Eklutna Hydroelectric Project

Fish Species Composition and Distribution

Year 2 Study Report

DRAFT

Prepared by:
Audrey Thompson
Mike Gagner
MaryLouise Keefe
Alice Shelly
Kleinschmidt Associates

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Terms, Acronyms, and Abbreviations

1991 Agreement	1991 Fish and Wildlife Agreement
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AWC	Anadromous Waters Catalog
AWWU	Anchorage Water and Wastewater Utility
BP	beaver pond
BR	boulder
bw	backwater
C	Celsius
cfs	cubic feet per second
CH	chute
CPUE	catch per unit effort
CS	cascade
DC	dry channel
DO	dissolved oxygen
ft	feet
FS	falls
FSP	final study plans
GL	glide
GPS	global positioning system
in	inch
m	meter
MJA	McMillen Jacobs Associates
mm	millimeter
N	total capture number
NMFS	National Marine Fisheries Service
NTU	nephelometric turbidity unit
NVE	Native Village of Eklutna
PD	puddle
PL	pool
PME	protection, mitigation, and enhancement
QA	Quality Assurance
QC	Quality Control
RF	riffle
RM	river mile
RP	rapid
sc	scour
TEK	Traditional Ecological Knowledge
TWG	Technical Work Group
µS	microsiemens

USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service

1 INTRODUCTION

The 1991 Fish and Wildlife Agreement (1991 Agreement) was executed amongst the Municipality of Anchorage, Chugach Electric Association, Inc., Matanuska Electric Association, Inc. (collectively "Project Owners"), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and the State of Alaska as part of the sale of the Eklutna Hydroelectric Project (Project) from the Federal government to the now Project Owners. The 1991 Agreement requires that the Project Owners conduct studies that examine and quantify, if possible, the impacts to fish and wildlife from the Project. The studies must also examine and develop protection, mitigation, and enhancement (PME) measures for fish and wildlife affected by such hydroelectric development. This examination shall consider the impact of fish and wildlife measures on fish in the Eklutna River as well as available means to mitigate these impacts. The Project Owners initiated consultation in 2019 and have implemented studies to inform the development of the future Fish and Wildlife Program for the Project. As part of these studies, the Project Owners contracted Kleinschmidt Associates to describe and evaluate fish species composition and distribution in the Project area.

The Eklutna River (Waterbody No. 247-50-10175) is documented in the Anadromous Waters Catalog (AWC) as supporting five species of Pacific salmon (Geifer and Blossom 2020). The upstream extent of anadromous habitat in the AWC at the outset of this study extended approximately 4.8 km (3 mi.) upstream from the mouth of the Eklutna River and 0.8 km (0.5 mi.) upstream of the Thunderbird Creek confluence.

Thunderbird Creek, the Eklutna River's largest tributary, enters the left bank of the Eklutna River about one mile downstream from the lower dam site. There is a 200-foot-tall waterfall, Thunderbird Falls, on Thunderbird Creek about 1/3 mi. upstream from its confluence with the Eklutna River (U.S. Army Corps of Engineers [USACE] 2011). Surveys by Native Village of Eklutna (NVE) in 2003 reported Chinook Salmon, Chum Salmon, Coho Salmon, Pink Salmon, and Sockeye Salmon in the reach below the falls, which is a complete passage barrier.

After the lower dam removal in 2018, Alaska Department of Fish and Game (ADFG) conducted a fish sampling effort from the Old Glenn Highway bridge upstream to the lower dam site. A total of 57 juvenile Coho Salmon, 58 juvenile Chinook Salmon, and 26 Dolly Varden were captured in the reach from the bridge upstream to a point located 1.4 km (0.9 mi.) upