&G (AEA), FWS (Sue W.), ADNR (Marie S.), Jan Konigsberg (AEA)	3/20/13	AEA, Sue Walker, Marie Steele
Identify other fish passage at high head dam experts	3/20/13	MWH, R2, Ed Meyer
Issue updated meeting and workshop calendar (Gantt chart)	3/20/13	R2
Provide a list of all Susitna River species and life stages. Provide rationale of species not considered to travel to dam site	XXX	R2
Distribute updated table and data synthesis to TWG	3/26/13	R2
Issue sample biological tool spreadsheet and description of tool	3/26/13	R2
Presentation of videography at first workshop	4/9/13	AEA

ATTACHMENT A

RSP 9.11 – Fish Passage Meeting and Workshop Summary
(Prepared for TWG Meeting #1 held on 2/22/2013)

February 22, 2013 – Fish Passage TWG Mtg #1 (Portland, OR)

Purpose:
- Kick-off meeting to review study plan, set protocols, refine information needs, and review meeting schedules.

Agenda Items:
- Facilitate TWG member introductions and general kick-off
- Review goals for feasibility assessment
- Review RSP plan, deliverables, and schedule
- Provide more detail and refine feasibility process to be used
- Review and confirm TWG protocols
- Review and Confirm WORKSHOP and Meeting schedule
- Define additional, and obtain input on information needs
- Define action items

March 20, 2013 – Fish Passage TWG Meeting #2 (Web call)
- This is a placeholder for now, meeting only if needed

Purpose:
- Regularly scheduled interim check-in meeting for TWG, Tentative at this point in time to address any issues that may arise following Mtg #1.

Tentative Agenda Items:
- Review action items from Meeting #1.
- Discuss general progress
- Identify any additional data needs
- Review agenda for WORKSHOP #1

April 9-10, 2013 – Fish Passage TWG 2-DAY Workshop #1 – Review Background Information (Location TBD, Anchorage tentative)

Purpose:
- Review background project information

Agenda Items:
- Review of dam design and project operational concepts
- Review hydrologic conditions

- Review of physical conditions and site specific information
- Review of existing biological information and goals

May 22, 2013 – Fish Passage TWG Meeting #3 – Regular Check-in (web call)

Purpose:

- Regularly scheduled interim check-in meeting for TWG

Agenda Items:

- Review action items from WORKSHOP #1.
- Review information needs.
- Discuss preparation for Site Reconnaissance planned for Meeting #4
- Discuss upcoming Brainstorming WORKSHOP #2

June 19, 2013 – Fish Passage TWG Meeting #4 – Site Reconnaissance (AEA Offices and Site Tour)

Purpose:

- TWG to tour site

Agenda Items:

- Logistics and safety protocols
- Site tour
- Debrief
- Prepare for upcoming Brainstorming WORKSHOP #2

July 23 – 24, 2013 (2 days) – Fish Passage TWG WORKSHOP #2 – Brainstorm Alternatives, Task 4 (location TBD)

Purpose:

- Conceptual Alternatives Brainstorming

Agenda Items:

- Review background information, address any questions
- Review evaluation criteria
- Review evaluation process
- Brainstorm concepts, and record ideas
- Review Biological Performance Tool
- Assign action items for concept development

September 19, 2013 – Fish Passage TWG Meetings #5

Purpose:

- Regular check-in

Agenda Items:

- Review Workshop #2 Action Items
- Discuss general progress
- Identify any additional data needs

November 15, 2013 – Fish Passage TWG Meetings #6

Purpose:

- Regular check-in

Agenda Items:

- Review Action Items from last call
- Discuss general progress
- Identify any additional data needs
- Discuss agenda and prepare for upcoming WORKSHOP #3

January 14-15, 2014 – Fish Passage TWG WORKSHOP #3 – Critique and Refine Alternatives, Task 4 (location TBD)

Purpose:

- Critique and refinement of concepts
- Package concepts into fish passage alternatives

Agenda Items:

- Review updated alternatives.
- Review Biological performance tool.
- Prepare for next steps

March 19, 2014 – Fish Passage TWG Meetings #7

Purpose:

- Regular check-in

Agenda Items:

- Review Action Items from last meeting
- Review draft report
- Review alternatives and Pugh Matrix
- Discuss next steps

May 15, 2014 – Fish Passage TWG Meetings #8

Purpose:

- Regular check-in

Agenda Items:

- Review Action Items from last call
- Discuss general progress
- Discuss agenda and prepare for upcoming WORKSHOP #3

July 11, 2014 – Fish Passage TWG WORKSHOP #4 – Final Alternatives Selection, Task 5 (location TBD)

Purpose:

- Alternatives selection for final refinement.

Agenda Items:

- Review updated alternatives
- Review evaluation matrix
- Review biological performance tool results
- Select final list of alternatives
- Critique alternatives for final refinement and cost estimating assumptions

Meetings #9, #10 and #11 (confirm schedule and location)

- Purpose and Agenda items TBD
- Tentative dates are:
    - September 8, 2014
    - November 4, 2014
    - December 31, 2014

April 13, 2015 – Fish Passage TWG Meetings #12

Purpose:

- Review final report

Agenda Items:

- TBD

- **Susitna-Watana Hydroelectric Project**
- **Fish Passage Study**
- **Information Needs**
- **Rev #1: March 7, 2013**

- In meetings on September 24 and 25, 2012, Fisheries agencies and AEA agreed to an approach to the fish passage study and the general outline of data required for the study. After this meeting a list of information needed for the fish passage study was developed, reviewed by NMFS and issued to AEA on October 3, 2012. The Revised Study Plan (RSP) for fish passage was issued by AEA in December, 2012 as "RSP 9.11 Study of Fish Passage Feasibility at Watana Dam". This study plan listed data requirements from this table.

- On February 22, 2013 the kickoff meeting for the fish passage study was held in Portland. In this meeting a schedule of milestones and meetings were set for the first six months of the study. The next meeting will be Workshop No. 1 on April 9 and 10, 2013, which is intended to provide background information on the project for the fish passage study team. The first draft of information to be presented at this meeting is to be sent to the participants two weeks before the meeting, on March 26. Given the amount of information necessary for this study, we plan on ongoing development and updates to this information as the study progresses, with the goal of providing a thorough coverage of all subject matters prior to the Site Tour scheduled as Meeting #4 during the week of July 8.

- The list of information in the tables below is based on the previous list of data needs noted above, the NMFS letter dated March 2012 commenting on Scoping Document 1, the material listed in RSP 9.11, and input from the fish passage study consulting team. Additional information and guidance will be obtained from NMFS, Northwest Region, "Anadromous Salmonid Passage Facility Design", July 2011 and other accepted fish passage design books and papers.

- Please provide the data and information listed in the table below to Dennis Dorratcague by March 26. In the "Item" column is a list of data, needed in order to develop fish passage design concepts. Please attach the information and give it an Appendix number. The "Data" column will contain the data or the appendix reference where the data can be found. Much of the requested information is still being developed or augmented. We are asking that the latest information be supplied and that you use the "Comments" column to describe its limitations and whether additional information will be developed in the next two years. This table and the appendices will form the information packet used by the fish passage Technical Work Group (TWG) to supplement the Site Reconnaissance trip, and in the brainstorming session and development of fish passage alternatives.

Table 1 – Biological Data Needs

No.	Item	Data	Comments
B1	Target fish species for passage		
B2	List of other species in the system that may be accessible to any passage facilities		
B3	Life stage specific periodicity,		
B4	Migratory characteristics - routes, seasonal timing & duration by species & life stages		
B5	Estimated numbers & sizes of fish for upstream and downstream migrants		
B6	Life stage specific parameters – size, migratory behavior, swimming behavior & speed, other physical passage constraints		
B7	Fish relative abundance upstream and downstream of project including tributaries		
B8	Locations of spawning and rearing habitats		
B9	Predators – species, abundance, location		
B10	Existing ecological conditions – invasive species, light, temperature, flows		

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Table 2. Physical, Hydrologic and Engineering Information

No.	Item	Data	Comments
P1	Water quality & water temperature under existing conditions, main stem &B tributaries		
P2	Water quality & water temperature above & below proposed dam		
P3	Tailwater Rating curves at dam and expected trap location		Forebay rating information is in Item No P5 below
P4	Flow duration by month, through turbines, spillways, other outlets		From operations modeling
P5	Reservoir elevation duration curves by month		From operations modeling
P6	Other project operations data (rule curve, expected operating restrictions)		
P7	Ice cover on river and tributaries in project area before project		
P8	Ice cover on reservoir and in river below dam		
P9	Water temperatures during upstream migration period		
P10	Water temperatures during downstream migration period		
P11	Air temperature information by month (max, min, average)		
P12	Sediment information (transport rates, sediment gradation, sediment sources & their location)		

Table 2. Physical, Hydrologic and Engineering Information

No.	Item	Data	Comments
P13	River morphology trends after project operation		
P14	Topographic mapping of the project site and along river downstream		Fish passage will be sketched on these sheets
P15	Current dam layout drawings, plans, elevations, and cross sections (include details of outlet works and spillways)		Fish passage will be sketched on these sheets. Prefer simplified, scale drawings with a plan, section, and elevation suitable for brainstorm sketching in 11x17 format. Any 3D drawings showing general arrangement would also be helpful.
P16	Makeup of project components – turbines (number & type), outlet valves & gates		
P17	Projected operation of project turbines, gates, & valves		
P18	Site access or restrictions to access for operation and maintenance. Include entire project area at dam, along reservoir, and into tributaries (i.e., existing or planned access roads)		
P19	Electrical power availability		
P20	Amounts and types of debris expected in the reservoir		
P21	Amounts and types of debris expected below the dam		
P22	Location downstream of any barrier and trap & haul locations		
P23	Other data which you feel are important to fish passage		

SUSITNA-WATANA HYDRO

Meeting Notes
Fish and Aquatics
Fish Passage Technical Workgroup Meeting #2 – Regular Update
3/20/2013

LOCATION: **Teleconference**

TIME: **10:00 am – 11:30 am (AKST)**

SUBJECT: **Fish Passage Technical Workgroup – Regular Update Teleconference**

Goal: **Opportunity for the Fish Passage Technical Workgroup to coordinate on any items prior to the next meeting**

ON PHONE: **Fish Passage TWG Attendees: MaryLouise Keefe** R2, **Dana Postlewait** R2, **Dan Turner** R2, **Ed Meyer** NMFS, **Dennis Dorratcague** MWH, **Catherine Berg** USFWS, **Stormy Haught** ADF&G, **Ed Zapel** NHC, **Graham Hill** NHC, **Jeff Davis** ARRI, **Betsy McGregor** AEA, **Bryan Carey** AEA.

Other Attendees: Wayne Dyok AEA, **Steve Padula** McMillen, **Kathryn Peltier** McMillen, **Justin Crowther** AEA, **Chuck Sensiba** VNF, **Leslie Jensen** ARRI, **Becky Long** CSDA.

Materials and the agenda for today's meeting can be found at the Susitna Watana Hydro website (http://www.susitna-watanahydro.org). The purpose of these meeting notes is to capture any significant information not provided in the meeting materials. Following the text are tables capturing any active action items including unfinished items from previous meetings, decisions made, and topics for future discussion ("parking lot items").

After introductions, Steve Padula began the meeting by presenting the agenda and asking attendees if any modifications are necessary. None were requested.

Steve Padula explained that the 2/22/13 meeting notes had been posted days prior to today. Because of the limited review time, he proposed that attendees have another week to suggest edits. The protocol for providing meeting notes for review and edits by the Fish Passage TWG members in attendance was agreed as follows: Meeting notes will be distributed to Fish Passage TWG members in attendance for review within two weeks of the meeting by the note taker as a MSword file. Recipients will edit the review draft in track changes and send the file "reply all" to the original email. The note taker will compile all redlines into a single document and it will be posted to the Project website within two weeks from the original review draft being distributed.

Meeting notes will include a summary of action items, decisions made during the meeting, and parking lot items.

Tracking of action items was discussed. It was agreed that a running action item list would be maintained. A unique ID will be attributed to each action item, consisting of the date of the meeting and a sequential number; columns will be added to indicate the distribution method of the action and the status of the action item. An archive list will be created and populated with action items as they are completed.

Steve Padula presented the list of 2/22/13 meeting action items and decisions. While mentioning each item, the responsible party updated the group on that item's status. The items below are those which initiated further discussion.

02.22-01 <u>Strategy Statement update</u>

Wayne Dyok is awaiting Brian Bjorkquist's approval of the modified strategy statement. Wayne Dyok explained that fish passage is not specified in senate bill 42, but he has included language in the modified fish passage strategy statement to include AEA's fish passage responsibilities. Wayne Dyok expects this item to be completed by 3/31/13 and he agreed to distribute it to the fish passage group. The statement will be included in the Final Study Plan and the Initial Study Report (ISR).

<u>02.22-02 Further define "retrofit"</u>

The meaning of "retrofit" with respect to fish passage structures will be further defined in the Final Study Plan and ISR.

<u>02.22-03 Meeting locations</u>

Fish Passage TWG meetings will occur outside of Alaska (i.e. Washington or Portland, Oregon) if it is proven to be most cost efficient option for AEA. The next fish passage meeting (April 9th and 10th) will be located in Bellevue, WA at MWH's office, as indicated on today's meeting agenda. The location of future meetings will be determined based on cost and available facilities. WebEx will be provided for every meeting to accommodate participation by those who are unable to travel.

<u>02.22-04 Data Needs Table additions</u>

The Data Needs table includes suggestions from the 2/22/13 meeting. Additional comments to the table from the participants were due 3/8/13; no comments were provided. While additional comments can be received, these will not be flushed out in further detail in the 4/9-10/13 meeting materials to be distributed 3/26/13, as there is not sufficient time. Jeff Davis asked that reservoir effects on migration timing be included in the Data Needs table. Jeff Davis and Ed Zapel requested that reservoir effects on trophic cascade with respect to predatory lake trout be included in the table; Jeff Davis will provide detail clarifying this request to MaryLouise Keefe by 3/25/13. MaryLouise Keefe referenced the entrainment study and the predators item already included in the Data Needs table. Ed Zapel requested the citations for literature being reviewed for the biological needs be listed.

<u>02.22-07 Meeting protocol</u>

On 3/8/2013 Kathryn Peltier distributed an email summarizing the meeting protocol from the Preliminary Application Document (PAD). Further detail will be added and distributed to the group to clarify fish passage-specific protocols, as determined at this meeting (see above). Catherine Berg requested that she, ARRI (Jeff Davis) and NHC (Ed Zapel and Graham Hill) be included in the fish passage email list.

<u>02.22-08 Follow-up with potential Fish Passage TWG members</u>

Catherine Berg will follow-up with EPA and Wayne Dyok will contact FERC and Jan Konigsberg to determine their interest in participating in the Fish Passage TWG. Stormy Haught confirmed that he will represent ADF&G.

02.22-09 High head dam expertise

Dana Postlewait, Dan Turner, Dennis Dorratcague, and MaryLouise Keefe had created a list of potential experts to participate in the first two fish passage workshops. The list was narrowed from 8 individuals to two; Dana Schmidt (biologist) and Chick Sweeney (engineer). Ed Meyer was expecting more than 2 individuals to supplement the brainstorming sessions, but he doesn't want to duplicate expertise/experience. MaryLouise Keefe will email Ed Meyer the resume of Dana Schmidt (Ed Meyer is familiar with Chick Sweeney's credentials). Ed Meyer will review Dana Schmidt's resume. Participation in the brainstorming session by additional high head dam experts will be determined by AEA Friday, 3/22/13. Wayne Dyok indicated that it would be possible to add experts if it was warranted following the April 9 and 10, 2013 meetings.

02.22-10 Schedule and Gantt chart

An updated schedule and Gantt chart were provided (available on the website) to assist in understanding the scope and upcoming events. The Gantt chart currently mimics the schedule provided in the Fish Passage RSP. As dates are finalized, updates will be provided.

02.22-11 List of Susitna River species and rationale when not a target species

Rationale for not including some Susitna River fish species as target species for fish passage will be provided in the Biological Data Needs table.

02.22-13 Biological Tool

Jeff Davis asked for clarification of what would be provided in the March 26th meeting materials pertaining to the biological spreadsheet tool. He asked if the spreadsheet with coefficients would be provided. R2 clarified that an example from a past project would be provided not the spreadsheet model. That the model would be built after the workshop. MaryLouise Keefe commented that the coefficients would be transparent in the model once the Project-specific model was developed.

The location and time of the April 9 and 10, 2013 workshop was discussed. The meeting will be located in Bellevue, WA at MWH's office from 8 am – 3 pm AKST (9 am – 4 pm PST). A draft agenda will be posted to the Susitna Watana Project website by COB 3/27/2013. As indicated in the 2/22/13 action items, the meeting materials will be posted 3/26/13. Betsy McGregor reminded attendees that some of the meeting materials are summaries of larger reports, such as the fish data synthesis report which is currently available on the Project website.

ID	Action Item	Date	Responsibility	Distribution Method
03.20-01	Distribute MSWord document of 2/22/13 meeting notes to attendees for edits	3/20/13	KPeltier	Email
03.20-02	Create an archive list of completed action items	3/20/13	KPeltier	Email
03.20-03	Update communication protocol and distribute	3/22/13	KPeltier	Email
03.20-04	Distribute list of all Fish Passage team members	3/22/13	KPeltier	Email
03.20-05	Provide Ed Meyer with Dana Schmidt's resume	3/21/13	MKeefe	Email
03.20-06	Review Dana Schmidt's and Chick Sweeney's resumes as high head dam fish passage experts	3/22/13	EMeyer	Email
03.20-07	Add to applicable entrainment reference in the data needs table	3/26/13	MLKeefe	Data Needs Table
03.20-08	Include reservoir effects on migration timing is in the data needs table	3/26/13	MKeefe	Data Needs Table
03.20-09	Provide MaryLouise Keefe with a detailed description regarding data needs of trophic cascade information	3/25/13	JDavis	Email, Data Needs Table
03.20-10	Distribute draft Agenda for April 9&10 Fish Passage Meeting	3/27/13	AEA	Website: Meeting Materials for April 9&10; Listserve email

ID	Decisions
03.20-01	Modify communications protocol to include delivery of draft review meeting notes to the Fish Passage TWG members in attendance in MSWord for their review/revisions.
03.20-02	At this time, AEA will approve two additional high-head dam experts to participate in the first FP TWG worksession and the brainstorming worksession.

SUSITNA-WATANA HYDRO

Meeting Notes
Fish and Aquatics
Fish Passage Technical Workshop #1
April 9-10, 2013

LOCATION:	**MWH Office** **2353 130th Ave NE, Suite 200** **Bellevue, WA 98005**
TIME:	**8:00 am – 4:00 pm (AKST); 9:00 am – 5:00 pm (PST) both days**
SUBJECT:	**Fish Passage Technical Workgroup – Review background Project information**
Goal:	**Review existing Physical Data**
IN PERSON:	**Fish Passage TWG Attendees: MaryLouise Keefe** R2, **Dana Postlewait** R2, **Dan Turner** R2, **Ed Meyer** NMFS, **Dennis Dorratcague** MWH, **Stormy Haught** ADF&G, **Ed Zapel** NHC, **Graham Hill** NHC, **Jeff Davis** ARRI, **Dana Schmidt** Golder Associates, **Chick Sweeney** Alden Labs. **Other Attendees: Leslie Jensen,** ARRI**, Kirby Gilbert** MWH, **John Haapala** MWH, Aled Hughes MWH, **Bill Fullerton** Tetratech (4/9/13 only), **Rob Plotnikoff** Tetratech (4/9/13 only).
ON PHONE:	**Fish Passage TWG Attendees: Catherine Berg** USFWS, **Betsy McGregor** AEA, **Bryan Carey** AEA. **Other Attendees: Sue Walker** NMFS, **Eric Rothwell** NMFS, **Robin Beebee** HDR (4/9/13 only).

Materials and the agenda for the two-day workshop are found at the Susitna Watana Hydro website (http://www.susitna-watanahydro.org). The purpose of these workshop meeting notes is to identify action items and give a brief overview of the subject matter covered and to capture any key information not provided in the meeting materials or noted in the working tables and materials the team is developing. A table of action items is presented at the end of the notes, summarizing key action items

After introductions, Kirby Gilbert began the meeting by presenting the agenda and status of 2/22/13 meeting notes and 3/20/13 meeting notes. Other than edits provided by Catherine Berg 3/20/13, no other edits have been provided to AEA. AEA requested all edits by 4/10/13. AEA distributed 3/20/13 meeting notes in MSWord to the FPTWG members that had attended the meeting and requested edits be returned to AEA in two weeks (4/23/13).

Prior to starting with the agenda items, Ed Meyer asked about the composition of the TWG, wondering if additional high-head dam fish passage experts were going to join the study team. Dana Postelwait mentioned that Dana Schmidt had joined the team as had Chick Sweeney and Phil Hilgert would be available at other times. Ed Meyer recommended Al Giorgi join the team for the brainstorming workshop, noting his experience with fish movements and high-head dams. There was further discussion about limitations to the size of the group and additional costs and the need to have ice processes expertise, which Dana Schmidt brings to the team. Betsy McGregor agreed to have Wayne Dyok follow up with Ed Meyer on this item.

The Data Needs table was requested to be provided in MSWord format instead of Adobe PDF; it was emailed to the group during the meeting. Susan Walker requested the titles of the various appendices be included within the website link for each appendix.

The study meeting schedule presented at the March 20th FPTWG meeting was reviewed. Chick Sweeney mentioned a conflict with the August 15-20th workshop schedule, and noted his availability August 21st and 22nd, 2013. Dana noted the schedule would be revisited again later. The next meeting will be a teleconference on May 21, 2013 to start at 9:00 am Alaska Daylight Time.

Kirby Gilbert provided an overview of the general Project layout and Project area. Chick Sweeney asked about where the hydrographic transects were located, particularly near the dam. Betsy McGregor noted that Appendix 2 of the 2012 Open-water Flow Routing study report, currently available on the Project website, has the locations presented as Figures 4.2-2 through 4.2-19.

Aled Hughes of MWH went over the dam design parameters, statistics and answered questions about dam design information. Aled noted the current design is a “snapshot in time”, and the fish passage team should be aware that changes may be made as the work progresses. Dana P. noted that the team is aware of this, and will work with AEA and the design team to stay informed of significant changes that could be relevant to fish passage conceptual designs.

Rob Plotnikoff provided an overview of the water quality studies performed in 2012 and plans for 2013/14. There was some discussion about the historical data in terms of the frequency of sampling and that some data might not be directly comparable to today’s more continuous data. Rob also went over the reservoir water quality modeling plan, discussing how the effort is expected to help predict the amount of vertical stratification in temperatures in the reservoir. There was further discussion about turbidity and potential turbidity changes in the reservoir with the fish passage team expressing interest in understanding how turbidity might change.

Bill Fullerton went over the geomorphology study (RSP Section 6.5), as well as the fluvial geomorphology modeling study (RSP Section 6.6) noting that the goal of the studies is to assess the potential effects of the Project on the geomorphology of the river. Bill went over the work accomplished in 2012 and then described the 2013 and 2014 studies. There was discussion about the timing of when results might be ready from this work and the water quality studies.

There was mention of how it was important for the fish passage group to understand some basic information about stratification including how cool water from tributaries might enter the reservoir and how selective withdrawal at the dam might be used. Rob mentioned that John Hamrick of this study team could probably help the group with a demonstration of the modeling of the reservoirs. There was further discussion about finding other lake systems or reservoirs in cold climates where fish behavior has been studied so the group could get some idea of fish movements. Dana Schmidt noted there is a large set of data about Chinook and coho salmon movements with regard to temperature. Stormy noted that Kluane Lake in the Yukon may have some research information of use to the group. It was agreed that Dana Schmidt could look at previous data sets on glacial fed lakes and get back to the group with some possible examples.

After lunch John Haapala presented information on the reservoir operations modeling to date. There was follow on discussion about development of a reservoir operations rule curve, but it was noted that at this time this operation scenario is only based on the 61 years of historical record from the USGS, minimum flows considered in the 1980s

(Case EV-1 minimum instream flow), and also to meet the full load following electrical load demands of the Railbelt all on an hourly basis.

There was some follow on discussion about running a run-of-river operational flow alternative as noted in FERC's April 1st Study Plan Determination. John Haapala noted he can run a run-of-river flow scenario but it would not be very realistic for the dam being considered to date. Bryan Carey noted that run-of-river would provide the most energy at a time when it is least needed, and provide the least output when energy is needed the most. There was further discussion that the fish passage study probably needs some kind of operational scenario in between the maximum load following and run-of-river, and the conclusion was that perhaps Wayne could provide some guidance to the study team on when other operating alternatives might be available. The study team noted the design considerations for the two alternatives discussed would be widely different so something more in between the two might be of more use to the feasibility study effort. There was a also a request for John Haapala to provide the flow outputs in an Excel format for use by the fish passage study team. Sue Walker noted that AEA had discussed using a base load alternative in its analysis also.

Robin Beebee went over the ice studies to date, noting ice bridges and example break up conditions in the upper segment of the Susitna River. Jeff asked about predicting ice formation in the reservoir, particularly how ice might form at tributaries. It was noted that Mica Reservoir in B.C. has ice formations and information from that project might be useful. Rob noted that he will take some of the groups questions back to his study team to find out more about assumptions and observations his modeling group can perhaps use to help the fisheries engineering team with regard to how reservoir ice and break up might affect tributaries.

Bill Fullerton discussed sediment loads and how the dam might affect sediment movement and channel formations along with potential changes to tributary mouths, noting there was a technical memo from 2012 studies on sediment balance in the system, which is available on AEA's Porject website. Bill noted that his study team should know more after this summer's work and some 1D modeling.

Based on the discussion and presentations of the day, the table of information needs was filled out further by Dana Postlewait, in collaboration with the group. It was noted the table will be updated regularly and posted prior to the next workshop.

Chick Sweeney noted that prior to the next fish passage workshop it would be good to get a synthesis of existing information on sediment, flows, and drawings before the workshop and Dana noted that was the plan so the workshop participants had materials to review prior to the workshop. Sue Walker asked how the hydrological information might factor in results of the climate change study. Ed Meyer noted the fish passage study team would be interested in seeing the results of such a study to determine if it would affect the potential designs developed by the team. It was noted that Dennis Dorratcague would work with Eric Zimmerman of MWH to create some detail maps of the reservoir and its tributaries prior to the brainstorming workshop. There was discussion about how to access the videography of the Susitna River from 2012 and it was noted that Sara Nogg at AEA could provide a loaner hard drive, or study team members could send in their own hard drives and AEA would load the files. Kirby handed out the CEII forms to be signed by all meeting participants in order to be able to review the dam design details for use in the fish passage feasibility studies. The first day of the workshop closed with Chick Sweeney noting that he could provide the group with an example of EFDC modeling results from Round Butte Dam by May 7, 2013.

DAY 2 – 4/10/13

Other than Rob Plotnikoff, Bill Fullerton, and Robin Beebee, the attendees where the same as Tuesday 4/9; with Sue Walker, Catherine Berg and Betsy McGregor on the telephone and the rest in person at MWH Bellevue offices. There was a brief recap noting that yesterday was intended to be an overview presentation of physical, hydrologic and engineering information needs and today was set aside to discuss biological data needs for the fish passage feasibility study team.

Tim Sullivan of R2 went over a series of slides that covered Appendices B1 – B10. For Appendix B1, Target Fish Species, it was noted how limited the information was for upriver distribution of Chinook salmon in particular. There was further discussion as to what species of fish the fish passage study team should consider and there was agreement to consider all species of salmon that might exist in the area. After much discussion, the table of information needs was updated for this section to include the species the team agreed upon. This discussion led into Appendix B2, about other species potentially accessing the upper river and Stormy noted that there could be some concerns if we end up introducing some species into the upper basin that we do not want in the upper basin due to potential conflicts with resident species. Stormy also noted that Lake Trout was considered a native species. For Appendix B3, there was agreement made to update the headers to clarify and specify the meanings of the categories and then, if needed update the periods noted in the table. During the presentation of Appendix B5, number and size of target fish species, there was discussion about potential for sorting juvenile fish and Ed Meyer noted the group should start developing management questions that might affect the design options being considered. Stormy Haught agreed to identify management considerations from ADF&G staff and bring information back to the group. The study team agreed to start a list of management considerations in a section of the information needs table. For Appendix B6 it was noted that the group could lump whitefish, and Stormy noted that humpback whitefish were a common species found in a 2011 study of the upper river. Prior to a break, the group discussed that it may be good to initially consider designs to accommodate the maximum fish numbers, and scale down from there.

After a short break Tim Sullivan went over Appendix B6, life stage specific passage information and he discussed what is known about swimming abilities. There was discussion that the group needs more information on burbot populations and connectivity of populations. Under Appendix B7, Fish Relative Abundance, there was a question if lamprey were found in the Middle River as it was noted that they are found in the Lower River. For Appendix B8, location of spawning and rearing habitats, there was clarification on what was meant by adult/juvenile salmon in terms of what was presented in the pie chart verses the text, this is to be clarified for next version as noted in the table by Dana Postlewait. For Appendix B9, Predation, it was noted that Mustelid section is labeled incorrectly in the appendix report. For Appendix B10, Existing Environmental Conditions, there was discussion about whether turbidity changes will increase or decrease predation and the concensus for now was that the table would just note that predation will change, affecting some species more than others.

Prior to the lunch break Marylouise Keefe noted that if we designed a conceptual passage program for hundreds of thousands of anadromus fish, the smaller numbers of resident fish could get shortchanged in the system's ability to accommodate their specific needs. If we use theoretical escapement, those numbers will drive the collection facilities design. Ed Meyer noted that we should keep in mind for any facilities the group designs it will be important to evaluate it in terms of how it might perform for all species. Betsy McGregor noted that the group should design for both what is there now (i.e., small numbers of Chinook and resident fish) as well as adaptations for future expansion to accommodate future population levels.

After Lunch, Marylou presented slides on the 2012 upper river fish distribution and habitat study. There was further discussion about what tributaries might or might not have Chinook salmon present. Jeff noted that the group should probably not just focus on Kosina Creek, where salmonids have been found, until we know in the next few years where we find Chinook. Marylou went over salmon migration studies and the group went to a break.

After the break Tim Sullivan went over Appendix B11, the biological performance tool under development. After much discussion about the comparative aspects of the tool there was more discussion about the potential uses of the tool. It was noted that one purpose was just to get the study team to discuss ranges presented in the tool. The next step is to start populating values for the brainstorming session. Phil Hilgert and Tim are going to develop a strawfish version for use in the August workshop. They noted there might be another tool that evaluates alternatives, from which the biological performance tool would serve as likely input. Another purpose of the tool is to raise red flags on information or data the team might need. The meeting concluded with Stormy noting he will try and develop more of the management consideration portion of the table for the next meeting.

ACTION ITEMS From 4/9 and 4/10:

ID	Action Item	Date	Responsibility	Distribution Method
04.09-01	Provide edits to 2/22/13 FPTWG meeting notes to AEA	4/10/13	FPTWG 2/22 meeting attendees	Email
04.09-02	Provide edits to 3/20/13 FPTWG meeting notes to AEA	4/23/13	FPTWG 3/20 meeting attendees	Email
04.09-03	AEA to discuss its choice of additional fish passage experts with Ed Meyer/Sue Walker	4/16/13	W Dyok	Phone call
04.09-04	Provide FPTWG Information Needs Table in MSWord	4/09/13	B McGregor	Email
04.09-05	Include appendix titles in website link description/title	4/09/13	J Crowther	Susitna-watanahydro.org
04.09-06	Distribute report on glacial lakes study, if one was produced	6/7/13 if data is available	D Schmidt; AEA	Email; ARLIS
04.09-07	Rob to get John Hamrick to provide some background information on simulating reservoirs and fish movements based on past experience		Rob Plotnikoff	Next Meeting
04.09-08	Flow duration data in Excel; data presented today plus totals	5/7/13	John Haapala	
04.09-09	Need guidance from Wayne/AEA on how run of river scenario will be handled; and importantly when some scenarios with environmental flows will be available to be modeled and available to the FPTWG (in between run of river and maximum load following).	5/7/13	W Dyok	

04.09-10	Find out from Stuart when he will be completed with estimating flows in tributaries to reservoirs and just below dam – when that data will be available to the fish passage study team.		MaryLou	
04.09-11	Request to Rob Plotnikoff to find out when his reservoir ice study will have some results to report to the Fish Passage group, or at least some findings of preliminary observations, particularly effects of ice formation and breakup at tributary mouths in reservoir.	5/7/13	Rob Plotnikoff	
04.09-12	Get synthesis book to hand out before brainstorming out by July 8-12 site vist			
04.09-13	Request wind speed data in excel file format to assist in estimating wave heights/loads	6/24/13	Dennis Dorratcague	Dennis will work with John Haapala
04.10-01	Update biological appendices to account for other target species added to Target Species list (those added into Table 1- No. B1 Biological Data Needs)	6/24/13	Marylou and Tim Sullivan	Nusiance species is another list and to date we have not included periodicity type information on those nuisance species.
04.10-02	Fix appendix B2 to note lake trout are native	6/24/13	Tim Sullivan	
04.10-03	Table B3 needs the headings/categories clarified and if appropriate update periods.	6/24/13	Tim Sullivan	If needed follow up with smaller group of Stormy, Jeff Davis, Marylou.
04.10-04	Add a series or component to the Information Needs table that relate to management considerations of the target species (policy information on species management or how to handle nuisance species)	6/24/13	Dana P./Stormy	Stormy to go back to ADF&G staff and try and get more information on what might be policy considerations that could be identified. Dana going to draft template for June 24th.
04.10-05	Take out Adult Chinook relative abundance bulleted item in the B7 slide (on relative abundance)	6/24/13	Tim Sullivan	At request of Jeff Davis and Sue Walker – not really needed
04.10-06	Create combined table to address design criteria information for B3-B6 for target species	6/24/13	Tim and Marylou	
04.10-07	Get Chick input to Evaluation of Alternatives Matrix	August workshop	Chick Sweeney/Tim Sullivan	
04.10-08	Biological Performance Tool to be populated/created as straw man	August Workshop	Tim S. / Phil H.	For review at brainstorming meeting.

04.10-09	Compile available mapping of tributaries with plan/profile information to extent possible prior to the workshop	August Workshop	Dennis D., Dana P.	For review/use at brainstorming meeting.

SUSITNA-WATANA HYDRO

Meeting Notes
Fish and Aquatics
Fish Passage Technical Workgroup Meeting #3 – Regular Update
May 21, 2013

LOCATION: **Web Meeting**

TIME: **8:00 am – 10:00 am (AKST); 9:00 am – 11:00 am (PST)**

SUBJECT: **Fish Passage Technical Workgroup Meeting #3 – Regular Update**

GOAL: **Regularly scheduled interim check-in meeting**

PARTICIPANTS: **Fish Passage TWG Attendees: Betsy McGregor** AEA, **Wayne Dyok** AEA, **Dana Postlewait** R2, **Tim Sullivan** R2, **Al Giorgi** BioAnalysts, **Chick Sweeney** Alden Labs, **Dennis Dorratcague** MWH, **Ed Meyer** NMFS, **Stormy Haught** ADF&G, **Ed Zapel** NHC, **Jeff Davis** ARRI, , **Catherine Berg** USFWS,

Other Attendees: **Kirby Gilbert** MWH, **Matt Love** Van Ness Feldman, **Becky Long** Coalition for Susitna Dam Alternatives, **Leanne Hanson** USGS, Steve Padula **McMillen**, Sandie Hayes **AEA**

This meeting was a regularly scheduled check-in amongst the Fish Passage Technical Workgroup, the third such check-in meeting and the first since the April 9-10 Fish Passage Technical Workshop (Workshop #1). These meeting notes are intended to give a brief overview of discussions, review the status of prior action items, and identify new action items. New action items from this meeting as well as the status of remaining action items from Workshop #1 are provided in a table at the end of this document; a copy of the agenda is also attached. After introductions, Steve Padula began the meeting by presenting the agenda.

<u>Last Meeting Note Review</u>

Betsy McGregor mentioned that the notes from the 2/22/13 and 3/20/13 meetings have been posted to the Project website. Regarding the meeting notes from Workshop #1, Ed Meyer mentioned that Sue Walker had some comments to be added, which she would provide to AEA shortly via email. Jeff Davis was also still reviewing and would have comments to AEA shortly via email. No other comments from Workshop #1 meeting notes were pending.

<u>Fish Passage TWG Meeting Composition</u>

Wayne Dyok announced the addition of Al Giorgi as a new member of the Fish Passage Technical Workgroup (FPTWG) and participants welcomed Al to the group.

<u>Action Item Review</u>

Dana Postlewait followed by leading into a review of the status of action items identified during Workshop #1. Status updates and new action items are listed in the table below.

<u>Operational Scenarios</u>

A discussion followed on different operational scenarios that could be considered for the fish passage study, specifically regarding the nature and availability of environmental flow modeling for use by the group and whether a run-of-river scenario will be incorporated. Becky Long asked if only three scenarios will be considered, and explained that the impetus behind the run-or-river request was to help the NGO's address ice processes. Wayne confirmed that initially only three operational scenarios will be developed but that the need for a fourth (or additional) modeling scenarios will be considered as the Project proceeds and that this will need to be addressed within the larger technical working groups (Fish and Aquatics, IFIM, Geomorphology, Ice Processes, etc.). Wayne summarized that the three current planned operational scenarios are:

1) A maximum load-following scenario (which John Haapala presented to the FPTWG at Workshop #1),
2) A baseload generation scenario, and
3) Some intermediate level of load-following depending on energy system demands and natural resource needs. This scenario will bracket the above two bounding case scenarios, and will be more representative of the anticipated operations that will meet the Rail Belt needs and provide a balance with natural resource needs.

Ed Zapel inquired as to when a fourth scenario might be defined, to which Wayne responded that it would depend on results from the 2013 field season and would most likely be in late 2014 or 2015. This discussion concluded with a plan for Wayne, Becky Long, and Sue Walker (per Ed Meyer's request) to follow up offline for further discussion.

The topic of post-construction ice conditions at reservoir tributary mouths was raised. Betsy explained that tributary mouths were surveyed this past winter, providing an indication of existing conditions; she will follow up with Rob Plotnikoff to clarify whether modeling efforts will provide information related to post-construction ice conditions at tributary mouths. Wayne added that ice thickness information was provided during the 1980s studies and if this was based on predicted conditions, then it might prove reasonable as a first cut if needed.

<u>Information Needs Table</u>

Dana P. moved on to the status of the updated information needs table which had been previously distributed to the group. Dana suggested waiting on the review of the information needs table until the group has finished providing comments. Jeff D. requested that the updated table be provided in MS Word to facilitate providing comments electronically; Betsy agreed to send the file as a MS Word document to participants. Dana requested that comments be provided by 6/18/13 so that a revised table could be available for the next meeting.

<u>Study Schedule</u>

Discussion turned to the schedule for the Fish Passage study. Dana described a proposed schedule modification that would shift the planned site visit to late August or early September to take advantage of better weather and lower flows that would allow better access, and shift the brainstorming session until late February or early March 2014 that would allow the group to take advantage of the 2013 field season preliminary results. The second week of September, 2013 was proposed for the site visit for discussion. Ed Meyer raised concerns regarding potential difficulties associated with the end of the federal fiscal year and federal furlough days, and that the change would affect many people's schedules who had planned around the previously published dates. Wayne then explained that the change was necessary to address AEA budget constraints, and that he was comfortable proposing the schedule change for this study because the additional information available for the brainstorming would benefit the process. It was agreed that Dana and Betsy will work on circulating a Doodle Poll among the group to identify a suitable time for the site visit, including the following options:

- August 19-22, 2013
- September 3-6, 2013
- September 9-12, 2013

Time initially scheduled for the site visit was held for the next check-in meeting, which is now scheduled to occur on July 9, 2013 from 8:00 am – 10:00 am AKST (9:00 am – 11:00 am PST).

The revised schedule for the brainstorming session was tentatively set as March 18-19, 2014, which was identified to accommodate the anticipated time constraints of those associated with the production and review of Initial Study Reports that are due for release on February 3, 2014. The location for the brainstorming session is still to be determined.

The meeting concluded with a review of new action items which are summarized in the table below.

ACTION ITEMS From 4/9 and 4/10:

ID	Action Item	Date/Status	Responsibility	Distribution Method
04.09-01	Provide edits to 2/22/13 FPTWG meeting notes to AEA	Complete. Notes posted	FPTWG 2/22 meeting attendees	Email for edits. Susitna-watanahydro.org
04.09-02	Provide edits to 3/20/13 FPTWG meeting notes to AEA	Complete. Notes posted	FPTWG 3/20 meeting attendees	Email for edits. Susitna-watanahydro.org
04.09-03	AEA to discuss its choice of additional fish passage experts with Ed Meyer/Sue Walker	Complete/ Added Dr. Al Giorgi to FPTWG	W Dyok	Phone call
04.09-04	Provide FPTWG Information Needs Table in MSWord	Complete	B McGregor	Email
04.09-05	Include appendix titles in website link description/title	Complete. Posted	J Crowther	Susitna-watanahydro.org
04.09-06	Distribute report on glacial lakes study, if one was produced	6/7/13 if data is available	D Schmidt; AEA	Email to study leads. Post after review. Potentially available on ARLIS (http://www.arlis.org/resources/susitna-watana/)

ID	Action Item	Date/Status	Responsibility	Distribution Method
04.09-07	Rob P. to get John Hamrick to provide some background information on simulating reservoirs and fish movements based on past experience	Pending	Rob Plotnikoff	Update for next meeting
04.09-08	Flow duration data in Excel; data presented today plus totals	Posted – Dennis D. to reprint with pagination corrected for re-posting	John Haapala, D. Dorratcague	Susitna-watanahydro.org
04.09-09	Need guidance from Wayne/AEA on how run of river scenario will be handled; and importantly when some scenarios with environmental flows will be available to be modeled and available to the FPTWG (in between run of river and maximum load following).	See 05.21-02	W Dyok	
04.09-10	Find out from Stuart when he will be completed with estimating flows in tributaries to reservoirs and just below dam – when that data will be available to the fish passage study team.	Complete. Stage data to be collected this year, and stage/ discharge relationships to be developed in 2014 with results available after 2014 season.	MaryLou	
04.09-11	Request to Rob Plotnikoff to find out when his reservoir ice study will have some results to report to the Fish Passage group, or at least some findings of preliminary observations, particularly effects of ice formation and breakup at tributary mouths in reservoir.	Prior to next meeting	Rob Plotnikoff	
04.09-12	Get synthesis book to hand out before brainstorming out by July 8-12 site visit	TBD – prior to rescheduled site tour	Dana P., Dennis D., Tim S.	

ID	Action Item	Date/Status	Responsibility	Distribution Method
04.09-13	Request wind speed data in excel file format to assist in estimating wave heights/loads	6/24/13	Dennis Dorratcague	Dennis will work with John Haapala
04.10-01	Update biological appendices to account for other target species added to Target Species list (those added into Table 1-No. B1 Biological Data Needs)	6/24/13	MaryLou and Tim Sullivan	Nuisance species is another list and to date we have not included periodicity type information on those nuisance species.
04.10-02	Fix appendix B2 to note lake trout are native	6/24/13	Tim Sullivan	
04.10-03	Table B3 needs the headings/categories clarified and if appropriate update periods.	6/24/13	Tim Sullivan	If needed follow up with smaller group of Stormy, Jeff Davis, MaryLou.
04.10-04	Add a series or component to the Information Needs table that relate to management considerations of the target species (policy information on species management or how to handle nuisance species)	6/24/13	Dana P./Stormy	Stormy to go back to ADF&G staff and try and get more information on what might be policy considerations that could be identified. Dana going to draft template for June 24th.
04.10-05	Take out Adult Chinook relative abundance bulleted item in the B7 slide (on relative abundance)	6/24/13	Tim Sullivan	At request of Jeff Davis and Sue Walker – not really needed
04.10-06	Create combined table to address design criteria information for B3-B6 for target species	6/24/13	Tim S. and MaryLou K.	
04.10-07	Get Chick input to Evaluation of Alternatives Matrix	TBD – prior to March 2014 workshop	Chick Sweeney/Tim Sullivan	
04.10-08	Biological Performance Tool to be populated/created as straw man	TBD – prior to March 2014 Workshop	Tim S. / Phil H.	For review at brainstorming meeting.
04.10-09	Compile available mapping of tributaries with plan/profile information to extent possible prior to the workshop	TBD – prior to March 2014 Workshop	Dennis D., Dana P.	For review/use at brainstorming meeting.

ID	Action Item	Date/Status	Responsibility	Distribution Method
05.21-01	Provide remaining edits to April 9-10, 2013 Workshop #1 meeting notes to AEA	5/24/13	Jeff Davis and Sue Walker	Email
05.21-02	AEA to follow up off-line with B. Long and S. Walker regarding operational scenarios	6/25/13	Wayne Dyok	Phone call
05.21-03	AEA to follow up with Rob P. regarding the timing/availability of ice modeling results	6/25/13	Betsy McGregor	Update for next meeting
05.21-04	Provide edits to Information Needs List and update table	Edits to AEA by 6/18/13	Workshop #1 participants	B. McGregor to email MS-Word version participants for editing. Updated table distributed for 7/9/13 meeting.
05.21-05	Doodle Poll for site reconnaissance	5/31/13	Dana Postlewait, Betsy McGregor	Email
05.21-06	Rework schedule/meeting list including 7/9/13 check-in and March 18-19, 2014 brainstorm session	6/25/13	Dana Postlewait	Email
05.21-07	Draft notes of 5/21/13 check-in meeting and action items	5/31/13	S. Padula, D. Postlewait, T. Sullivan	Email

Agenda
Fish Passage TWG
Fish Passage Meeting #3
5/21/2013

LOCATION: **Web Call**

TIME: **8:00 am – 10:00 am (AKST); 9:00 am – 11:00 pm (PST)**

SUBJECT: **Regularly scheduled interim check-in meeting for Fish Passage Technical Team**

GoTo MEETING: https://www4.gotomeeting.com/register/291822519
1-800-315-6338 Code 3957#

Introductions

Meeting Purpose and Objectives

- **Regularly schedule interim check-in meeting.**

Review Workshop #1 Meeting Items (held on April 9-10, 2013)

- **Review meeting notes and action items**
- **Review information needs list updates**
- **Review fish passage technical team composition**

Discuss preparation for site reconnaissance planned for Meeting #4

- **Schedule meeting, suggest late August, early September for better flow conditions**
- **Planning needs**

Discuss upcoming Brainstorming Workshop #2

- **Schedule meeting, suggest late February or early March 2014 so we have results of 2013 studies**
- **Planning needs**

Review Fish Passage Study Schedule and Next Steps

- **Review meeting schedule and set dates**

2013-05-21 FPTWG_Agenda_Draft_V2.docx

SUSITNA-WATANA HYDRO

Meeting Notes
Fish and Aquatics
Fish Passage Technical Workgroup Meeting #3a – Regular Update
July 09, 2013

LOCATION: **Web Meeting**

TIME: **8:00 am – 10:00 am (AKST); 9:00 am – 11:00 am (PST)**

SUBJECT: **Fish Passage Technical Workgroup Meeting #3a – Regular Update**

GOAL: **Regularly scheduled interim check-in meeting**

PARTICIPANTS: ***Fish Passage TWG Attendees***: **Betsy McGregor** AEA, **Dana Postlewait** R2, **MaryLou Keefe** R2, **Tim Sullivan** R2, **Chick Sweeney** Alden Labs, **Ed Meyer** NMFS, **Stormy Haught** ADF&G, **Ed Zapel** NHC, **Catherine Berg** USFWS, **Sue Walker** NMFS, **Dan Turner** R2, **Dana Schmidt** Golder, **Graham Hill** NHC

Other Attendees: **Steve Padula** McMillen, **Kathryn Peltier** McMillen, **Justin Crowther** AEA

This meeting was a regularly scheduled check-in amongst the Fish Passage Technical Workgroup, the fourth such check-in meeting and the second since the April 9-10 Fish Passage Technical Workshop (Workshop #1). These meeting notes are intended to give a brief overview of discussions, review the status of prior action items, and identify new action items. Active action items from this meeting as well as those not completed from previous meetings are provided in a table at the end of this document; a copy of the agenda is also attached. Completed action items and "parking lot items" are included in separate tables, also following these meeting notes. After introductions, Steve Padula began the meeting by presenting the agenda.

Previous Meeting Note Review

On June 24, 2013 the previous meeting notes were distributed for attendees' review. The NMFS representatives indicated that they would be conferring internally but did not anticipate any comments on the meeting notes.

Action Item Review

Dana Postlewait reviewed the status of action items identified during the May 21st TWG #4. Action items are listed in the tables below. Red text indicates updates to previous action items still considered active.

Information Needs Table

Tim Sullivan led a review of the Information Needs Table (Rev 4, dated May 16, 2013). The updates and edits to the appendices referenced in the table are not completed for all of the appendices. The attendees agreed that it would be most useful to wait until all appendices are completed before distributing to the group. The next major update will occur at least two weeks prior to the September 17-20, 2013 site visit. An addendum to this update will be planned for early January to have a more complete product for the March 18-19, 2014 brainstorm workshop, which will allow for incorporation of any updates prepared after this field season, and other information that becomes available that will assist this group.

An additional two weeks was provided for FP TWG members to review the Information Needs Table. Any correspondence regarding suggested edits should be sent to Dana Postlewait and CCed to Betsy McGregor by July 23, 2013.

Site Visit Logistics

The site reconnaissance dates have been confirmed as September 17-20, 2013. Dana Postlewait informed attendees that it may be useful for them to review the aerial videos prior to the trip. Dana said that he will provide any relevant data that is available from the 2013 field season during the scheduled meeting times in Talkeetna. Two weeks prior to the trip, multiple items will be distributed to the fish passage team as noted above. These are detailed in action item 07.09-01. Two days prior to the trip, Dana Postlewait will review the weather conditions and coordinate with Betsy McGregor to determine the feasibility of flying. If conditions are not favorable for flying, the trip may be rescheduled to "Plan B" or postponed for a future date. Notification will be made by e-mail. Agency members are responsible for procuring their own lodging and travel. AEA members and consultants will arrange lodging through AES at the Talkeetna field camp.

The detailed schedule was discussed as presented below. No concerns were expressed.

Plan A – Good Weather

1. Tuesday, Sept 17 – travel day
    a. Fly to Anchorage
    b. Drive to Talkeetna
    c. Potential for an informal group dinner
    d. Overnight in Talkeetna
2. Wednesday, Sept 18 – site tour (weather allowing)
    a. Tour the site via helicopters, AEA will arrange for travel and will accommodate federal personnel travel requirements. This will take about 4 to 5 hours if the weather allows.
    b. Debrief in a conference room
    c. Overnight in Talkeetna
3. Thursday, Sept 19
    a. Meet in a conference room to debrief and share ideas. Plan on 4 hours.
    b. Drive back to Anchorage
    c. Overnight in Anchorage (or fly out if standby seats are available)
4. Friday, Sept 20
    a. Travel home

Plan B – Can't fly Wednesday due to Weather

1. Tuesday, Sept 17 – travel day
    a. Fly to Anchorage
    b. Drive to Talkeetna
    c. Potential for an informal group dinner
    d. Overnight in Talkeetna
2. Wednesday, Sept 18 – If can't fly due to weather
    a. Meet for the day in a conference room
        i. Discuss flight plans and trip needs
        ii. Discuss updated material

iii. Informal brainstorm with initial concepts. Goal will be to record initial ideas, discuss criteria, site access, etc., and record ideas to help initiate the formal brainstorming session planned for next March.

b. Overnight in Talkeetna

3. Thursday, Sept 19 – Site Tour (weather allowing)
   a. Tour the site via helicopters, AEA will arrange for travel and will accommodate federal personnel travel requirements.
   b. Short debrief in a conference room
   c. Drive back to Anchorage
   d. Overnight in Anchorage (or fly out if standby seats are available)
4. Friday, Sept 20
   a. Travel home

<u>Study Schedule</u>

Dana reviewed a proposed schedule which included modifications that shifted the planned site visit to September and shifted the brainstorming session into early March 2014. The detailed schedule updated per this discussion is provided below.

An updated study schedule (Gantt chart) and meeting list is attached.

<u>Brainstorm Meeting</u>

A brainstorm meeting is scheduled for March 18-19, 2014 in the MWH Bellevue, WA offices. Dana Postlewait explained the importance of being in person for any active TWG member. Sue Walker mentioned Dara Glass' (CIRI) opposition to holding meetings outside of Alaska. Betsy McGregor will contact CIRI on this issue.

<u>Additional Discussion</u>

The FP TWG agreed there was no need to schedule another meeting prior to the September site visit. If something unexpected occurs, it will be communicated by e-mail.

ID	Active Action Items	Date Due	Responsibility	Distribution	Notes
04.09-06	Distribute report on glacial lakes study, if one was produced.	1/2/2014	D Schmidt; AEA	Email to study leads. Post after review. Potentially available on ARLIS (http://www.arlis.org/resources/susitna-watana/)	7.9.13 - Dana Schmidt will reach out to Siberia and Scandinavia
04.09-07	Rob Plotnikoff to request John Hamrick provide some background information on simulating reservoirs and fish movements based on past experience.	Pending	Rob Plotnikoff	Update for next meeting	7.9.13 – MaryLou K and D Postlewait will follow up with Rob Plotnikoff.
04.09-09	Need guidance from Wayne/AEA on how run of river scenario will be handled; and importantly when some scenarios with environmental flows will be available to be modeled and available to the FPTWG (in between run of river and maximum load following).	See 05.21-02	W Dyok		
04.09-11	Determine when reservoir ice study will have some results to report to the Fish Passage group, or at least some findings of preliminary observations, particularly effects of ice formation and breakup at tributary mouths in reservoir.	Prior to next meeting	Rob Plotnikoff		7.9.13 – MaryLou K and D Postlewait will follow up with Rob Plotnikoff.
04.09-12	Distribute synthesis book to hand out before July 8-12 site visit. [now planned for Sept 17-19]	9/3/2013	Dana Postlewait, Dennis Dorratcague, Tim Sullivan	Planned for email and posting Susitna-watanahydro.org	To be distributed by September 3, 2013 (2-weeks prior to site tour).
04.09-13	Request wind speed data in excel file format to assist in estimating wave heights/loads	9/3/2013	Dennis Dorratcague	Dennis will work with John Haapala	

ID	Active Action Items	Date Due	Responsibility	Distribution	Notes
04.10-01	Update biological appendices to account for other target species added to Target Species list (those added into Table 1- No. B1 Biological Data Needs)	9/3/2013	MaryLou Keefe, Tim Sullivan	Nuisance species is another list and to date we have not included periodicity type information on those nuisance species.	
04.10-02	Fix appendix B2 to note lake trout are native	9/3/2013	Tim Sullivan		
04.10-03	Clarify Table B3 headings/categories and if appropriate update periods.	9/3/2013	Tim Sullivan	If needed follow up with smaller group of Stormy Haught, Jeff Davis, MaryLou Keefe.	
04.10-05	Take out Adult Chinook relative abundance bulleted item in the B7 slide (on relative abundance)	9/3/2013	Tim Sullivan	At request of Jeff Davis and Sue Walker – not really needed	
04.10-06	Create combined table to address design criteria information for B3-B6 for target species	9/3/2013	Tim Sullivan, MaryLou Keefe		
04.10-07	Obtain Chick Sweeney's input to Evaluation of Alternatives Matrix	9/3/2013	Chick Sweeney, Tim Sullivan, Dana Postlewait		Chick will provide draft to Dana Postlewait and Tim Sullivan by 8/26/2013. Tim and Dana to add to 9/3/2013 distribution package.
04.10-08	Biological Performance Tool to be populated/created as straw man	1/2/2014	Tim Sullivan, Phil Hilgert	For review at brainstorming meeting.	See updated schedule.
04.10-09	Compile available mapping of tributaries with plan/profile information to extent possible prior to the workshop	9/3/2013	Dennis Dorratcague, Dana Postlewait	For review/use at brainstorming meeting.	Expect this will be updated following site tour to prepare for brainstorm session in March, 2013.
05.21-02	AEA to follow up off-line with B. Long and S. Walker regarding operational scenarios (related to 04.09-9).	7/9/2013	Wayne Dyok	Phone call	Sue Walker will remind Wayne 7/9/2013 call.
05.21-03	AEA to follow up with Rob Plotnikoff regarding the timing/availability of ice modeling results	9/3/2013	Betsy McGregor	Update for next meeting	Betsy emailed Rob 7/9/2013

ID	Active Action Items	Date Due	Responsibility	Distribution	Notes
05.21-06	Rework schedule/meeting list including 7/9/13 check-in and March 18-19, 2014 brainstorm session	7/15/2013	Dana Postlewait	Email	Done - Distributed with draft Meeting Notes on 7/23/2013
07.09-01	Materials to be distributed 2 weeks prior to site visit - AI 04.09-12 - AI 04.10-04 - AI 04.10-07 - AI 04.10-09 - Information Needs Appendices - Safety/gear requirements for site visit - Workbook	9/3/2013			
07.09-03	Review of the Information Needs Table	7/23/2013	FP TWG	Email to Dana Postlewait, with cc to Betsy McGregor.	R2 and MWH will consider comments for update to Table, to be distributed on 9/3/2013.
07.09-04	Contact CIRI regarding their concern with AEA hosting meeting outside of Alaska	9/18/2013	Betsy McGregor	Update for next meeting	
07.09-05	Confirm additional Fish Passage "other participants and contacts" - Eric Rothwell (NMFS) - CIRI - FERC - NGOs (see AI 07.09-06)	9/18/2013	Betsy McGregor	Update for next meeting	
07.09-06	Review previous fish passage meeting for attending NGOs to potentially add to the Fish Passage "other participants and contact"	9/18/2013	Betsy McGregor, Wayne Dyok	Update for next meeting	
07.09-07	Confirm site tour travel is feasible based on latest weather.	9/16/2013, by 17:00 ADT	Dana Postlewait	Email to meeting attendees	Dana Postlewait will confirm feasibility of helicopter travel based on latest weather forecast, and coordinate with Betsy McGregor.

ID	Parking Lot Item	Date Noted	Responsibility	Distribution	Notes
02.22-01	Identify Strategy Statement (e.g., Senate Bill; PAD)	3/31/2013	AEA	Will be in FSP, ISR	
02.22-02	Clarify meaning of "retrofit" with space/time components	3/8/2013	R2	Will be in FSP and ISR	
02.22-06	Include discrepancies in data to information table	3/8/2013	R2	Will be in final product.	
04.10-04	Add a series or component to the Information Needs table that relate to management considerations of the target species (policy information on species management or how to handle nuisance species)	9/3/2013	Dana Postlewait, Stormy Haught	Stormy to go back to ADF&G staff and try and get more information on what might be policy considerations that could be identified. Dana going to draft template for June 24, 2013.	ADF&G finds it is premature to comment. They prefer 1-2 years of field data before considerations are made. - parking lot item 07.09-02 created
07.09-02	ADF& G policy information on species management or how to handle nuisance species	7/9/2013	Dana Postlewait, Stormy Haught	ADF&G finds it is premature to comment. They prefer 1-2 years of field data before considerations are made.	ADF&G will comment in year 2015 after field data is available.

ID	Completed Action Items	Date Completed	Responsibility	Distribution	Notes
02.22-03	Confirm next meeting location	3/8/2013	AEA		Done. Next meeting will be held in Bellevue, WA. Future meetings will be held at most cost-effective locations.
02.22-04	Data needs table: Input from TWG on list of items	3/8/2013	All participants		
02.22-05	Add changes in spawning and rearing habitat in proposed inundation zone to data needs table	3/8/2013	R2		
02.22-07	Produce/distribute communications protocol from PAD (cc: Betsy, Ed, Sue)	3/8/2013	McMillen		Done 3/8/2013.
02.22-08	Standing agenda item for agendas – review and approve previous meeting notes and future meeting schedule	NA	NA		
02.22-09	Follow-up with others re: future participation in TWG; FERC (AEA), EPA (Catherine Berg), NGOs (AEA), ADF&G (AEA), FWS (Sue Walker), ADNR (Marie Steele), Jan Konigsberg (AEA)	3/20/2013	AEA, Catherine Berg, Marie Steele	Email	
02.22-10	Meeting protocol – summarize action items, decisions, parking lot items	NA	NA		
02.22-11	Identify other fish passage at high head dam experts	3/20/2013	MWH, R2, Ed Meyer		Done 3/20/2013.
02.22-12	Issue updated meeting and workshop calendar (Gantt chart)	3/20/2013	R2	FP TWG email	Done 3/20/2013.
02.22-13	Provide a list of all Susitna River species and life stages. Provide rationale of species not considered to travel to dam site	3/26/2013	R2	Website: Meeting Materials for April 9 and 10; Listserve email	
02.22-14	Distribute updated data needs table and data synthesis to TWG	3/26/2013	R2	Website: Meeting Materials for April 9 and 10; Listserve email	Done 3/26/2013.
02.22-15	Provide a list of all Susitna River species and life stages. Provide rationale of species not considered to travel to dam site	3/26/2013	R2		Done 3/26/2013.

ID	Completed Action Items	Date Completed	Responsibility	Distribution	Notes
02.22-16	Distribute sample biological tool spreadsheet and description of tool	3/26/2013	R2	Website: Meeting Materials for April 9 and 10; Listserve email	Done 3/26/2013.
02.22-17	Presentation of videography at first workshop	4/9/2013	AEA	April 9 and 10, 2013 FP TWG	
03.20-01	Distribute MSWord document of 2/22/13 meeting notes to attendees for edits	3/20/2013	Kathryn Peltier	Email	Done. Betsy McGregor distributed to FP TWG 3/22/2013.
03.20-02	Create an archive list of completed action items	3/20/2013	Kathryn Peltier	Email	Done. Distributed to FP TWG 4/8/2013.
03.20-03	Update communication protocol and distribute	3/22/2013	Kathryn Peltier	Email	Done. Distributed to FP TWG in 3/20/2013 mtg notes on 4/8/2013.
03.20-04	Distribute list of all Fish Passage team members	3/22/2013	Kathryn Peltier	Email	Done. Distributed to FP TWG on 4/8/2013.
03.20-05	Provide Ed Meyer with Dana Schmidt's resume	3/21/2013	MaryLou Keefe	Email	Done. MaryLou Keefe sent to Ed Meyer 3/21/2013.
03.20-06	Review Dana Schmidt's and Chick Sweeney's resumes as high head dam fish passage experts	3/22/2013	Ed Meyer	Email	Done.
03.20-07	Add to applicable entrainment reference in the data needs table	3/26/2013	MaryLou Keefe	Data Needs Table	Done.
03.20-08	Include reservoir effects on migration timing is in the data needs table	3/26/2013	MaryLou Keefe	Data Needs Table	Done.
03.20-09	Provide MaryLouise Keefe with a detailed description regarding data needs of trophic cascade information	3/25/2013	Jeff Davis	Email, Data Needs Table	Done 3/26/2013.
03.20-10	Distribute draft Agenda for April 9 and 10 Fish Passage Meeting	3/27/2013	AEA	Website: Meeting Materials for April 9 and 10; Listserve email	
04.09-01	Provide edits to 2/22/2013 FPTWG meeting notes to AEA	Complete. Notes posted	FPTWG 2/22/2013 meeting attendees	Email for edits. Susitna-watanahydro.org	

ID	Completed Action Items	Date Completed	Responsibility	Distribution	Notes
04.09-02	Provide edits to 3/20/2013 FPTWG meeting notes to AEA	Complete. Notes posted	FPTWG 3/20/2013 meeting attendees	Email for edits. Susitna-watanahydro.org	
04.09-03	AEA to discuss its choice of additional fish passage experts with Ed Meyer/Sue Walker	Complete. Added Dr. Al Giorgi to FP TWG	Wayne Dyok	Phone call	
04.09-04	Provide FPTWG Information Needs Table in MSWord	Complete	Betsy McGregor	Email	Dana Postlewait distributed by email for Betsy McGregor.
04.09-05	Include appendix titles in website link description/title	Complete. Posted	Justin Crowther	Susitna-watanahydro.org	
04.09-08	Flow duration data in Excel; data presented today plus totals	Posted	John Haapala, Dennis Dorratcague	Susitna-watanahydro.org	Dennis Dorratcague to reprint with pagination corrected for re-posting.
04.09-10	Find out from Stuart when he will be completed with estimating flows in tributaries to reservoirs and just below dam – when that data will be available to the fish passage study team.	Complete.	MaryLou		Stage data to be collected this year, and stage/ discharge relationships to be developed in 2014 with results available after 2014 season.
05.21-01	Provide remaining edits to April 9-10, 2013 Workshop #1 meeting notes to AEA	5/24/2013	Jeff Davis and Sue Walker	Email	
05.21-04	Provide edits to Information Needs List and update table	Edits to AEA by 6/18/2013	Workshop #1 participants	Betsy McGregor to email MS-Word version participants for editing. Updated table distributed for 7/9/2013 meeting.	Distributed 6/24/2013
05.21-05	Doodle Poll for site reconnaissance	5/31/2013	Dana Postlewait, Betsy McGregor	Email	Completed confirming 9/17-9/20
05.21-07	Draft notes of 5/21/2013 check-in meeting and action items	5/31/2013	Steve Padula, Dana Postlewait, Tim Sullivan	Email	

SUSITNA-WATANA HYDRO

Agenda
Fish Passage TWG
Fish Passage Meeting #3a
7/9/2013

LOCATION: Web Call

TIME: 8:00 am – 10:00 am (AKDT); 9:00 am – 11:00 am (PDT)

SUBJECT: Regularly scheduled interim check-in meeting for Fish Passage Technical Team

GoTo MEETING: https://www4.gotomeeting.com/register/800785847
1-800-315-6338 Code 3957#

Introductions

Meeting Purpose and Objectives

- Regularly schedule interim check-in meeting.
- Plan for site reconnaissance trip

Review May 21 Meeting Items (Meeting #3)

- Review meeting notes and action items
- Review information needs list updates

Discuss preparation for site reconnaissance planned for Meeting #4

- Date confirmed
- Travel logistics
- Review agenda

Review Fish Passage Study Schedule and Next Steps

- Review updated meeting schedule and Gantt chart schedule
- Critical path items

Discuss upcoming Brainstorming Workshop #2

- Scheduled for March 18-19, 2014
- Planning needs

PART A - APPENDIX B: BIOLOGICAL INFORMATION

Table B-1. List of biological data needs. The available information as of January 8, 2014 follows in this appendix. Except where the noted initial compilation of information was provided to the FPTWG prior to Workshop #1 (April 9 and 10, 2013) and updates provided prior to the Site Visit (September 18 and 19, 2013).

Item	Description	Comments
B1	Target fish species for upstream and downstream passage.	Added to Table B1: coho, sockeye, chum, rainbow trout, steelhead, arctic lamprey, Bering cisco. Passage facilities will require species sorting. Consider species that we do not want to pass (nuisance species). Updated appendices to reflect additional species, including periodicity and numbers. Specified which species documented in Upper River.
B2	List of other species in the system that may be accessible to any passage facilities.	Changed lake trout to be considered as native species.
B3	Life stage specific periodicity	Updated table headings and created a combined fish passage design table for Items B3, B4, B5, and B6 (See Item B17).
B4	Migratory characteristics - routes, seasonal timing & duration by species & life stages	Created a combined fish passage design table for Items B3, B4, B5, and B6 (See Item B17). Reference routes in Item B8 also.
B5	Estimated numbers & sizes of fish for upstream and downstream migrants	Created a combined fish passage design table for Items B3, B4, B5, and B6 (See Item B17). Reference upper reservoir future fish community study (note this is a management decision). Consider how large numbers of potential anadromous fish could impact passage of resident fish. Intent for passage facility design is to create bookends for feasibility analysis. Later work needs to revisit this issue, and plans could consider flexibility, phased approach, etc. Provide 2 columns in the population number estimate table: best estimate of numbers (design for what is there now), and potential future fish numbers. Note potential rate of increase, as feasible.
B6	Life stage specific parameters – size, migratory behavior, swimming behavior & speed, other physical passage constraints	Created a combined fish passage design table for Items B3, B4, B5, and B6. See Item B17
B7	Fish relative abundance upstream and downstream of project including tributaries	Merged with Item B5.
B8	Locations of spawning and rearing habitats	Updated B8 with new data on Chinook observation maps. Reference migration routes with Item B4.
B9	Predators – species, abundance, location	Will be used to help compare alternatives, may be a data need. Likely a management issue. This item has been added to the management table, and will be retained here also.
B10	Existing ecological conditions – invasive species, light, temperature, flows	See Water Quality Items P1 and P11.
B11	Bio performance tool	See update distributed on 1/8/14. Not on current short-term critical path.
B12	Influence of the reservoir on juvenile and smolt migration timing, and	Merged with Item B6 See temperature model being developed this summer by R.

Item	Description	Comments
	migration routes from tributaries to the reservoir to the intake or capture location.	Plotnikoff which may also provide velocity information (RSP 5.6 – Water Quality Modeling Study).
B13	Influence of post-project reservoir on ice formation on juvenile and smolt migration from tributaries.	See temperature model output noted in Item B12. Is there risk of increased ice conditions that could affect downstream migration and the ability to collect fish out of tributaries?
B14	Influence of the reservoir on fish community and target species including the introduction and proliferation of predators (i.e. Lake Trout) in the modified reservoir environment.	Merged with Item B9
B15	Risk of entrainment of non-target species into the intake or capture device under different passage alternatives	Merged with Item B2
B16	Influence of seasonal and longitudinal changes in turbidity, and thermocline presence and depth on predation and migration routes (depth).	Merged with B10. See water quality model output (RSP 5.6 – Water Quality Modeling Study), which will indicate thermal barriers, etc. (Items P2 and P9)
B17	Combined fish passage design table	Combines information from Items B3, B4, B5, and B6

INFORMATION ITEM B1. TARGET FISH SPECIES FOR PASSAGE

1. TARGET SPECIES SELECTION RATIONALE

The proposed Susitna-Watana Project would block the upstream passage of Chinook salmon and resident fish that migrate through and otherwise use the dam site and upstream habitat in the Upper Susitna River and its tributaries. Likewise, the proposed dam and reservoir could potentially affect the downstream movement of fish in the Upper River that exhibit migratory behavior. This information item provides a preliminary list of target species for consideration in the Study of Fish Passage Feasibility at Watana Dam.

As a first step in selecting target species, only those fish species that have been documented in the Upper River (upstream of the dam site) were considered. This criterion is based on the assumption that, compared to current conditions, the Project has the potential to affect connectivity of habitat and/or gene flow for species that have documented presence in the Upper River. From the list of Upper River fish species, target species were then selected based on the following three criteria.

- ***Exhibit migratory behavior*** **–** Fish passage has a greater importance to species that may exhibit migratory behavior as part of their natural life history compared to fish that exhibit only localized movement, especially when the migration is necessary to complete the life cycle of the species.
- ***High relative abundance*** **–** Species that are relatively abundant in the Upper River and its tributaries would theoretically utilize fish passage facilities with greater frequency than less abundant species, disregarding other criteria (e.g., migratory behavior).
- ***Importance to commercial, sport, or subsistence fisheries*** **–** Species that are harvested in commercial, sport, or subsistence fisheries have added importance with regard to the study of fish passage feasibility.

Preliminary target species were selected if they met two of the three criteria listed above. Because the amount of available information related to these criteria is inconsistent for each species, this assessment was qualitative and in some cases relied on assumptions based on out-of-basin literature. For each criterion, categorical scores of *High*, *Moderate*, and *Low/None* were assigned to each species and only those rated as *High* or *Moderate* were deemed to meet that criterion. This approach does not account for any current of future conservation or management objectives that may exist for a given species.

Table B1-1 shows the criteria scores for all fish species known to occur in the Upper River and identifies those selected as target species based on the criteria. For those selected as target species, the following sections provide a brief rationale for the scores assigned. Other appendices to this document provide further details regarding migratory behavior (Information Item B4) and relative abundance (Information Item B7) in support of these scores. Brief descriptions of other species that were not selected as target species but are known to occur in the Upper River and could potentially access passage facilities are provided in Information Item B2.

The Fish Passage Technical Workgroup meeting held on March 9-10, 2013 (Workshop #1) included a discussion as to whether the fish passage study team should consider additional species beyond the target species identified based on the criteria above. There was agreement to consider all species that might exist in the area, including anadromous fish documented in the Middle River. Based on this discussion, these additional species will also be considered target species and are included in Table B1-1 as well as the sections below.

2. ARCTIC GRAYLING

- Evidence of movement between tributaries in the Upper River with use of the main channel as a migratory corridor (Delaney et al. 1981b). In the Middle River, documented migrations of up 40 miles to overwinter in the mainstem near Talkeetna (Sundet 1986).
- High relative abundance in the Upper Susitna River compared to catches of other species (Delaney et al. 1981b; AEA unpublished data).
- An important species comprising a significant component of the sport fish harvest in the Susitna River Drainage (Jennings et al. 2007, 2011).

3. ARCTIC LAMPREY

- Arctic lamprey populations in the Susitna River are thought to exhibit both anadromous and freshwater life histories (Schmidt et al. 1983). Ammocoetes undergo a metamorphosis in the fall and migrate as young adults to the sea, or to lakes and larger rivers. After an undetermined period, adults migrate upstream to spawn (Delaney et al. 1981a).
- Arctic lamprey are primarily distributed in the lower Susitna River (downstream of RM 50.5), but have been found as far upstream as Gash Creek (RM 111.5) (Schmidt et al. 1983, Sundet and Wenger 1984).
- Arctic lamprey are believed to be abundant in the Susitna River below HRM 50.5 with decreased abundance upstream (Sundet and Wenger 1984).
- Added as a target species following TWG discussions.

4. BERING CISCO

- Susitna River Bering cisco are anadromous (Delaney et al. 1981a).
- Bering cisco are known to be present in the Lower Susitna River and are thought to bee distributed primarily downstream of the confluence with the Chulitna River (Jennings 1985). During the 1980s only one Bering cisco was ever documented upstream of the three rivers confluence. They have not been documented in the Upper River.
- While information is not specifically provided for Bering cisco, whitefish spp. as a whole comprise a small component of the sport fish harvest in the Susitna River Drainage (Jennings et al. 2007, 2011).
- Added as a target species following TWG discussions.

5. BURBOT

- Burbot are generally sedentary except for pre- and post-spawning migrations documented to extend up to 70 miles based on telemetry and mark-recapture studies in the Middle Susitna River (Schmidt et al. 1983).
- Widely distributed in the Upper River, but at relatively low abundance compared to other target species (Delaney et al. 1981b; AEA unpublished data).
- An important species comprising a significant component of the sport fish harvest in the Susitna River Drainage (Jennings et al. 2007, 2011).

6. CHINOOK SALMON

- Exhibit extensive upstream spawning and downstream smolt migrations as part of obligate anadromous life history.
- Low relative abundance based on juvenile sampling and adult aerial surveys in the Susitna River and its tributaries upstream of Devils Canyon (AEA unpublished data; Buckwalter 2011; Barrett 1985).
- Comprise a major component of the sport fish harvest in the Susitna River drainage (Jennings et al. 2007, 2011) and supports commercial (Shields 2010) and subsistence (Fall et al. 2009) harvest in Cook Inlet.

7. CHUM SALMON

- Exhibit upstream spawning and downstream smolt migrations as part of obligate anadromous life history.
- Have not been documented in the Upper River but are present in the Middle River.
- Comprise a major component of the sport fish harvest in the Susitna River drainage (Jennings et al. 2007, 2011) and supports commercial (Shields 2010) and subsistence (Fall et al. 2009) harvest in Cook Inlet.
- Added as a target species following TWG discussions.

8. COHO SALMON

- Exhibit upstream spawning and downstream smolt migrations as part of obligate anadromous life history.
- Have not been documented in the Upper River but are present in the Middle River.
- Comprise a major component of the sport fish harvest in the Susitna River drainage (Jennings et al. 2007, 2011) and supports commercial (Shields 2010) and subsistence (Fall et al. 2009) harvest in Cook Inlet.
- Added as a target species following TWG discussions.

9. DOLLY VARDEN

- Limited available information regarding migration but some evidence from 1980s Middle River studies suggest upstream spawning movements up tributaries and post-spawn movements to the mainstem for overwintering (Schmidt et al. 1983; Sautner and Stratton 1983; Sundet and Wenger 1984).
- Infrequently encountered in the Upper River during 1980s studies (Delaney et al. 1981b) though more recent sampling upstream of Devils Canyon indicates a higher relative abundance and broader distribution compared to other species (AEA unpublished data; Buckwalter 2011)
- An important species comprising a significant component of the sport fish harvest in the Susitna River Drainage (Jennings et al. 2007, 2011).

10. HUMPBACK WHITEFISH

- Evidence of upstream spawning migration (>10 miles) in the main channel of the Middle River (Schmidt et al. 1983; Sundet and Wenger 1984). Limited indication of possible spring migration from overwintering areas (Schmidt et al. 1983).
- Low relative abundance compared to other species based on sampling upstream of Devils Canyon (AEA unpublished data; Buckwalter 2011; Delaney et al. 1981b).
- Whitefish spp. comprise a small component of the sport fish harvest in the Susitna River Drainage (Jennings et al. 2007, 2011). In addition, whitefish are components of subsistence harvest in several Alaska rivers.

11. LONGNOSE SUCKER

- In the Middle River, some indication of limited upstream movement in the spring associated with spawning, though migration distances are unknown (Schmidt et al. 1983). Adults are generally thought to move from lakes into inlet streams or from deep pools to shallow, gravel-bottomed areas in streams (Morrow 1980). Longnose suckers are not thought to exhibit any definite migrations except to and from spawning areas (Morrow 1980).
- Moderate relative abundance compared to other species based on sampling upstream of Devils Canyon (Delaney et al. 1981b; Buckwalter 2011; AEA unpublished data).
- Longnose sucker are not listed in sport fish harvest reports (Jennings et al. 2007, 2011) and are thought to comprise a negligible component of sport fish harvest. However, Morrow (1980) describes harvest elsewhere in their range outside of Alaska. Likewise, longnose sucker have been reported as a component of subsistence harvest in various parts of Alaska (Krieg et al. 2005; Simeone and Kari 2005; Andersen et al. 2004).

12. RAINBOW TROUT / STEELHEAD

- Rainbow trout have not been documented in the Upper River but are present in the Middle River.
- During spawning migrations, adult rainbow trout spawning migrations typically begin in March prior to ice break-up when adults move from main channel holding areas to spawning tributaries (Sundet 1986). Post-spawning movements occur from tributaries to overwintering habitat in the mainstem and side channels. After emergence, juvenile rainbow trout primarily reside in natal tributary habitats throughout the year (Schmidt et al. 1983). Rainbow trout exhibiting an anadromous life history (i.e., steelhead) have not been documented in the Middle Susitna River.
- Rainbow trout comprise a component of the sport fish harvest in the Susitna River Drainage (Jennings et al. 2007, 2011).
- Added as a target species following TWG discussions.

13. ROUND WHITEFISH

- In the Middle River, some evidence of an upstream migration in the main channel thought to be associated with spawning (Schmidt et al. 1983; Sundet and Wenger 1984). Some fish documented moving over 10 miles.
- Moderate relative abundance compared to other species based on sampling upstream of Devils Canyon (Delaney et al. 1981b; Buckwalter 2011; AEA unpublished data).
- Whitefish spp. comprise a small component of the sport fish harvest in the Susitna River Drainage (Jennings et al. 2007, 2011).

14. SOCKEYE SALMON

- Exhibit upstream spawning and downstream smolt migrations as part of obligate anadromous life history.
- Have not been documented in the Upper River but are present in the Middle River.
- Comprise a major component of the sport fish harvest in the Susitna River drainage (Jennings et al. 2007, 2011) and supports commercial (Shields 2010) and subsistence (Fall et al. 2009) harvest in Cook Inlet.
- Added as a target species following TWG discussions.

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16. TABLES

Table B1-1. List of fish species documented in the Upper Susitna River, a qualitative assessment of their potential for migratory behavior, relative abundance, and harvest importance, and the identification of preliminary target species for the Study of Fish Passage Feasibility at Watana Dam. Additional target species identified during TWG discussions are also listed; corresponding information for these species can be found in Information Items B3 through B8.

Species	Latin Name	Documented in Upper River Basin	Migratory Potential	Relative Abundance[3]	Harvest Importance	Target Species
Arctic Grayling	*Thymallus arcticus*	Yes	Moderate	High	High	✓
Arctic Lamprey	*Thymallus arcticus*	No	Included based on TWG discussion			✓
Bering Cisco	*Coregonus laurettae*	No	Included based on TWG discussion			✓
Burbot	*Lota lota*	Yes	Moderate	Low	High	✓
Chinook Salmon	*Oncorhynchus tshawytscha*	Yes	High	Low	High	✓
Chum Salmon	*Oncorhynchus keta*	No	Included based on TWG discussion			✓
Coho Salmon	*Oncorhynchus kisutch*	No	Included based on TWG discussion			✓
Dolly Varden	*Salvelinus malma*	Yes	Moderate	High	High	✓
Humpback Whitefish[1]	*Coregonus pidschian*	Yes	Moderate	Low	Moderate	✓
Lake Trout	*Salvelinus namaycush*	Yes	Low	Low	High	
Longnose Sucker	*Catostomus catostomus*	Yes	Moderate	Moderate	None	✓
Rainbow Trout/ Steelhead	*Oncorhynchus mykiss*	No	Included based on TWG discussion			✓
Round Whitefish	*Prosopium cylindraceum*	Yes	Moderate	Moderate	Moderate	✓
Sculpin[2]	*Cottus spp.*	Yes	Low	High	None	
Sockeye Salmon	*Oncorhynchus nerka*	No	Included based on TWG discussion			✓

Notes:

1 Whitefish species that were not identifiable to species by physical characteristics in the field were called humpback by default. This group may have included lake *(Coregonus clupeaformis)* or Alaska *(Coregonus nelsonii)* whitefish.

2 Sculpin species were generally not differentiated in the field. In addition to slimy sculpin *(Cottus cognatus)*, species may include others belonging to the *Cottus* genus.

3 Reflects relative abundance in the Upper River Basin based on best available information.

INFORMATION ITEM B2. OTHER SPECIES POTENTIALLY ACCESSIBLE TO ANY PASSAGE FACILITIES

1. INTRODUCTION

Information Item B1 describes proposed target species for the Study of Fish Passage Feasibility at Watana Dam. These target species were identified based on their documented presence in the Upper Susitna River, the degree to which they are expected to exhibit migratory behavior, their relative abundance, and their importance to harvest. In addition, several other fish species were identified for inclusion as target species following TWG discussions. Two other taxa, lake trout and sculpin, have also been identified in the Upper Susitna basin but were not proposed as target species for the Study of Fish Passage Feasibility at Watana Dam. Nonetheless, these taxa would have the potential to encounter fish passage facilities at the Project. This information item provides a summary of available life history, distribution, and abundance information for these taxa, as well as rationale by which they are proposed as non-target species.

2. LAKE TROUT

2.1. General Life History and Periodicity

Similar to other species of char, lake trout spawn in the fall generally between September and October before freeze-up (Morrow 1980). Lake trout are broadcast spawners and do not excavate a redd, but instead congregate in large groups over coarse, rocky habitats at night and broadcast eggs and milt over spawning beds. Lake trout are a slow-growing, long lived fish species that spend their entire lives in lake habitats. Lake trout are sexually mature after 5 to 8 years. Larvae emerge in the spring though little is known about subsequent juvenile behavior. Lake trout are slow-growing and can often live for 25 years, though have been documented as old as 62 years (Burr 1987). Lake trout generally do not spawn every year. Little is known about their early life history. Prey items include a combination of zooplankton, aquatic invertebrates, and other fish species (Bendock 1994).

2.2. Distribution and Relative Abundance

Lake trout primarily occupy deep lake habitats that can include both clear-water and glacial lakes, although they tend to only occupy clear-water systems in northern Alaska (Bendock 1994). Lake trout have been documented in lake outlet channels, though their use of connected stream and river systems is less clear (Burr 1987).

Jennings (1985) reported that lake trout occur in relatively large and deep lakes throughout the Susitna Basin. Occasionally, lake trout can also be found in the inlet or outlet streams of these lakes (Jennings 1985). Lake trout were not captured during surveys of mainstem-influenced areas of the Susitna River below Devil Canyon in the 1980s (ADF&G 1981, 1983; Schmidt et al. 1984). They are most widely distributed in the upper Susitna River drainage, but also are present in lakes of the eastern side of the Susitna River drainage. Lake trout distribution in the Susitna River basin is not well understood, but they have been documented in Beaver, Clarence, Crater, Curtis, Stephens, Louise, Little Louise, and Butte lakes (Burr 1987) as well as Deadman and Sally lakes (Sautner and Stratton 1983).

Little detailed information is available from the studies of the 1980s regarding lake trout in the Susitna River basin. The most detailed information comes from sampling during 1981 in Deadman Lake and during 1981 and 1982 in Sally Lake, which would have been inundated under the proposed project configuration of the 1980s (Delaney et al. 1981a; Sautner and Stratton 1983). Sampling in Sally Lake during 1981 was primarily by gillnet with some angling; only angling was attempted at Deadman Lake. Lake trout were captured in both Sally Lake (32 fish, 2 by angling) and Deadman Lake (3 fish, all by angling). Lake trout in Sally Lake were captured in less than 6 feet of water and within 100 feet of shore. The length of Lake Trout in Sally Lake ranged from 305 mm to 508 mm with a mean of 410 mm. Most scales removed from Lake Trout were unreadable, precluding age determination. During 1982, sampling in Sally Lake resulted in the capture of 32 Lake Trout (Sautner and Stratton 1983). Similar to the 1981 sampling, fish sizes ranged from 260 to 490 mm with an average length of 419 mm.

2.3. Rationale as Non-Target Species

- Lake trout are thought to exhibit little migratory behavior outside of lacustrine habitat, with observations of movement to lotic habitat in the Susitna Basin limited to inlet/outlet streams (Jennings 1985). Thus, any connectivity afforded by passage facilities would be expected to provide little benefit for this species.
- Although frequently found in some Susitna Basin lakes, lake trout were not documented in the mainstem Susitna River (AEA unpublished data; Jennings 1985; Sautner and Stratton 1983). While the potential exists for lake trout to inhabit the Project reservoir following impoundment, it appears unlikely that they would move past the dam site under current conditions.
- Although lake trout are an important component of sport fisheries in the Susitna Basin (Jennings et al. 2007, 2011), their importance with regard to the study of fish passage feasibility is thought to be negligible. Should lake trout ultimately inhabit the future Project reservoir, predation by lake trout and entrainment may be considerations. Predation risks associated with Fish Passage are addressed in Information Item B9. The probability of lake trout inhabiting the future Project reservoir and potential entrainment risks will be considered in RSP 9.10 - The Future Watana Reservoir Fish Community and Risk of Entrainment Study.

3. SCULPIN

3.1. General Life History and Periodicity

Sculpin observed in the Susitna River during the 1980s were generally not differentiated by species, and as a result, there is little information about individual species (AEA 2012). The slimy sculpin (*Cottus congnatus)* is the most abundant sculpin species and the only sculpin species conclusively identified as present within the Susitna River drainage (Delaney et al. 1981a, 1981b). This section includes information specific to slimy sculpin where available, but otherwise may reflect information related to sculpin *(Cottus spp.)* generally.

Slimy sculpin spawn between late March and late May following ice break-up in freshwater streams and lakes. Males construct a nest, approximately 2 to 4 cm high, beneath the cover of rocks and logs. As a ripe female approaches the nest, courtship ensues, and milt and eggs are released into the nest (Morrow 1980). Males usually mate with two or three females, who deposit their eggs into the male's nest. Males attend the nest for approximately 30 days during incubation (Morrow 1980; Scott and Crossman 1973). One week after hatching, the young leave the nest and occupy habitats similar to those used by adult sculpin. Sexual maturity is normally reached at age 2, and slimy sculpin may live up to 7 years. Aside from movement into shallow spawning waters, migration seldom occurs with this species (Morrow 1980).

Sculpin in the Susitna River are sedentary with spawning, juvenile rearing and adult movements confined to a limited area (Schmidt et al. 1983). Limited periodicity data is available for sculpin species in the Susitna River. Late July catches of young-of-the-year suggests that spawning occurs between spring break-up and mid-June (Delaney et al. 1981b). The duration of incubation is thought to be about 30 days (Morrow 1980).

3.2. Distribution and Relative Abundance

The slimy sculpin is a freshwater species that resides in lakes and streams (Mecklenburg et al. 2002). As lake residents, they can be found from rocky near-shore shallows to depths up to 210 m, although depths ranging from 37 to 108 m appear to be most common (McPhail and Lindsey 1970; Mecklenburg et al. 2002). As stream residents, slimy sculpin prefer fast-flowing streams with rocky and gravelly bottoms (Mecklenburg et al. 2002; Scott and Crossman 1973). Slimy sculpin spawning habitat typically includes rocky lake shores and gravel-bottom streams with water depths of 2 to 30 cm. Spawning occurs when water temperatures are between 4.5°C and 10°C (McPhail and Lindsey 1970; Morrow 1980).

Sculpin are distributed throughout the mainstem Susitna River (ADF&G 1981, 1983). Sculpin were documented in the lower, middle, and upper Susitna River during the 1980s (AEA 2012). Below Devils Canyon, slimy sculpin were widely distributed and occurred at almost all study sites (Schmidt et al. 1983). Sculpin were documented in most locations sampled in the upper Susitna River, including abundant populations in the Oshetna River, Fog Creek and Tsusena Creek (Delaney et al. 1981a). Slimy sculpin were captured in minnow traps within all tributaries sampled in 1981 except Jay Creek (Delaney et al. 1981a). Sculpin were also collected in Sally Lake in the Upper Susitna River drainage (Delaney et al. 1981a).

Slimy sculpin almost exclusively eat insects (Morrow 1980). Aquatic insect larvae and nymphs (e.g., mayflies, caddisflies, dipterans, and odonates) are primary food items for fish of all sizes, although larger fish tend to consume larger prey items (Scott and Crossman 1973). Predation on crustaceans and small fish, and consumption of aquatic vegetation have also been reported for this species (Morrow 1980; Scott and Crossman 1973).

Sculpin were observed in all Designated Fish Habitat sites sampled in 1982 (Schmidt et al. 1983). Populations of slimy sculpin in the Upper Segment were widely distributed in almost all tributary streams sampled (Delaney et al. 1981b), however their abundance relative to Lower and Middle segment populations is uncertain. Upstream of Devils Canyon, slimy sculpin were most abundant in the Oshetna River, Fog Creek, and Tsusena Creek (Delaney et al. 1981a).

3.3. Rationale as Non-Target Species

- Sculpin in the Susitna River are sedentary with spawning, juvenile rearing and adult movements confined to a limited area (Schmidt et al. 1983). Thus, any connectivity afforded by passage facilities would be expected to provide little benefit for this species.
- While abundant and widely distributed, sculpin are not targeted for harvest and lack the added importance of harvested species with regard to fish passage considerations.

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INFORMATION ITEM 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 information item 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 warranted. 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 B3-12. Although details regarding the migratory characteristics of each target species are presented in Information Item 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 B3-12 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. 1981a;

Delaney et al. 1981b; 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. ARCTIC LAMPREY

- Susitna River Arctic lamprey populations include both anadromous and freshwater life histories, with approximately 30% following an anadromous life history based on analysis of length frequency (Schmidt et al. 1983). However, little is known about the periodicity of either life history in the Susitna River (Sundet and Wenger 1984). Thus, there was insufficient information to develop a periodicity table for Arctic lamprey.
- Arctic lamprey were captured in the Susitna River from the beginning of May through mid-October in 1982 (Schmidt et al. 1983).
- Arctic lamprey spawn during spring in streams with low-to moderate flow. Spawning was observed at the Birch Creek and Slough site during late June (Schmidt et al. 1983).
- Embryos develop into a larval stage, during which one to four years are spent burrowed into soft substrate. Recent studies with other lamprey species suggest that lamprey ammocoetes are generally widely dispersed from spawning areas downstream throughout the river where suitable habitat is found (Jolley et al. 2012).
- Ammocoetes undergo a metamorphosis in the fall and migrate as young adults to the sea, or to lakes and larger rivers.
- Downstream migrant traps in 1983 collected most Arctic lamprey between May and late June suggesting outmigration during this time (Sundet and Wenger 1984).
- After an undetermined period, adults migrate upstream to spawn (Delaney et al. 1981a).

4. BERING CISCO

- Bering cisco periodicity is shown in Table B3-2.

- The ecology of Bering cisco in Alaska is not well understood. Most Bering cisco in Alaska disperse to estuarine or marine habitats during winter, though some populations appear to reside entirely within freshwater (Morrow 1980).
- Adult Bering cisco were captured at fishwheel traps but were never captured during other summer or winter sampling in the Susitna River in 1982 (Schmidt et al. 1983). As a result, little is known regarding adult Bering periodicity.
- Upstream spawning migrations of Bering cisco in the Susitna River occurred from early August through October, though fishwheel operation ended October 1 in 1982 and earlier in other years, so the end of migration is not well defined (ADF&G 1983). Migration appeared to peak in late September during 1982 (ADF&G 1983). Spawning during 1982 and 1983 occurred during September and October, with peak activity in early October (ADF&G 1983, Barrett et al. 1984). No spawning was observed in the Middle Segment during 1981, 1982, or 1983 (ADF&G 1983, Barrett et al. 1984).
- Egg incubation and emergence timing is not well defined for Bering cisco populations. In general, egg incubation of other cisco (e.g., arctic cisco) occurs through the winter and early spring and fry hatch in the spring (Morrow 1980). Based on this general timing, Bering cisco egg incubation is estimated to occur from early September through June and fry emergence is presumed to occur in May and June. Soon after emergence, cisco fry migrate to the estuarine environment to rear (Morrow 1980). Juvenile fry migration from natal areas in the Lower Susitna is estimated to occur from mid-May through mid-July.
- In the Susitna River, most Bering cisco appear to migrate to estuarine or marine areas as age-0+ fry, but the duration of residence in saltwater habitats is not known (ADF&G 1983, Jennings 1985).

5. BURBOT

- Burbot periodicity is shown in Table B3-3.
- 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).

6. CHINOOK SALMON

- Chinook periodicity is shown in Table B3-4.
- 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 1983, 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). 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.

7. CHUM SALMON

- Chum salmon periodicity is shown in Table B3-5.
- In the Middle Susitna River, adult chum salmon migration during the 1980s studies typically began in mid- July and peaked during September in mainstem and tributary habitats (Jennings 1985, Thompson et al. 1986). The timing of entry into spawning tributaries by adult chum can be delayed for a week or more as fish hold near the mouth of the tributary, based on radio tag studies in the early 1980s (ADF&G 1981, ADF&G 1983).
- Spawn timing was observed to differ among side slough, tributary and mainstem habitats (Jennings 1985). The tributary spawning period was from early August through September and peaked in late August and early September (Barrett et al. 1985, Jennings 1985, Thompson et al. 1986). In side slough habitats, chum spawning occurred from early August through mid-October, with peak activity occurring during September (Barrett et al. 1985, Jennings 1985, Thompson et al. 1986). Mainstem spawning occurred from early September through early October, though most chum spawned during early September (Barrett et al. 1985, Jennings 1985, Thompson et al. 1986).

- Incubation of chum salmon eggs began at the start of spawning in each habitat type: early August in tributary and side sloughs, and early September in main channel areas (Barrett et al. 1985, Jennings 1985, Thompson et al. 1986). Egg incubation conditions among these habitats differ considerably, particularly in terms of water temperature, and such differences can affect egg development timing (Wangaard and Burger 1983, Vining et al. 1985). Intergravel water temperatures in tributary and main channel are strongly influenced by surface streamflow, which suggests that incubation temperatures are high during fall and near freezing during winter (Vining et al. 1985). In contrast, intergravel water temperatures in side slough habitats are typically higher relative to tributary and main channel areas during winter due to the influence of thermally stable groundwater upwelling (Vining et al. 1985). Timing of chum fry emergence in tributary and main channel areas is estimated to begin in early March, approximately two weeks later than the estimated start of emergence in side slough areas, based on evaluation of chum egg incubation and development in variable temperature regimes (Wangaard and Burger 1983, Vining et al. 1985). The duration of chum emergence periods among habitats are not well defined due to sampling difficulty during this time, however, based on the small size of juvenile chum captured at downstream traps in late May, it is assumed that emergence in tributary and main channel areas extends through mid-May (Bigler and Levesque 1985, Roth and Stratton 1985).
- Juvenile chum salmon emigrate from the natal habitats to marine areas as age-0+ smolts, though some may feed within nursery habitats for one to three months prior to or during migration (Morrow 1980, ADF&G 1983, Jennings 1985). Primary nursery habitats for age-0+ chum generally corresponded with areas highly utilized by adult chum spawners (i.e., tributary and side slough); areas with the highest juvenile density also supported the highest spawning density (Jennings 1985, Dugan et al. 1984). Tributary mouths and side channels were also occupied by juvenile chum, though their use was low relative to side slough and tributary areas (Schmidt et al. 1983). Downstream migration of juvenile chum began prior to the start of outmigrant trap seasonal operation in mid- and late May 1983 and 1985, and fyke trap data collected in the Lower River suggest an early May start of juvenile chum movement (Dugan et al. 1984, Roth et al. 1986). Based on these capture data, age-0+ chum movement in the Middle Segment is estimated to occur from early May through mid-August and peak during late May and June, though peak timing was variable during the 1980s and correlated with Susitna River discharge levels (Roth et al. 1984, Dugan et al. 1984, Roth et al. 1986). The vast majority (> 95 percent) of juvenile chum movement was completed by mid-July during 1980s studies (Jennings 1985, Roth et al. 1986).

8. COHO SALMON

- Coho salmon periodicity is shown in Table B3-6.
- Upstream spawning migration of adult coho salmon into the Middle River of the Susitna River typically began in late July and continued through early October based on studies conducted in during the 1980s, with peak movement during early and mid-August (Jennings 1985, Thompson et al. 1986). Adult coho primarily used main channel areas for migration to access tributary spawning sites (Jennings 1985). Timing of upstream

migration into spawning tributaries was delayed from main channel movement due to holding and milling behavior by adult coho in the lower extent of the Middle Segment or proximal to spawning tributaries (ADF&G 1981, ADF&G 1983). Based on observed milling and/or delay between date of radio tagging and tributary entry, the timing of tributary entry and upstream migration is estimated to occur from early August through early October, with peak movement in late August and early September.

- Adult coho salmon spawning occurred almost entirely within clear water tributaries, though occasional use of one main channel habitat has been observed in the Middle Segment (ADF&G 1984, Barrett et al. 1985, Merizon et al. 2010). Radio tracking studies conducted in 2009 indicated that approximately 1 percent of all tagged coho salmon (n = 275) spawned in mainstem (i.e., main channel, side channel and/or off-channel) habitats in the Middle Segment (Merizon et al. 2010). No spawning was observed by coho salmon in surveyed slough or tributary mouth habitats during 1980s studies (Barrett et al. 1985, Jennings 1985). Coho spawning during 1980s studies occurred from mid-August through early October and peaked during mid- and late September. The spawn period for coho salmon main channel spawning is assumed to be the same as tributary spawning due to sparse main channel spawning data. Primary spawning tributaries in the Middle Segment are Indian River (RM 138.6), Gash Creek (RM 111.6), Chase Creek (RM 106.4), and Whiskers Creek (RM 101.4) (Jennings 1985, Thompson et al. 1986).
- The timing and duration of coho egg incubation and fry emergency is not well defined in the Susitna River due to sparse winter data. The incubation period is considered to coincide with the start of spawning in mid-August and continue through fry emergence. Coho fry emergence began prior to the start of outmigrant trap seasonal operation in mid-May 1983 and 1985, though ice cover precluded trap operation prior to this point (Schmidt et al. 1983, Roth et al. 1986). Salmon egg incubation time depends on water temperature and the duration necessary for coho egg development from the point of fertilization to fry emergence can range from 228 days at water temperatures of 2° C to 139 days at 5° C (Murray and McPhail 1988, Quinn 2005). Based on these data and approximate timing of coho salmon emergence in similar areas, coho fry emergence in the Susitna River is estimated to begin in early March (Scott and Crossman 1973). The small size (35 mm) of age-0+ coho captured in June and July of 1981, 1982 and 1983 suggests that emergence may continue through May or beyond (Jennings 1985).
- Age 0+ coho salmon utilized natal tributaries for nursery habitats immediately following emergence, but many emigrated from tributaries soon after emergence to mainstem habitats between early May through October (Jennings 1985). Within the Susitna River mainstem, age-0+ coho primarily used clear upland sloughs and side sloughs relative to turbid areas affected by main channel streamflow (Schmidt and Bingham 1983, Dugan et al. 1984). Many age-0+ coho salmon moved downstream to the Lower River during the open water period based on outmigrant trap catch data (Roth et al. 1984). Downstream movement of age-0+ coho to the Lower River appeared to begin in early May, prior to outmigrant trap seasonal operation each year, and continued through October, with peak movement from late June to late August (Jennings 1985, Roth et al. 1986). Observed movement by age-0+ coho observed in September and October may have been a reflection of dispersal to suitable winter nursery habitats, which were primarily located in side sloughs and upland sloughs in the Middle Segment (Jennings 1985, Roth et al.

1986). Catch at the Flathorn Station (RM 22) outmigrant trap during fall suggested that some age-0+ coho may have immigrated to marine or estuarine areas (Roth and Stratton 1985).

- Ages-1+ and 2+ coho salmon primarily utilize clear water natal tributaries, side sloughs, and upland sloughs as nursery habitat in the Middle Segment (Dugan et al. 1984). Juvenile coho salmon that remain in the Susitna Basin as age-1+ parr, typically disperse from natal tributaries and mainstem nursery habitats within the Middle Segment to Lower River habitats, as few age- 2+ coho were captured within the Middle Segment during the 1980s (Stratton 1986). Coho parr that remain within the Middle Segment during winter utilize tributaries, side sloughs and upland sloughs as nursery habitats (Delaney et al. 1981a, Stratton 1986). During winter and early spring, juvenile coho parr disperse from nursery habitats, though the timing and pattern of this movement is not well understood. Limited data collected during winter 1984-1985 suggested that juvenile coho parr exhibit similar movements as juvenile Chinook salmon, in that downstream migration from tributaries, and possibly mainstem nursery habitats, begins between early November and February (Stratton 1986). Downstream movement of age-1+ coho from the Middle Segment occurs throughout the open water season, with peak activity between late May and early July (Schmidt et al. 1983, Roth et al. 1984, Roth et al. 1986). Age 2+ emigration from the Middle Segment habitats begins in early winter and continues through June, with peak migration in late May and early June (Schmidt et al. 1983, Roth et al. 1984, Roth et al. 1986).

9. DOLLY VARDEN

- Dolly Varden periodicity is shown in Table B3-7.
- 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. 1981a).
- 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. 1981a, 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. 1981a, 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. 1981a, Schmidt et al. 1983, Suchanek et al. 1984). 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. 1981a, 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).

10. HUMPBACK WHITEFISH

- Humpback whitefish periodicity is shown in Table B3-8.
- 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).

11. LONGNOSE SUCKER

- Longnose sucker periodicity is shown in Table B3-9.
- 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. 1984).

12. RAINBOW TROUT / STEELHEAD

- Rainbow trout periodicity is shown in Table B3-10.
- Rainbow trout in the Susitna River are distributed throughout tributary and mainstem areas downstream of Devils Canyon (RM 150) (Schmidt et al. 1983). Comparison of 1982 capture data indicated that adult rainbow trout are more abundant in the Middle Segment of the Susitna River relative to the Lower River (Schmidt et al. 1983). Estimated abundance of rainbow trout greater than 150 mm in length during the early 1980s in the Middle Segment was approximately 4,000 fish based on a tag-recapture study conducted during 1981–1983 (Sundet and Wenger 1984). The age range of rainbow trout captured during the 1980s was up to 9 years old and all captured fish that were known to spawn were 5 years old or older (Sundet and Wenger 1984).
- Adult rainbow trout in the Susitna Basin utilize clear, non-glacial tributary habitats to spawn (Schmidt et al. 1983). Adult spawning migrations from main channel holding areas to spawning tributaries began in March prior to ice breakup and continued through early June (Schmidt et al. 1983, Suchanek et al. 1984, Sundet 1986). Most rainbow trout spawning occurred during late May and early June (Schmidt et al. 1983, Suchanek et al. 1984, Sundet and Pechek 1985). Migration and spawn timing for rainbow trout appears to be generally similar between Middle and Lower Susitna Segments, though it was noted that timing of upstream migration into tributary habitats could occur as much as 10 days earlier in the Lower River (Sundet and Pechek 1985). Primary spawning tributaries in the 1980s were 4th of July Creek (RM 131.1) and Portage Creek (RM 148.9) in the Middle Segment and the Talkeetna River (RM 97.2), Montana Creek (RM 77.0) and Kashwitna River (RM 61.0) in the Lower River (Sundet and Pechek 1985).
- After spawning, adults primarily hold and feed during the open water period in tributary and tributary mouth habitats, though some utilization of clear side slough habitat was observed during the 1980s (Schmidt et al. 1983). Holding and feeding areas during the open water period were closely associated with salmon spawning areas (Chinook, chum and pink salmon) (Sundet and Pechek 1985). Primary holding and feeding locations for rainbow trout were 4th of July Creek (RM 131.1) and Indian River (RM 138.6) tributary mouths and Slough 8A (RM 125.1) and Whiskers Creek Slough (RM 101.2) (Schmidt et al. 1983).
- During late summer in 1983 and 1984, adult rainbow trout migrated from tributary habitats during late August and September, such that many individuals had moved to tributary mouths by mid-September and few remained in tributaries by early October (Suchanek et al. 1984, Sundet and Wenger 1984, Sundet and Pechek 1985). Migration timing to winter holding areas in main channel and side channel areas occurred from mid-September through early February, with peak movement in October and late December (Schmidt and Estes 1983, Sundet 1986). In the Middle Segment, rainbow trout utilize main channel areas during winter, whereas tagged fish in the Lower River were observed to typically use side channel habitat during the 1980s (Sundet and Pechek 1985). By December, most adult rainbow trout were in main channel areas apart from spawning tributaries (Sundet and Wenger 1984). Movements to winter holding habitats were commonly in a downstream direction from spawning or feeding tributaries (Sundet and Pechek 1985). Many adults hold during winter close to spawning tributaries (0.1 – 4

miles), though some exhibit long-distance migrations that typically range from 10-20 miles downstream but can extend over 76 miles (Schmidt and Estes 1983, Sundet 1986). Specific habitat features of winter holding areas during the 1980s were difficult to measure, though upwelling and ice cover appeared to be common features (Schmidt et al. 1983, Sundet and Pechek 1985). Tagged rainbow trout distribution in winter was patchy and groups of fish were often observed within 100 feet of an open water lead during winter, suggesting that ice cover was important in addition to the presence of upwelling (Sundet and Pechek 1985, Sundet 1986). No radio tagged fish were observed in areas with anchor ice during radio telemetry studies in the 1980s (Sundet 1986).

- There is minimal information relating to rainbow trout incubation and emergence timing in the Susitna River from studies conducted in the 1980s; however, incubation is assumed to begin in May based on observed spawn timing (Schmidt et al. 1983, Suchanek et al. 1984, Sundet and Pechek 1985). The start of rainbow trout fry emergence in tributary habitats is estimated to occur in early July and continue through mid-August based on generalized incubation times for rainbow trout in cold water temperature regimes (5-8° C) (Crisp 1988, Quinn 2005).
- Juvenile rainbow trout primarily reside in natal tributary habitats throughout the year, though occasional use of tributary mouths and clear sloughs has been documented (Schmidt et al. 1983). Capture of juvenile rainbow trout in main channel areas was very low, though use of tributary mouths and clear sloughs was observed (Sundet and Pechek 1985). Lake systems associated with the 4th of July and Portage creeks were believed to possibly supplement rainbow trout production in each basin based on analysis of juvenile scale patterns, though no direct evidence of juvenile rearing in these lakes was recorded (Sundet and Pechek 1985). Winter rearing for juvenile rainbow trout occurred primarily in tributaries with occasional use of clear side slough habitats (Schmidt et al. 1983).

13. ROUND WHITEFISH

- Round whitefish periodicity is shown in Table B3-11.
- 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. 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).

14. SOCKEYE SALMON

- Sockeye salmon periodicity is shown in Table B3-12.
- Adult sockeye salmon in the Middle Segment, which are comprised of second run stock, typically began upstream migration during the 1980s in early July with peak movement during late July and early August (Jennings 1985, Thompson et al. 1986). Minimal

holding or milling behavior was observed by adult sockeye salmon, so observed main channel migration timing at Curry (RM 120) and Talkeetna (RM 103) stations is likely similar to upstream movements into side slough spawning sites (ADF&G 1983). Adult sockeye in the Middle Segment utilize main channel and side channel areas to access primary spawning areas in side sloughs (Jennings 1985).

- Nearly all sockeye spawning in the Middle Segment occurred within side sloughs, though active spawning in the mainstem and occasional use of tributaries was observed (Jennings 1985, Thompson et al. 1986). Sockeye salmon spawning in side sloughs occurred from early August through early October and peaked during the month of September (Jennings 1985, Thompson et al. 1986). Mainstem spawning in 1983 and 1984 was observed during mid- and late September, while the few observations of adult sockeye spawning in tributaries occurred in early September (Barrett et al. 1984, Barrett et al. 1985). Primary spawning sloughs in the Middle Segment during the 1980s were Slough 21 (RM 141.1), Slough 11 (RM 135.3), and Slough 8A (RM 125.1) (Jennings 1985).
- Sockeye egg incubation in the Middle Segment is initiated at the start of spawning in early August and is estimated to continue through May based on observations of sockeye egg development during winter 1982 (Schmidt and Estes 1983, Jennings 1985, Roth and Stratton 1985). Emergence timing for sockeye in side slough habitats is estimated to occur from late March through May, though timing is likely variable among sites due to differences in intergravel incubation conditions (e.g., water temperature and dissolved oxygen levels) (Schmidt and Estes 1983, Wangaard and Burger 1983, Jennings 1985). The duration of incubation at two Middle Segment sites, Slough 11 (RM 135.3) and Slough 21 (RM 141.1), was approximately 130-140 days and sockeye fry emergence was either initiated or completed at these two sites by late April (Schmidt and Estes 1983). The wide size range of juvenile sockeye salmon fry captured at outmigrant traps and Lower River sampling sites may indicate that emergence continues over a long period (Roth and Stratton 1985).
- Age-0+ juvenile sockeye salmon in the Middle Segment primarily utilize natal side sloughs and upland sloughs for nursery habitat (Schmidt et al. 1983, Dugan et al. 1984). Juvenile sockeye capture data following breaching events in side sloughs in 1983 suggested that age-0+ sockeye dispersed from breached side sloughs and redistributed to upland slough areas during late summer (Dugan et al. 1984). Use of main channel, side channel, tributary and tributary mouth habitats by juvenile sockeye in the Middle Segment was low during 1980s studies (Dugan et al. 1984). Juvenile sockeye use of main channel and side channel areas was highest in backwatered areas with low water velocity (Dugan et al. 1984). Most age-0+ sockeye from the Middle Segment disperse downstream during the open water season to either reside in Lower River nursery habitats for the winter or emigrate to marine areas as age-0+ smolts (Roth and Stratton 1985, Suchanek et al. 1985, Roth et al. 1986). Dispersal of age-0+ sockeye from natal habitats was typically underway prior to the start of mainstem outmigrant trapping at Talkeetna Station (RM 13), but likely began in early May, peaked in late June and July and declined in September (Roth and Stratton 1985, Roth et al. 1986). High juvenile sockeye use was observed in Side Slough 11 (RM 135.3) and upland Slough 6A (RM 112.3) during summer 1983 (Dugan et al. 1984).

- Age-1+ sockeye salmon typically began emigration from the Middle Segment prior to mainstem outmigrant trap seasonal operation during the 1980s studies, but fyke net traps operated in Lower River side channels suggest that downstream movement may have begun in early April (Bigler and Levesque 1985). Age-1+ migration peaked during late May and early June and was completed by early or late July among sampling years in the 1980s (Schmidt et al. 1983, Roth et al. 1984, Roth and Stratton 1985). Based on the low number of age-1+ sockeye captured at outmigrant traps, it was hypothesized that most juvenile sockeye salmon from the Middle Segment dispersed to the Lower River prior to winter (Roth et al. 1984, Roth and Stratton 1985).

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16. TABLES

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

Life Stage[1]	Habitat Type[2]						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																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

Table B3-2. Periodicity of Bering cisco utilization among macro-habitat types in the Susitna River by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

	Habitat Type[2]																	
Life Stage[1]	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[3]																		
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Juvenile Migration[4]																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

3 Adult Bering Cisco holding and feeding habitat use in the Susitna River is not known; it is possible these fish reside in marine areas until spawning.

4 Juvenile rearing is not represented here because Bering cisco fry migrate to marine nursery habitats soon after hatching.

Table B3-3. Periodicity of burbot utilization among macro-habitat types in the Susitna River by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

	Habitat Type[2]																	
Life Stage[1]	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																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

Table B3-4. 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. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

Life Stage[1]	Habitat Type[2]						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary												
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Age 0+ Rearing																		
Age 0+ Migration[3]																		
Age 1+ Rearing																		
Age 1+ Migration																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

3 Age 0+ migration reflects movement out of a given macro-habitat type. Roth and Stratton (1985) suggest that, upon emergence, most Chinook salmon fry either rear in natal tributaries through winter, rear in natal tributaries for part of the first summer before rearing and overwintering in mainstem habitats, or migrate to the lower Susitna River as fry; some may also migrate to the ocean as Age 0+, but these comprise only a small component of adult returns. While Age 0+ may move between the macro-habitat types listed above (e.g., from tributaries to mainstem habitats), the destination of such movements are not necessarily reflected by this utilization periodicity.

Table B3-5. Periodicity of chum salmon utilization among macro-habitat types in the Middle River (RM 184 – 98.5) by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

Life Stage[1]	Habitat Type[2]						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Tributary												
Adult Migration																		
Spawning																		
Incubation																		
Fry Emergence																		
Age 0+ Rearing																		
Age 0+ Migration																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

Table B3-6. Periodicity of coho salmon utilization among macro-habitat types in the Middle River (RM 184 – 98.5) by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

	Habitat Type[2]																	
Life Stage[1]	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																		
Age 2+ Rearing																		
Age 2+ Migration																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

Table B3-7. Periodicity of Dolly Varden in the Susitna River by life history stage and habitat type. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

Life Stage[1]	Habitat Type[2]						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 (a)	Light	Light	Dark	Light		Dark						Light	Light	Light	Light	Light		
Adult Holding (b)	Dark	Dark					Light	Light	Light	Light	Light	Light			Light	Light	Light	Light
Adult Migration (a)			Dark			Dark						Light	Light		Light	Light		
Adult Migration (b)	Dark	Dark									Light (2nd half)	Light			Light (2nd half)	Light	Light (1st half)	
Spawning						Dark									Light (2nd half)	Dark		
Incubation						Dark	Light	Light	Light	Light	Light				Light (2nd half)	Light	Light	Light
Fry Emergence						Dark				Light	Light							
Juvenile Rearing						Dark	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

Table B3-8. Periodicity of humpback whitefish utilization among macro-habitat types in the Susitna River by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

	Habitat Type[2]																		
Life Stage[1]	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[3]																		

Notes:

1. Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.
2. Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.
3. A portion of juvenile humpback whitefish may utilize estuarine habitats to rear during the first two years of life.

Table B3-9. Periodicity of longnose sucker in the Susitna River by life history stage and habitat type. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

Life Stage[1]	Habitat Type[2]						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[1]																		
Incubation																		
Fry Emergence																		
Juvenile Migration																		
Juvenile Rearing																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

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

Table B3-10. Periodicity of rainbow trout utilization among macro-habitat types in the Susitna River by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

Life Stage[1]	Habitat Type[2]						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																		

Notes:

1. Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.
2. Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

Table B3-11. Periodicity of round whitefish utilization among macro-habitat types in the Susitna River by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

Life Stage[1]	Habitat Type[2]						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																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

Table B3-12. Periodicity of sockeye salmon utilization among macro-habitat types in the Middle River (RM 184 – 98.5) by life history stage. Areas shaded light gray indicate timing of utilization by macro-habitat type and dark gray shading represents areas and timing of peak use.

Life Stage[1]	Habitat Type[2]																	
	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																		

Notes:

1 Life stages are separated into two rows if available information suggested different utilization periodicities for certain macro-habitat types. For life stages presented in a single row, available information did not warrant differentiating utilization periodicity by macro-habitat type.

2 Peak utilization of certain macro-habitat types is based on relative numbers of captures or observations described by studies conducted during the 1980s.

INFORMATION ITEM 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 Information Item B3 in terms by life stage. The following information item 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

- 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. 1981a, Delaney et al. 1981b, 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. ARCTIC LAMPREY

- Because Arctic lamprey have not been identified in the Upper River, the following information is based on lower sections of the Susitna River as well as general species information.

3.1. Adult Movements

- Relatively little information regarding the life history of Arctic lamprey is available. Arctic lamprey spawn during spring in streams with low to moderate flow and were observed at the Birch Creek and Slough site during late June (Schmidt et al. 1983). Prior to spawning, anadromous adults would presumably exhibit upstream migrations. No data were available on the spawning migrations of adults exhibiting freshwater life histories in the Susitna River.

3.2. Juvenile Movements

- Ammocoetes undergo a metamorphosis in the fall, or from August to November and migrate as young adults to the sea, or to lakes and larger rivers, depending upon their degree of anadromy (Scott and Crossman 1973). Downstream migrant trapping during 1983 study efforts collected most Arctic lamprey between May and late June, although the size/lifestage of these captures were not reported (Sundet and Wenger 1984).

4. BERING CISCO

- Because Bering cisco have not been identified in the Upper River, the following information is based on cisco in the lower Susitna River as well as general species information.

4.1. Adult Movements

- Bering cisco in the Susitna River are anadromous (Delaney et al. 1981a). Based on fishwheel catches in 1982, the Bering cisco migration into the Susitna river drainage was limited to the mainstem Susitna river reach below Talkeetna (RM 97) (Barrett et al. 1983). Peak spawning occurred in the second week of October, with adults occupying spawning sites for 15 – 20 days (Delaney et al. 1981a). As an anadromous species, Bering cisco used the mainstem as a migratory channel from Cook Inlet to their respective spawning areas (FERC 1984). Based on fishwheel catch in 1982, Bering cisco appeared to utilize the mainstem channels for passage, apparently not utilizing the sloughs or tributaries upstream of the confluence zones (Barrett et al. 1983). After spawning, Bering cisco adults migrate downstream to the sea (Delaney 1981a) but may also overwinter in freshwater as described by Morrow (1980).

4.2. Juvenile Movements

- In the Susitna River, most Bering cisco appear to migrate to estuarine or marine areas as age-0+ fry, but the duration of residence in saltwater habitats is not known (ADF&G 1983, Jennings 1985). Morrow (1980) reported that after emerging from mid-May to mid-July, cisco fry emigrated to the estuarine environment to rear.

5. BURBOT

5.1. 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).

5.2. Juvenile Movements

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

6. CHINOOK SALMON

6.1. 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.

6.2. 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 1983, 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.

7. CHUM SALMON

- Because chum salmon have not been identified in the Upper River, the information provided below is based on observations from the Middle River.

7.1. Adult Movements

- Adult chum salmon migration in the Middle River typically began in mid- July during 1980s studies, peaking during September in mainstem and tributary habitats (Jennings 1985, Thompson et al. 1986). Timing of entry into spawning tributaries by adult chum can be delayed for a week or more as fish hold near the mouth of the tributary, based on radio tag studies in the early 1980s (ADF&G 1981, ADF&G 1983). Chum salmon utilize a range of mainstem and tributary habitat to access Middle River spawning areas located in tributary, side slough, side channel and main channel habitats (Jennings 1985).
- Adult chum salmon primarily spawned in tributary and side slough habitats during the 1980s, though some spawning occurred in mainstem habitats (Jennings 1985, Thompson et al. 1986). Less than 10 percent of observed chum spawning during 1981-1984 occurred in mainstem habitats in the Middle River (Jennings 1985).
- Spawn timing was observed to differ among side slough, tributary and mainstem habitats (Jennings 1985). The tributary spawning period was from early August through September and peaked in late August and early September (Barrett et al. 1985, Jennings 1985, Thompson et al. 1986). In side slough habitats, chum spawning occurred from early August through mid-October, with peak activity occurring during September

(Barrett et al. 1985, Jennings 1985, Thompson et al. 1986). Mainstem spawning occurred from early September through early October, though most chum spawned during early September (Barrett et al. 1985, Jennings 1985, Thompson et al. 1986). Portage Creek (RM 148.9), Indian River (RM 138.6) and 4th of July Creek (RM 131.1) were the primary chum spawning tributaries during the 1980s, while sloughs 21 (RM 141.1), 11 (RM 135.3), and 8A (RM 125.1) were principal side sloughs used for spawning (Jennings 1985).

7.2. Juvenile Movements

- Juvenile chum salmon emigrate from natal habitats to marine areas as age-0+ smolts, though some may feed within nursery habitats for one to three months prior to or during migration (Morrow 1980, ADF&G 1983, Jennings 1985). Primary nursery habitats for age-0+ chum generally corresponded with areas highly utilized by adult chum spawners (i.e., tributary and side slough); areas with the highest juvenile density also supported the highest spawning density (Jennings 1985, Dugan et al. 1984). Tributary mouths and side channels were also occupied by juvenile chum, though their use was low relative to side slough and tributary areas (Schmidt et al. 1983).
- Downstream migration of juvenile chum began prior to the start of outmigrant trap seasonal operation in mid- and late May 1983 and 1985, and fyke trap data collected in the Lower River suggest an early May start of juvenile chum movement (Dugan et al. 1984, Roth et al. 1986). Based on these capture data, age-0+ chum movement in the Middle River is estimated to occur from early May through mid-August and peak during late May and June, though peak timing was variable during the 1980s and correlated with Susitna River discharge levels (Roth et al. 1984, Dugan et al. 1984, Roth et al. 1986). The vast majority (> 95 percent) of juvenile chum movement was completed by mid-July during 1980s studies (Jennings 1985, Roth et al. 1986).

8. COHO SALMON

- Because coho salmon have not been identified in the Upper River, the information provided below is based on observations from the Middle River.

8.1. Adult Movements

- Upstream spawning migration of adult coho salmon into the Middle River of the Susitna River typically began in late July and continued through early October based on studies conducted in during the 1980s, with peak movement during early and mid-August (Jennings 1985, Thompson et al. 1986).
- Adult coho primarily used main channel areas for migration to access tributary spawning sites (Jennings 1985). Timing of upstream migration into spawning tributaries was delayed from main channel movement due to holding and milling behavior in the lower extent of the Middle River or proximal to spawning tributaries (ADF&G 1981, ADF&G 1983).

- Based on observed milling and/or delay between date of radio tagging and tributary entry, the timing of tributary entry and upstream migration is estimated to occur from early August through early October, with peak movement in late August and early September.

8.2. Juvenile Movements

- Age 0+ coho salmon utilized natal tributaries for nursery habitats immediately following emergence, but many emigrated from tributaries soon after emergence to mainstem habitats between early May through October (Jennings 1985).
- Within the Susitna River mainstem, age-0+ coho primarily used clear upland sloughs and side sloughs relative to turbid areas affected by main channel streamflow (Schmidt and Bingham 1983, Dugan et al. 1984). Many age-0+ coho salmon moved downstream to the Lower River during the open water period based on outmigrant trap catch data (Roth et al. 1984). Downstream movement of age-0+ coho to the Lower River appeared to begin in early May, prior to outmigrant trap seasonal operation each year, and continued through October, with peak movement from late June to late August (Jennings 1985, Roth et al. 1986).
- Observed movement by age-0+ coho observed in September and October may have been a reflection of dispersal to suitable winter nursery habitats, which were primarily located in side sloughs and upland sloughs in the Middle River (Jennings 1985, Roth et al. 1986). Catch at the Flathorn Station (RM 22) outmigrant trap during fall suggested that some age-0+ coho may have immigrated to marine or estuarine areas (Roth and Stratton 1985).
- Ages-1+ and 2+ coho salmon primarily utilize clear water natal tributaries, side sloughs, and upland sloughs as nursery habitat in the Middle River (Dugan et al. 1984). Juvenile coho salmon that remain in the Susitna Basin as age-1+ parr, typically disperse from natal tributaries and mainstem nursery habitats within the Middle River to Lower River habitats, as few age- 2+ coho were captured within the Middle River during the 1980s (Stratton 1986). Coho parr that remain within the Middle River during winter utilize tributaries, side sloughs and upland sloughs as nursery habitats (Delaney et al. 1981a, Stratton 1986). During winter and early spring, juvenile coho parr disperse from nursery habitats, though the timing and pattern of this movement is not well understood.
- Limited data collected during winter 1984-1985 suggested that juvenile coho parr exhibit similar movements as juvenile Chinook salmon, in that downstream migration from tributaries, and possibly mainstem nursery habitats, begins between early November and February (Stratton 1986). Downstream movement of age-1+ coho from the Middle River occurs throughout the open water season, with peak activity between late May and early July (Schmidt et al. 1983, Roth et al. 1984, Roth et al. 1986). Age 2+ emigration from the Middle River habitats begins in early winter and continues through June, with peak migration in late May and early June (Schmidt et al. 1983, Roth et al. 1984, Roth et al. 1986).

9. DOLLY VARDEN

9.1. 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).

9.2. 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. 1984). 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).

10. HUMPBACK WHITEFISH

10.1. 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).

10.2. 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).

11. LONGNOSE SUCKER

11.1. 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).

11.2. 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).

12. RAINBOW TROUT / STEELHEAD

- Rainbow trout have not been identified in the Upper River and steelhead were not distinguished from rainbow trout during the 1980s studies; presumably, anadromy is not a common life history type for this species in the Susitna River. Therefore, the information provided below is based on observations of rainbow trout from the Middle River.

12.1. Adult Movements

- Adult spawning migrations from main channel holding areas to spawning tributaries began in March prior to ice breakup and continued through early June (Schmidt et al. 1983, Suchanek et al. 1984, Sundet 1986). Most rainbow trout spawning occurred during late May and early June (Schmidt et al. 1983, Suchanek et al. 1984, Sundet and Pechek 1985). Migration and spawn timing for rainbow trout appears to be generally similar between Middle and Lower Susitna Segments, though it was noted that timing of upstream migration into tributary habitats could occur as much as 10 days earlier in the Lower River (Sundet and Pechek 1985). Primary spawning tributaries in the 1980s were 4th of July Creek (RM 131.1) and Portage Creek (RM 148.9) in the Middle River and the Talkeetna River (RM 97.2), Montana Creek (RM 77.0) and Kashwitna River (RM 61.0) in the Lower River (Sundet and Pechek 1985).
- During late summer in 1983 and 1984, adult rainbow trout migrated from tributary habitats during late August and September, such that many individuals had moved to tributary mouths by mid-September and few remained in tributaries by early October (Suchanek et al. 1984, Sundet and Wenger 1984, Sundet and Pechek 1985).
- Migration timing to winter holding areas in main channel and side channel areas occurred from mid-September through early February, with peak movement in October and late December (Schmidt and Estes 1983, Sundet 1986). In the Middle River, rainbow trout utilize main channel areas during winter, whereas tagged fish in the Lower River were observed to typically use side channel habitat during the 1980s (Sundet and Pechek 1985). By December, most adult rainbow trout were in main channel areas apart from spawning tributaries (Sundet and Wenger 1984). Movements to winter holding habitats were commonly in a downstream direction from spawning or feeding tributaries (Sundet and Pechek 1985). Many adults hold during winter close to spawning tributaries (0.1 – 4

miles), though some exhibit long-distance migrations that typically range from 10-20 miles downstream but can extend over 76 miles (Schmidt and Estes 1983, Sundet 1986).

12.2. Juvenile Movements

- Juvenile rainbow trout primarily reside in natal tributary habitats throughout the year (Schmidt et al. 1983) and no data on movements outside of tributaries was available. Low capture rates of juvenile rainbow trout in the main-channel was very low and limited to tributary mouths and clear water slough habitats (Sundet and Pechek 1985).
- Lake systems associated with the 4th of July and Portage creeks were believed to supplement rainbow trout production in these basins based on analysis of juvenile scale patterns, though no direct evidence of juvenile rearing in these lakes or movement into or out of lakes was documented (Sundet and Pechek 1985).

13. ROUND WHITEFISH

13.1. 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).

13.2. 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).

14. SOCKEYE SALMON

- Because sockeye salmon have not been identified in the Upper River, the information provided below is based on observations from the Middle River.

14.1. Adult Movements

- Adult sockeye salmon in the Middle River, which are comprised of second run stock, typically began upstream migration during the 1980s in early July with peak movement during late July and early August (Jennings 1985, Thompson et al. 1986). Minimal holding or milling behavior was observed by adult sockeye salmon, so observed main channel migration timing at Curry (RM 120) and Talkeetna (RM 103) stations is likely similar to upstream movements into side slough spawning sites (ADF&G 1983). Adult sockeye in the Middle River utilize main channel and side channel areas to access primary spawning areas in side sloughs (Jennings 1985).

14.2. Juvenile Movements

- Age-0+ juvenile sockeye salmon in the Middle River primarily utilize natal side sloughs and upland sloughs for nursery habitat (Schmidt et al. 1983, Dugan et al. 1984). Following breaching events in side sloughs, capture data suggested that age-0+ sockeye dispersed from breached side sloughs and redistributed to upland slough areas during late summer (Dugan et al. 1984). Most age-0+ sockeye from the Middle River disperse downstream during the open water season to either reside in Lower River nursery habitats for the winter or emigrate to marine areas as age-0+ smolts (Roth and Stratton 1985, Suchanek et al. 1985, Roth et al. 1986). Dispersal of age-0+ sockeye from natal habitats was typically underway prior to the start of mainstem outmigrant trapping at Talkeetna Station (RM 13), but likely began in early May, peaked in late June and July and declined in September (Roth and Stratton 1985, Roth et al. 1986
- Age-1+ sockeye salmon typically began emigration from the Middle River prior to mainstem outmigrant trap seasonal operation during the 1980s studies, but fyke net traps operated in Lower River side channels suggest that downstream movement may have begun in early April (Bigler and Levesque 1985). Age-1+ migration peaked during late May and early June and was completed by early or late July among sampling years in the 1980s (Schmidt et al. 1983, Roth et al. 1984, Roth and Stratton 1985). Based on the low number of age-1+ sockeye captured at outmigrant traps, it was hypothesized that most juvenile sockeye salmon from the Middle River dispersed to the Lower River prior to winter (Roth et al. 1984, Roth and Stratton 1985).

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INFORMATION ITEM B5. NUMBER AND SIZE OF TARGET FISH SPECIES

1. INTRODUCTION

This information item provides information on the number and size of target fish species that could potentially use passage facilities at Watana Dam. Target species identified in Information Item B1 include Arctic grayling, burbot, Chinook salmon, Dolly Varden, humpback whitefish, longnose sucker, and round whitefish. Of these seven target species only Chinook salmon are considered to have an obligate anadromous life history. Humpback whitefish are usually, but not always considered anadromous (Morrow, 1980) and Dolly Varden are considered to have a facultative anadromous life history pattern, but primarily exhibit a resident life history in the Middle Susitna River (Jennings 1985). Schmidt et al. (1983) suggested anadromous Dolly Varden may be present in the Susitna River, but no empirical evidence is available to confirm this life history pattern.

Additional species that have not been documented in the Upper River but inhabit the Middle River were identified for inclusion as target species during the April, 2013 Fish Passage TWG Workshop. These include Arctic lamprey, Bering cisco, three additional salmon species (chum, coho, and sockeye salmon), and rainbow trout/steelhead. While Bering cisco can exhibit anadromous or freshwater life histories across their range, the Lower Susitna River population is thought to be anadromous (Delaney et al. 1981a). Susitna River Arctic lamprey populations include both anadromous and freshwater life histories (Schmidt et al. 1983). The aforementioned salmon species exhibit an anadromous life history in the Susitna River. Steelhead were not distinguished from rainbow trout during the 1980s studies and anadromy is presumably not a life history type expressed by this species in the Susitna River.

For species that have not been identified in the Upper River, there is increased uncertainty regarding the number and size of fish that could use passage facilities at Watana Dam. Relative abundance and size information from the Middle or Lower River are the only data available and are presented below. Barrick et al. (1983) also developed estimates of production potential in the Upper Susitna River basin for the four salmon target species. These potential production values are included below and represent upper estimates of the number of upstream adult and downstream juvenile salmon migrants that could potentially use passage facilities.[1] These production values were primarily derived based on estimated habitat area and production rates from out-of-basin literature sources. Estimates of adult production potential incorporated marine mortality rates but presumably did not account for any freshwater adult mortality that could occur between the marine environment and the Upper River.

In addition to the information described above, information related to fish relative abundance upstream and downstream of the Project, including tributaries, has been added to current

[1] The production potential estimates presented by Barrick et al. (1983) focused on the area upstream of Devils Canyon and, as such, included areas downstream of the currently proposed Watana Dam site. To the extent possible, water bodies located below the Watana Dam site (e.g., Tsusena and Fog creeks) were subtracted from the overall production potential totals to more accurately reflect production potential upstream of the dam site. The location of some water bodies (e.g., Sandy Creek) named by Barrick et al. (1983) could not be identified on topographic maps or GIS layers. Production potential values for these water bodies were included in the totals presented below based on the assumption that they were more likely to fall within the larger drainage area upstream of the Watana Dam site and because they were generally not major contributors to the overall production potential totals.

iteration of this information item. This information had been initially provided in Information Item B7 "Fish Relative Abundance". However, discussions during the April, 2013 Fish Passage TWG Workshop concluded that Information Item B7 should be merged with Information Item B5 to consolidate relevant information.

2. ARCTIC GRAYLING

2.1. Relative Abundance / Potential Use of Passage Facilities

- Arctic grayling appear to be the most abundant fish species in the Upper River, particularly in tributaries (Table B5-1).
  - Total estimated population size for tributaries surveyed during 1981 was 10,279 Arctic grayling.
  - Total estimated population size for tributaries surveyed during 1982 was 16,346 Arctic grayling.
- Arctic grayling are relatively common in the Middle Susitna River, particularly at tributary mouths (Figure B5-1).
- 6,027 Arctic grayling were tagged during 1981/1982 in tributaries upstream of the three impediments and there were 953 recaptures (15.8%).
  - 871 (91.4%) of recaptures were in the tributary where tagged.
  - 82 (8.6%) of the recaptures were in a tributary or slough upstream or downstream of the tributary where tagged.
    - 61 (6.4%) moved to a tributary or slough downstream.
    - 21 (2.2%) moved to a tributary or slough upstream.
    - 19 of 5593 (0.3%) tagged upstream of Watana Dam site moved to downstream of Watana Dam Site; farthest movement was Jay Creek to Fog Creek.
    - 7 of 434 (1.6%) tagged downstream of Watana Dam site (one from Fog Creek, 6 from Tsusena Creek) moved to upstream of Watana Dam site; farthest movement was from Fog Creek to Oshetna River.
- One fish tagged in Jay Creek during 1981 was recaptured during 1982 by an angler 75 miles upstream in Salt Creek, which drains to Tyone Lake.
- While Arctic grayling are relatively abundant and have been documented to exhibit extensive movements, the number that might utilize passage facilities is unknown.

2.2. Fish Size

- Arctic grayling live up to 10 years of age in the Susitna River; Age 5 represented about 31 percent of the sample population collected by angling during 1982.
- The maximum size of sampled fish upstream of Devils Canyon during 1982 was 420 mm.

- Length at age from 1981 and 1982 is depicted in Figure B5-2.
- Length frequency of Arctic grayling collected during 2012 is depicted in Figure B5-3.
- No weight information is available from the Susitna River.

3. ARCTIC LAMPREY

3.1. Relative Abundance / Potential Use of Passage Facilities

- Arctic lamprey are not known to be present upstream of Devils Canyon. The species has been documented up to Gash Creek at RM 111.5. Although abundance is relatively low over most of the river, Schmidt et al. (1983) suggested Arctic lamprey were abundant at tributary mouths downstream of RM 50.5.
- Surveys during 1982 captured 62 Arctic lamprey.
  - Sampling at Designated Fish Habitat (DFH) Sites documented 31 at Birch Creek and Slough (RM 98.6), 3 at Whiskers Creek and Slough (RM 101.2), and 1 at Sunshine Creek and Side Channel (RM 85.7)
  - Sampling at Selected Fish Habitat (SFH) Sites documented 7 Arctic lamprey downstream of RM 58.0.
  - Downstream Migrant traps collected 18 Arctic Lamprey.
- 40 Arctic lamprey were captured in the lower river during 1981.
- The number of Arctic lamprey that might utilize passage facilities is uncertain, but likely to be relatively few, if any under their current distribution.

3.2. Fish Size

- During 1981, captured Arctic lamprey ranged in size from 115 to 315 mm.
- During 1982, captured Arctic lamprey ranged in size from 84 to 290 mm.

4. BERING CISCO

4.1. Relative Abundance / Potential Use of Passage Facilities

- Bering cisco are not known to be present upstream of Devils Canyon. Surveys during the 1980s suggested their distribution was primarily below the Chulitna River confluence (RM 98.6). A single Bering cisco was observed upstream of the Chulitna River confluence at RM 101.9 during 1982.
- 834 Bering cisco captured during 1981, primarily by lower river fish wheel.
- 518 Bering cisco were captured in the lower river during 1982.
- The number of Bering cisco that might utilize passage facilities is uncertain, but likely to be relatively few, if any, under their current distribution.

4.2. Fish Size

- During 1981, Bering cisco size ranged from 284 to 385 mm from three age classes (3, 4 and 5 year olds).
- During 1982, Bering cisco size ranged from 235 to 405 mm from three age classes (4, 5 and 6 year olds).

5. BURBOT

5.1. Relative Abundance / Potential Use of Passage Facilities

- Burbot are commonly found in the mainstem Susitna River both upstream and downstream of Devils Canyon.
- They are generally not present in smaller tributaries, except at the mouth; however, they are present and abundant in the larger tributaries downstream of Devils Canyon, such as the Yentna and Deshka rivers.
- 88 burbot were captured by trotline during 1981 near tributary mouths upstream of Devils Canyon; maximum catch rate was 1.14 fish per trotline; average 0.68 fish per trotline.
- 135 burbot were captured by trotline during 1982 at mainstem sites upstream of Devils Canyon with a maximum catch rate of 3.5 fish per trotline and average 0.7 fish per trotline.
- For comparison, 130 trotlines were set at 17 DFH sites in the Middle and Lower River during 1982 with a maximum catch rate of 2.7 burbot per trotline and average of 0.4 burbot per trotline.
- While relatively abundant, the numbers of burbot that might utilize passage facilities is unknown.

5.2. Fish Size

- Burbot in the Susitna River can live up to 14 years; fish up to Age 10 were captured upstream of Devils Canyon in 1981 and 1982; maximum size of burbot captured downstream of Devils Canyon was 900 mm in 1981; maximum size recorded upstream of Devils Canyon was 740 mm in 1981 (Figure B5-4).
- No weight information is available from the Susitna River.

6. CHINOOK SALMON

6.1. Relative Abundance / Potential Use of Passage Facilities

- Adults
  - — Adult relative abundance declines rapidly from the first impediment to the Watana Dam site (Tables B5-2 and B5-3) although Chinook have been observed in Kosina

Creek and the Oshetna River. Relative abundance is higher downstream of Three Rivers confluence; the Middle River accounts for up to about 10 percent of Susitna River production.

- — Based on existing information, Chinook adult passage above Watana Dam are unlikely to number more than a few hundred. The highest peak spawning count was 16 fish in Kosina Creek during 2012 (HDR 2013). No adult Chinook were observed upstream of the proposed Watana Dam site during surveys from 1981-1985 (ADF&G 1981, ADF&G 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson 1986).
- — On the order of 10,000 to 20,000 adult Chinook escapement to Curry fishwheel (RM 120) during 1983-1985 (ADF&G 1981, ADF&G 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson 1986).
- — In the Middle River, Chinook spawn exclusively in tributary streams. Approximately 90+ percent of Middle River Chinook escapement is to Indian River and Portage Creek (ADF&G 1981, ADF&G 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson 1986).
- — In 2012, 317 Chinook salmon were radio-tagged at Curry. For those with mainstem or tributary final destinations, 26 (8.2%) passed the first impediment, 22 (6.9%) passed the second impediment, 12 (3.8%) passed all three impediments, and 6 (1.9%) had final destinations upstream of the proposed Watana Dam site (LGL 2013).
- — Based on estimates from Barrick et al. (1983), the production potential of Chinook salmon in the Upper River is 2,931 adults.
- — The potential use of passage facilities by adult Chinook salmon is unknown with any precision.

- Juveniles
  - — Chinook salmon juveniles primarily use side sloughs and side channels in the Middle River for summer rearing and overwintering, but most juveniles that exit tributaries during the open water period appear to migrate to the Lower Susitna River.
  - — Chinook fry have been infrequently observed in low numbers upstream of proposed Watana Dam site (Kosina Creek – 3 fish, Oshetna River – 3 fish; Buckwalter 2011).
  - — Observations of Chinook young of year during 2012 in Cheechako Creek and an unnamed tributary downstream of the proposed Watana Dam site (HDR 2013).
  - — All Chinook juveniles observed by Buckwalter (2011) were young-of-year less than 75 mm.
  - — Based on estimates from Barrick et al. (1983), the production potential of Chinook salmon in the Upper River is 97,704 smolts of unspecified age.
  - — The potential use of passage facilities by fry or age 1+ Chinook salmon is unknown.

6.2. Fish Size

- Adults.

— 10 Chinook radio-tagged at Curry that passed the third impediment were 66 to 101 cm FL (mean 83.9 cm).

— 492 Chinook captured at Curry during 2012 were 33 to 123 cm FL (mean 71 cm); cumulative length frequency is shown in Figure B5-5 (LGL 2013).

— No empirical weight information from the Susitna River.

— Age of Chinook returns to fishwheels during the 1980s varied considerably from year to year. Age 4, 5 and 6 typically predominate with some Age 3 and relatively few Age 7 (ADF&G 1981, ADF&G 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson 1986). The length frequency distribution from 1984 Curry Station fishwheel catches is shown in Figure B5-6.

- Fry.
  - — Emergence at approximately 32 mm.
  - — By late September young of year are typically 50 to 85 mm (weighted average 63.2 mm; Roth and Stratton 1985, Roth et al. 1986).
- Age 1+ (Roth et al. 1986)
  - — Typically 65 to 120 mm at Middle and Lower River outmigrant traps during 1984, weighted average 86.1 mm.

7. CHUM SALMON

7.1. Relative Abundance / Potential Use of Passage Facilities

- Adults
  - — Chum salmon are not known to be present upstream of Devils Canyon. However a significant number of chum salmon spawn in Middle Susitna River tributaries downstream of Devils Canyon.
  - — The average adult chum salmon escapement to the Curry Station fishwheel from 1981 to 1985 was 27,450 fish with a range of 13,068 to 49,278 fish (ADF&G 1981, ADF&G 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson 1986).
  - — Indian River and Portage Creek account for the majority tributary spawning in the Middle Susitna River while Sloughs 11, 8A, and 21 account for the majority of slough spawning.
  - — Based on estimates from Barrick et al. (1983), the production potential of chum salmon in the Upper River is 9,344 adults.
  - — Numbers of adult chum salmon that might utilize passage facilities is uncertain, but likely to be relatively few, if any, under their existing distribution.
- Juveniles

- — Chum salmon outmigrate primarily as fry with 50 percent of the run generally passing Talkeetna by mid-June and nearly 100 percent by the end of July (Roth and Stratton 1985; Roth et al. 1986).
- — During 1983 chum fry were primarily observed in tributaries (34.1%) and side sloughs (59.3%) (Dugan et al. 1984).
- — Based on estimates from Barrick et al. (1983), the production potential of chum salmon in the Upper River is 934,1994 smolts that would presumably be age 0+.
- — Numbers of juvenile chum salmon that might utilize passage facilities is uncertain, but likely to be relatively few, if any, under their existing distribution.

7.2. Fish Size

- Adults
  - — On average, chum salmon have predominately returned to the Susitna River at Age 4 (80.0 percent) and Age 5 (12.8 percent) with a few Age 3 and Age 6 fish returning (ADF&G 1981, ADF&G 1983, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986).
  - — During 1983 adult males captured at Curry Station ranged from 53 to 68 cm (average 60.6 cm) and females ranged from 42 to 68 cm (average 59.9 cm). These sizes are typical of other years. The length frequency distribution from 1984 Curry Station fishwheel catches is shown in Figure B5-7.
  - — The cumulative length frequency from 2012 Curry Station fishwheel captures is shown in Figure B5-5 (LGL 2013).
- Juveniles
  - — Chum salmon fry appeared to emerge at sizes of less than 35 mm (Roth and Stratton 1985). During 1984, the average size of outmigrating chum salmon was approximately 40 to 45 mm Roth and Stratton (1985).

8. COHO SALMON

8.1. Relative Abundance / Potential Use of Passage Facilities

- Adults
  - — Coho salmon are not known to be present upstream of Devils Canyon. However a significant number of coho salmon spawn in Middle Susitna River tributaries downstream of Devils Canyon, with occasional use of mainstem channels and sloughs.
  - — Relative abundance is higher downstream of Three Rivers confluence; Middle River accounts for less than 5 percent of Susitna River production. About 1.5 percent of coho salmon radio-tagged at Flathorn Station had a final destination in the Middle Susitna River downstream of Devils Canyon.

- — The average adult coho salmon escapement to the Curry Station fishwheel from 1981 to 1985 was 1,613.4 fish with a range of 761 to 2,438 fish (ADF&G 1981, ADF&G 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson 1986).
- — The average returns to the Talkeetna Station from 1981 to 1984 was 5,666 coho salmon (range 2,399 to 11,847). However, this is an overestimate because many fish captured at Talkeetna Station spawn in the lower river.
- — Whiskers Creek, Indian River and Chase Creek (RM 106.9) account for the majority of the tributary spawning in the Middle Susitna River.
- — Peak spawning counts in Portage Creek averaged 55.6 coho salmon (range 22 to 128) from 1981 to 1985.
- — Based on estimates from Barrick et al. (1983), the production potential of coho salmon in the Upper River is 4,884 adults.
- — Numbers of coho salmon that might utilize passage facilities is uncertain, but likely to be relatively few, if any, under their existing distribution.

- Juveniles
  - — Based on estimates from Barrick et al. (1983), the production potential of coho salmon in the Upper River is 48,853 smolts of unspecified age.

8.2. Fish Size

- Adults
  - — On average, coho salmon have predominately returned to the Susitna River at Age 4 (58.0 percent) and Age 3 (40.4 percent) with a few Age 5 (ADF&G 1981, ADF&G 1983, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986).
  - — During 1983 adult males captured at Curry Station ranged from 42 to 61 cm (average 51.8 cm) and females ranged from 35.4 to 60 cm (average 53.0 cm). These sizes are typical of other years. The length frequency distribution from 1984 Curry Station fishwheel catches is shown in Figure B5-8.
  - — The cumulative length frequency from 2012 Curry Station fishwheel captures is shown in Figure B5-5 (LGL 2013)
- Juveniles
  - — Coho young of year range from about 35 mm to 75 mm.
  - — Coho Age 1+ range from about 65 mm to 115 mm
  - — During 1985 Age 2+ coho salmon averaged 132 mm with a range of 109 mm to 174 mm (Roth et al. 1986).

9. DOLLY VARDEN

9.1. Relative Abundance / Potential Use of Passage Facilities

- Few (17) Dolly Varden were captured in the Susitna River and tributaries upstream of Devils Canyon during 1981 and 1982.
- HDR (2013) captured 246 Dolly Varden in the Susitna River and tributaries upstream of Devils Canyon during 2012.
- In 2003 and 2011, ADF&G documented two Dolly Varden during sampling at 11 sites in the Kosina Creek Basin and 11 Dolly Varden during sampling at 11 sites in the Oshetna River Basin (Buckwalter 2011).
- Downstream of Devils Canyon, Dolly Varden are present, but relatively uncommon in the Middle River. Maximum catch at DFH sites during 1982 from all gear types was two fish per sample period. Eight of 17 DFH sites had zero catch of Dolly Varden.
- Schmidt and Bingham (1983) suggested Dolly Varden had a higher relative abundance downstream of the Three Rivers Confluence compared to Middle River.
- Numbers of Dolly Varden that might utilize passage facilities is unknown.

9.2. Fish Size

- Maximum size of Dolly Varden captured during 1981 and 1982 was 205 mm.
- During 2012 the size range was 26 – 366 mm (Figure B5-9).

10. HUMPBACK WHITEFISH

10.1. Relative Abundance / Potential Use of Passage Facilities

- During 1981, 1982 and 2013 three humpback whitefish were captured upstream of Devils Canyon, one each year.
- ADF&G captured additional humpback whitefish in the Upper Susitna River Basin in 2011; however, these observations were limited to areas upstream of the MacClaren River confluence (Buckwalter 2011).
- Humpback whitefish are present but not abundant in the Middle River downstream of Devils Canyon. Maximum total catch at 12 DFH sites upstream of Three Rivers Confluence during 1982 was five fish per site and period 3 sites had zero catch, and three sites had one or zero fish captured each period (Figure B5-10).
- Numbers of humpback whitefish that might utilize passage facilities is unknown.

10.2. Fish Size

- Size of humpback whitefish captured upstream of Devils Canyon ranged from 231 (captured 2013) to 347 mm (captured 1981); size of humpback whitefish captured in 1982 not reported.
- In the Lower and Middle Susitna River downstream of Devils Canyon, humpback whitefish live up to Age 13.
  - Lower River fish tend to be larger than fish from the Middle River.
  - The maximum size captured in the Lower River was an Age 8 fish 489 mm in length.
  - The maximum size captured in the Middle River was an Age 8 fish 437 mm in length.
- No empirical weight information is available.

11. LONGNOSE SUCKER

11.1. Relative Abundance / Potential Use of Passage Facilities

- Longnose sucker are common both upstream and downstream of Devils Canyon.
- During 1981, 144 longnose suckers were captured near tributary mouths upstream of Devils Canyon by gillnet.
- During 1982, 66 longnose suckers were captured by gillnet at four of seven mainstem sampling sites.
- During 2012, 32 longnose suckers were captured primarily by backpack electrofishing within mainstem habitats (20 fish) or tributary plumes by boat electrofishing (8 fish).
- Longnose appear to be slightly more abundant in the Lower River compared to the Middle River downstream of Devils Canyon (Figure B5-11).
- Movement patterns of longnose sucker upstream of Devils Canyon are unknown.
- The number of longnose suckers that might utilize passage facilities is unknown.

11.2. Fish Size

- Longnose sucker in the Susitna River live up to Age 11.
- Range of longnose suckers captured upstream of Devils Canyon during 1981 was 105 to 505 mm (Figure B5-12).
- Range of longnose suckers captured upstream of Devils Canyon during 1982 was 210 to 495 mm.
- Range of longnose suckers captured in the Upper Susitna River during 2012 was 20 to 404 mm.

12. RAINBOW TROUT / STEELHEAD

12.1. Relative Abundance / Potential Use of Passage Facilities

- Steelhead were not distinguished from rainbow trout during the 1980s studies. Presumably, anadromy is not expressed by the *Onchorynchus mykiss* in the Susitna River.
- Rainbow are not known to be present upstream of Devils Canyon. However a significant number of rainbow trout utilize the Middle Susitna River for rearing and overwintering downstream of Devils Canyon.
- Rainbow trout spawning and juvenile rearing occurs in tributaries. Surveys at 17 DFH sites downstream of Devils Canyon during 1982 suggest rainbow trout are commonly observed near tributary mouths in the Susitna River downstream of Devils Canyon (Figure B5-13). During late summer rainbow trout were frequently observed near side channels and sloughs used by chum and sockeye salmon for spawning.
- Mark-recapture during 1981 to 1983 estimated there were about 4,000 rainbow trout greater than 150 mm using the reach from Talkeetna to Devils Canyon (Jennings 1985).
- Numbers of rainbow trout that might utilize passage facilities is uncertain, but likely to be relatively few, if any, under their existing distribution.

12.2. Fish Size

- Rainbow trout in the Susitna River live up to Age 9.
- Range of rainbow trout captured from the Three Rivers Confluence to Devils Canyon was 84 to 612 mm (Figure B5-14).

13. ROUND WHITEFISH

13.1. Relative Abundance / Potential Use of Passage Facilities

- During 1981, 33 round whitefish were captured near tributary mouths upstream of Devils Canyon by gillnet. During 1982, 5 round whitefish were captured by gillnet at one of seven mainstem sampling sites upstream of Devils Canyon.
- In 2003 and 2011, ADF&G documented 42 round whitefish during sampling at 11 sites in the Kosina Creek Basin, 22 round whitefish during sampling at 11 sites in the Oshetna River Basin, and 92 round whitefish during sampling at 7 sites in the Watana Creek Basin (Buckwalter 2011). Additional round whitefish observations in the Upper Susitna River Basin were located upstream of the Oshetna River confluence.
- In the Upper River Basin during 2012, 14 round whitefish were captured primarily by backpack electrofishing within mainstem habitats (20 fish) or tributary plumes by boat electrofishing (8 fish).
- Schmidt and Bingham (1983) suggested round whitefish were ten times more abundant than humpback whitefish downstream of Devils Canyon.

- Surveys at 17 DFH sites downstream of Devils Canyon during 1982 suggest round whitefish are more abundant in the Middle River downstream of Devils Canyon than in the Lower River (Figure B7-4).
- Movement patterns of round whitefish upstream of Devils Canyon are unknown
- The number of round whitefish that might utilize passage facilities is unknown.

13.2. Fish Size

- Round whitefish in the Susitna River live up to Age 12 (Schmidt et al. 1983).
- Range of round whitefish captured upstream of Devils Canyon during 1981 was 315 to 440 mm (Figure B5-6).
- Size of round whitefish captured upstream of Devils Canyon during 1982 was not reported.
- Maximum size of round whitefish captured downstream of Devils Canyon during the 1980s was 444 mm.
- Range of round whitefish captured in the Upper Susitna River during 2012 was 20 to 404 mm.

14. SOCKEYE SALMON

14.1. Relative Abundance / Potential Use of Passage Facilities

- Adults
  - Sockeye salmon are not known to be present upstream of Devils Canyon. However, a relatively small number of sockeye salmon spawn in Middle Susitna River side sloughs and side channels downstream of Devils Canyon. Most (95+%, Yanusz et al 2011a, 2011b) Susitna River sockeye salmon spawn in Susitna River tributaries such as the Talkeetna River, Chulitna River, Yentna River, Deshka River, Birch Creek, Alexander Creek, etc.
  - There are two distinct sockeye salmon runs to the Susitna River. First run sockeye salmon spawn exclusively in lower river tributaries. Second run sockeye salmon utilize spawn in Lower Susitna River tributaries and Middle Susitna River side sloughs and side channels.
  - The average second run adult sockeye salmon escapement to the Curry Station fishwheel from 1981 to 1985 was 2,467 fish with a range of 1,261 to 3,593 fish (ADF&G 1981, ADF&G 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson 1986).
  - Within the Middle Susitna River downstream from Devils Canyon, sockeye salmon primarily spawned in Sloughs 11, 8A, and 21. Some sloughs were used for spawning by sockeye salmon in all years while others were only intermittently used

- — Based on estimates from Barrick et al. (1983), the production potential of sockeye salmon in the Upper River is 158,261 adults.
- — The number of sockeye salmon that might utilize passage facilities is uncertain, but likely to be relatively few, if any, under their existing distribution.

- Juveniles
  - — Based on estimates from Barrick et al. (1983), the production potential of sockeye salmon in the Upper River is 1,582,598 smolts of unspecified age.

14.2. Fish Size

- Adults
  - — On average, sockeye salmon have predominately returned to the Susitna River at Age 4 (37.0 percent) and Age 5 (56.6 percent) with a few Age 3 and Age 6 fish returning (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986).
  - — During 1983 adult males captured at Curry Station ranged from 40 to 64 cm (average 48.1 cm) and females ranged from 38 to 58 cm (average 51.5 cm). These sizes are typical of other years. The length frequency distribution from 1984 Curry Station fishwheel catches is shown in Figure B5-16.
  - — The cumulative length frequency from 2012 Curry Station fishwheel captures is shown in Figure B5-5 (LGL 2013).
- Juveniles
  - — Sockeye salmon fry emerged at approximately 32 mm in size (Roth and Stratton 1985). By the end of September sockeye salmon fry are about 55 to 60 mm in length.
  - — During 1985 Age 1+ sockeye salmon juveniles captured with outmigrant traps at the Talkeetna Station were 11 mm in length shorter on average than Age 1+ sockeye salmon juveniles captured at the Flathorn Station (69 mm compared to 80 mm).

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16. TABLES

Table B5-1. Estimated Arctic grayling population sizes in tributaries to the upper Susitna River during 1981 and 1982. Source: Delaney et al. (1981b), Sautner and Stratton (1983).

	1981[1]		1982[1]	
Stream	Point Estimate (fish)	95% Confidence Interval (fish)	Point Estimate (fish)	Point Estimate (fish/mile)
Oshetna River	2,017	1,525 - 2,976	2,426	1,103
Goose Creek	1,327	1,016 - 1,913	949	791
Jay Creek	1,089	868 - 1,462	1,592	455
Kosina Creek	2,787	2,228 - 3,720	5,544	1,232
Deadman Creek	979	604 - 2,575	734	1,835
Tsusena Creek	1,000	743 - 1,530		
Fog Creek	176	115 - 369		440
Watana Creek			3,925	324
Upper Susitna River	10,279	9,194 - 11,654	16,346[2]	

Notes:

1 Fish densities were not reported for 1981. Confidence intervals were not reported for 1982.

2 Total of point estimates from 1982 plus 1981 point estimates for Tsusena and Fog creeks.

Table B5-2. Chinook salmon escapement survey results from 1982 to 1985 upstream of RM 152. Surveys conducted by helicopter.

Stream	1982				1983				1984				1985			
	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page
Cheechako Cr	9	6-Aug	16	589/314	2	1-Aug	25	1450/111	7	1-Aug	29	2748/60, 506	11	24-Jul	18	3412/127
Chinook Cr	5	6-Aug	5	589/314	2	1-Aug	8	1450/111	7	1-Aug	15	2748/60, 506	11	23-Aug	1	3412/128
Devil Cr	*16.1.1.1.1.1.1.* 5		0	589/314	1	1-Aug	1	1450/111	6		0	2748/60, 506	11		0	3412/128
Fog Cr	0			2748/60	0			2748/60	4	21-Jul	2	2748/60, 506	3		0	3412/128
Bear Cr	0				0			2748/151	4		0	2748/506	3		0	3412/128
Tsusena Cr	0				0			2748/151	4		0	2748/507	3		0	3412/128
Deadman Cr	0				0				3		0	2748/507	0			
Watana Cr	0				0				2		0	2748/507	0			

Table B5-3. Chinook salmon information from Buckwalter (2011) Synopsis of ADF&G's Upper Susitna Drainage Fish Inventory, August 2011.

Stream	River Mile	Date	Lifestage	Number of Fish	Method	Reference
Above Devils Canyon (RM 152)						
Fog Creek	176.7	8/1/2003	adults	2	helicopter/foot	Buckwalter 2011, AWC Survey ID: FSS03USU01
Tsusena Creek	181.3	8/1/2003	adults	1	helicopter/foot	Buckwalter 2011, AWC Survey ID: FSS03USU02
Fog Creek	176.7	8/13/2003	juveniles	5	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0305A01
Fog Creek Trib	176.7	8/6/2011	juveniles	8	electrofishing	Buckwalter 2011, AWC Survey ID: FSS1104c01
Fog Creek	176.7	8/6/2011	redds			Survey ID: FSS1104B01
Above Watana Dam Site (RM 184)						
Kosina Creek	201	8/14/2003	juveniles	1	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0306A01
Oshetna River	225	8/14/2003	juveniles	3	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0306A05
Kosina Creek	201	8/15/2003	juveniles	2	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0307A06
Kosina Creek	201	7/27/2011	adults	1	helicopter/foot	Buckwalter 2011, Survey ID: FSS1101G04

17. FIGURES

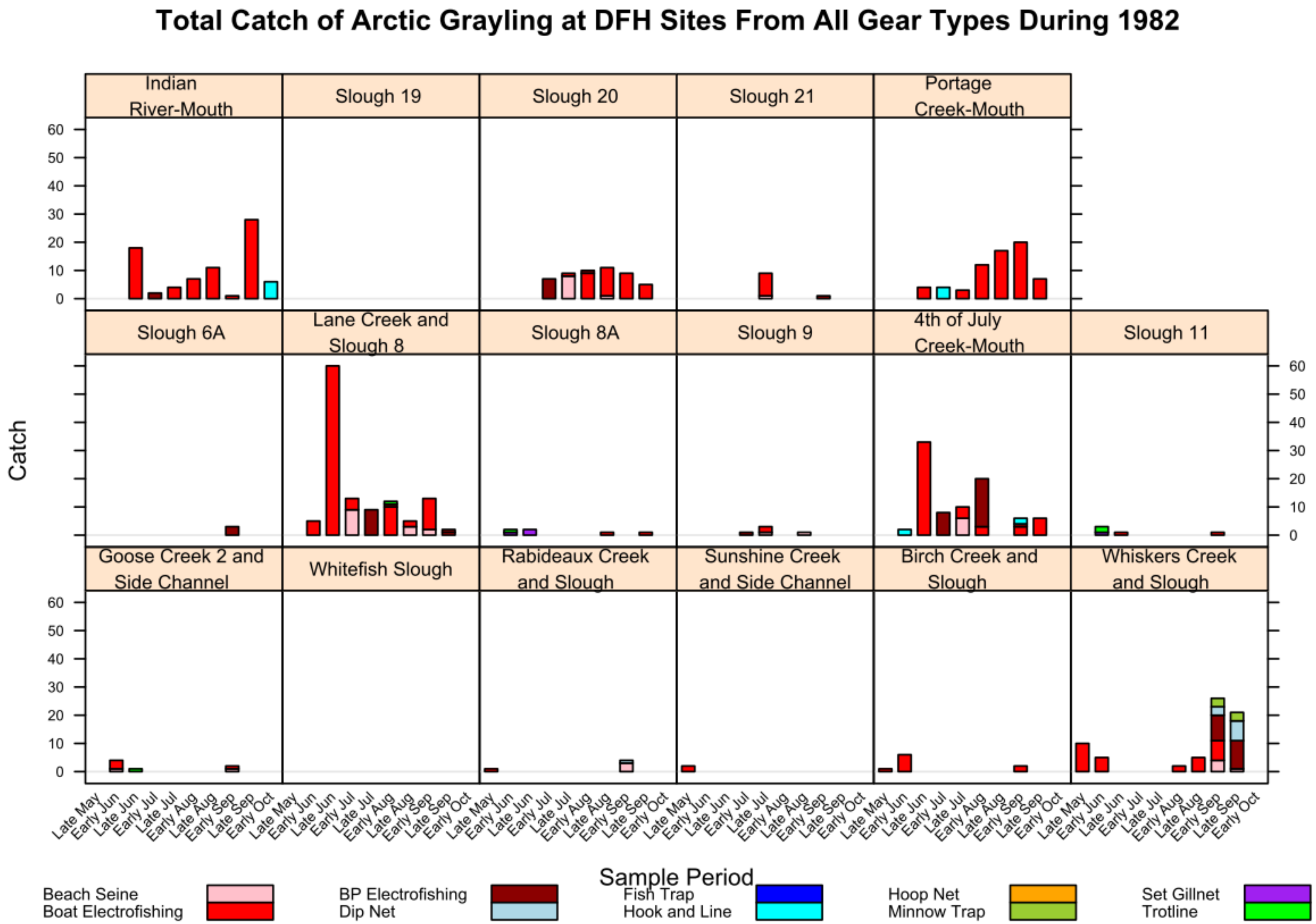

Figure B5-1. Total catch of Arctic grayling at DFH sites in the Lower and Middle Susitna River during 1982. Source: Schmidt et al. (1983).

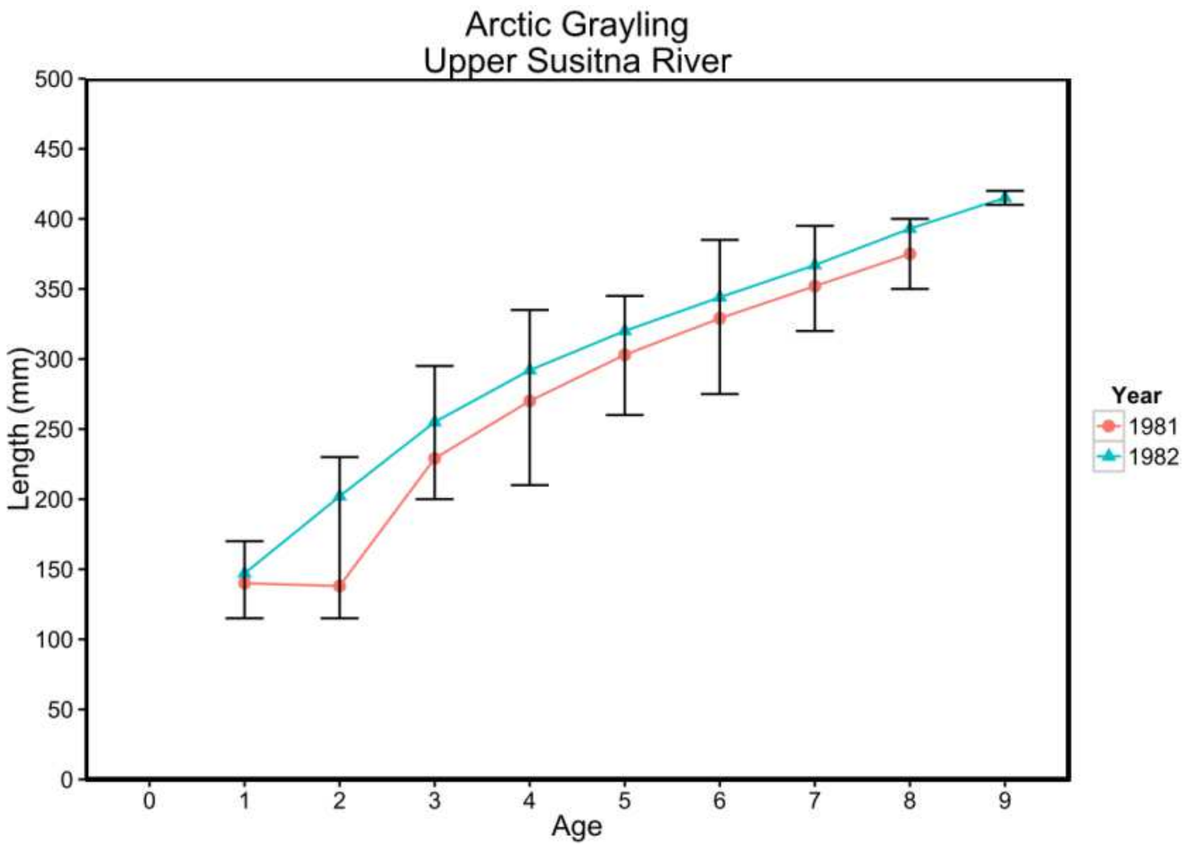

Figure B5-2. Age and length of Arctic grayling collected in the upper Susitna River during the open water seasons of 1981 and 1982. Source: Delaney et al. (1981), Sautner and Stratton (1983).

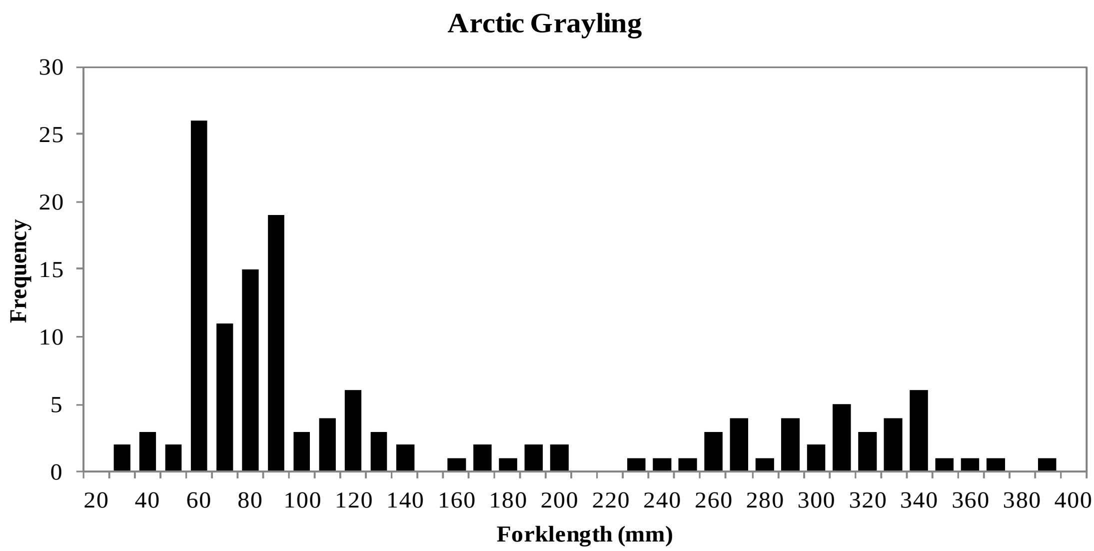

Figure B5-3. Length Frequencies for Arctic Grayling (n=143) captured in tributary, tributary plume, and lake habitats in the Upper Susitna River study area, July-August, 2012. Fish were captured by boat-mounted electrofisher, backpack electrofishing, minnow traps, angling, and fyke nets. Source: HDR (2013).

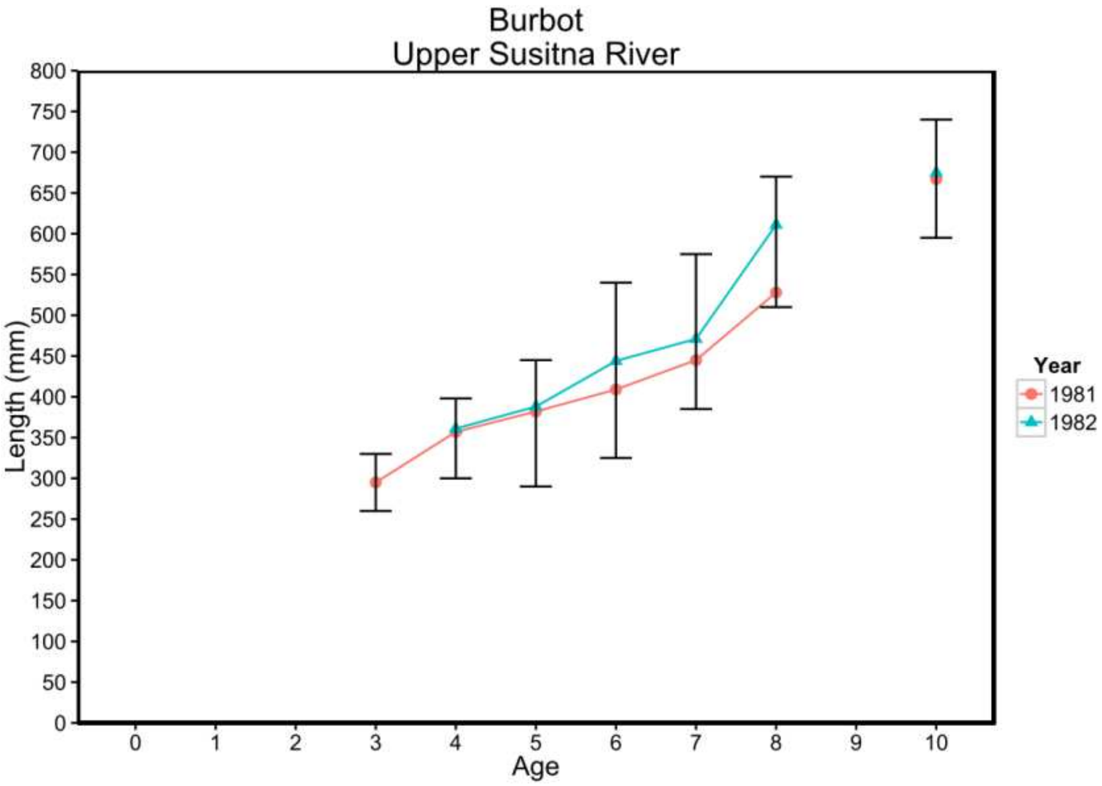

Figure B5-4. Age and length of burbot collected upstream of Devils Canyon during the open water seasons of 1981 and 1982. Source: Delaney et al. (1981), Sautner and Stratton (1983).

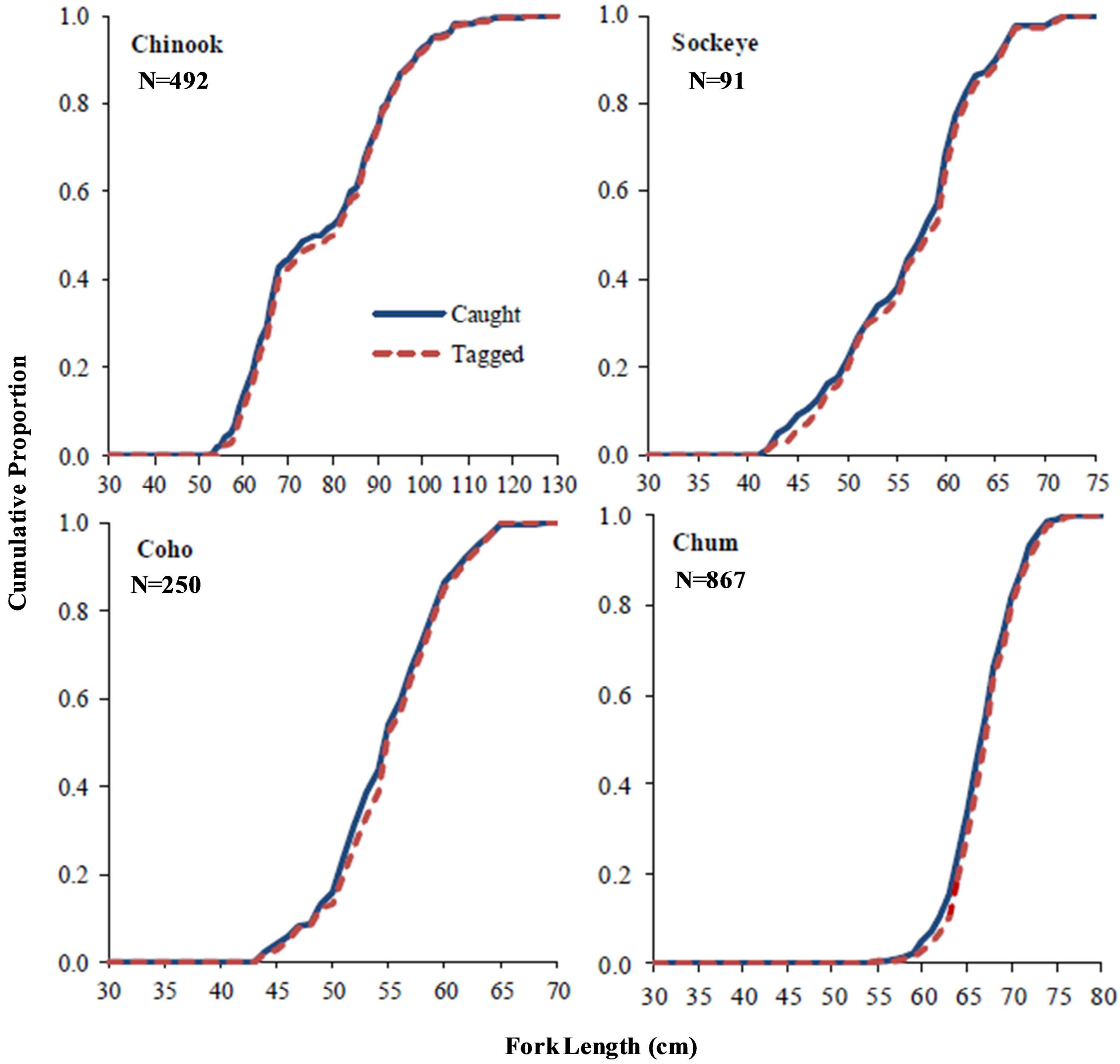

Figure B5-5. Cumulative length-frequency distributions of adult salmon caught at two fishwheels near Curry (RM 120) on the Susitna River in 2012. Also shown is the length-frequency distribution for the subset of each species implanted with radio tags. Source: modified from LGL (2013).

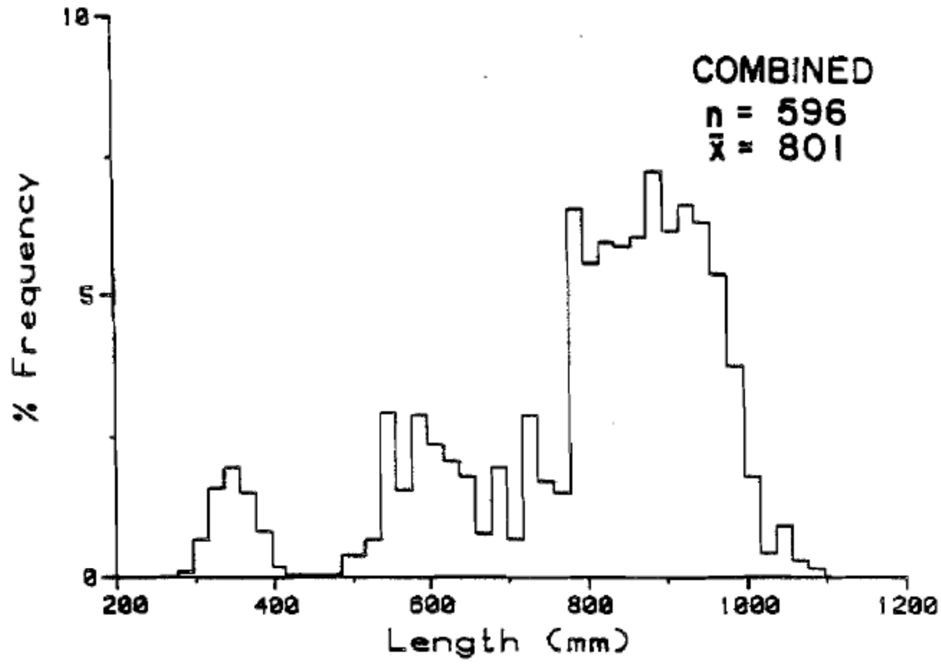

Figure B5-6. Chinook salmon 1ength frequencies at Curry Station weighted by fishwheel catch per unit effort in 1984. Source: Barrett et al. (1985).

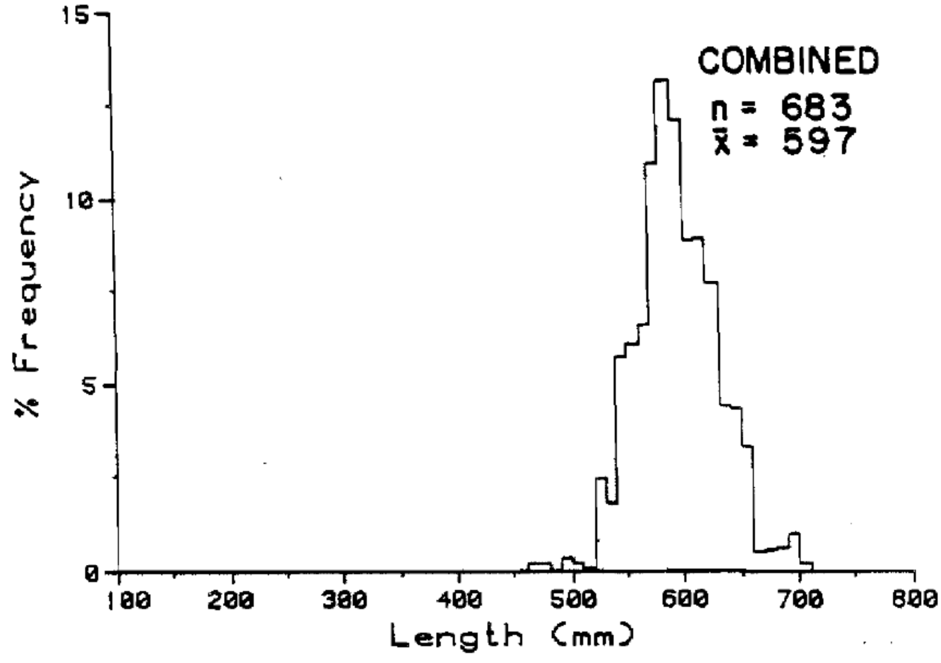

Figure B5-7. Chum salmon length frequencies at Curry Station weighted by fishwheel catch per unit effort in 1984. Source: Barrett et al. (1985).

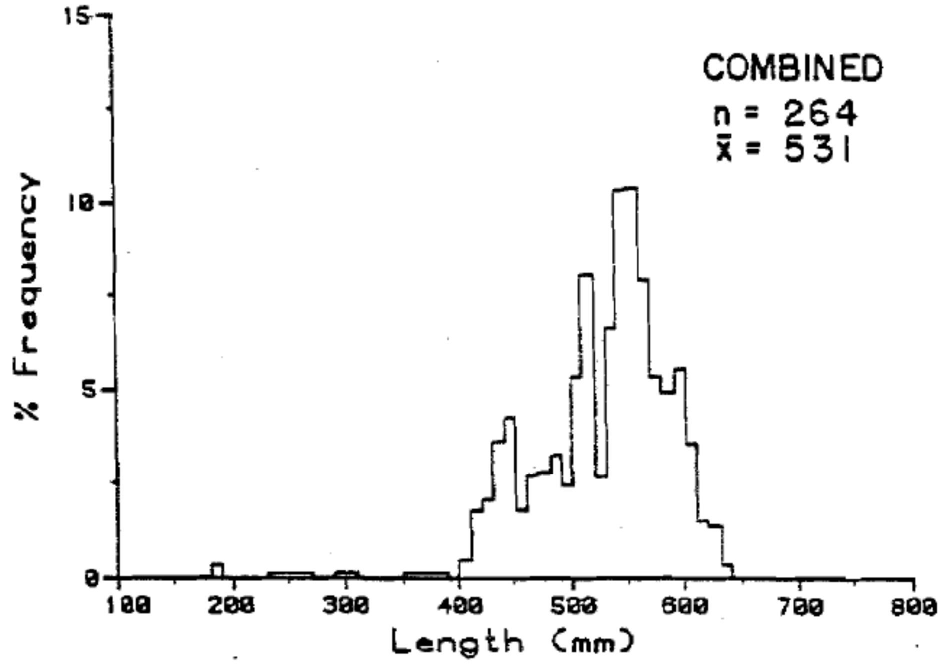

Figure B5-8. Coho salmon length frequencies at Curry Station weighted by fishwheel catch per unit effort in 1984. Source: Barrett et al. (1985).

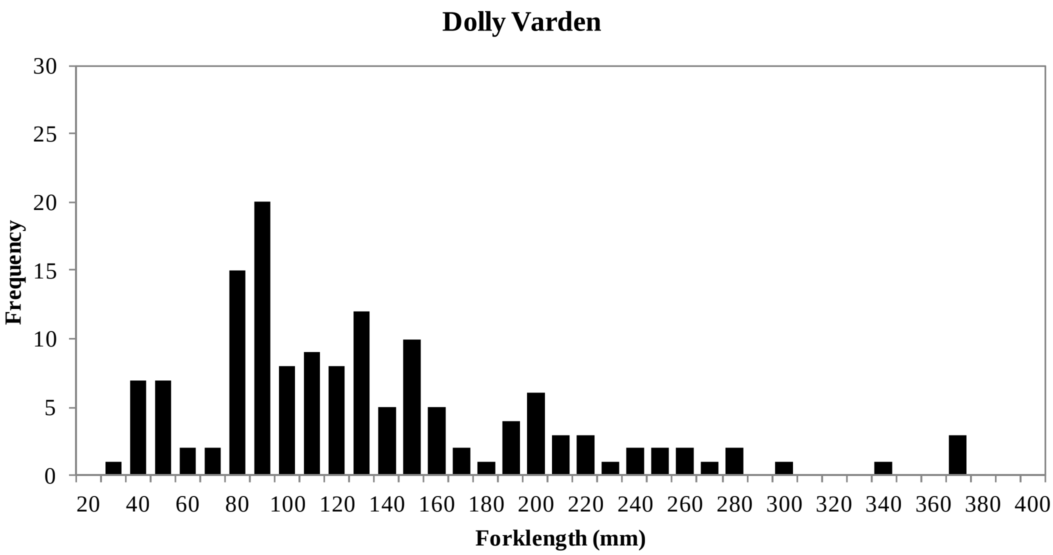

Figure B5-9. Length Frequencies for Dolly Varden (n=145) captured in tributary, tributary plume, and lake habitats in the Upper Susitna River study area, July-August, 2012. Fish were captured by boat-mounted electrofisher, backpack electrofishing, minnow traps, angling, and fyke nets. Source: HDR (2013).

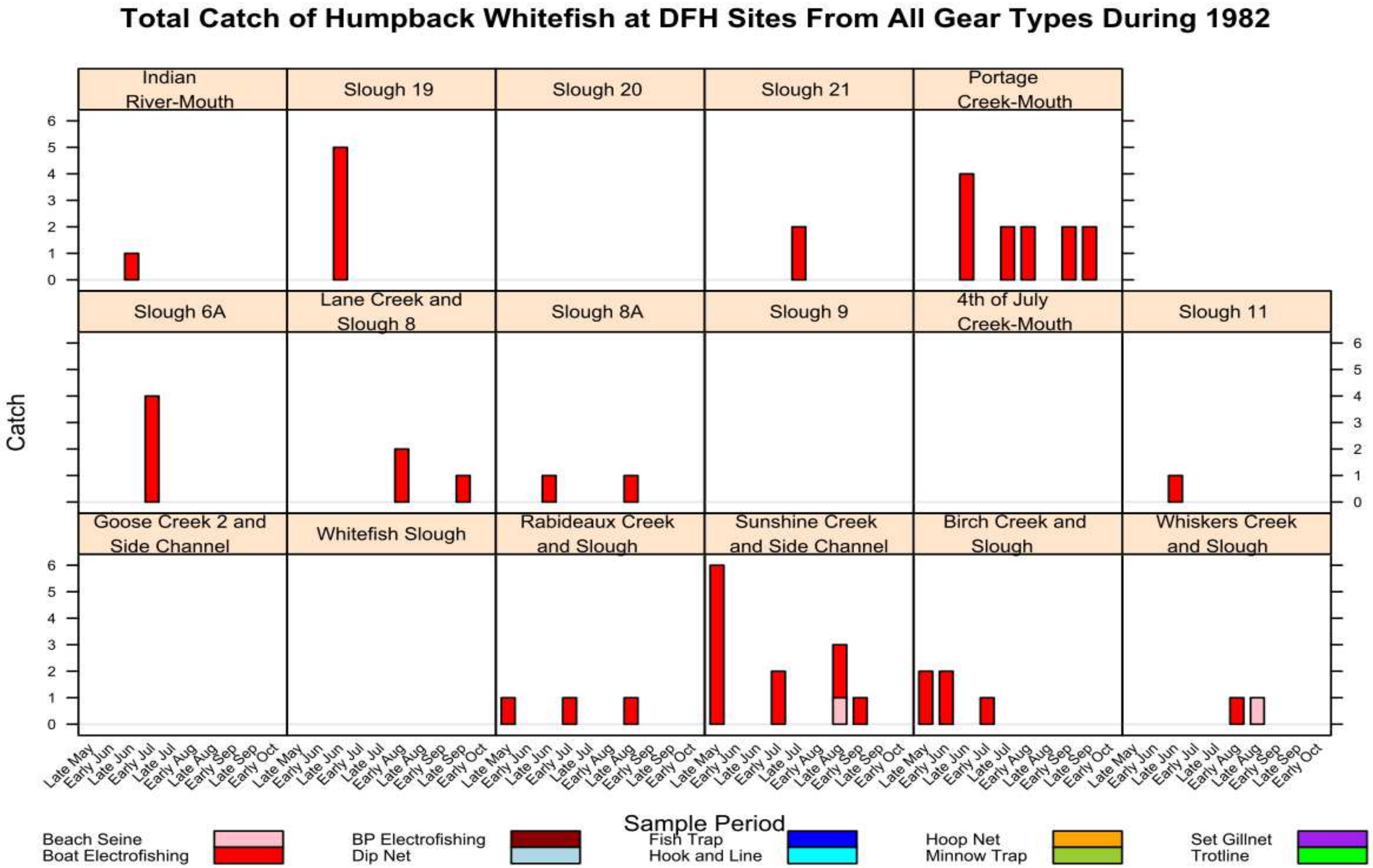

Figure B5-10. Total catch of humpback whitefish at DFH sites during 1982 by gear type. Source: Schmidt et al. (1983).

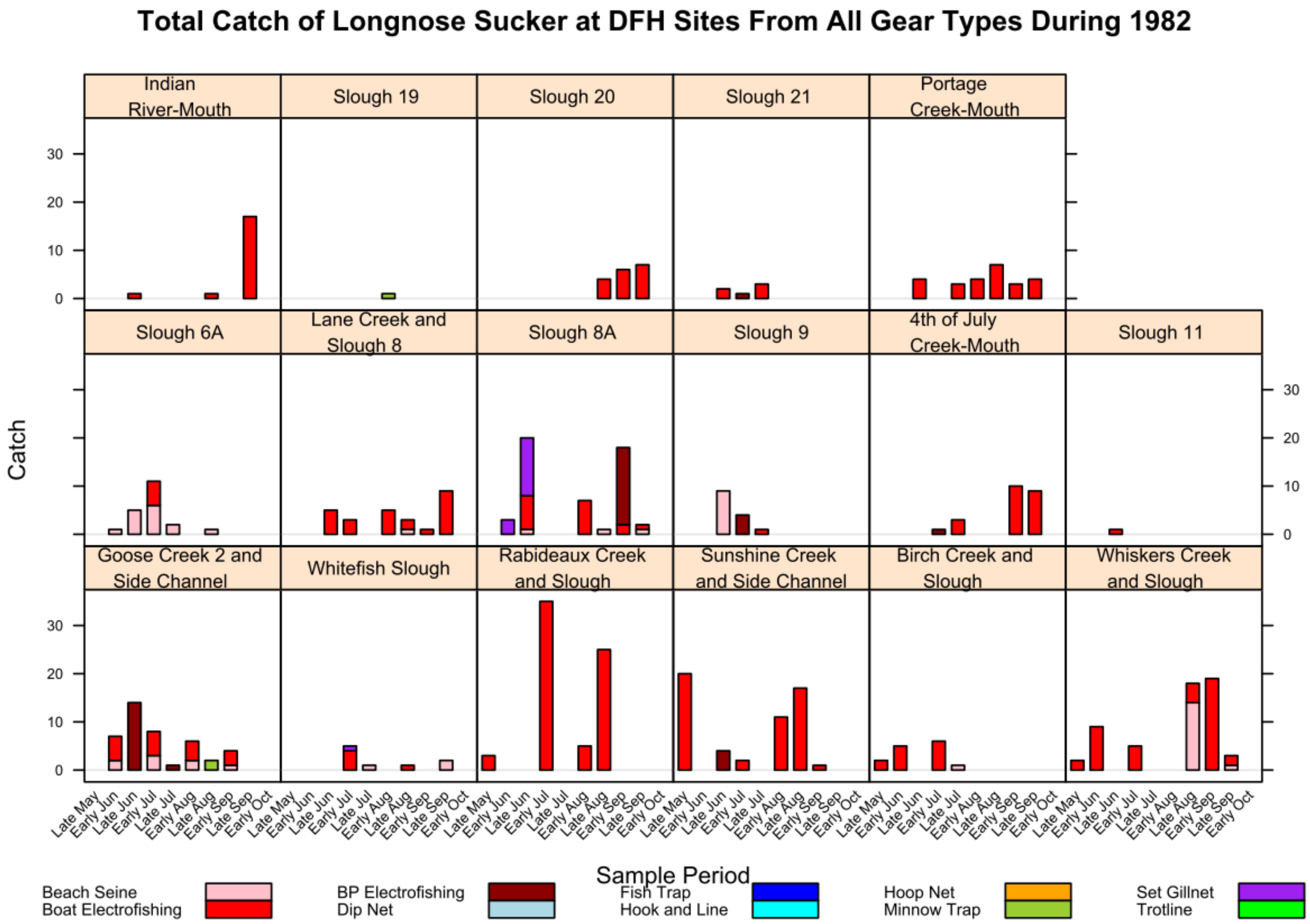
Total Catch of Longnose Sucker at DFH Sites From All Gear Types During 1982
Indian River-Mouth
Slough 19
Slough 20
Slough 21
Portage Creek-Mouth
Slough 6A
Lane Creek and Slough 8
Slough 8A
Slough 9
4th of July Creek-Mouth
Slough 11
Goose Creek 2 and Side Channel
Whitefish Slough
Rabideaux Creek and Slough
Sunshine Creek and Side Channel
Birch Creek and Slough
Whiskers Creek and Slough
Catch
0
10
20
30
Late May
Early Jun
Late Jun
Early Jul
Late Jul
Early Aug
Late Aug
Early Sep
Late Sep
Early Oct
Sample Period
Beach Seine
Boat Electrofishing
BP Electrofishing
Dip Net
Fish Trap
Hook and Line
Hoop Net
Minnow Trap
Set Gillnet
Trotline

Figure B5-11. Total catch of longnose sucker at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

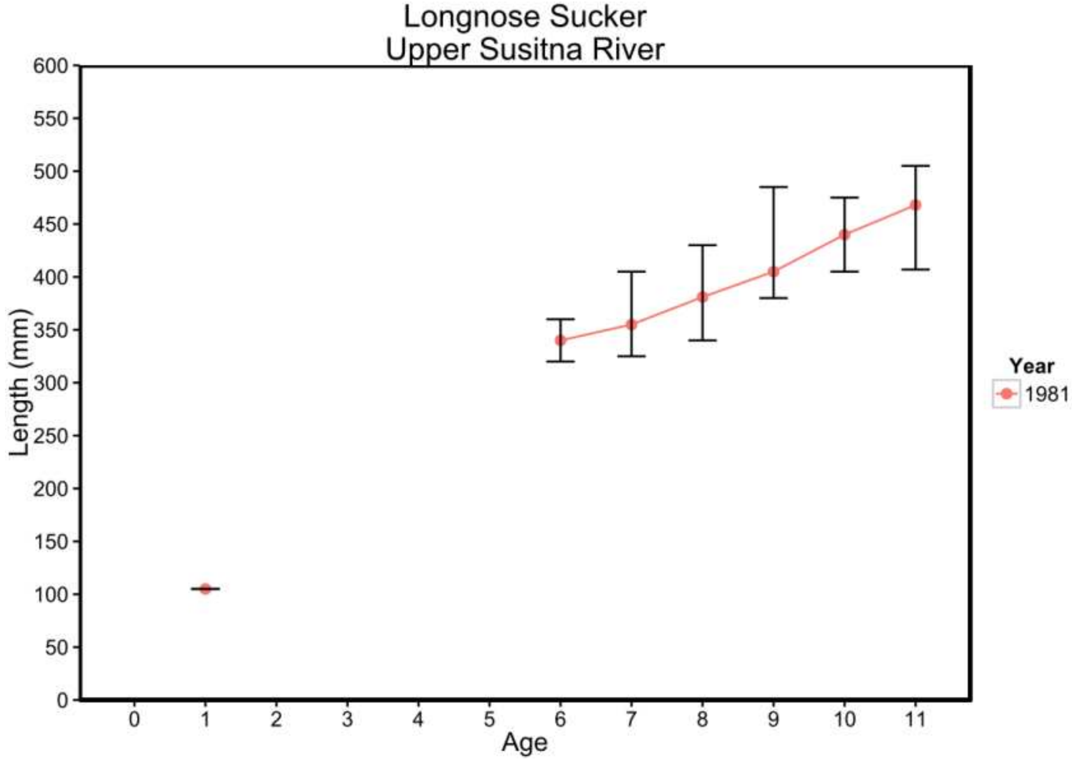

Figure B5-12. Age and length of longnose sucker collected in the upper Susitna River during the open water season of 1981 Source: Delaney et al. (1981).

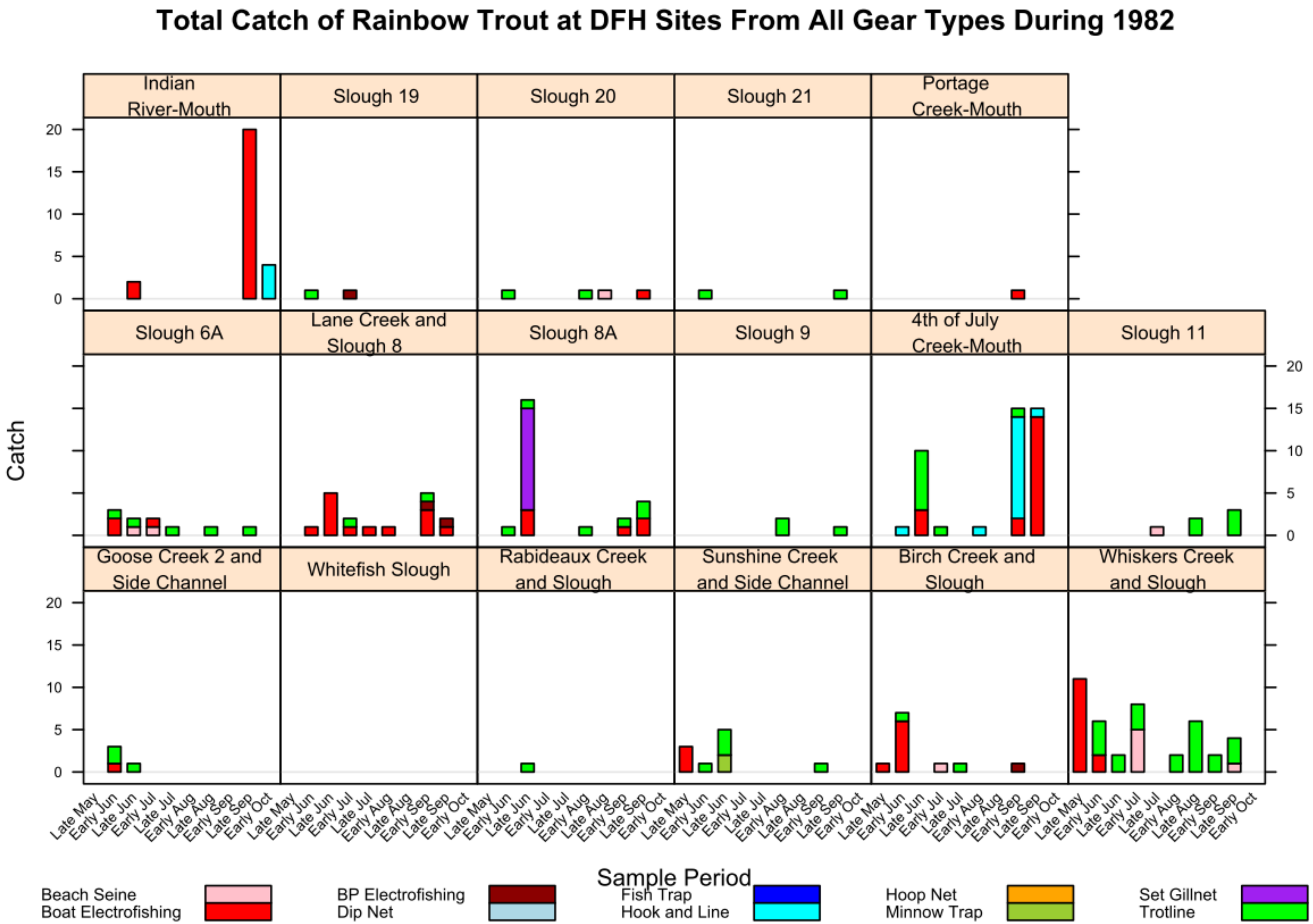

Figure B5-13. Total catch of rainbow trout at DFH sites during 1982 by gear type. Source: Schmidt et al. (1983).

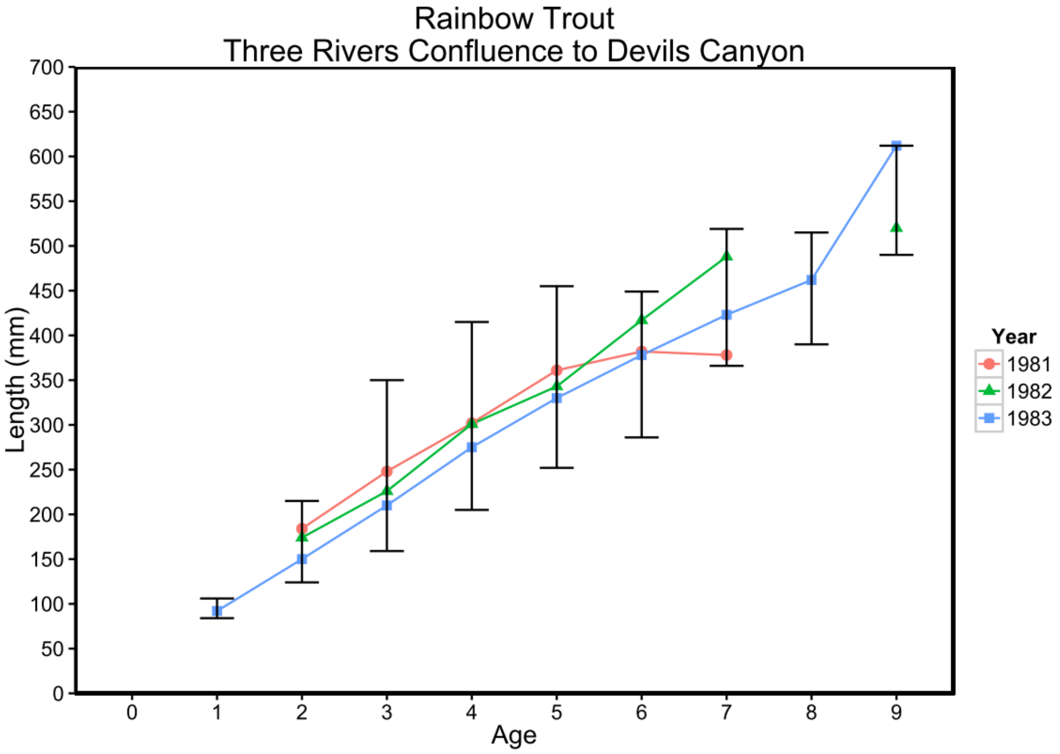

Figure B5-14. Age and length of rainbow trout collected in the Middle Susitna River downstream of Devils Canyon during the open water seasons of 1981 to 1983. Data Source: Delaney et al. (1981) Schmidt et al. (1983, 1984).

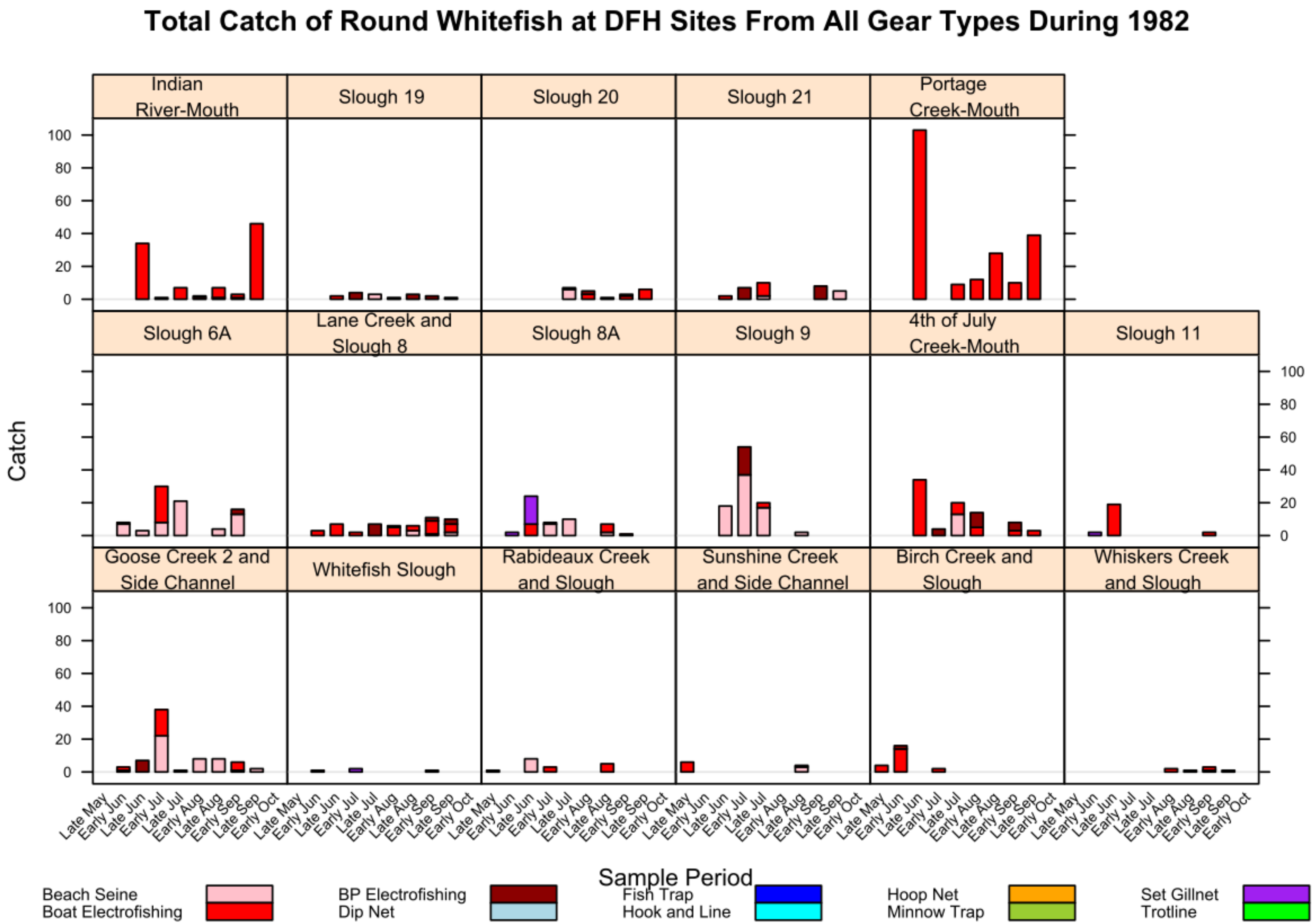

Figure B5-15. Total catch of round whitefish at DFH sites during 1982 by gear type. Source: Schmidt et al. (1983).

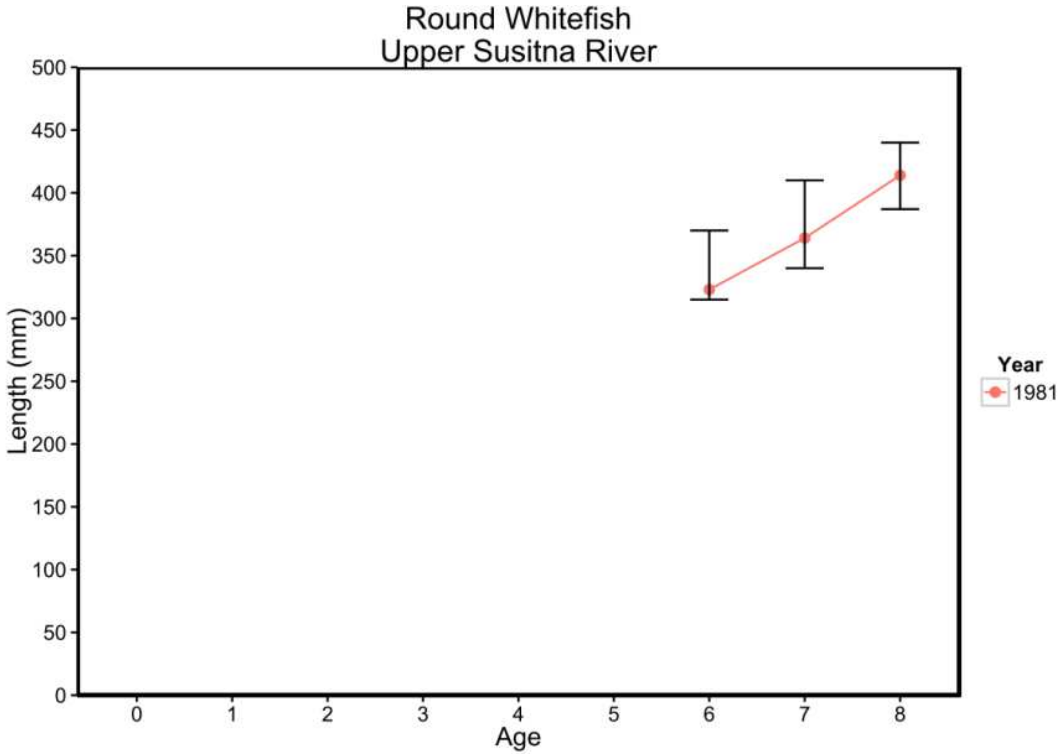

Figure B5-16. Age and length of round whitefish collected in the upper Susitna River during the open water season of 1981. Source: Delaney et al. (1981).

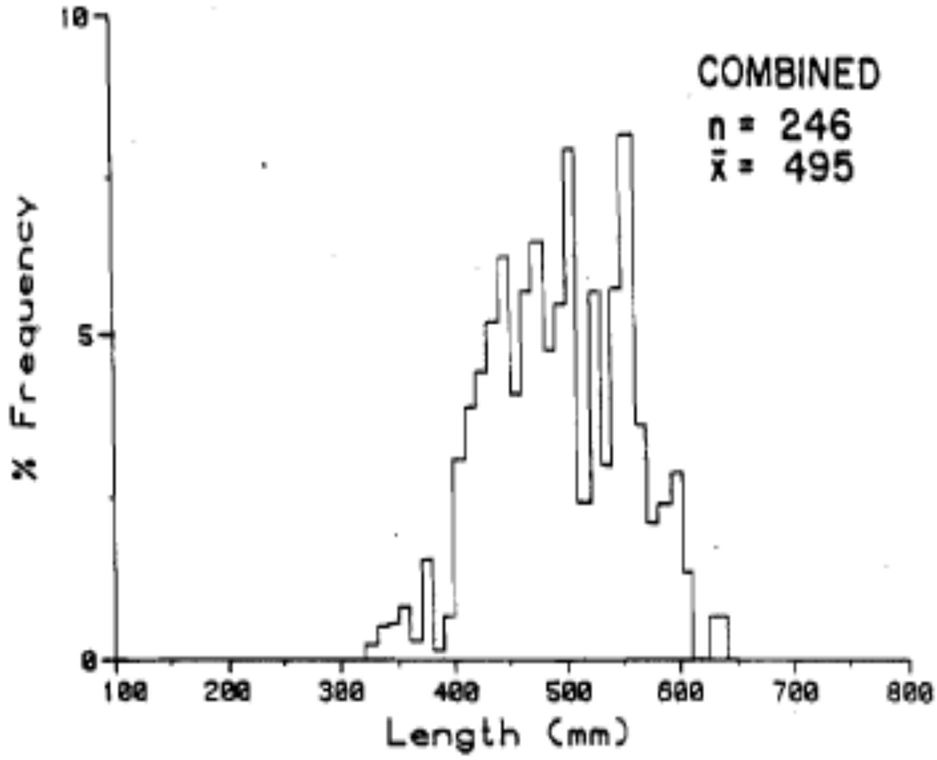

Figure B5-17. Sockeye salmon length frequencies at Curry Station weighted by fishwheel catch per unit effort in 1984. Source: Barrett et al. (1985).

INFORMATION ITEM B6. LIFE STAGE SPECIFIC PASSAGE INFORMATION

1. INTRODUCTION

Migratory behavior, fish size, and other factors associated with movement of target fish species will be an important consideration in identifying the design, location, and sizing of various fish passage alternatives. Swimming ability of target species is also an important factor as it relates to the development of fish passage alternatives.

Modes of fish swimming can be classified as one of three categories: sustained, prolonged, or burst swimming (Beamish 1978). Sustained swimming is that which can be maintained indefinitely (i.e., longer than 200 minutes) and is also referred to as cruising speed. Prolonged swimming is a moderate speed that can be maintained for a specific period of time (i.e., up to 200 minutes). Burst swimming is the fastest speed achievable and can only be maintained for short durations (i.e., less than 20 seconds) as it utilizes more anaerobic metabolism than the other swimming modes. Another measurement of fish swimming ability commonly reported in the literature is U_{crit}, (or critical swimming speed), which is a standardized calculation of the maximum swimming speed a fish can maintain for a predetermined period of time. As these times are typically between 10 and 200 minutes, U_{crit} falls under the category of prolonged swimming speed. For the purposes of evaluating fish passage alternatives, we focused on burst swimming and prolonged swimming (or U_{crit}) as the two most relevant swimming modes. Burst swimming provides an indication of the ability of fish to traverse discrete high velocity areas such as those occurring at fish ladder weirs or at the entrance to a collection facility. Prolonged swimming is an indication of the ability of fish to traverse longer distances within a fish ladder or to avoid impingement or entrainment near turbine intakes.

Species utilize different modes for swimming related to their body shape. Katapodis (1992) describes these modes as follows.

> *Most of the data gathered involve fish swimming in the subcarangiform and anguilliform modes. Subcarangiform is an undulatory mode of swimming characterized by small side-to-side amplitude at the anterior and large amplitude only in the posterior half or one-third of the body. The characteristic body shape is fusiform, the caudal peduncle is fairly deep and the caudal fin has a rather low aspect ratio. In the anguilliform mode most or all of the length of the body participates in propulsion. The body is long and thin, the anterior cylindrical, the posterior compressed and caudal fin is usually small.*

This information item summarizes the available information related to the behavior, size and swimming ability of target species.

Although lake trout are an important component of sport fisheries in the Susitna Basin (Jennings et al. 2007, 2011), their importance with regard to the study of fish passage feasibility is thought to be negligible. Should lake trout ultimately inhabit the future Project reservoir, predation by lake trout and entrainment may be considerations. Predation risks associated with Fish Passage are addressed in Information Item B9. The probability of lake trout inhabiting the future Project reservoir and potential entrainment risks will be considered in RSP 9.10 - The Future Watana Reservoir Fish Community and Risk of Entrainment Study.

2. ARCTIC GRAYLING

2.1. Fish Size

2.1.1. Adults

- Maximum length of fish sampled upstream of Devils Canyon during 1982 was 420-mm
- Maturity reached as early as age-4; average length of age-4 grayling in Upper Susitna River was approximately 275 mm (see Information Item B5, Figure B5-1).

2.1.2. Juveniles

- Juveniles generally thought to reside in natal tributaries for 1 year.
- Thus, those potentially exhibiting movement range in length from approximately 150-mm (age-1) to 250-mm (age-3) based on average age-specific lengths (see Information Item B5, Figure B5-2).

2.2. Migratory and Swimming Behavior

- A preliminary review indicates that information regarding movement patterns in tailrace or forebay areas of hydroelectric facilities is lacking.
- Springtime monitoring of arctic grayling movements at an experimental dam on Poplar Grove Creek, Alaska indicated that peak activity of both upstream and downstream migrants was in late afternoon or early evening, though corresponding increase in water temperature was thought to be an important determinant as well (MacPhee and Watts 1975).
- Spring migration away from overwintering areas is thought to be triggered by a general environmental stimulus such as day length, water temperature, or discharge but can begin prior to break up at temperatures of 1°C or lower (Tack 1980). Pre-spawning migrations intensify during flow increases associated with breakup, with the majority occurring when rivers are at or near flood stage (Tack 1980). Tack (1980) also theorizes that timing upstream migrations with the spring freshet may allow grayling to use channel margins and eddies with slow velocities that only are available during higher flows, as opposed to higher velocities of well defined channels at lower flows.

2.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- Burst swimming ability of 213 to 426 cm/s for fish 20.3 to 30.5 cm FL (Bell 1991 as cited by Furniss 2008).
- Length-specific critical (i.e. prolonged) swimming speeds provided in Figure B6-1 (from Jones et al. 1974).

2.4. Other Passage Considerations

- Observations of arctic grayling leaping behavior at experimental dam (MacPhee and Watts 1976).
- Limited information regarding arctic grayling use of passage facilities, though Katapodis (1992) lists adults of this species as showing some use of Denil, vertical slot, weir or culvert fishways.

3. ARCTIC LAMPREY

3.1. Fish Size

- The length range of Arctic lamprey captured in the Susitna River during 1981-1982 was 84 to 315 mm (Schmidt et al. 1983). Neither life stages nor length-at-age information were provided; thus, this length range likely includes both adults and juveniles.

3.2. Migratory and Swimming Behavior

- There is little information regarding the migratory and swimming behavior of Arctic lamprey in the Susitna River, though the species is thought to exhibit both anadromous and freshwater life histories in the basin.
- Migrating adults are often seen in large swarms, especially at obstructions (Scott and Crossman 1973).
- While it is unclear if Arctic lamprey exhibit similar behavior, adult Pacific lamprey (*Lampetra tridentata*) are primarily nocturnal in their movements at hydropower facilities on the Columbia River (Moser et al. 2005, 2006).

3.3. Swimming Ability

- Like burbot, lamprey exhibit an anguilliform swimming mode (Katapodis 1992).
- No information on Arctic lamprey swimming ability could be identified.
- Mean burst swimming ability for Pacific lamprey (mean TL 14.7 cm) of 82.3 cm/s (Moursund et al. 2003 as cited by Furniss 2008).
- Mean prolonged swimming ability for Pacific lamprey (mean TL 14.7 cm) of 39.6 cm/s.

3.4. Other Passage Considerations

- Adults die after spawning (Scott and Crossman 1973).
- At Bonneville Dam, adult Pacific lamprey are often delayed or obstructed at fishway entrances and transition, collection, and count station areas but are more successful and pass more rapidly through pool and weir fishway sections (Moser et al. 2006).

4. BERING CISCO

4.1. Fish Size

- Lengths of age-3+ to age-6+ Bering cisco captured in the Susitna River during 1981-1982 ranged from 235 to 405 mm (ADF&G 1981, 1983). No lengths of Bering cisco younger than age-3+ were reported.

4.2. Migratory and Swimming Behavior

- A preliminary review indicates that information regarding movement patterns in tailrace or forebay areas of hydroelectric facilities is lacking.
- Bering cisco spawning migrations appear to be quite rapid in nature and feeding is not thought to occur during the migration (ADF&G 1981).
- Upstream spawning migrations of adult Bering cisco in the Susitna River occurs from early August through October, with a peak in late September and early October (ADF&G 1983, Barrett et al. 1984).

4.3. Swimming Ability

- Bering cisco presumably exhibit a subcarangiform swimming mode, as reported for other cisco (*Coregonus artedii*) (Katapodis 1992).
- While information on the swimming ability of Bering cisco could not be identified, cisco (*Coregonus artedii*) were found to have prolonged swimming speeds of 46 to 63 cm/s for fish with a mean FL of 13.5 cm (Bernatchez and Dodson 1985 as cited by Furniss 2008).
- Bell (1991) reports a burst (darting) swimming speed of approximately 183 cm/s for Arctic cisco *(Coregonus autumnalis)* with a length of 42 cm.

4.4. Other Passage Considerations

- In western and interior Alaska, Alt (1973) did not find evidence of repeat spawning in Bering cisco that were age-3 to age-8.

5. BURBOT

5.1. Fish Size

5.1.1. Adults

- Maximum size of burbot captured downstream of Devils Canyon was 900 mm in 1981; maximum recorded upstream of Devils Canyon was 740 mm in 1981.
- Maturity reached as early as age-6 in interior Alaska (Morrow 1980); average length of age-6 burbot in Upper Susitna River was approximately 425 mm (see Information Item B5, Figure B5-3).

5.1.2. Juveniles

- Little is known regarding the movement of juvenile burbot. Aside from spawning and post-spawning migrations, burbot are thought to be relatively sedentary. Thus, the size of juveniles potentially exhibiting migratory behavior is unknown.

5.2. Migratory and Swimming Behavior

- A preliminary review indicates that information regarding movement patterns in tailrace or forebay areas of hydroelectric facilities is lacking.
- Burbot movement studies associated with the proposed Dunvegan Hydroelectric Project on the Peace River, Alberta indicated a preference for channel margins as migratory corridors (Mainstream Aquatics 2006).

5.3. Swimming Ability

- Exhibit anguilliform swimming mode (Katapodis 1992).
- Burst swimming ability of 36 to 121 cm/s for fish 20 to 70 cm FL (Bell 1991 as cited by Furniss 2008).
- A recent flume study of volitional swimming (Vokoun and Watrous 2009) indicated that Burbot shifted from prolonged to burst swimming at around 4.72 body lengths per second. Swimming performance decreased markedly once flume velocities reached 105 cm/s.
- Length-specific critical (i.e. prolonged) swimming speeds provided in Figure B6-1 (from Jones et al. 1974); however, length was not a significant factor (p=0.1).

5.4. Other Passage Considerations

- Burbot are considered benthically oriented, particularly in lakes, inhabiting depths up to 300 m (McPhail and Paragamian 2000).
- Burbot are a large-bodied species with an elongate and cylindrical morphology.
- They are relatively poor swimmers compared to other proposed target species.

6. CHINOOK SALMON

6.1. Fish Size

6.1.1. Adults

- 10 Chinook radio-tagged at Curry that passed the third impediment were 66 to 101 cm FL (mean 83.9 cm).
- 492 Chinook captured at Curry during 2012 were 33 to 123 cm FL (mean 71 cm).

6.1.2. Juveniles

- Fry emerge at approximately 32 mm and by late September young of year are typically 50 to 85 mm (weighted average 63.2 mm; Roth and Stratton 1985, Roth et al. 1986).
- Age 1+ were typically 65 to 120 mm at Middle and Lower River outmigrant traps during 1984, weighted average 86.1 mm (Roth et al. 1986).

6.2. Migratory and Swimming Behavior

- Upstream adult migration is thought to occur primarily during daylight hours, though some may also migrate upstream at night (Groot and Margolis 1991).
- Downstream movement of fry and subyearling primarily occurs at night, though smaller numbers may move during the day (Groot and Margolis 1991). Yearling smolts appear to be less nocturnal.
- Triggers for downstream movement are poorly understood but increases in flow and density-dependent factors have been suggested (Groot and Margolis 1991).In the Columbia River, yearling smolts tend to migrate at a faster rate exhibiting a more directed outmigration that is independent of river flows compared to subyearling smolts (Groot and Margolis 1991).

6.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- For adult Chinook salmon, burst swimming ability ranges from 335 to 671 cm/s and prolonged swimming ability ranges from 91 to 335 cm/s (Bell 1991).
- Sambilay (2005, citing Randall et al. 1987) reports burst swimming ability of juvenile Chinook salmon as 3.019 body lengths per second (SL 19.9 cm) and 2.250 body lengths per second (SL 31.5 cm). This equates to 60.1 cm/s and 70.9 cm/s, respectively.
- For juvenile Chinook salmon, several prolonged swimming speeds were reported by Smith and Carpenter (1987, as cited by Furniss et al. 2008): 20.6 cm/s at 10°C (mean FL 4.06 cm), 16.4 cm/s at 7°C (mean FL 3.5 cm), and 14.0 cm/s at 4°C (mean FL 3.95 cm).

6.4. Other Passage Considerations

- Bates and Whiley (2000) summarize various design considerations for Chinook salmon passage:
    - Variable results observed when artificial light provided at fishway entrances; flexibility in the intensity of light should allow for adjustment based on changing conditions.
    - Unlike pink and chum salmon, adult Chinook will exhibit leaping behavior while moving upstream.
    - Within a fish ladder, early-run Chinook tend to use orifices while late-run Chinook prefer weirs.

7. CHUM SALMON

7.1. Fish Size

7.1.1. Adults

- Adult chum salmon captured at the Curry fishwheel in 2012 ranged in FL from 52 to 77 cm, with an average FL of 67 cm (LGL 2013).

7.1.2. Juveniles

- Chum salmon fry appeared to emerge at sizes of less than 35 mm (Roth and Stratton 1985). During 1984, the average size of outmigrating chum salmon was approximately 40 to 45 mm Roth and Stratton (1985).

7.2. Migratory and Swimming Behavior

- While all juvenile chum salmon in the Susitna River outmigrate as age-0+ and are generally thought to migrate downstream shortly after emergence, some may spend one to three months rearing in freshwater (Jennings 1985).
- In the Middle River, chum fry outmigration was strongly correlated (r = 0.89) with discharge (Roth et al. 1984).
- Adult chum salmon migration rates between Talkeetna Station (RM 103) and Curry Station (RM 120) ranged from 4.5 miles per day in 1981 to 8.5 miles per day in 1984 (Barrett et al. 1984,1985).
- In the Yukon River, autumn run adult chum salmon migrate close to the river banks, exhibiting a preference for left vs. right banks depending on the tributary stock to which they belong (Buklis 1981, Buklis and Barton 1984; as cited by Groot and Margolis 1991).

7.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- Smith and Carpenter (1987; as cited by Furniss 2008) reported prolonged swimming speeds of juvenile chum salmon (mean FL of 3.8 to 3.9 cm) ranging from 12.9 cm/s at 4°C to 18.1 cm/s at 10°C.
- For adult chum salmon, a prolonged swimming speed of 158 cm/s was reported for fish with a mean length of 76.2 cm (Aaserude and Orsborn 1986 as cited by Furniss 2008).
- Hunter and Mayor (1986 as cited by Furniss 2008) provide the following equation for prolonged chum salmon swimming speeds based on increased velocity tests:

$$V=93.59\ TL^{1.89} \quad V(m/s);\ TL(m)$$

- A burst swimming speed of 244 cm/s for chum salmon with a mean TL of 76.2 cm was reported by Powers and Orsborn (1985; as cited by Furniss 2008).

7.4. Other Passage Considerations

- While relatively large-bodied and strong swimmers, adult chum salmon are not leapers and are generally reluctant to enter long fish ladders; they are typically found below the first major barrier within a river (Groot and Margolis 1991).
- Small plunging drops of less than a foot can be a barrier for adult chum salmon, while they can easily negotiate a steep four-foot high chute (Bates and Whiley 2000).

8. COHO SALMON

8.1. Fish Size

8.1.1. Adults

- Adult coho salmon captured at the Curry fishwheel in 2012 ranged in FL from 35 to 69 cm, with an average FL of 55 cm (LGL 2013).

8.1.2. Juveniles

- Coho young of year range from about 35 mm to 75 mm.
- Coho Age 1+ range from about 65 mm to 115 mm.
- During 1985 Age 2+ coho salmon averaged 132 mm with a range of 109 mm to 174 mm (Roth et al. 1986).

8.2. Migratory and Swimming Behavior

- Juvenile coho salmon in the Middle River exhibit a pattern of downstream movement throughout the summer which includes some juvenile coho of all age classess (age 0+, 1+, 2+; Jennings 1985).
- The timing of adult upstream migration may be influenced by river discharge based on reduced fishwheel catches at Sunshine Station when flows reached 100,000 cfs or more Jennings 1985).
- Adult coho salmon migration rates between Talkeetna Station (RM 103) and Curry Station (RM 120) ranged from 2.8 miles per day in 1984 to 11.3 miles per day in 1981 (Barrett et al. 1984,1985).

8.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- For juvenile coho salmon, Bell (1991) reports a range of prolonged (sustained) swimming speeds by length class:

5-cm Length = 15 to 37 cm/s

9-cm Length = 30 to 52 cm/s

12-cm Length = 40 to 64 cm/s

- Smith and Carpenter (1987; as cited by Furniss 2008) reported prolonged swimming speeds of juvenile coho salmon (mean FL of 3.4 cm) ranging from 13.1 cm/s at 7°C to 15.3 cm/s at 10°C.
- For adult coho salmon, a prolonged swimming speed of 96.9 cm/s was reported for fish with a mean length of 59.5 cm (Lee et al. 2003 as cited by Furniss 2008).
- Hunter and Mayor (1986 as cited by Furniss 2008) provide the following equations for prolonged coho salmon swimming speeds based on increased velocity tests at different temperature ranges:

8 to 12°C *V=3.02 TL^0.52 t^-0.1 V(m/s); TL(m); t(s)*

13 to 15°C *V=5.67 TL^0.70 t^-0.1 V(m/s); TL(m); t(s)*

18 to 20°C *V=5.87 TL^0.70 t^-0.1 V(m/s); TL(m); t(s)*

- For adult coho salmon, Bell (1991) reports a range of prolonged (sustained) swimming speeds of 122 to 335 cm/s.
- For adult coho salmon, Bell (1991) reports a range of burst (darting) swimming speeds of 335 to 640 cm/s.
- A burst swimming speed of 420.6 cm/s for coho salmon with a mean TL of 58.3 cm was reported by Weaver (1963; as cited by Furniss 2008).

8.4. Other Passage Considerations

- Adults can exhibit vertical leaps in excess of 2 meters (Groot and Margolis).
- In general, adult coho salmon tend to migrate upstream during daylight hours (Groot and Margolis 1991).

9. DOLLY VARDEN

9.1. Fish Size

9.1.1. Adults

- Maximum size of Dolly Varden captured during 1981 and 1982 was 205 mm.
- Maturity reached as early as age-4 for the southern form of Dolly Varden (i.e., south of the Alaska Range; Morrow 1980). However, because length-at-age information is unavailable for Dolly Varden in the Upper River, the minimum size at which Dolly Varden would be expected to exhibit any pre-spawning migrations cannot be predicted. However, the length-frequency information is shown in Information Item B5 (Figure B5-4).

9.1.2. Juveniles

- Little is known regarding the movement patterns of juvenile Dolly Varden. Likewise, length-at-age information from the Upper River is lacking. Thus, it is difficult to predict the size at which any movements associated with the juvenile life stage would occur. However, the length-frequency information shown in Information Item B5 (Figure B5-4) provides some indication of size distribution in the Upper River.

9.2. Migratory and Swimming Behavior

- A preliminary review indicates that information regarding movement patterns in tailrace or forebay areas of hydroelectric facilities is lacking.

9.3. Swimming Ability

- While not reported, presumably exhibit subcarangiform swimming mode.
- Although information is unavailable regarding Dolly Varden *(Salvelinus malma)* swimming ability, other studies have examined swimming ability of the closely related bull trout *(Salvelinus confluentus)* and arctic char *(Salvelinus alpinus)*.
- Length-specific critical (i.e. prolonged) swimming speeds provided for bull trout in Figure B6-1 (from Zydlewski et al. 2004).
- Beamish (1980 as cited by Furniss 2008) reports burst swimming speeds ranging from 109 cm/s (at 10°C) to 133 cm/s (at 12°C) for arctic char (mean TL 340 mm).

9.4. Other Passage Considerations

- Although examples of Dolly Varden use of passage facilities are limited, several passage facilities designed for or utilized by bull trout have been constructed, with varying degrees of success.

10. HUMPBACK WHITEFISH

10.1. Fish Size

- Only three humpback whitefish have been captured upstream of Devils Canyon; these ranged in size from 231 to 347 mm.
- The size of juvenile humpback whitefish in the Upper River is unknown.

10.2. Migratory and Swimming Behavior

- A preliminary review indicates that information regarding movement patterns in tailrace or forebay areas of hydroelectric facilities is lacking.

10.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- Length-specific critical (i.e. prolonged) swimming speeds for humpback whitefish (reported as *Coregonus clupeaformis*) provided in Figure B6-1 (from Jones et al. 1974).
- Burst swimming ability of 91.4 to 122 cm/s for fish 15.2 to 45.7 cm in length (Bell 1991 as cited by Furniss 2008).

10.4. Other Passage Considerations

- Limited information regarding humpback use of passage facilities, though Katapodis (1992) lists adults of this species as showing some use of Denil, vertical slot, weir or culvert fishways.

11. LONGNOSE SUCKER

11.1. Fish Size

11.1.1. Adults

- Maximum length of fish sampled upstream of Devils Canyon was 495-mm during 1982, 505-mm during 1981, and 404-mm during 2012 (See Information Item B5).
- Maturity may be reached as early as age-5 or age-6 in northern populations (Delaney et al. 1981), which corresponds to a size of approximately 325-mm in the Upper Susitna (see Information Item B5, Figure B5-5).

11.1.2. Juveniles

- Some evidence of downstream movement of age-0 juveniles (See Information Item B3) though subsequent movement of juveniles is unknown.
- Thus, the size range of juveniles potentially exhibiting migratory behavior is unknown.

11.2. Migratory and Swimming Behavior

- A preliminary review indicates that information regarding movement patterns in tailrace or forebay areas of hydroelectric facilities is lacking.

11.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- Burst swimming ability of 121 to 242 cm/s for fish 10 to 46 cm in length (Bell 1991 as cited by Furniss 2008).
- Length-specific critical (i.e. prolonged) swimming speeds provided in Figure B6-1 (from Jones et al. 1974).

11.4. Other Passage Considerations

- Longnose sucker documented passing vertical slot and Denil fishways, though performance was better in vertical slot (Schwalme et al. 1985).
- Afternoon and evening peaks in fishway use (Schwalme et al. 1985, Thiem et al. 2012).

12. RAINBOW TROUT / STEELHEAD

12.1. Fish Size

- Rainbow trout in Alaska mature as early as age-3+. The length range of age 3+ rainbow trout captured in the Middle River during 1981-1983 was 16 to 62 cm (Delaney et al. 1981, Schmidt et al. 1983, 1984).
- The length of age-1+ and age 2+ rainbow trout captured in the Middle River ranged from roughly 8 to 22 cm (Delaney et al. 1981, Schmidt et al. 1983, 1984).

12.2. Migratory and Swimming Behavior

- Adult spawning migrations from main channel holding areas to spawning tributaries are thought to begin in March prior to ice breakup and continue through early June (Schmidt et al. 1983, Suchanek et al. 1984, Sundet 1986).
- After spawning, adults primarily hold and feed during the open water period in tributary and tributary mouth habitats, though some utilization of clear side slough habitat was observed during the 1980s (Schmidt et al. 1983).
- Adult rainbow trout migrated from tributary habitats during late August and September, such that many individuals had moved to tributary mouths by mid-September and few remained in tributaries by early October (Suchanek et al. 1984, Sundet and Wenger 1984, Sundet and Pechek 1985).
- By December, most adult rainbow trout were in main channel areas apart from spawning tributaries (Sundet and Wenger 1984). Movements to winter holding habitats were commonly in a downstream direction from spawning or feeding tributaries (Sundet and Pechek 1985).
- Juvenile rainbow trout primarily reside in natal tributary habitats throughout the year, though occasional use of tributary mouths and clear sloughs has been documented (Schmidt et al. 1983).

12.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- Prolonged swimming speeds for rainbow trout compiled by Furniss (2008) ranged from 66 cm/s (mean length of 11 cm; Jones 1971) to 80 cm/s (mean length of 17 cm; Tsukamoto 1975).

- Hunter and Mayor (1986; as cited by Furniss 2008) provide the following equation for rainbow trout burst swimming speeds based on a TL range of 10 to 28 cm :

$$V=7.16\ TL^{0.77}\ t^{-0.46} \quad V(m/s);\ TL(m);\ t(s)$$

- For adult steelhead, Bell (1991) provides reports prolonged (sustained) swimming speeds of 152 to 457 cm/s and burst (darting) speeds of 457 to 823 cm/s.

13. SOCKEYE SALMON

13.1. Fish Size

13.1.1. Adults

- Adult sockeye salmon captured at the Curry fishwheel in 2012 ranged in FL from 32 to 72 cm, with an average FL of 54 cm (LGL 2013).

13.1.2. Juveniles

- Sockeye salmon fry emerged at approximately 32 mm in size (Roth and Stratton 1985). By the end of September sockeye salmon fry are about 55 to 60 mm in length.
- During 1985 Age 1+ sockeye salmon juveniles captured with outmigrant traps at the Talkeetna Station were 11 mm in length shorter on average than Age 1+ sockeye salmon juveniles captured at the Flathorn Station (69 mm compared to 80 mm).

13.2. Migratory and Swimming Behavior

- Due to the lack of suitable rearing lakes in the Middle River, juvenile sockeye either rear in sloughs or leave the Middle River as age-0+ (Jennings 1985). Whether age-0+ sockeye leaving the Middle River go directly to see is unclear, though the survival of such juveniles appears low.
- Adult sockeye salmon migration rates between Talkeetna Station (RM 103) and Curry Station (RM 120) ranged from 2.4 miles per day in 1982 to 8.5 miles per day in 1984 (Barrett et al. 1984,1985; Jennings 1985).
- Based on the relationship between fishwheel counts and river discharge, spikes in discharge over 100,000 cfs at Sunshine Station appear to delay sockeye salmon migration timing (Jennings 1985).

13.3. Swimming Ability

- Exhibit subcarangiform swimming mode (Katapodis 1992).
- Taylor and Foote (1991; as cited by Furniss 2008) reported a prolonged swimming speed for juvenile sockeye salmon (mean FL of 7.8 cm) of 60.1 cm/s.
- Bell (1991) reports a range of prolonged (sustained) swimming speeds for juvenile sockeye (12.7 cm in length) of 58 to 67 cm/s.

- Brett and Glass (1973; as cited by Furniss 2008) provide the following equations for prolonged coho salmon swimming speeds based on increased velocity tests at different temperatures:

2°C	*V=1.499 TL^0.6294 V(m/s); TL(m)*
5°C	*V=1.6 TL^0.6243 V(m/s); TL(m)*
10°C	*V=1.965 TL^0.6294 V(m/s); TL(m)*
15°C	*V=2.5 TL^0.6345 V(m/s); TL(m); t(s)*
20°C	*V=2.3 TL^0.629 V(m/s); TL(m)*

- Lee et al. (2003; as cited by Furniss 2008) reported prolonged swimming speeds for adult sockeye ranging from 90 to 137 cm/s.
- For adult sockeye salmon, Bell (1991) reports a range of prolonged (sustained) swimming speeds of 122 to 335 cm/s.
- For adult sockeye salmon, Bell (1991) reports a range of burst (darting) swimming speeds of 335 to 640 cm/s.

13.4. Other Passage Considerations

- Outmigrating juvenile sockeye generally school and exhibit active rather than passive migration; in most lake systems, increased downstream migration occurs during the darkest hours of the day (Groot and Margolis 1991).
- In pool-type fishways, adult sockeye appear to prefer to pass over weirs as opposed to through orifices (Bates and Whiley 2000).
- Adult sockeye exploit slower velocities and eddies during upstream migration and tend to travel along stream banks (Groot and Margolis 1991).

14. ROUND WHITEFISH

14.1. Fish Size

- Maximum size of round whitefish captured upstream of Devils Canyon was 440 mm during 1981 and 404 mm during 2012 (See Information Item B5).
- Maturity is reached from age-5 to age-7 (Morrow 1980), corresponding to approximately 300 mm (See Information Item B5, Figure B5-6).
- While there is some evidence of juvenile downstream migration, the size distribution, age, and magnitude of movements is unclear.

14.2. Migratory and Swimming Behavior

- While round whitefish are thought to exhibit upstream or downstream migrations from summer feeding habitats to spawning areas, they do not exhibit the concentrated migrations exhibited by other whitefish species in Alaska.

- Little is known regarding migratory behavior associated with winter habitat use.
- Preliminary review indicates that information regarding movement patterns in tailrace or forebay areas of hydroelectric facilities is lacking.

14.3. Swimming Ability

- While not reported, presumably exhibit subcarangiform swimming mode.
- Information regarding the swimming ability of round whitefish *(Prosopium cylindraceum)* is unavailable. However, information for the congeneric mountain whitefish *(Prosopium williamsoni)* is available.
- Burst swimming ability reported for mountain whitefish of 48.8 to 106.7 cm/s for fish with a mean length of 304 mm (Bell 1991 as cited by Furniss 2008).
- Critical (i.e. prolonged) swimming speed for mountain whitefish of 42.5 cm/s for fish with a mean length of 304 mm (Jones et al. 1974 as cited by Furniss 2008).

14.4. Other Passage Considerations

- Preliminary review indicates that information is lacking regarding performance of round whitefish in passage facilities, migratory cues, and behavior associated with passage.

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16. FIGURES

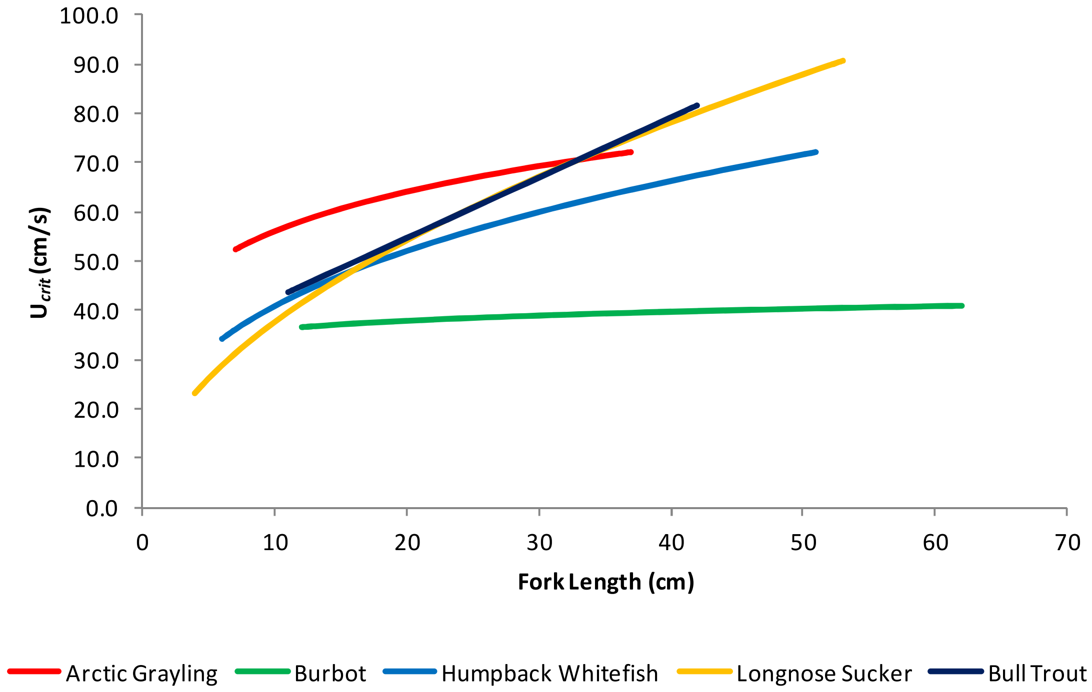

Figure B6-1. Relationship between fork length and critical swimming speeds (U_{crit}) of arctic grayling, burbot, humpback whitefish, and longnose sucker (Jones et al. 1974) and bull trout (Mesa et al. 2004) as a congeneric surrogate for Dolly Varden.

INFORMATION ITEM B8. LOCATION OF SPAWNING AND REARING HABITATS

1. INTRODUCTION

This information item provides information on the location of spawning and rearing habitat for target fish species anticipated to potentially need passage at Watana Dam. The target species identified in Information Item B1 include Arctic grayling, burbot, Chinook salmon, Dolly Varden, humpback whitefish, longnose sucker, and round whitefish. With the exception of Chinook salmon, specific spawning locations for target species in the Susitna River basin and its tributaries are poorly understood. However, some generic information about the type of habitat utilized for spawning is available for the resident fish species. Similarly, there is some general information about juvenile and adult habitat utilization by the resident fish species. Some specific resident fish rearing location information is available from surveys investigating their distribution and relative abundance. Additional information related to migration routes can be found in Information Item B4 (Migratory Characteristics). Information provided in Information Item B7 (Fish Relative Abundance) also provides information on specific rearing locations where fish were collected.

2. ARCTIC GRAYLING

- Spawning
  - 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 Rearing
  - 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. 1981, 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). Although winter use of mainstem habitat is poorly understood, some evidence main channel overwintering exists (Sundet 1986).
- Juvenile Rearing
  - 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. ARCTIC LAMPREY

- Spawning

- Spawning sites are believed to include tributary mouths and sloughs (e.g., Whiskers Creek and Slough, Birch Creek, and Gash Creek) based upon the capture of ammoceotes. Spawning occurs from late to early July (Scott and Crossman 1973) and observations of spawning lamprey occurred during late June at Birch Creek and Slough (Schmidt et al. 1983).
- Spawning occurs in nests dug in small gravel substrate with low to moderate flow.

- Adult Rearing
  - Arctic lamprey may be anadromous or freshwater. Based upon size (<180 mm), Schmidt et al. (1983) and Sundet and Pechek (1985) believed that most Arctic lamprey in the Susitna River are the freshwater form and anadromous Arctic lamprey primarily spawn downstream of RM 40.6.
- Juvenile Rearing
  - Ammoceotes rear in silty substrate for up to four years then migrate to the ocean, lakes, or larger rivers following metamorphosis (Delaney et al. 1981).

4. BERING CISCO

- Spawning
  - Identifying specific spawning locations for Bering cisco is difficult because of the onset of winter conditions during the spawning period (mid-October).
  - Spawning occurs in clear water tributaries (Morrow 1980). Spawning substrates range from silt to cobble, but mostly 1- to 3- inch gravel and cobble while velocities ranged from 0.5 to 5.8 fps (Delaney et al. 1981).
  - Nine ripe females were observed between RM 76.8 and 77.8 during 1982. Relatively high numbers were also observed near RM 81.2, but use of the area as a spawning site could not be confirmed.
- Adult Rearing
  - Arctic lamprey may be anadromous or freshwater. Based upon size (<180 mm), Schmidt et al. (1983) and Sundet and Pechek (1985) believed that most Arctic lamprey in the Susitna River are the freshwater form and anadromous Arctic lamprey primarily spawn downstream of RM 40.6.
- Juvenile Rearing
  - Freshwater rearing habitat is unknown. Overwintering is assumed to be in brackish waters (Morrow 1980).

5. BURBOT

- Spawning
  - Burbot spawn from mid-January to early April. (Jennings et al. 1985)

- — Specific locations of burbot spawning in the Middle and Upper River have not been identified (Jennings et al. 1985); however, some spawning is known to occur in the Middle River because larvae have been collected upstream of Talkeetna (Schmidt and Bingham 1983).
- — Schmidt et al. (1983) and Sundet and Wenger (1984) suggested that tributary mouths, slough mouths, and mainstem areas with groundwater upwelling are likely burbot spawning habitat types. In the Susitna River burbot spawning likely occurs under ice-over conditions; however, areas with groundwater upwelling may be conducive to the development of open leads.

- Adult Rearing
  - — Adult burbot rear in turbid mainstem water, avoid clearwater areas, and are widely distributed in the mainstem Susitna River (Schmidt and Bingham 1983)
- Juvenile Rearing
  - — Little is known about the habitat utilization by burbot larvae in the Susitna River. However, during 1982 larvae were collected in silty, low velocity areas near the mouths of sloughs.

6. CHINOOK SALMON

- Spawning
  - — Spawning occurs almost exclusively in tributary streams
  - — During 1982 two Chinook redds were observed in the mixing zone downstream of the mouth of Cheechako Creek (ADF&G (1983). This is the only observation of non-tributary spawning during the 1980s.
  - — Aerial spawning ground surveys conducted in 2012, identified adult Chinook in Kosina Creek (peak daily count n = 16; Figure B8-1). These were the only adult Chinook identified in the Upper River during the 2012 aerial spawning ground surveys (HDR 2013).
- Juvenile Rearing
  - — Rearing primarily occurs in tributaries, tributary mouths, side channels, side sloughs, and upland sloughs (Figure B8-2).
  - — Main channel habitat is used as a migratory corridor. The amount of extended rearing in the main channel, if any, is unknown.

7. CHUM SALMON

- Spawning
  - — Adults spawn in tributaries, side channels, and side sloughs.

- Indian River and Portage Creek account for the majority tributary spawning in the Middle Susitna River while Sloughs 11, 8A, and 21 account for the majority of slough spawning.

- Juvenile Rearing
  - Rearing primarily occurs in side sloughs and tributaries, with minor utilization of side channels and upland sloughs (Figure B8-3).

8. COHO SALMON

- Spawning
  - Adults spawn primarily in tributary streams with occasional use of mainstem channels and sloughs.
  - Whiskers Creek, Indian River and Chase Creek (RM 106.9) account for the majority of the tributary spawning in the Middle Susitna River.
- Juvenile Rearing
  - Rearing primarily occurs in tributaries and upland sloughs, with some utilization of side sloughs and side channels (Figure B8-4).
  - Main channel habitat is used as a migratory corridor. The amount of extended rearing in the main channel, if any, is unknown.

9. DOLLY VARDEN

Schmidt et al (1983) and Sundet and Wegner (1984) suggested Dolly Varden primarily spawn and rear in the upper extents of tributary streams, but some rearing may occur at tributary mouths. Schmidt and Bingham (1983) suggested Dolly Varden move downstream in tributaries in the fall and upstream during the spring. Overwintering habitat for Dolly Varden is poorly understood for the Susitna River.

10. HUMPBACK WHITEFISH

Sundet and Wegner reported there are anadromous and resident stocks of humpback whitefish. Anadromous whitefish overwinter in the estuary. Sundet and Wegner (1984) also suggested humpback whitefish spawn in tributaries, but specific spawning locations were unknown. Adult humpback whitefish primarily rear at mouths of sloughs and tributaries and use the mainstem as a migration corridor (Jennings 1985).

11. LONGNOSE SUCKER

Based upon ADF&G reports from 1983 and 1984 *(*Schmidt et al. 1983, Sundet and Wenger 1984) Jennings (1985) summarized the following: "*In the Talkeetna-to-Devil Canyon reach (RM*

98.6-152), longnose suckers are primarily associated with tributary and slough mouths, although the mainstem is also used throughout the open-water season. The major overwintering and juvenile rearing areas of this species are unknown. The mouths of Trapper Creek (RM 91.5) and Sunshine Creek and side channel (RM 85.7) are known spawning areas."

12. RAINBOW TROUT / STEELHEAD

- Spawning
  - Spawning occurs in clear water tributary streams including Fourth of July Creek and Portage Creek in the middle River.
- Juvenile Rearing
  - In Fourth of July Creek and Portage Creek, rearing occurs primarily in lakes (Sundet and Pechek 1985).
- Adults
  - Many larger juveniles and adults move to areas with chum and pink salmon spawning during late summer to forage for eggs.
  - Overwintering occurs primarily in the mainstem Susitna River, but little information is available regarding habitat characteristics, except that some areas appear to be associated with open leads with moderate water velocities influenced by ground water inflow (Sundet and Pechek 1985).

13. ROUND WHITEFISH

Based upon ADF&G reports from 1983 and 1984 (Schmidt et al. 1983, Sundet and Wenger 1984), Jennings (1985) summarized the following: *"Round whitefish were found in tributaries and sloughs more often than mainstem areas in 1982 and 1983. The mainstem is used for some spawning and juvenile rearing, and as a migrational corridor….. This species spawns in the mainstem and at tributary mouths in October. During 1981 through 1983, nine spawning areas were identified upstream of Talkeetna. Mainstem sites were: RM 100.8, 102.0, 102.6, 114.0, 142.0 and 147.0. Round white fish may also spawn in tributaries, such as Indian River and Portage Creek. Juvenile round whitefish rear mainly in the mainstem and sloughs. Slow velocities and turbid water are apparently preferred. Overwintering areas of round whitefish have not been identified."*

14. SOCKEYE SALMON

- Spawning
  - Adults spawn in tributaries, side channels, and side sloughs.
  - Sloughs 11, 8A, and 21 account for the majority of spawning in the Middle Susitna River.

- Juvenile Rearing
  - Rearing primarily occurs in upland sloughs and side sloughs, with minor utilization of side channels and tributaries (Figure B8-5).

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16. FIGURES

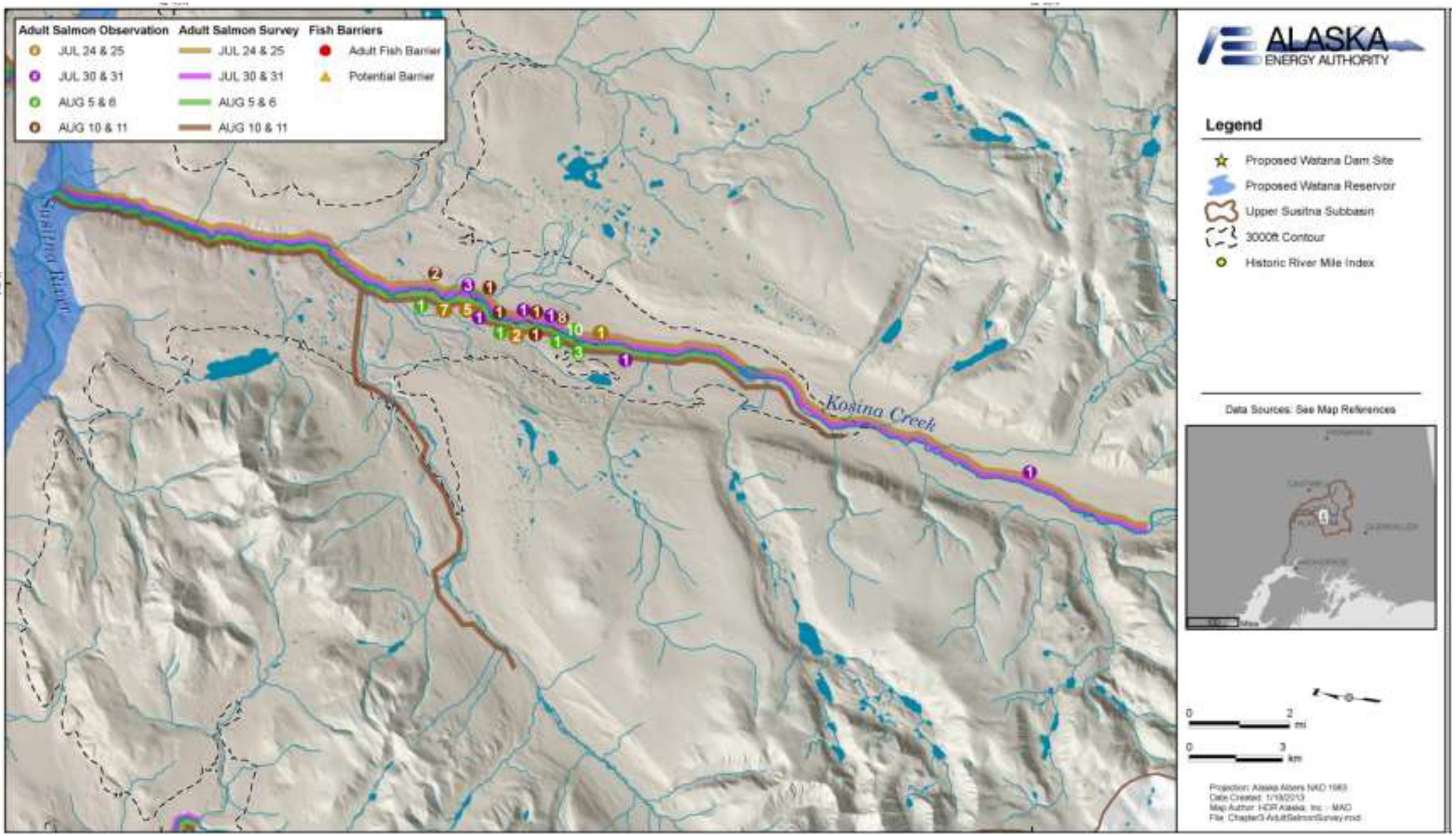

Figure B8-1. Adult Chinook salmon counts in Kosina Creek for all 2012 survey dates. Source: HDR (2013).

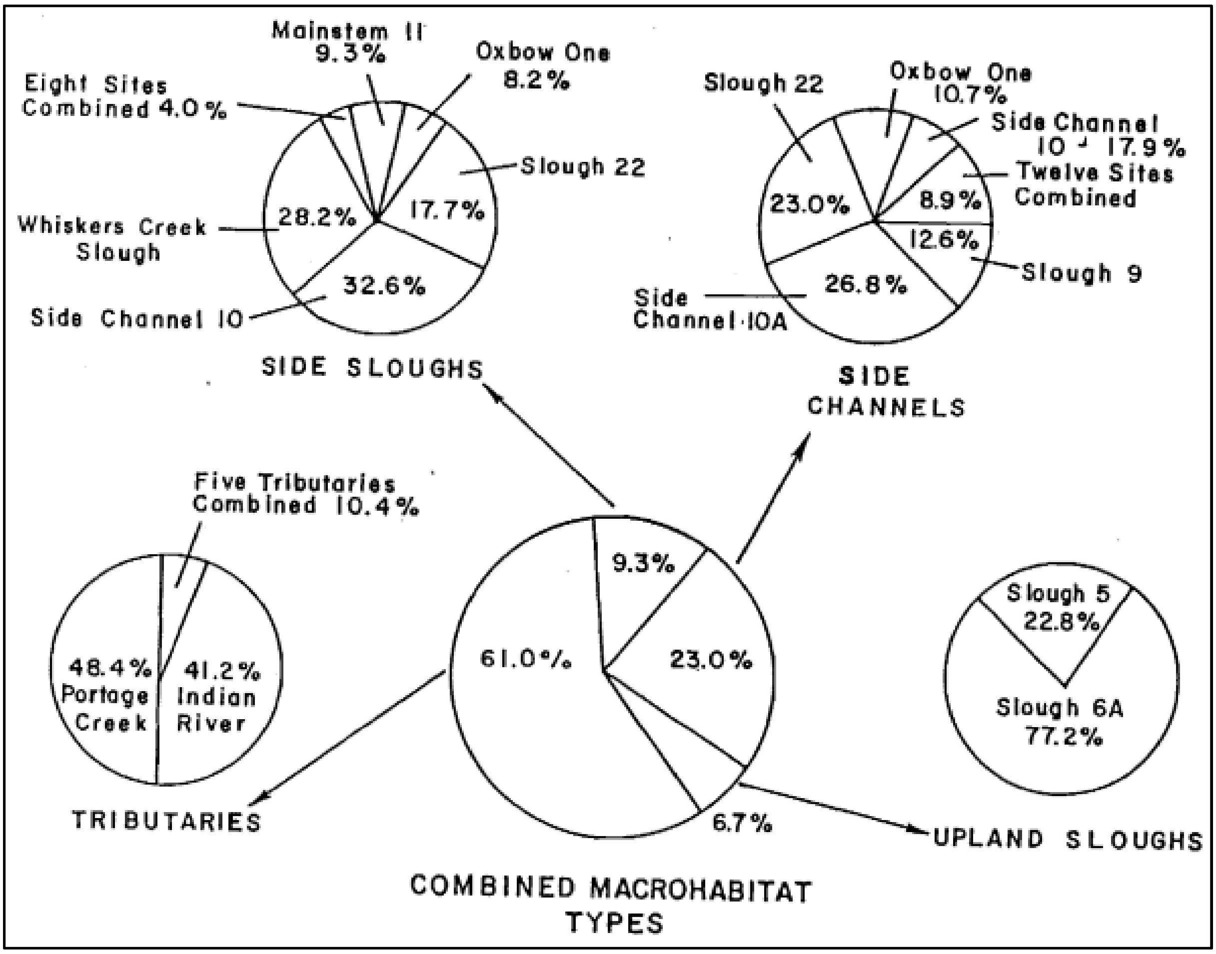

Figure B8-2. Density distribution and juvenile Chinook salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

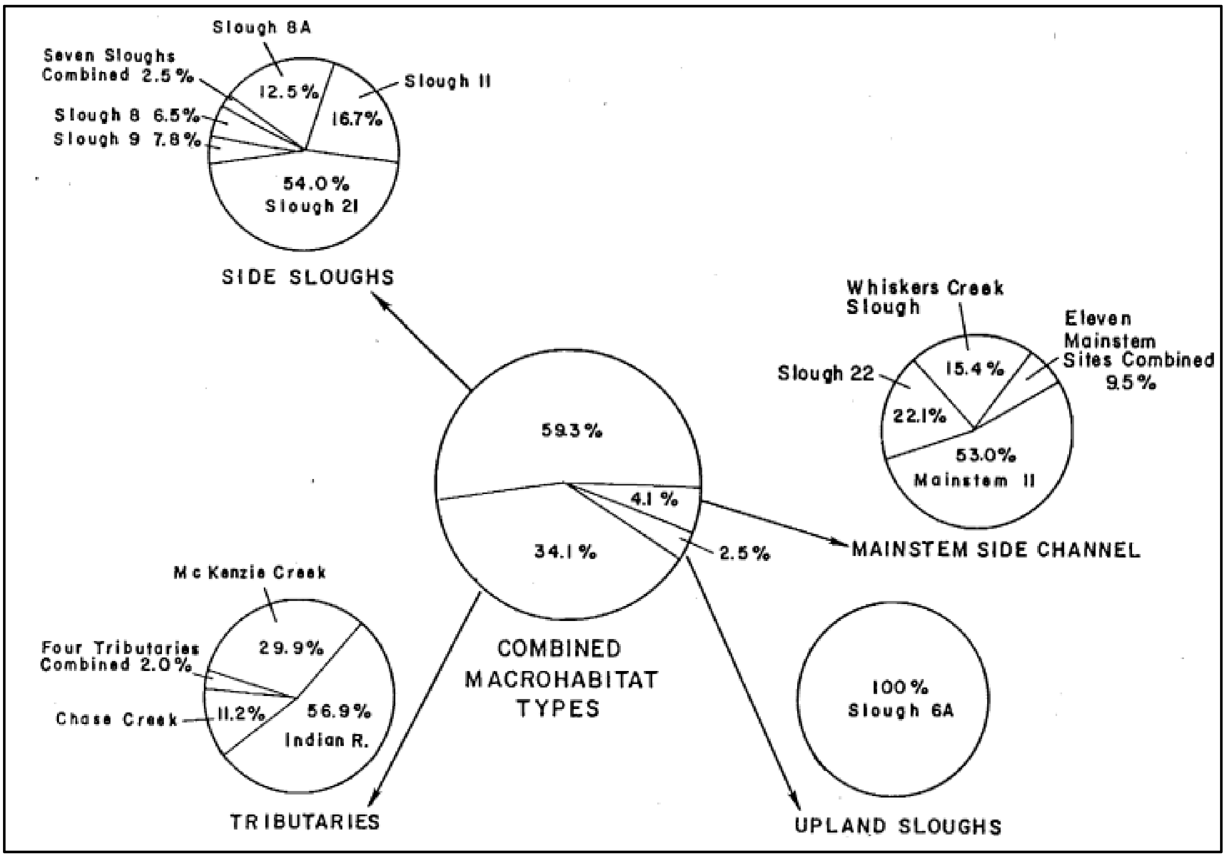

Figure B8-3. Density distribution and juvenile chum salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

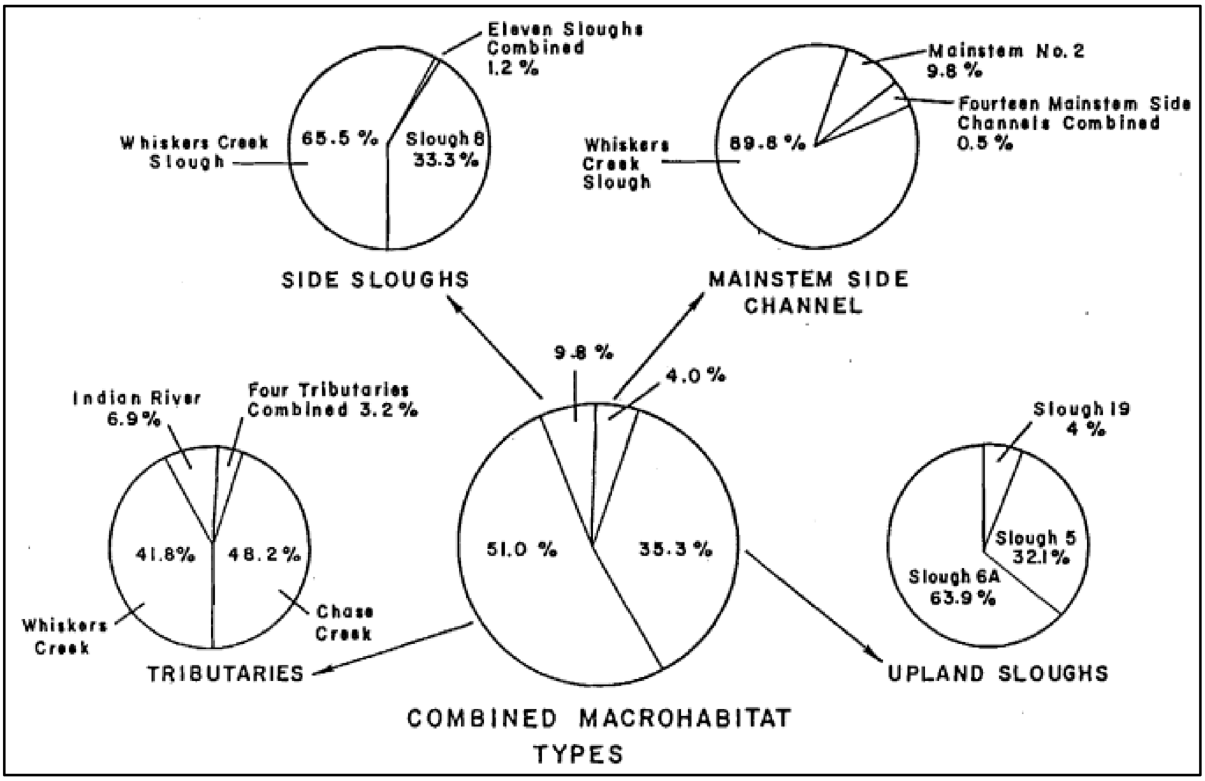

Figure B8-4. Density distribution and juvenile coho salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

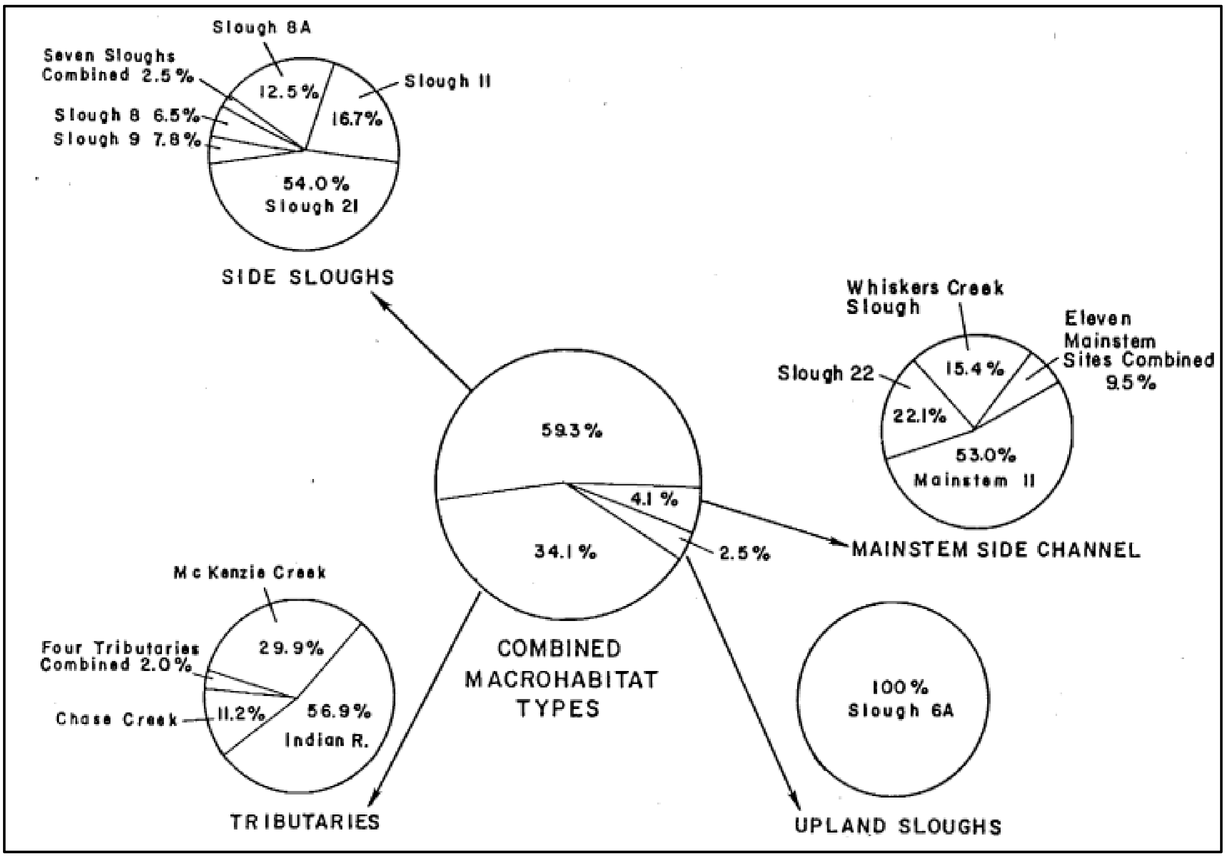

Figure B8-5. Density distribution and juvenile chum salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

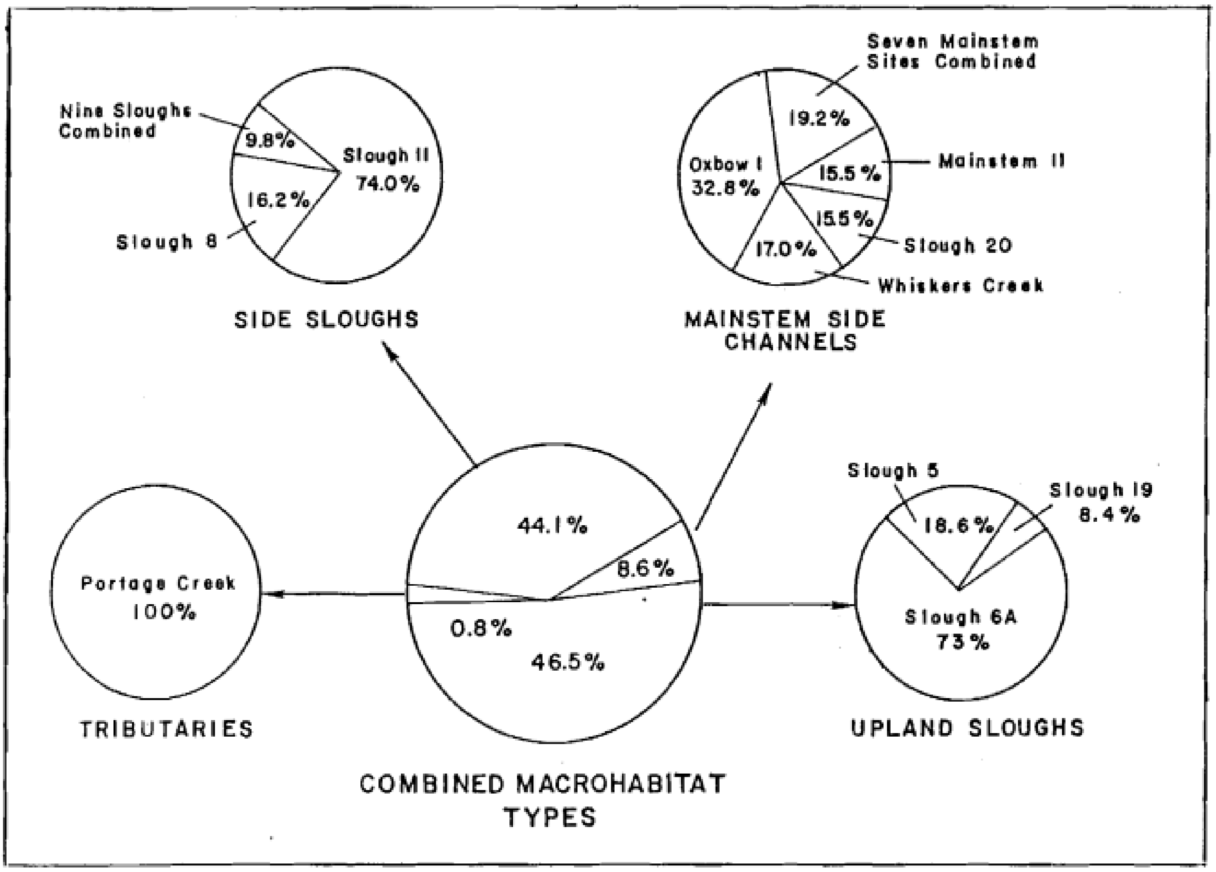

Figure B8-4. Density distribution and juvenile sockeye salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

INFORMATION ITEM B9. PREDATION

1. PREDATION

Several fish species in Alaska, in particular anadromous salmon provide valuable food resources for a variety of aquatic and terrestrial vertebrates. Cederholm et al. (2000) reported that 130 species of terrestrial vertebrates native to Pacific Northwest benefit (or historically benefited) from salmon and 80 of these species regularly utilize salmon. Salmon are consumed by a wide variety of aquatic and terrestrial wildlife including fishes, amphibians, reptiles, waterfowl, gulls, corvids, raptors, rodents, mustelids, canids, and ursids, pinnipeds, and cetaceans (Hilderbrand et al. 2004). The large and concentrated numbers of prey available during downstream and upstream migrations of salmon make these events attractive to many of the predatory species listed above.

Dams, spillways, regulating outlets, and fish passage facilities may increase susceptibility to predation by concentrating and constricting migratory fish, causing fatigue from migration delay, disorientation or injury during passage, or by other means. Focused predation efforts are often evident on migratory fish upstream and downstream of dams when fish are delayed and/or concentrated and the dam forebay and tailrace habitats offer suitable habitat for predatory species. Migrating species may suffer increased susceptibility to predation in the vicinity of an installation as a consequence of operations or passage conditions, for example if fish becoming trapped in turbulence or recirculating eddies or after passage through or spill over a dam if fish are injured, stressed or disoriented.

In addition, as a consequence of altering a stream to create a reservoir, the fish community can be impacted resulting in the expansion and growth of some populations and the decline of others. Often the fish species that can best adapt and thrive in the comparatively slow moving and deep lacusterine environment of a reservoir are different from those that inhabit swift moving riverine environments and frequently are non-native. The results for fish that have evolved migrating through a riverine system can be substantial.

In the extensively studied Columbia River, stress associated with passage through the mainstem dams has made smolts more vulnerable to piscine predators in the immediate vicinity of the dams (Rieman et al. 1991, Mesa 1994, Mesa and Warren 1997). Piscivorous fishes consume large numbers of juvenile salmonids in the Columbia River basin. Annually, an estimated 16 million juvenile salmonids were consumed throughout the basin by a native fish predator, northern pikeminnow (*Ptychocheilus oregonensis*), in the early 1990s (Ward et al. 1995; Beamesderfer et al. 1996). This consumption estimate led to large scale management activities, such as the establishment of bounty fisheries to reduce the number of predatory-sized pikeminnow and reconfiguration of dam outflows to reduce predation rates.

Predation by piscivorous birds on migrating juvenile salmonids may represent a large source of predation mortality. In the Columbia River, piscivorous birds aggregate below hydroelectric dams in the spring to feed on outmigrating fish (Ruggerone 1986). Juvenile salmonids are especially vulnerable to birds and other predators directly below dams because of the disorienting effect of passage and upwelling waters that carries fish close to the surface. Predation on juvenile salmonids during out-migration to the Pacific Ocean is considered a limiting factor in the recovery of Columbia River basin salmonid populations (NMFS 2008a). Studies of avian predation in the Columbia River basin have focused on colonial waterbirds that nest in the estuary, which currently hosts the largest known colonies of Caspian terns *Hydroprogne caspia* and double-crested cormorants *Phalacrocorax auritus* in western North America (Evans et al. 2012; Lyons et al. 2010).

Research by Evans et al. (2012) indicates that avian predation on outmigrant salmonids can vary by bird and salmonid species. Of the eight salmonid ESUs evaluated, minimum predation rates were highest steelhead, with an estimated 14-16% consumed by terns and cormorants. Among avian predators in the estuary, predation on steelhead was significantly higher from terns (9.7–10.7%) than from cormorants (3.1–5.5%). Of the four Chinook salmon ESUs evaluated, minimum predation rates by terns and cormorants in the estuary varied from 2.5-4.6%. Terns and cormorants in the estuary consumed between 0.9% and 2.4% of available Chinook salmon, which suggests that Chinook salmon ESUs exhibited similar susceptibility to predation. The combined minimum predation rate on Snake River sockeye salmon by terns and cormorants in the estuary was estimated at 3.0%; the predation rate on sockeye salmon was higher for cormorants (2.1%) than for terns (0.9%;).

The following additional factors to consider affect fish predation are taken from Bell (1990).

- Unusual congregations of fish, which could result from screens, diversions, bypasses, other obstructions, or large numbers of fish being released at a given location, can lead to increased predation from aquatic, avian, and terrestrial predators.
- Delayed migration, which can result from obstructions and/or disorientation associated with releases, may increase predation.
- Small or juvenile fish concentrated in shallow ponded areas may be particularly vulnerable to predation from certain avian species, such as mergansers, kingfishers, gulls, and blue herons.
- Downstream migrants that have been stressed and/or injured as a result of fish capture and/or handling are more vulnerable to predation.
- Turbid water conditions offer a measure of protection to smaller fish species and life stages by reducing their visibility to aquatic and avian predators.
- Shadowed pathways may be used advantageously by aquatic predators.
- Aquatic predators may utilize sheltered low-velocity areas to attack small fish moving in an active current, such as those associated with the bypasses and collection areas.

2. SUSITNA RIVER FISH PREDATORS

Potential piscivorous fish species in the Study Area include: Arctic grayling, burbot, Dolly Varden, lake trout, northern pike, and rainbow trout (Table B9-1).

2.1. Arctic Grayling

Grayling typically feed on a variety of aquatic and terrestrial invertebrates in the water column or air-water interface (Armstrong 1986). Adult arctic grayling are sight feeders, which consume a wide array of food items primarily in drift. As adults they depend heavily on benthic and terrestrial insects in stream drift but have been observed to feed opportunistically on fish eggs, small fish, and small mammals (Armstrong 1986; Bishop 1967; Moore and Kenagy 2004; Stewart et al. 2007). Arctic grayling have been found to feed on their own eggs and the eggs of salmon, and small fish including ninespine stickleback and sockeye salmon fry (Warner 1958; Williams 1969; Northcote 1993).

Arctic Grayling are distributed throughout the entire Susitna River Basin, including the following tributaries: Oshetna River (HRM 233.4), Kosina Creek (HRM 206.8), Portage Creek (HRM 148.9), Indian River (HRM 138.6), Montana Creek (HRM 77.0), Kashwitna River (HRM 61.0) and Deshka River (HRM 40.6) (Delaney et al. 1981a, Delaney et al. 1981b, Sundet and Pechek 1985). In the Middle Susitna River, Arctic grayling primarily use mainstem habitats for overwintering and tributaries for spawning and rearing (Schmidt et al. 1983, Schmidt et al. 1984). Upstream of Talkeetna, Arctic grayling move into tributaries to spawn in May and early June (Schmidt et al. 1983, Schmidt et al. 1984). Based on 1980s mark-recapture data, estimated Arctic grayling abundance was higher in the Upper Susitna River relative to the Middle and Lower segments; although, comparable abundance data are limited (Delaney et al. 1981a, Delaney et al. 1981b, Schmidt et al. 1983). Estimated abundance of grayling greater than 200 mm fork length in the Upper Segment was 10,279 (95% confidence interval: 9,194 – 11,654) based on 1981 mark-recapture data, and was 6,783 (95% confidence interval: 4,070 – 15,152) in the Middle Segment based on 1981-1984 data (Delaney et al. 1981b, Sundet and Pechek 1985).

2.2. Burbot

Adult burbot are typically described as piscivores, although the diet can include invertebrates (insects, iso-pods, leeches and crayfish). Numerous studies reviewed by Polacek et al. (2006) indicate that the diet of adult fish is comprised from 38-100% fish. Fish prey made up 75% of the diet in Great Slave Lake (Rawson 1951) and by age-4 fish dominated the diet of burbot in upper Yukon and Tanana River drainages, Alaska (Chen 1969). Common prey items can include ciscoes, sticklebacks, whitefish, etc., as available (McPhail and Lindsey 1970). During the winter, large burbot may shift their diets to include more benthic macroinvertebrates.

Burbot occur throughout the lower, middle, and upper Susitna River basin (Delaney et al. 1981a, Delaney 1981b, Schmidt et al. 1983). Burbot were documented in 8 tributaries in the Upper Susitna River with Jay Creek and Watana Creek supporting the highest abundances (Delaney 1981a). In the mainstem Susitna River, the mouth of the Deshka River (HRM 40.5) is a known spawning area (Schmidt et al. 1983). Burbot spawning also occurs in the Deshka River and likely in the Alexander River (Sundet and Pechek 1985).

Based on studies from the 1980s, burbot appear to be more abundant downstream from the Chulitna River confluence (HRM 98.6) (Sundet and Wenger 1984). In 1983, 15 burbot were estimated to occur between RM 138.9 and140.1 (Sundet and Wenger 1984). This abundance estimate should be viewed as an approximation because few fish were caught during this study (Sundet and Wenger 1984). During the 1983 sampling efforts, 163 burbot were caught in the Middle Segment of the Susitna River between the Chulitna confluence and Devils Canyon (Sundet and Wenger 1984).

2.3. Dolly Varden

Dolly Varden feed on fish eggs, small fishes and benthic organisms including molluscs, mysids, amphipods, chironomids, plecopterans and other insect larvae and crustaceans (Palmisano and Helm

1971; Stevens and Deschermeier 1986). As Dolly Varden grow and mature, feeding activity decreases and aquatic insects became less important in the diet while crustaceans and fish became more important (Palmisano and Helm 1971). Adult fish incorporate juvenile salmon in the diet (Roos 1959).

Dolly Varden occur in the Susitna River Basin upstream to at least the Oshetna River (Delaney et al. 1981a, Sautner and Stratton 1983). In the Talkeetna-to-Devils Canyon reach, Dolly Varden are found primarily in the upper reaches of tributaries and at tributary mouths (Schmidt et al. 1983, Sundet and Wenger 1984) but also in the mainstem for overwintering (Sundet and Wenger 1984). Spawning and juvenile rearing areas are suspected to be in tributaries (Schmidt et al. 1983). Dolly Varden have been documented in the Upper Susitna River including Lake Louise, the mouth of Fog Creek and within Cheechako, Devil, Watana, Jay, and Deadman creeks (Delaney et al. 1981a, Sautner and Stratton 1983). During June to September 1981, sampling in the Cook Inlet to Talkeetna reach collected Dolly Varden at 52 percent of the habitat locations sampled (Delaney et al. 1981b). Based on two-week sampling periods, the presence of Dolly Varden during sampling efforts ranged from 8 to 20 percent of habitat locations sampled. Dolly Varden were captured most consistently in tributary stream mouth habitat locations, with the highest catches occurring at the mouth of Portage Creek (R.M. 148.8) in early June. Sampling conducted in 1982 captured Dolly Varden at only nine (53%) of the 17 Designated Fish Habitat (DFH) sites (Schmidt et al. 1983). Total Dolly Varden catch was greatest at the Lane Creek and Slough 8 site (n=8); however, only 28 were capture at all DFH sites combined. The population size of Dolly Varden in the Talkeetna-to-Devils Canyon reach appears to be low; they are apparently more abundant downstream from the Chulitna River confluence (RM 98.6) (Schmidt et al. 1984).

2.4. Lake Trout

Lake trout are opportunistic feeders, food items may include zooplankton, insect larvae, small crustaceans, clams, snails, leeches, fish, small mammal and birds. Adult fish incorporate more fish into the diet and may feed extensively on whitefish, grayling, sticklebacks, sculpin, and juvenile salmon (Redick 1967; Morrow 1980).

Jennings (1985) reported that Lake trout occur in the relative large and deep lakes throughout the Susitna Basin. Occasionally, lake trout can also be found in the inlet or outlet streams of these lakes (Jennings 1985). Lake trout distribution in the Susitna River basin is not well understood, but they have been documented in Beaver, Clarence, Crater, Curtis, Stephens, Louise, Little Louise, and Butte lakes (Burr 1987) as well as Deadman and Sally lakes (Sautner and Stratton 1984). Lake trout have not been captured in the mainstem-influenced areas of the Susitna River below Devils Canyon (Jennings 1985). The most detailed information comes from sampling during 1981 in Deadman Lake and during 1981 and 1982 in Sally Lake, which would have been inundated under the proposed project configuration of the 1980s (Delaney et al. 1981a, Sautner and Stratton 1983).

2.5. Rainbow trout

Rainbow trout are opportunistic predators that feed on a wide variety of prey items, including various insects (e.g., dipteran larvae and adults), plankton, crustaceans, snails, leeches, fish eggs, smaller fishes, and adult salmon carcasses (Morrow 1980, Quinn 2005, Scott and Crossman

1973). As fish grow and mature they incorporate fish, salmon carcasses, eggs, and small mammals into the diet.

Within the Susitna River, rainbow trout populations are found up to and including Portage Creek at RM 148.8 (ADF&G 1983). No rainbow trout have been identified upstream of Devils Canyon in the impoundment zone (FERC 1983). Rainbow trout in the Susitna River are distributed throughout tributary and mainstem areas downstream of Devils Canyon (RM 152; Schmidt et al. 1983). Upstream of the Chulitna River confluence (RM 98.6), Whiskers Creek (RM 104.4), Lane Creek (RM 113.6), Fourth of July Creek (RM 131.1), and Portage Creek are the major spawning areas (Sundet and Wenger 1984, Sundet and Pechek 1985). Primary spawning tributaries in the 1980s were the Talkeetna River (RM 97.2), Montana Creek (RM 77.0), and Kashwitna River (RM 61.0) in the Lower Segment (Sundet and Pechek 1985). Primary holding and feeding locations for rainbow trout were the Fourth of July Creek and Indian River (RM 138.6) tributary mouths, Slough 8A (RM 125.1), and Whiskers Creek Slough (RM 101.2; Schmidt et al. 1983).Data collected in the 1980s indicate that adult rainbow trout are more abundant in the Middle Segment of the Susitna River than in the Lower Segment (Schmidt et al. 1983). Based on a tag-recapture study conducted from 1981 to 1983, the estimated abundance of rainbow trout greater than 150 mm in FL in the Middle Segment was approximately 4,000 fish (Sundet and Wenger 1984). In the Lower River in 1984, a total of 155 rainbow trout were captured using multiple capture methods (Sundet and Wenger 1984). The highest number of rainbow trout captures (i.e., 62 fish) occurred in the Deshka River.

2.6. Northern Pike

Northern pike feed primarily on other fish, including their own species. Prey selection is largely based on availability. In Alaska, major prey items include whitefish, small pike, blackfish, burbot, suckers, dragonflies and damselflies (Morrow 1980). Adults may also consume water fowl, frogs, small mammals, and crayfish (Morrow 1980). Northern pike are known to consume large portions of stocked and migrating juvenile salmonids. In southcentral Alaska, juvenile salmon and trout, particularly coho salmon, sockeye salmon, and rainbow trout, are preferred prey for pike (Rutz 1996, 1999). All five species of pacific salmon, along with Arctic grayling, Arctic char, Dolly Varden, burbot, whitefish, blackfish and threespine stickleback are potential prey items (Rutz 1999).

Northern pike are not native to South-central Alaska. They have been illegally released into lakes and streams on the Kenai Peninsula, the Anchorage area, and in the Matanuska-Susitna valleys, and have spread through connected water bodies (Rutz 1999). Within the Susitna River, Northern Pike have been documented in Lower River tributaries as far upstream as the Deshka River (RM 45). The suspected distribution extends to tributaries up to the Three Rivers (Ivey 2009).There is little information specific to the Susitna River regarding northern pike spawning, juvenile emergence, or juvenile rearing. Telemetry studies suggest that adult northern pike do not migrate significant distances within the Susitna Basin; a 1996 study found that over the course of one year, only one out of 18 radio-tagged northern pike moved a distance greater than 10 km and many moved less than 1 km (Rutz 1999).

3. SUSITNA RIVER AVIAN PREDATORS

Of the avifauna that may occur in the study area, cormorants, terns, mergansers, kittiwakes, loons, gulls, kingfishers, grebes, and osprey pose the greatest predation threat to juvenile salmonids (Table B9-2). Other avifauna potentially occurring in the study area that pose a lesser threat but that have been documented to prey on early life stage salmon or small fish include: dippers, goldeneye, scoters, magpies, ravens, canvasbacks, gadwall, scaup, shovelers, swans, and wimbrels (Table B9-2).

3.1. Double breasted cormorant

The double-breasted cormorant *Phalacrocorax auritus* is presently rare in the study area (Table B9-2). The diet of double-breasted cormorants consists largely of fish (generally slow-moving or schooling species), with some occurrence of aquatic animals such as insects, crustaceans, reptiles, and amphibians (Johnsgard 1993, Hatch and Weseloh 1999). They eat a wide variety of fish (more than 250 species have been reported). Its diet it almost exclusively fish with a few crustaceans, with the prey species changing depending on locality. Prey is caught by pursuit-diving, and individuals can fish co-operatively, sometimes with thousands of birds together at one time. Fish prey are usually slow-moving or schooling fish, ranging in size from 3-40 cm [1.2-16 in]), although most commonly less than 15 cm (6 in). The daily dietary requirement of double breasted cormorants is around 500 grams of fish/day (Major et al. 2003). Double-breasted cormorants respond rapidly to high concentrations of fish and will congregate where fish are easily caught, such as “put and take” lakes, stocking release sites, and aquaculture ponds (Hatch and Weseloh 1999, Wires et al. 2001). Predation of juvenile salmonids in the Columbia River system has led to management and control actions including hazing to limit cormorant predation (NMFS 2008a).

3.2. Arctic Tern

Arctic terns *Sterna paradisaea* are fairly common in the lower river study area and pose one of the greatest threats to out migrating juvenile salmonids. Arctic terns typically gather in foraging flocks to plunge dive for juvenile salmonids migrating near the water surface in estuaries or the marine environment (Scheel and Hough 1997). The daily dietary requirement of terns is 60-230 grams of fish/day (Major et al. 2003).

3.3. Mergansers

Common merganser (*Mergus merganser)* and red-breasted merganser (*Mergus serrator*) may be present in the study area during the breeding season. In terms of relative abundance, both species are uncommon. During the outmigration period mergansers foraging in streams prey almost exclusively on juvenile salmon (Wood 1987). Juvenile salmon are consumed extensively by common merganser broods (contributing 80% of body mass at 10 days of age to 40% of body mass at 40 days of age) inhabiting streams in coastal British Columbia (Wood 1987). The daily dietary requirement of mergansers is around 240 grams of fish/day (Major et al. 2003).

3.4. Black-legged kittiwake

The black-legged kittiwake (*Rissa tridactyla*) is a piscivorous seabird that occurs rarely in the study area. Kittiwakes typically gather in foraging flocks to plunge dive for juvenile salmonids migrating near the water surface in estuaries or the marine environment (Scheel and Hough 1997).

3.5. Loons

Common loon (*Gavia immer*), Pacific loon (*Gavia pacifica*), and red throated loon (*Gavia stellata*), may be present in the study area. In terms of relative abundance, the common loon is fairly common while the other species are uncommon (Table B9-2). Loons are visual predators, locating fish by sight and diving deep to catch them. They generally hunt in water 2 to 4 meters deep. Because they rely on sight, clear water is critical to common loons. Loons are principle bird predators of lake resident sockeye salmon fry (Emmett et al. 1991) and other juvenile salmonids in estuaries (Allen and Hassler 1986; Cederaholm et al. 2001).

3.6. Herring gull

The herring gull *Larus argentatus is* uncommon in the study area. Small fish encompass the majority of the diet of herring gulls. Herring gulls can consume 200-430 grams of fish each day (Ruggerone 1986). Gulls aggregate at river-mouths during the season of chum salmon migration and feed heavily on juveniles (Kawamura et al. 2000). Predation by ring-billed gulls *(Larus delawarenis)* below hydroelectric dams has been identified as a significant threat to migrant steelhead and salmon smolts in the Columbia and Snake Rivers (Steuber et al 1995). This has led managers to install overhead wire/cable exclusion systems over the tailrace area of 12 dams to reduce gull predation (Steuber et al 1995).

3.7. Belted Kingfisher

The belted kingfisher *Megaceryle alcyon* is uncommon in the study area. The diet of the kingfisher is composed mainly of fish and 88.4% of the diet can be comprised of salmonids when present (Cornwell, 1963). Kingfishers consume salmonids 70-165 mm in length and require 60 grams of prey per day (Major et al 2003). Belted kingfishers are a common predator at hatcheries and smolt acclimation sites (Siegel and Fast 2005).

3.8. Grebes

Grebes that may be present in the study area include horned *Podiceps auritus,* Red-necked *Podiceps grisegena,* and double-crested *Phalacrocorax auritus.* In terms or relative abundance grebes are rare to uncommon in the study area (Table B9-2). Grebes can be significant avian predators of sockeye smolts (Cederholm et al. 2000).

3.9. Osprey

The osprey *Pandion haliaetus* is rare in the study area. The daily dietary requirement of osprey is around 350 grams of fish/day (Major et al. 2003). Fish prey are first sighted when the osprey is 10–40 m above the water surface, after which the bird hovers momentarily then plunges feet first into the water. While fish make up 99% of the osprey's diet, they are not likely to catch and prey on juvenile or adult salmon as they prefer prey 250-350 mm in length (Evans 1982).

4. SUSITNA RIVER MAMMALIAN PREDATORS

Throughout the Study Area, several terrestrial mammals that prey on fish have been documented (Table B9-3). Many of these species are primarily carnivorous and heavily reliant on fish as part of their diet, while other species exhibit more opportunistic or omnivorous feeding behavior. Fish represent a smaller portion of the diet of the opportunistic feeders. Mammals typically prey upon adult salmon during the migration run to spawning areas or on post-spawn carcasses.

4.1. Brown Bear

Brown bear (*Ursus arctos*) are known to seasonally congregate along salmon-bearing streams and feed heavily on salmon during adult salmon migration and spawning seasons. On the Kenai Peninsula, Alaska, spawning adult salmon and salmon carcasses are the single most important fall food resource to brown bears as they accumulate energy reserves necessary to meet the demands of hibernation and cub production (Hilderbrand et al. 2004). Brown bear presence in the Project Study Area is well known. Previous studies of brown bears in relation to the Project Area in the 1980s were conducted upstream of Devils Canyon; no downstream study was conducted for this species. Brown bears were studied from 1980 to 1985, during which time 97 bears were equipped with VHF radio-collars (Miller 1987). Density was estimated at 27.9 bears/1,000 km^2 (386 mi^2; Miller 1987). Studies in the western Susitna basin (south of the Alaska Range between the Yentna and Chulitna rivers) during 1998–2000 found that habitat use by brown bears varied significantly within years and among seasons for different bears, and habitat use also differed between daytime and night-time periods. Brown bears foraged heavily at salmon spawning streams and salmon consistently composed a major portion of their diet, making an important contribution to body condition (Belant et al. 2006). Black bears avoided salmon streams occupied by defensive brown bears and instead foraged heavily on berries (Belant et al. 2006). The Alaska Department of Fish and Game periodically estimates brown bear density in various parts of GMU 13 encompassing the Project area. Since 1979, those estimates have ranged from 16 to 41 bears/1,000 km^2 (386 mi^2), some of the highest brown bear densities in interior and northern Alaska (Tobey and Kelleyhouse 2007).

4.2. Black Bear

Black bear (*Ursus americanus*) also feed on salmon, but generally avoid salmon-bearing streams when brown bears are present. There are no current estimates of population size for black bears in the upstream or downstream study areas along the Susitna River (AEA PAD 2011). Although black bears in the upstream area occasionally ate moose calves, berries seemed to be their most important food source (LGL 1985). Bears spent most of their time in forested areas along creek bottoms, but moved out into adjacent shrublands during late summer as they foraged for berries, particularly in the area between Tsusena and Deadman creeks, near the proposed Watana reservoir (Miller 1987). Berries were an important food for black bears in the downstream area as well. In contrast to the upstream area, movement data showed that black bears in the downstream area moved to riparian areas in July and August. Miller (1987) hypothesized that those black bears were eating salmon along river sloughs; however, he conducted a scat study in late August and concluded that black bears were foraging almost exclusively on the berries of devil's club (*Oplopanax horridus*) rather than salmon.

4.3. Red fox

Red foxes (*Vulpes vulpes*) are canine species that consume fish as part of their diet. The red fox is an opportunistic predator and consumes a wide-variety of prey items, including both invertebrates and vertebrates. The population density of red foxes in the study area was estimated at 1 family/83 km² (32 mi²; Gipson et al. 1982). Radiotelemetry data showed that dispersing foxes readily crossed the Susitna River (Gipson et al. 1982).

4.4. Gray Wolf

Gray wolves (*Canis lupus*) are canine species that consume fish as part of their diet. The gray wolf commonly hunts large mammal species such as caribou (*Rangifer tarandus*), although recent studies in coastal Alaska and British Columbia suggest adult salmon may also be an important part of a wolf's diet, particularly during salmon spawning runs (Szepanski et al. 1999; Darimont and Reimchen 2002; Darimont et al. 2008). Since 2006, the number of wolves has been within the current management goal range of 135–165 wolves (3.3–4.1 wolves/1,000 km²) for the unit, after the end of the hunting and trapping seasons (AEA PAD 2011).

4.5. Mustelids (Weasel Family)

In years of low rodent numbers, salmon carcasses are a major component of the autumn diet of martens (Martes americana) in southeast Alaska (Ben-David et al. 1997). The population density of marten in the area that would have been inundated by both of the original APA Susitna Hydroelectric Project reservoirs was estimated at 84.7 animals/100 km² (Gipson et al. 1984). Marten occurred from Portage Creek to the Tyrone River, but their density was highest between Devil Creek and Vee Canyon (Gipson et al. 1982). The total population of marten in both impoundment zones was estimated as a minimum of 218 animals, but aerial track surveys suggested that the population could be up to twice that number (Gipson et al. 1984). Nearly three times as many marten were estimated to inhabit the Watana impoundment zone as the Devils Canyon impoundment zone (Gipson et al. 1982). Marten rarely crossed water that would require them to swim; the Susitna River and larger creeks formed home range boundaries (Gipson et al. 1982). Food habits were studied by analyzing marten scat and gastrointestinal tract contents (Gipson et al. 1984). Microtine rodents and squirrels were the most important food classes during fall, winter, and spring.

River otter (*Lontra canadensis*) mink, and weasel are small furbearing species that feed on a variety of prey items, including fish. These species are associated with riparian and aquatic habitats. River otters were distributed fairly evenly throughout the upper Susitna drainage below 1,200 m (3,936 ft) elevation. During a November survey in the 1980s, large numbers of otter tracks were seen on shelf ice along the Susitna River; those otters were through to have been feeding on grayling as the fish left tributaries to overwinter in the Susitna. River otters have been documented preying adult salmon in fish passage facilities (Mehaffey 2012). Mink tracks were observed along all major tributaries below 1,200 m elevation; 50 percent of all mink tracks were in the upper reaches of the Watana impoundment zone. Most (87 percent) of the weasel tracks recorded were in the upper reaches of the study area near the Oshetna River.

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6. TABLES

Table B9-1. Summary of life history, known Susitna River usage, and known extent of distribution of fish species within the Lower, Middle, and Upper Susitna River Segments (from RSP compiled from ADF&G 1981 a, b, c, etc.).

Common Name	Scientific Name	Life History [a]	Susitna Usage[b]	Distribution[c]	Piscivorous
Alaska blackfish	*Dallia pectoralis*	F	U	U	n/a
Arctic grayling	*Thymallus arcticus*	F	O, R, P	Low, Mid, Up	Yes
Arctic lamprey	*Lethenteron japonicum*	A,F	O, M_2, R, P	Low, Mid	n/a
Bering cisco	*Coregonus laurettae*	A	M_2, S	Low, Mid	No
Burbot	*Lota lota*	F	O, R, P	Low, Mid, Up	Yes
Chinook salmon	*Oncorhynchus tshawytscha*	A	M_2, R	Low, Mid, Up	n/a
Chum salmon	*Oncorhynchus keta*	A	M_2, S	Low, Mid	n/a
Coho salmon	*Oncorhynchus kisutch*	A	M_2, S, R	Low, Mid	n/a
Dolly Varden	*Salvelinus malma*	A,F	O, P	Low, Mid, Up	Yes
Eulachon	*Thaleichthys pacificus*	A	M_2, S	Low	No
Humpback whitefish[d]	*Coregonus pidschian*	A,F	O, R, P	Low, Mid, Up	No
Lake trout	*Salvelinus namaycush*	F	U	U	Yes
Longnose sucker	*Catostomus catostomus*	F	R, P	Low, Mid, Up	No
Northern pike	*Esox lucius*	F	P	Low, Mid	Yes
Pink salmon	*Oncorhynchus gorbuscha*	A	M_2, R	Low, Mid	n/a
Rainbow trout	*Oncorhynchus mykiss*	F	O, M_2, P	Low, Mid	Yes
Round whitefish	*Prosopium cylindraceum*	F	O, M_2, P	Low, Mid, Up	No
Sculpin[e]	*Cottid*	M_1[f], F	P	Low, Mid, Up	n/a
Sockeye salmon	*Oncorhynchus nerka*	A	M_2, S	Low, Mid	n/a
Threespine stickleback	*Gasterosteus aculeatus*	A,F	M_2, S, R, P	Low, Mid	No

Notes:

1 [a] A = anadromous, F = freshwater, M1 = marine
2 [b] O = overwintering, P = present, R = rearing, S = spawning, U = unknown, M2 = migration
3 [c] Low = Lower River, Mid = Middle River, Up = Upper River, U = Unknown
4 [d] Whitefish species that were not identifiable to species by physical characteristics in the field were called humpback by default. This group may have contained Lake (Coregonus clupeaformis), or Alaska (Coregonus nelsonii) whitefish.
5 [e] Sculpin species generally were not differentiated in the field. This group may have included Slimy (Cottus cognatus), Prickly (Cottus asper), Coastal range (Cottus aleuticus), and Pacific staghorn (Leptocottus armatus).
6 [f] Pacific staghorn sculpin were found in freshwater habitat within the Lower Susitna River Segment.

Table B9-2. Avian species potentially occurring in the study area (from AEA PAD 2011 and ABR 2011), relative abundance, and association with salmon predation by lifestage.

English Name	Scientific Name	Status[1]	Relative Abundance[2]	Salmon Predation[3]			
				Incubation	Freshwater Rearing	Spawning	Carcass
Alder Flycatcher	*Empidonax alnorum*	B	uncommon				
American Dipper	*Cinclus mexicanus*	R	uncommon	x	x		
American Golden-Plover	*Pluvialis dominica*	B	common				
American Kestrel	*Falco sparverius*	M	rare				
American Pipit	*Anthus rubescens*	B	common				
American Robin	*Turdus migratorius*	B	common	x			
American Three-toed woodpecker	*Picoides dorsalis*	R	uncommon				
American Tree Sparrow	*Spizella aborea*	B	abundant				
American Wigeon	*Anas americana*	B	fairly common				
Arctic Tern	***Sterna paradisaea***	**B**	**fairly common**		**X**		
Arctic Warbler	*Phylloscopus borealis*	B	fairly common				
Baird's Sandpiper	*Calidris bairdii*	B	uncommon				
Bald Eagle	*Haliaeetus leucocephalus*	B	uncommon			x	X
Bank Swallow	*Riparia riparia*	B	common				
Barrow's Goldeneye	*Bucephala islandica*	B	fairly common	x	x		x
Belted Kingfisher	***Megaceryle alcyon***	**B**	**uncommon**		**X**	**X**	
Black Scoter	*Melanitta americana*	B	fairly common	x	x		
Black-backed Woodpecker	*Picoides arcticus*	R	rare				
Black-billed Magpie	*Pica hudsonia*	R	uncommon		x		x
Black-capped Chickadee	*Poecile atricapillus*	R	uncommon				
Black-legged Kittiwake	***Rissa tridactyla***	**M**	**rare**		**X**		
Blackpoll Warbler	*Dendroica striata*	B	fairly common				
Blue-winged Teal	*Anas discors*	M	rare				
Bohemian Waxwing	*Bombycilla garrulus*	B	common				
Bonaparte's Gull	*Chroicocephalus philadelphia*	B, S	uncommon	x			x
Boreal Chickadee	*Poecile hudsonicus*	R	fairly common				
Boreal Owl	*Aegolius funereus*	R	rare				
Brant	*Brant bernicla*	M	not present				
Brown Creeper	*Certhia americana*	B	uncommon				
Bufflehead	*Bucephala albeola*	M	uncommon	x			
Canada Goose	*Branta canadensis*	M	uncommon				

English Name	Scientific Name	Status[1]	Relative Abundance[2]	Salmon Predation[3]			
				Incubation	Freshwater Rearing	Spawning	Carcass
Canvasback	*Aythya valisineria*	M	uncommon		x		
Cliff Swallow	*Petrochelidon pyrrhonota*	B	common				
Common Goldeneye	*Bucephala clangula*	B	fairly common	x	x		x
Common Loon	***Gavia immer***	**B**	**fairly common**		**X**		
Common Merganser	***Mergus merganser***	**B**	**uncommon**	**x**	**X**		
Common Raven	*Corvus corax*	R	common		x	x	X
Common Redpoll	*Acanthis flammea*	R	abundant				
Dark-eyed Junco	*Junco hyemalis*	B	common				
Double-crested Cormorant	***Phalacrocorax auritus***	**?**	**rare**		**X**		
Downy Woodpecker	*Picoides pubescens*	R	uncommon				
Eastern Kingbird	*Tyrannus tyrannus*	A	accidental				
Fox Sparrow	*Passerella iliaca*	B	fairly common				
Gadwall	*Anas strepera*	M, S	rare		x		
Golden Eagle	*Aquila chrysaetos*	B	fairly common			x	X
Golden-crowned Kinglet	*Regulus satrapa*	M	uncommon				
Golden-crowned Sparrow	*Zonotrichia atricapilla*	B	uncommon				
Gray Jay	*Perisoreus canadensis*	R	common				
Gray-cheeked Thrush	*Catharus minimus*	B	fairly common				
Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*	B	common				
Great Horned Owl	*Bubo virginianus*	R	uncommon				
Greater Scaup	*Aythya marila*	B	common	x			
Greater White-fronted goose	*Anser albifrons*	M	uncommon				
Greater Yellowlegs	*Tringa melanoleuca*	B	uncommon	x			
Green-winged Teal	*Anas crecca*	B	fairly common				
Gyrfalcon	*Falco rusticolus*	R	uncommon				
Hairy Woodpecker	*Picoides villosus*	R	uncommon				
Harlequin Duck	*Histrionicus histrionicus*	B	fairly common	x			
Hermit Thrush	*Catharus guttatus*	B	common				
Herring Gull	***Larus argentatus***	**M, S**	**uncommon**		**X**		**x**
Horned Grebe	*Podiceps auritus*	B	uncommon	x			
Horned Lark	*Eremophila alpestris*	B	common				
Lapland Longspur	*Calcarius lapponicus*	B	abundant				

English Name	Scientific Name	Status[1]	Relative Abundance[2]	Salmon Predation[3]			
				Incubation	Freshwater Rearing	Spawning	Carcass
Least Sandpiper	*Calidris minutilla*	B	fairly common				
Lesser Scaup	*Aythya affinis*	B	common		x		
Lesser Yellowlegs	*Tringa flavipes*	B, M	fairly common				
Lincoln's Sparrow	*Melospiza lincolnii*	B	uncommon				
Long-billed Dowitcher	*Limnodromus scolopaceus*	M	uncommon				
Long-tailed Duck	*Clangula hyemalis*	B	fairly common				
Long-tailed Jaeger	*Stercorarius longicaudus*	B	fairly common				
Mallard	*Anas platyrhynchos*	B	common	x			
Merlin	*Falco columbarius*	B	uncommon				
Mew Gull	*Larus canus*	B, S	common	x			
Northern Flicker	*Colaptes auratus*	B	uncommon				
Northern Goshawk	*Accipiter gentilis*	B	uncommon				
Northern Harrier	*Circus cyaneus*	B	fairly common				
Northern Hawk Owl	*Surnia ulula*	R	uncommon				
Northern Pintail	*Anas acuta*	B	common				
Northern Shoveler	*Anas clypeata*	B	uncommon		x		
Northern Shrike	*Lanius excubitor*	B	uncommon				
Northern Waterthrush	*Parkesia noveboracensis*	B	fairly common				
Northern Wheatear	*Oenanthe oenanthe*	B	uncommon				
Olive-sided Flycatcher	*Contopus cooperi*	B	uncommon				
Orange-crowned Warbler	*Oreothlypis celata*	B	uncommon				
Osprey	***Pandion haliaetus***	**M**	**rare**		**X**	**x**	
Pacific Loon	***Gavia pacifica***	**B**	**uncommon**		**X**		
Parasitic Jaeger	*Stercorarius parasiticus*	M	rare				
Pectoral Sandpiper	*Calidris melanotos*	M	uncommon				
Peregrine Falcon	*Falco peregrinus*	M	unknown				
Pine Grosbeak	*Pinicola enucleator*	R	uncommon				
Pine Siskin	*Spinus pinus*	B	uncommon				
Red-breasted Merganser	***Mergus serrator***	**B**	**uncommon**	**x**	**X**		
Redhead	*Aythya americana*	M	uncommon				
Red-necked Grebe	***Podiceps grisegena***	**B**	**uncommon**		**X**		
Red-necked Phalarope	*Phalaropus lobatus*	B	fairly common				
Red-tailed Hawk	*Buteo jamaicensis*	B	uncommon				

English Name	Scientific Name	Status[1]	Relative Abundance[2]	Salmon Predation[3] Incubation	Freshwater Rearing	Spawning	Carcass
Red-throated Loon	***Gavia stellata***	**B**	**uncommon**		**X**		
Ring-necked Duck	*Aythya collaris*	M	rare				
Rock Ptarmigan	*Lagopus muta*	R	common				
Ruby-crowned Kinglet	*Regulus calendula*	B	common				
Ruffed Grouse	*Bonasa umbellus*	R	rare				
Rusty Blackbird	*Euphagus carolinus*	B?, M, S	uncommon				
Sanderling	*Calidris alba*	M	rare				
Sandhill Crane	*Grus canadensis*	M	uncommon				
Savannah Sparrow	*Passerculus sandwichensis*	B	abundant				
Say's Phoebe	*Sayornis saya*	B	uncommon				
Semipalmated Plover	*Charadrius semipalmatus*	B	uncommon				
Semipalmated Sandpiper	*Calidris pusilla*	B, M	uncommon				
Sharp-shinned Hawk	*Accipiter striatus*	B	uncommon				
Short-eared Owl	*Asio flammeus*	B?, M, S	uncommon				
Smith's Longspur	*Calcarius pictus*	B	uncommon				
Snow Bunting	*Plectrophenax nivalis*	B	fairly common				
Snow Goose	*Chen caerulescens*	M	uncommon				
Snowy Owl	*Bubo scandiacus*	M	rare				
Solitary Sandpiper	*Tringa solitaria*	B	uncommon				
Spotted Sandpiper	*Actitis macularius*	B	common				
Spruce Grouse	*Falcipennis canadensis*	R	fairly common				
Surf Scoter	*Melanitta perspicillata*	B	fairly common				
Surfbird	*Aphriza virgata*	B	rare				
Swainson's Thrush	*Catharus ustulatus*	B	fairly common				
Townsend's Solitaire	*Myadestes townsendi*	B	uncommon				
Tree Swallow	*Tachycineta bicolor*	B	fairly common				
Trumpeter Swan	*Cygnus buccinator*	B	fairly common	x	x		
Tundra Swan	*Cygnus columbianus*	M	uncommon	x	x		
Upland Sandpiper	*Bartramia longicauda*	B	rare				
Varied Thrush	*Ixoreus naevius*	B	common	x			
Violet-green Swallow	*Tachycineta thalassina*	B	fairly common				
Wandering Tattler	*Tringa incana*	B, M	uncommon				
Western Wood-Pewee	*Contopus sordidulus*	B	rare				

English Name	Scientific Name	Status[1]	Relative Abundance[2]	Salmon Predation[3]			
				Incubation	Freshwater Rearing	Spawning	Carcass
Whimbrel	*Numenius phaeopus*	B	uncommon		x		
White-crowned Sparrow	*Zonotrichia leucophrys*	B	abundant				
White-tailed Ptarmigan	*Lagopus leucura*	R	uncommon				
White-winged Crossbill	*Loxia leucoptera*	B, S	fairly common				
White-winged Scoter	*Melanitta fusca*	M	fairly common		x		
Willow Ptarmigan	*Lagopus lagopus*	R	common				
Wilson's Snipe	*Gallinago delicata*	B	common				
Wilson's Warbler	*Wilsonia pusilla*	B	common				
Yellow Warbler	*Dendroica petechia*	B	rare				
Yellow-bellied Sapsucker	*Sphyrapicus varius*	?	rare				
Yellow-rumped Warbler	*Dendroica coronata*	B	common				

Notes:

1 [1] M = migrant (transient); B = breeding; S = summering; R = resident; ? = uncertain (Kessel et al. 1982; APA 1985: AEA PAD 2011 Appendices E5.3 and E6.3).

2 [2] From Kessel et al. (1982) and APA (1985: AEA PAD 2011 Appendices E5.3 and E6.3).

3 [3] predation of salmon by lifestage based on Cederholm et al. 2000; and birdlife.org. 2013; X: major predator, x: lesser predator

Table B9-3. Mammalian species potentially occurring in the study area (from AEA PAD 2011 and ABR 2011 and association with salmon predation by lifestage.

English Name	Scientific Name	Predation[1] Incubation	Freshwater Rearing	Spawning	Carcass
Alaska tiny shrew	*Sorex yukonicus*				X
Arctic ground squirrel	*Spermophilus parryii*				
Beaver	*Castor canadensis*				
Black bear	*Ursus americanus*			X	X
Brown bear	*Ursus arctos*			X	X
Brown lemming	*Lemmus trimucronatus*				
Caribou	*Rangifer tarandus*				
Cinereus shrew	*Sorex cinereus*				X
Collared pika	*Ochotona collaris*				
Coyote	*Canis latrans*				X
Dall's sheep	*Ovis dalli*				
Dusky shrew	*Sorex monticolus*				X
Hoary marmot	*Marmota caligata*				
Least weasel	*Mustela nivalis*				X
Little brown bat	*Myotis lucifugus*				
Lynx	*Lynx canadensis*				
Marten	*Martes americana*				X
Meadow jumping mouse	*Zapus hudsonius*				
Meadow vole	*Microtus pennsylvanicus*				
Mink	*Neovison vison*		X	X	X
Moose	*Alces americanus*				
Mountain goat	*Oreamnos americanus*				
Muskrat	*Ondatra zibethicus*				
Northern bog lemming	*Synaptomys borealis*				
Northern red-backed vole	*Myodes rutilus*				
Porcupine	*Erethizon dorsatum*				
Pygmy shrew	*Sorex hoyi*				
Red fox	*Vulpes vulpes*				X
Red squirrel	*Tamiasciurus hudsonicus*				
River otter	*Lontra canadensis*		X	X	X
Root vole	*Microtus oeconomus*				
Short-tailed weasel	*Mustela erminea*				X

English Name	Scientific Name	Predation[1]			
		Incubation	Freshwater Rearing	Spawning	Carcass
Singing vole	*Microtus miurus*				
Snowshoe hare	*Lepus americanus*				
Tundra shrew	*Sorex tundrensis*				X
Water shrew	*Sorex palustris*	X	X		X
Wolf	*Canis lupus*			X	X
Wolverine	*Gulo gulo*				X

Notes:

1 [1] predation of salmon by lifestage based on Cederholm et al. 2000

2 Sources: Kessel et al. (1982); APA (1985b: Appendix E7.3); MacDonald and Cook (2009); continental modifiers of English names (e.g., North American river otter) have been dropped from this list.

INFORMATION ITEM B10. EXISTING ENVIRONMENTAL CONDITIONS

1. INTRODUCTION

Understanding environmental conditions that influence fish behavior and movement and how these conditions may be altered as a result of proposed Susitna-Watana Project operations is essential to the development of sound fish passage concepts. Potential Project effects on ambient environmental conditions that can affect fish behavior include changes in flow, temperature, and turbidity/light penetration. In the sections that follow, relevant existing environmental conditions within the Susitna River drainage are briefly summarized and then followed by a bulleted list of literature-based information on how these conditions have the ability to influence fish movement and behavior and to ultimately affect the success of a fish passage program.

2. FLOW CONDITIONS

2.1. Existing Conditions

Annual stream flow patterns in the Susitna River basin (20,010 square miles) are governed by the relative timing and magnitude of glacier melt, snowmelt, and rainfall (Curran 2012). The relative contribution of each of these sources to the total flow varies among streams as a result of different subbasin characteristics (e.g., glacier cover). Nonetheless, annual stream flows in the basin typically follow a seasonal pattern. The low-flow period occurs during winter (i.e., approximately November through April), when ice and snow conditions are predominate the landscape. Breakup typically occurs in April or early May and coincides with an abrupt increase in flow as a result of ice and snow melt. In streams that are dominated by snowmelt contributions, peak flows typically occur between May and mid-June, although contributions from snowmelt continue throughout the summer months. Peak discharges in streams dominated by glacial melt typically occur later in the summer (e.g., July). After the glacial melt peak is reached, flows generally begin to decline, but may still remain relatively high. In lower elevation streams that are less driven by glacial melt, a second peak in flow may be observed in response to fall rains. Using the gaging station on the Susitna River at Gold Creek as an index, mean daily discharge for the Susitna River ranges from approximately 1,300 cubic feet per second (cfs) in January to approximately 28,000 cfs in July (USGS Gage 15292000 data from October 1, 1948 to September 30, 2011).

2.2. Effects on Fish Behavior and Movement

- Seasonal stream flow patterns are known to play an important role in triggering fish movement. See Information Item B4 for target species migratory characteristics.
- Using random-effects meta-analyses, Taylor and Cooke (2012) assessed the effects of flow magnitude on non-migratory fish movements, upstream migratory movements, downstream migratory movements, and fine-scale activity. River discharge had a positive and significant effect on non-migratory movement, and the magnitude of the effect appeared to be greater for non-salmonid species compared to salmonids. Discharge was also positively correlated with the rate, frequency, and probability of upstream migratory movement. Discharge was not significantly related to downstream

migratory movements or fine-scale activity, possibly due to differences in fish species, ambient stream conditions (e.g., temperature), season, habitat preferences, individual variation, and energy trade-offs associated with swimming and prey availability.

- In the Susitna River, Hale (1987, cited in Feist and Anderson 1991) found that the outmigrations of Chinook and sockeye salmon peaked along with river flow and sediment discharge peaks. However, separating the effects of increased turbidity from increased flow can be difficult (Bell 1991).
- Downstream migration rates have been directly related to flow velocities, since most downstream migrants move passively during high flows associated with runoff and snowmelt (Raymond 1968; Ruggles 1980 cited in Clarke et al. 2008; McCormick et al. 1998 cited in Clarke et al. 2008).
- In a regulated system, when spring runoff and snowmelt are stored, natural seasonal flows are reduced and can delay downstream migration (e.g., Raymond 1979 cited in Clarke et al. 2008).
- Flow regulation of tributaries to the Sacramento River has resulted in increased spring-summer flows and decreased flows in the fall, winter, and early spring, which has impeded Chinook salmon migration (Yoshiyama et al. 1998). Consequently, spawning and outmigration have been delayed compared to pre-regulation conditions, and these delays have contributed to the decline of Chinook salmon in the Central Valley Region (Yoshiyama et al. 1998).
- Spawning migration timing has been correlated with riverine conditions, particularly flow and water temperature. For example, Keefer et al. (2008) found that spring Chinook salmon migrations in the Columbia River occurred earliest in years with low river discharge or warm water temperatures and latest in years with high discharge and colder water temperatures.
- Returning adults are attracted to high velocity flows. Delays in upstream migration can result from “false attraction” flows associated with hydropower and fish passage operations (Clarke et al. 2008). For adult salmonids in the Pacific Northwest, delays in relation to tailrace attraction have been well documented and have been related to reduced spawning success (e.g., Fleming and Reynolds 1991).
- In an experimental study, Fleming and Reynolds (1991) used net pens to intentionally delay adult Arctic grayling that were migrating upstream to spawn; fish were delayed for 3, 6, and 12 days. Compared to control group fish, which were held for only 12 hours, adults that were delayed for three days or longer did not travel as far upstream to spawn. The authors suggest that such delays in Arctic grayling spawning migrations may lead to the use of non-preferred spawning habitat and ultimately decrease recruitment.
- The swimming performance of fish is affected by flow, as well as other factors such as species, fish size, temperature, stock, ecology/behavior, and physiological status (Feist and Anderson 1991). See Information Item B6 for details.
- Alterations in flow inherently change the amount and quality of habitat that is accessible to fish. Fish exhibit preferences for habitats that are characterized by specific depth, velocity, and substrate combinations. See Information Item B4 for target species migratory characteristics.

- Juvenile Chinook salmon are capable of detecting and responding to constant velocities of less than 1 inch per second (Hanson and Jacobson 1985 cited in Feist and Anderson 1991).
- With regard to fish passage systems, velocity may be used as a barrier or an attractant (Bell 1991).
- In clearwater systems, salmonid smolts have been reported to exhibit active swimming, maneuvering, and avoidance of changes in water velocity and hydrostatic pressure (Seitz et al. 2011). For example, in an assessment of fine-scale behavioral responses of Pacific salmonid smolts to altering flows, Kemp et al. (2005) noted that smolts exhibited behavioral choices for alternative flow conditions in open and constricted flume channels. Most smolts passed through the open channel, yet after controlling for the effects of flow, the rate at which smolts initially selected and subsequently rejected the constricted channel was greater. The authors concluded that knowledge of how diversion structures alter local hydraulic conditions and thus influence fish behavior is essential for successful fish guidance. However, it is unknown if smolts exhibit similar behavioral responses in turbid, high-velocity rivers (Seitz et al. 2011).
- Low winter discharge can result in increased anchor ice, and if the anchor ice forms in preferred winter habitats, it can result in fish displacement to less suitable habitats (Brown et al. 1993). Surface ice can protect against the formation of anchor ice, but warm water releases during the winter can impede surface ice formation (Lehmkuhl 1972 cited in Clarke et al. 2008).
- Frazil ice, which could form from turbulent water releases in the winter, has been related to respiratory complications in trout, and at high enough densities, can even cause suffocation (Brown et al. 1993).
- Changes in total dissolved gasses and hydrostatic pressure can occur as the result of flows plunging over spillways. The height and angle of the spillway as well as the depth to which the water plunges can produce supersaturated conditions that are lethal to fish. Rapid temperature increases and high amounts of photosynthetic activity further contribute to the likelihood that supersaturated conditions will result. Fish may develop gas bubble disease as a result of supersaturated conditions. Acute and chronic symptoms of this disease include stress-response behaviors, a loss of equilibrium, diminished swimming ability, reduced growth, and loss of lateral line sensitivity. (Clarke et al. 2008)

3. TEMPERATURE CONDITIONS

3.1. Existing Conditions

Existing thermal conditions in the Susitna River and its tributaries are not currently well known (Susitna-Watana Hydroelectric Project Revised Study Plan Section 5.5). Available historic data are not spatially or temporally continuous, thus limiting the ability to identify and describe thermal regimes within the Susitna River drainage. In 2012, a continuous water quality monitoring program was initiated, and additional monitoring will continue throughout 2013 and 2014. Although the temperature data set at this time is too small to draw conclusions regarding the temperature profile of the river, data from 21 sites that were monitored from July through October 2012 revealed that water temperatures in the mainstem river and its sloughs ranged from approximately 0 to 18 ºC during this time period (URS Corporation and Tetra Tech Inc. 2013).

3.2. Effects on Fish Behavior and Movement

- Spawning migration timing has been correlated with riverine conditions, particularly flow and water temperature (e.g., Keefer et al. 2008). However, the degree to which temperature may affect migration and spawn timing is species-specific and may be a function of different life history strategies and optimal embryonic development and juvenile rearing conditions (Quinn and Adams 1996).
- Adversely warm temperature conditions may delay or obstruct the migration and spawning of adult salmonids (Bell 1991; McCullough 1999).
- Under adverse thermal conditions, adults may utilize thermal refugia in cooler tributaries (e.g., Fish and Hanavan 1948 cited in McCullough 1999), areas of groundwater upwelling (e.g., Berman and Quinn 1991 cited in McCullough 1999), or deep holding pools (e.g., Moyle 1976 cited in McCullough 1999).
- Torgersen et al. (1999) found that adult Chinook salmon distribution was positively correlated with stream temperature patterns at reach-level spatial scales, although the strength of this correlation was diminished in a cold water stream compared to a warmer stream. At smaller spatial scales, habitat use patterns may be distinguishable provided that local variation in water temperatures is large enough to elicit a biologically significant response (e.g., Ebersole et al. 2001 cited in USEPA 2001).
- Temperature has been found to be negatively correlated with juvenile salmonid densities in both the field (e.g., Bjornn 1978 cited in McCullough 1999) and in the lab (Hahn 1977 cited in McCullough 1999). The temperature effect on density may occur through a combination of survival effects, behavioral avoidance, and interspecific competition (McCullough 1999).
- In the Snake and Clearwater rivers, Connor et al. (2002) found statistically significant correlations between stream temperature and juvenile fall Chinook salmon life history characteristics (i.e., fry emergence, growth to parr size, and smolt emigration), and they observed that the percentage of parr that overwintered in freshwater and outmigrated the following spring increased when spring water temperatures decreased. The authors hypothesized that dam construction and the subsequent flooding of historic spawning habitat has altered the life history of this stock, by forcing adults to use cooler headwater streams for spawning.
- In an experiment to simulate the transport of fish from warm tributaries to cold tailwaters, Clarkson and Childs (2000) found that a sudden decrease in water temperature from 20 to 10 ºC caused a loss of equilibrium in young life stages of sucker, chub, and squawfish. Such losses of equilibrium could potentially increase mortality through involuntary drift.
- Because fish have the ability to sense a temperature differential of approximately 0.3 ºC, it is possible that they may avoid higher than optimal temperatures (Bell 1991). However, there is no direct evidence suggesting that freshwater fish actively and immediately avoid higher than optimal temperatures (Bell 1991). In some instances, it is

possible that brief forays into physiological stressful habitats may provide a net benefit (e.g., food consumption, predator avoidance; USEPA 2001). Fish may remain in habitats with temperatures near their upper tolerance limits for long periods of time before moving to cooler waters, and acclimation to warmer water temperatures may be an important factor in triggering a movement response (Bell 1991). Fish do not necessarily move away from high temperature areas until temperatures are greater than their upper tolerance levels (Bell 1991). Fish may seek cooler waters based on indirect factors (e.g., innate responses to conserving body fat) or other potentially unrelated factors (e.g., light conditions, instream cover; Bell 1991). Alternatively, relatively warmer areas (e.g., upwellings) may be utilized during periods of critically low temperatures (Bell 1991).

- Indirect effects associated with increased water temperatures (e.g., decreased dissolved oxygen concentrations, habitat productivity/food availability, intraspecific competition) may also elicit behavioral responses in fishes. Behavioral responses to limited oxygen availability include changes in activity (e.g., ventilation frequency, feeding, less predator avoidance), increased use of air breathing or aquatic surface respiration, and vertical or horizontal habitat movements (Kramer 1987). Ambient temperature and dissolved oxygen levels, among other factors such as fish length, species, and flow conditions, can affect fish swimming ability (Bell 1991). Although the authors did not specifically address temperature conditions, Näslund et al. (1993) found that some individuals of a land-locked Arctic char population residing in an oligotrophic lake in Sweden migrated to distant productive lake habitats for summer foraging when food conditions in the primary lake were limited.

4. TURBIDITY/LIGHT CONDITIONS

4.1. Existing Conditions

The Susitna River is characterized by naturally occurring turbid waters, as a result of glacial inputs. Available turbidity data for the Susitna River has been compiled from historic USGS stations and the 1980s study program (Susitna-Watana Hydroelectric Project Pre-Application Document Appendix 4.4-1). As expected, turbidity measurements varied seasonally, with the greatest turbidity measurements observed in the summer months. During the summer, maximum turbidity measurement at each mainstem site ranged from 200 to 1,056 nephelometric turbidity units (NTUs). Observed winter values ranged from 0 to 3 NTUs. Spring and fall measurements were generally moderate to high and ranged from 0.01 to 590 NTUs. During the 2013 and 2014 Baseline Water Quality Study (Susitna-Watana Hydroelectric Project Revised Study Plan Section 5.5), turbidity will be monitored at several main channel and slough sites along the length of the Susitna River.

Clear-water inputs (e.g., tributaries) to Susitna River have the ability to attenuate the turbidity of mainstem waters. However, given the large width of the mainstem river, the spatial extent of such attenuation is limited. Clear-water plumes from tributaries are typically limited to the mainstem bank downstream of the tributary confluence, and the spatial extent of a clear-water plume is expected to fluctuate with discharge, as well as natural changes in turbidity throughout the seasons. Clear-water areas can also be found in slough and tributary habitats. Relative to the mainstem, sloughs and tributaries may be less turbid, because they are fed by different source flows (e.g., upwellings and non-glacial headwaters). In addition, the relatively low velocities of slough habitats allow suspended sediments to settle out of the water column, thereby reducing turbidity.

4.2. Effects on Fish Behavior and Movement

- Overall, the effects of turbidity on fish behavior and movement are quite variable. This variation appears to be related to differences in species, life stage, naturally occurring turbidity levels, acclimation to altered conditions, the magnitude of turbidity increases/exceedances, and other ambient conditions (Feist and Anderson 1991).
- Some observed behavioral responses of fish to acutely altered turbidity conditions include: 1. alarm-type responses (e.g., hiding in gravel, sporadic swimming); 2. decreased reaction distance to prey, as observed in juvenile coho salmon (Berg and Northcote 1985 cited in Feist and Anderson 1991); 3. decreased use of overhead cover; 4. increased activity; and 5. reduced substrate associations for brook trout and creek chubs (Gradall and Swenson 1982 cited in Feist and Anderson 1991).
- Juvenile salmonids typically avoid chronically turbid streams (Lloyd et al. 1987 cited in Bjornn and Reiser 1991), except for migratory purposes.
- Daily periods of outmigration for Pacific salmon have been found to be extended during turbid water conditions (e.g., McDonald 1960 cited in Feist and Anderson 1991; Noggle 1978 cited in Feist and Anderson 1991; Bell 1991). In the Susitna River, Hale (1987, cited in Feist and Anderson 1991) found that the outmigrations of Chinook and sockeye salmon peaked along with river flow and sediment discharge peaks. However, the effects of increased turbidity from increased flow were indistinguishable (Bell 1991).
- The distribution of downstream migrants across a stream channel is typically non-uniform with most fish located along the shoreline, although this pattern is likely to vary among species. Shorelines naturally guide migrating fish, presumably because they provide a visual reference. Other factors, such as light intensity, instream cover, and velocity, may also be important in understanding why the lateral distribution of fish is often greatest along the shoreline. (Bell 1991)
- The vertical distribution of downstream migrants is typically characterized by a greater number of fish in the top half of the water column, yet this distribution may be influenced by light intensity and time of day as well as water temperature, fish size, and species (Bell 1991).
- Ephemerally high concentrations of suspended sediments, such as those associated with storms and snow melt, appear to have little effect on larger juvenile and adult salmonids (Cordone and Kelley 1961 cited in Bjornn and Reiser 1991; Sorenson et al. 1977 cited in Bjornn and Reiser 1991). However, increased straying of adult fall Chinook and coho salmon from the Toutle River was observed in response to extremely elevated sediment concentrations as a result of the 1980 eruption of Mount St. Helens (Martin et al. 1984).
- Breeser et al. (1988) studied burbot movement in the upper Tanana River, a glacial tributary of the Yukon River. Radio-tagged burbot were most commonly detected in the main river channel, even when peak summer flows resulted in increased turbidity.

- Turbidity offers a measure of protection from piscivorous fish species (Bell 1991; Gregory and Levings 1998). Gregory and Levings (1998) found that predation rates of juvenile Chinook salmon were significantly less in the naturally turbid Fraser River (27-108 NTU) than in the clear-water Harrison River (1 NTU).
- Because fish often rely on visual cues for movement, turbidity can affect movement by obscuring targets and other visual references (Bell 1991; Brett and Groot 1963).
- Light levels, as well as other factors, play a role in the feeding, shelter seeking, and movement patterns of fish (Feist and Anderson 1991). Fish respond to shadow and light patterns and generally favor cover (Bell 1991), although specific responses to light and shadow tend to vary by species, developmental stage, and adaptation to ambient light levels (Feist and Anderson 1991).
- Sensitivity to light was found to increase during smolting in both coho and sockeye salmon, as evidenced by their seeking cover or deeper water (Hoar et al. 1957).
- Both natural and artificial light conditions, among other factors such as velocity, channel shape, depth, sound, odor, and temperature, play a role in fish guidance and passage at dams and diversions (Bell 1991). Depending on ambient stream conditions and light intensity, light can be used for fish guidance as both a deterrent and attractant (Bell 1991). Artificial lighting generally repels fish at higher intensities and attracts them at lower intensities (Fields et al. 1958). The effectiveness of artificial lighting as a deterrent may be diminished in more turbid water (Fields et al. 1958). During night time hours, artificial lighting can reduce the hours of normal darkness and thus impede movement (Bell 1991).

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INFORMATION ITEM B11. BIOLOGICAL PERFORMANCE TOOL

1. BIOLOGICAL PERFORMANCE TOOL

An important component of the Study of Fish Passage Feasibility at Watana Dam is the development of a biological performance tool that can be used to qualitatively estimate potential passage outcomes for different fish passage alternatives identified, developed, and refined as the feasibility study progresses. The feasibility of providing fish passage will be dependent on a suite of biological, hydrologic, and engineering factors to be considered collectively for a given passage alternative. The biological performance tool will provide a means of integrating these various factors to estimate likely passage outcomes for each alternative in terms of passage success.

Factors that will likely be incorporated into the biological performance tool include:

1.1. Biological Factors

- multiple target species
- relevant life stages
- life stage periodicity
- passage behavior (e.g., flow-related migration)
- reservoir survival
- dam passage survival (e.g., turbine, spill, or passage facility survival)

1.2. Hydrologic Factors

- daily inflow
- various water-year types

1.3. Engineering Factors

- project operations
- passage facility alternatives
- expected performance of specific facility alternatives (e.g., collection efficiency or percent passage)

Specific to downstream passage, the biological performance tool will be developed based on the following assumptions:

- Up to 5 species
- Up to 3 lifestages (smolts, fingerlings, fry)
- Flow conditions based on daily inflow
- Model output for 5 different flow years (high, med-high, medium, med-low, low)

- 4 discrete downstream passage alternatives, including provisions for turbine/spill survival (e.g., tributary collector, upper reservoir collector, lower reservoir floating surface collector, conventional screens)

The Clackamas River Downstream Migrant Mortality Model developed for a multi-dam hydroelectric project on the Clackamas River, Oregon provides an example of a downstream module that would be included in the biological performance tool. The Clackamas model is a daily simulation model that routes water and fish through various flow routes in the system. There are several potential routes at each dam facility, and the flow is first apportioned to the bypass, then to the turbine and finally to the spillway. The model incorporates user specified periodicity to account for the fish migration distribution during different periods in a year. The model also incorporates a "flow response factor" to adjust the rate of migration as a function of river flow; higher rates of migration can be assigned to higher flow periods if deemed appropriate for a given species. The model also provides for a mechanism to alter the percentage of fish that pass via various routes in a facility as a function of river flow. Thus, when river flows are high, the model can simulate more fish passing over the spillway. Along each potential route, the model utilizes user-specified route-specific mortality rates to account for the route passage condition. Example model input/output interfaces are shown in Figures B11-1 through B11-4. While the Clackamas model is more complex than the Susitna-Watana Project because it includes multiple dams, it illustrates conceptually the modeling approach proposed.

In addition to a downstream passage module, as described above, the biological performance tool can include module(s) to address specific upstream passage issues. Examples of challenging issues that can be addressed with this tool include volitional passage versus collection and transport and options to sort species and stocks. This module will be developed to address specific upstream passage concerns.

The biological performance tool will provide output with which to compare various passage scenarios. In addition, the biological performance tool will include a user interface that will allow for "real-time gaming" in which input parameters and scenarios can be readily modified. The intent of providing such an interface is to allow for discussion-based modifications to the model in support of the workshop approach of the feasibility study.

While the biological performance tool can provide estimates of expected passage outcomes, the considerable uncertainty related to post-project conditions (including fish behavior and migration, community structure, and population levels) will limit the accuracy of any estimates of future passage performance. Nonetheless, the biological performance tool will provide a relative means to compare the performance of different scenarios for evaluating fish passage feasibility.

2. FIGURES

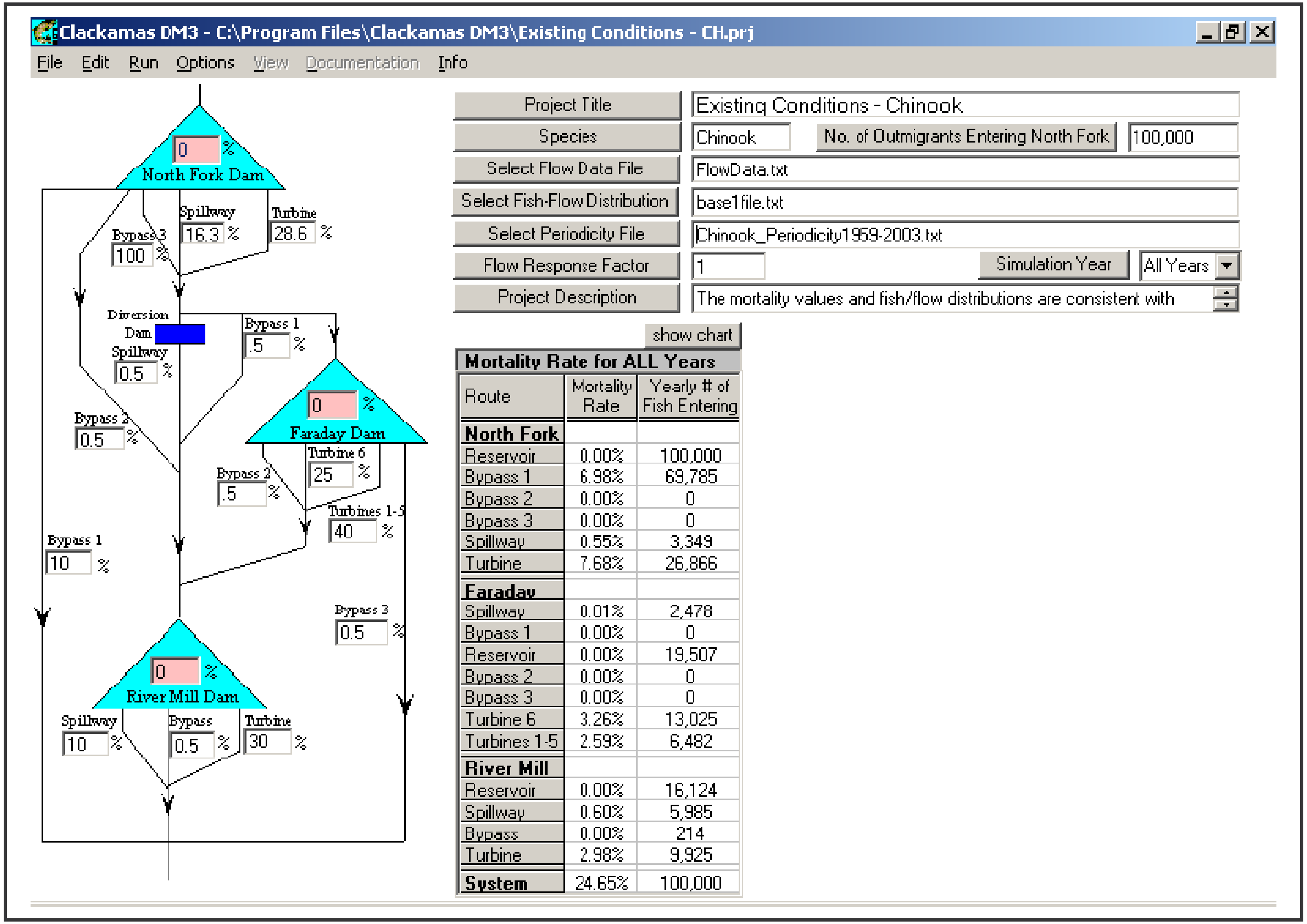


Figure B11-1. Main startup screen of the Clackamas River Downstream Migrant Mortality Model.

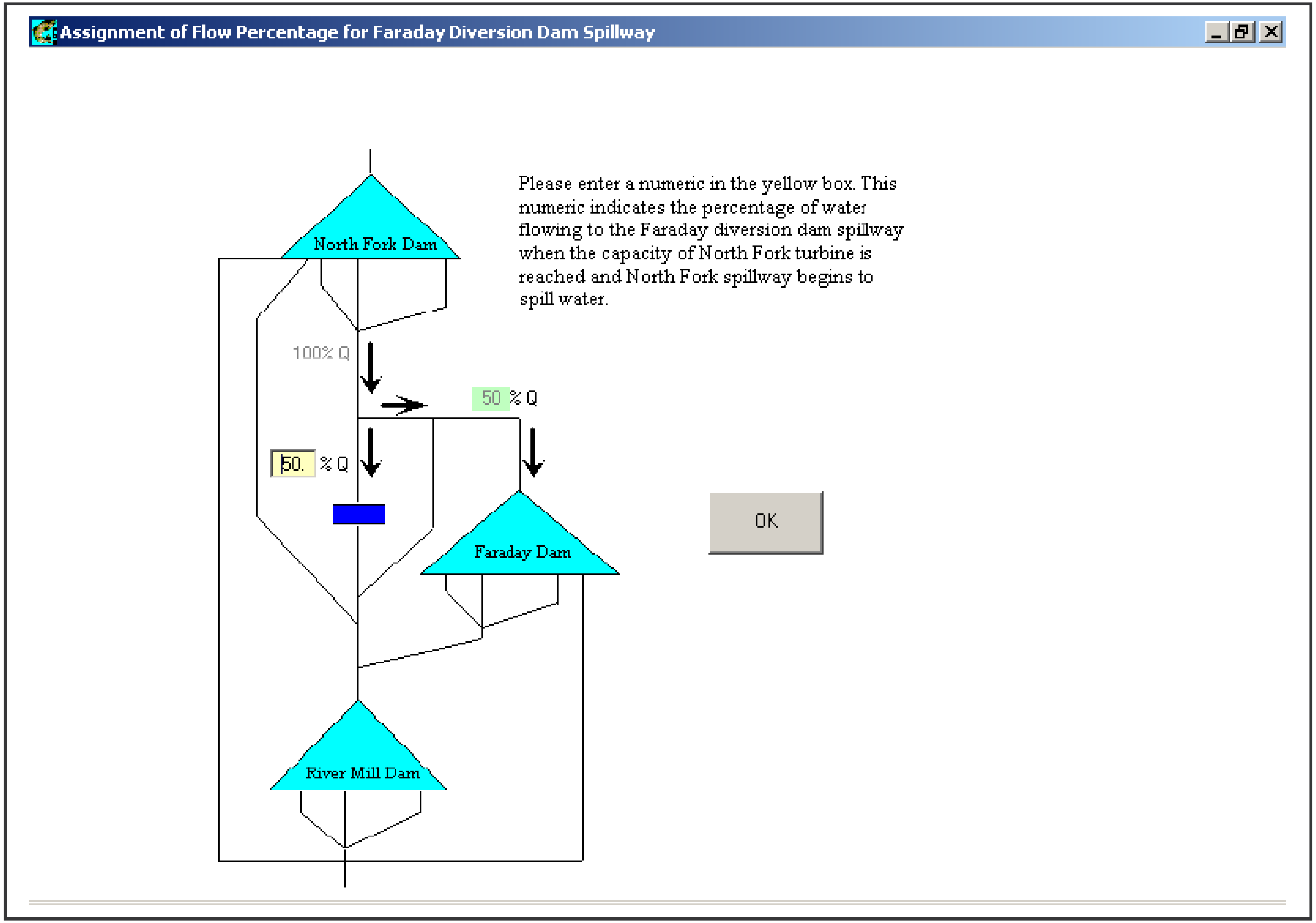
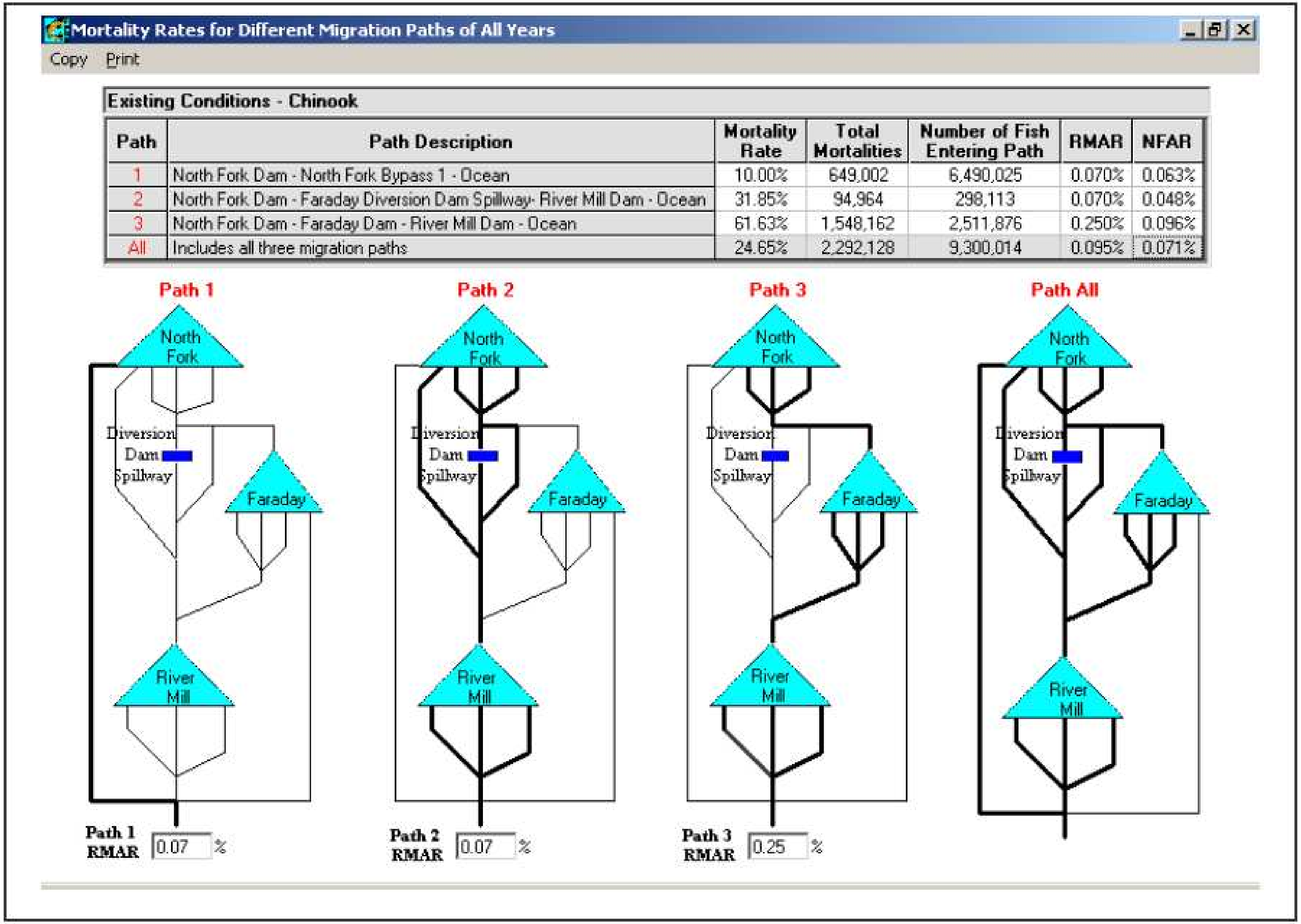
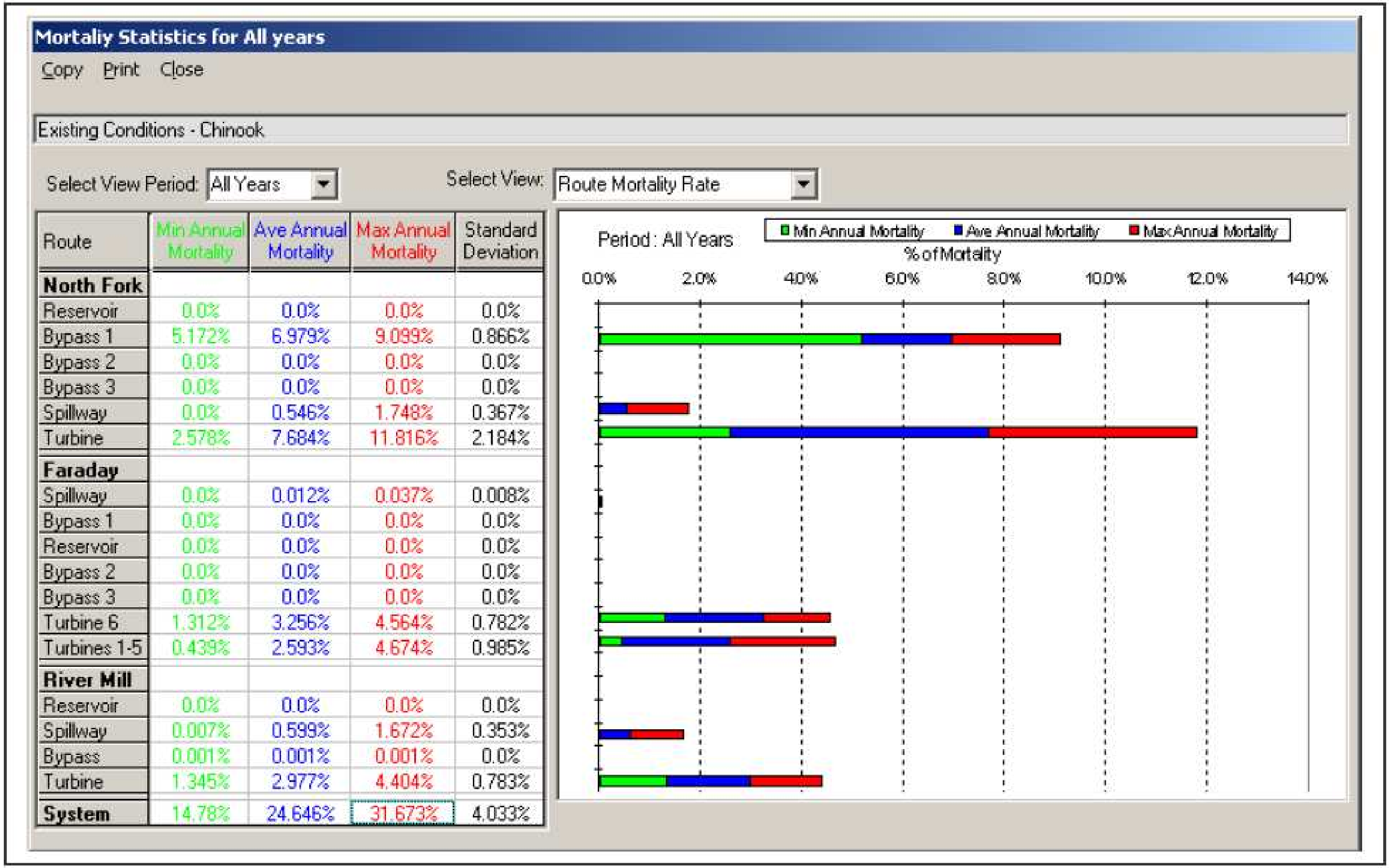


Figure B11-2. Assignment of flow percentage in the Clackamas River Downstream Migrant Mortality Model.



Path	Path Description	Mortality Rate	Total Mortalities	Number of Fish Entering Path	RMAR	NFAR
1	North Fork Dam - North Fork Bypass 1 - Ocean	10.00%	649,002	6,490,025	0.070%	0.063%
2	North Fork Dam - Faraday Diversion Dam Spillway- River Mill Dam - Ocean	31.85%	94,964	298,113	0.070%	0.048%
3	North Fork Dam - Faraday Dam - River Mill Dam - Ocean	61.63%	1,548,162	2,511,876	0.250%	0.096%
All	Includes all three migration paths	24.65%	2,292,128	9,300,014	0.095%	0.071%

Figure B11-3. Assignment of mortality rates for different migration paths in the Clackamas River Downstream Migrant Mortality Model.



Route	Min Annual Mortality	Ave Annual Mortality	Max Annual Mortality	Standard Deviation
North Fork				
Reservoir	0.0%	0.0%	0.0%	0.0%
Bypass 1	5.172%	6.979%	9.099%	0.866%
Bypass 2	0.0%	0.0%	0.0%	0.0%
Bypass 3	0.0%	0.0%	0.0%	0.0%
Spillway	0.0%	0.546%	1.748%	0.367%
Turbine	2.578%	7.684%	11.816%	2.184%
Faraday				
Spillway	0.0%	0.012%	0.037%	0.008%
Bypass 1	0.0%	0.0%	0.0%	0.0%
Reservoir	0.0%	0.0%	0.0%	0.0%
Bypass 2	0.0%	0.0%	0.0%	0.0%
Bypass 3	0.0%	0.0%	0.0%	0.0%
Turbine 6	1.312%	3.256%	4.564%	0.782%
Turbines 1-5	0.439%	2.593%	4.674%	0.985%
River Mill				
Reservoir	0.0%	0.0%	0.0%	0.0%
Spillway	0.007%	0.599%	1.672%	0.353%
Bypass	0.001%	0.001%	0.001%	0.0%
Turbine	1.345%	2.977%	4.404%	0.783%
System	14.78%	24.646%	31.673%	4.033%

Figure B11-4. Mortality statistics from the Clackamas River Downstream Migrant Mortality Model.

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Table 1. Upstream Passage Sorting Requirements and Design Data by Fish Species.

Species Information						Release Destination – Tank[A]						Design Data					Run Timing[B]											
Species	Documented Distribution	Life History: Anadromous	Life History: Freshwater	Life History: Unknown	Life Stage[F]	Down-River	Below Dam	Reservoir Above Dam	Upstream Tributaries	Head of Reservoir	Cull	Length Range (cm)	Body Width Range (cm)	Fish Design Length (cm)	Fish Design Weight (lbs)	Design Peak Daily (no.)	J	F	M	A	M	J	J	A	S	O	N	D
Arctic grayling	U, M, L		X		A			✓	✓	✓		21-42[J]	NA[I]	35[K]	NA[I]	<100[D]				-	-	-		-	-	-		
Arctic lamprey	M, L	X	X		A			✓	✓	✓		8-32[L]	NA[I]	20[K]	NA[I]	<100[D]					-	-	-					
Bering cisco	M, L	X			A			✓	✓	✓		24-41[M]	NA[I]	33[K]	NA[I]	<100[D]								-	-	-		
Burbot	U, M, L		X		A			✓	✓	✓		26-74[N]	NA[I]	48[K]	NA[I]	<100[D]	-	-	-					-	-	-	-	-
Chinook salmon	U, M, L	X			A			✓	✓	✓		55-125[O]	NA[I]	71[H]	16.7[G]	293[C]						X	X	-				
Chum salmon	M, L	X			A			✓	✓	✓		55-80[O]	NA[I]	67[H]	7.7[G]	934[C]							-	X	-	-		
Coho salmon	M, L	X			A			✓	✓	✓		45-70[O]	NA[I]	55[H]	6.1[G]	488[C]							-	X	-	-		
Dolly Varden	U, M, L		X	X	A			✓	✓	✓		12-37[P]	NA[I]	25[K]	NA[I]	<100[D]					-	-	-		-	-	-	
Humpback Whitefish	U, M, L		X	X	A			✓	✓	✓		23-35[Q]	NA[I]	29[K]	NA[I]	<100[D]							-	X	-	-	-	
Longnose sucker	U, M, L		X		A			✓	✓	✓		29-67[R]	NA[I]	40[L]	NA[I]	<100[D]						X	X					
Rainbow trout/steelhead	M, L		X	X	A			✓	✓	✓		16-62[S]	NA[I]	39[K]	NA[I]	<100[D]			-	-	-	-						
Round Whitefish	U, M, L		X		A			✓	✓	✓		32-44[T]	NA[I]	37[K]	NA[I]	<100[D]						-		-	-	-		
Sockeye salmon	M, L	X			A			✓	✓	✓		45-75[O]	NA[I]	54[H]	6.5[G]	15,826[C]							X	X	-	-		
Other (i.e. invasive/non-native spp.)	L[E]		X	X	A, J						✓	NA[I]	NA[I]	NA[I]	NA[I]	<100[D]	NA[I]											

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Table 1 Notes:

A Potential destinations provided here have been selected for discussion purposes only and are likely to change during TWG sessions and as management objectives develop.

B "X" denotes peak run-timing; "-" denotes the remaining run timing interval. For some species, periods of peak run-timing could not be discerned from available information.

C Calculated as 10% of total Upper River adult production potential reported by Barrick et al. (1983). For comparison, maximum daily catch by species at Curry fishwheels comprised 10.7% (Chinook), 10.4% (chum), 8.0% (coho), and 7.6% (sockeye) of total catch in 2012 (LGL 2013).

D For species that do not exhibit an obligate anadromous life history, are not abundant, or for which information is lacking to estimate potential numbers that would utilize passage facilities, "<100" was selected as an initial estimate. These values are subject to refinement during TWG sessions.

E Northern pike have been documented in the Lower River and their suspected distribution extends to tributaries up to the Three Rivers (Ivey 2009). The distribution of Alaska blackfish is unknown in the Susitna River basin (AEA 2012, USFWS 2008).

F "A" denotes adult; "J" denotes juvenile.

G Reflect fish weights used by Barrick et al. (1983) to estimate Upper River production potential; based on the average size of commercially-harvested Susitna River fish.

H Reflect average FL from 2012 Curry fishweel captures (LGL 2013).

I "NA" indicates no available information or pending review.

J Length (FL) range of Arctic grayling age-4+ and older captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1983)

K Midpoint of referenced length range.

L Length range of Arctic lamprey captured in the Susitna River during 1981-1982 (Schmidt et al. 1983). Neither life stages nor length-at-age information were provided; thus, this length range likely includes juveniles.

M Length range of age-3+ to age-6+ Bering cisco captured in the Susitna River during 1981-1982 (ADF&G 1981, 1983).

N Length range of age-3+ to age-10+ burbot captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1982).

O Length range from 2012 Curry fishwheel captures (note, based on 5-cm bin sizes) (LGL 2013)

P Upstream of Devils Canyon, HDR (2012) captured Dolly Varden ranging from 2.6 to 36.6 cm FL using methods more likely to catch juveniles, whereas Sautner and Stratton (1983) captured Dolly Varden ranging from 12.0 to 20.5 cm FL primarily by angling. Thus, 12 cm was selected as the lower adult length range.

Q Length range of humpback whitefish captured upstream of Devils Canyon by HDR (2013) and Delaney et al. (1981).

R Length range of longnose sucker age-4+ and older captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1982).

S Length range of rainbow trout age-3+ and older captured in the Middle River during 1981-1983 (Delaney et al. 1981, Schmidt et al. 1983, 1984).

T Length range of round whitefish age-6+ and older captured upstream of Devils Canyon during 1981 (Delaney et al. 1981).

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Table 2. Downstream Passage Sorting Requirements and Design Data by Fish Species.

Species Information						Collection Location[A]		Release Location[A]				Design Data					Run Timing[D]											
Species	Documented Distribution	Life History: Anadromous	Life History: Freshwater	Life History: Unknown	Life Stage[F]	Tributary Collector	Collector at Dam	Below Dam	Reservoir	Tributaries	Cull	Length Range (cm)	Body Width Range (cm)	Fish Design Length (cm)	Fish Design Weight (lbs)	Design Peak Daily (no.)	J	F	M	A	M	J	J	A	S	O	N	D
Arctic grayling	U, M, L		X		A, J	✓	✓	✓				12-42[I]	NA[H]	27[J]	NA[H]	<100[C]								-	X	-		
Arctic lamprey	M, L	X	X		J	✓	✓	✓				8-32[K]	NA[H]	20[J]	NA[H]	<100[C]								-	-	-	-	
Bering cisco	M, L	X			A[M], J	✓	✓	✓				24-41[L]	NA[H]	33[J]	NA[H]	<100[C]					-	-	-					
Burbot	U, M, L		X		A, J	✓	✓	✓				9-74[Q]	NA[H]	42[J]	NA[H]	<100[C]						X	X	-	-			
Chinook salmon	U, M, L	X			J	✓	✓	✓				4-12[R]	NA[H]	8[J]	0.01[G]	9,770[B]		-	-	-	X	X	X	X	-			
Chum salmon	M, L	X			J	✓	✓	✓				3-7[S]	NA[H]	5[J]	0.0008[G]	93,420[B]					X	X	-	-				
Coho salmon	M, L	X			J	✓	✓	✓				3-17[T]	NA[H]	10[J]	0.02[G]	4,885[B]	-	-	-	-	X	X	X	X	-	-		
Dolly Varden	U, M, L		X	X	A	✓	✓	✓				12-37[O]	NA[H]	25[J]	NA[H]	<100[C]									-	-		
Humpback Whitefish	U, M, L		X	X	A[N], J	✓	✓	✓				3-35[V]	NA[H]	19[J]	NA[H]	<100[C]						-	X	X	-	-		
Lake trout	U		X		A, J	✓	✓		✓			NA[I]	NA[H]	NA[I]	NA[H]	<100[C]	NA[H]											
Longnose sucker	U, M, L		X		A, J	✓	✓	✓				2-67[X]	NA[H]	35[J]	NA[H]	<100[C]						X	-	X	X			
Rainbow trout/steelhead	M, L		X	X	A	✓	✓	✓				16-62[P]	NA[H]	39[J]	NA[H]	<100[C]	X	-						-	X	X	-	X
Round Whitefish	U, M, L		X		A[N], J	✓	✓	✓				2-44[W]	NA[H]	23[J]	NA[H]	<100[C]					-	X	X	-	-			
Sockeye salmon	M, L	X			J	✓	✓	✓				3-9[U]	NA[H]	6[J]	0.017[G]	158,260[B]				-	X	X	X	-	-			
Other (i.e. invasive/non-native spp.)	L[E]		X	X	A, J	✓	✓				✓	NA[H]	NA[H]	NA[H]	NA[H]	<100[C]	NA[H]											

DRAFT: Preliminary Version for September 2013 Site Visit

Table 2 Notes:

A Potential collection and release locations provided here have been selected for discussion purposes only and are likely to change during TWG sessions and as management objectives develop.
B Calculated as 10% of total Upper River smolt production potential reported by Barrick et al. (1983).
C For species that do not exhibit an obligate anadromous life history, are not abundant, or for which information is lacking to estimate potential numbers that would utilize passage facilities, "<100" was selected as an initial estimate. These values are subject to refinement during TWG sessions.
D "X" denotes peak run-timing; "-" denotes the remaining run timing interval. For some species, periods of peak run-timing could not be discerned from available information.
E Northern pike have been documented in the Lower River and their suspected distribution extends to tributaries up to the Three Rivers (Ivey 2009). The distribution of Alaska blackfish is unknown in the Susitna River basin (AEA 2012, USFWS 2008).
F "A" denotes adult; "J" denotes juvenile.
G Reflect fish weights used by Barrick et al. (1983) to estimate Upper River production potential.
H "NA" indicates no available information or pending review.
I Length (FL) range of Arctic grayling age-1+ and older captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1983)
J Midpoint of referenced length range.
K Length range of Arctic lamprey captured in the Susitna River during 1981-1982 (Schmidt et al. 1983). Neither life stages nor length-at-age information were provided; thus, this length range likely includes juveniles and adults. Adults die after spawning (Scott and Crossman 1973).
L Length range of age-3+ to age-6+ Bering cisco captured in the Susitna River during 1981-1982 (ADF&G 1981, 1983). No lengths of Bering cisco younger than age-3+ were reported.
M The timing of post-spawn Bering cisco downstream migrations are unknown; in 1982, no adults were captured during winter sampling or sampling methods other than fishwheel traps (Schmidt et al. 1983).
N The timing of post-spawn humpback and round whitefish downstream migrations are unknown; overwinter habitat use is unknown due to low winter capture rates (Schmidt et al. 1983, Sundet and Pechek 1985).
O Upstream of Devils Canyon, HDR (2012) captured Dolly Varden ranging from 2.6 to 36.6 cm FL using methods more likely to catch juveniles, whereas Sautner and Stratton (1983) captured Dolly Varden ranging from 12.0 to 20.5 cm FL primarily by angling. Thus, 12 cm was selected as the lower adult length range.
P Length range of rainbow trout age-3+ [earliest age of sexual maturity (Morrow 1980)] and older captured in the Middle River during 1981-1983 (Delaney et al. 1981, Schmidt et al. 1983, 1984).
Q Length range of age-0+ to age-10+ burbot captured upstream and downstream of Devils Canyon during 1981-1982 (ADF&G 1981, Delaney et al. 1981, Sautner and Stratton 1982).
R Combined length range of age-0+ (3.6-9.5 cm) and age-1+ (6.1-11.7 cm) Chinook salmon captured at the Talkeetna Station outmigrant trap in 1984 (Roth and Stratton 1985).
S Length range of age-0+ chum salmon captured in the Talkeetna Station outmigrant trap in 1984 (Roth and Stratton 1985).
T Combined length range of age-0+ (2.8-8.7 cm) and age-1+ (5.1-15.0 cm) coho salmon captured at the Talkeetna Station outmigrant trap and age-2+ (10.9-17.4 cm) captured throughout the Susitna River in 1985 (Roth et al. 1986).
U Combined length range of age-0+ (2.5-9.1 cm) and age-1+ (5.6-10.2 cm) sockeye salmon captured at the Talkeetna Station outmigrant trap in 1984 (Roth and Stratton 1985).
V Minimum length reflects the smallest humpback whitefish captured in juvenile outmigrant traps in 1983 (Sundet and Wenger 1984), while maximum length reflects the largest adult captured upstream of Devils Canyon in 1981 (Delaney et al. 1981).
W Minimum length reflects the smallest round whitefish captured in juvenile outmigrant traps in 1983 (Sundet and Wenger 1984), while maximum length reflects the largest adult captured upstream of Devils Canyon in 1981 (Delaney et al. 1981).
X Minimum length reflects the smallest longnose sucker captured in juvenile outmigrant traps in 1983 (Sundet and Wenger 1984), while maximum length reflects the largest adult captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1982).

PART A - APPENDIX C: PHYSICAL, HYDROLOGICAL, AND ENGINEERING INFORMATION

[See separate file for appendix.]

PART A - APPENDIX D: DETAILED SCHEDULE UPDATED JULY 10, 2013

[See separate file for appendix.]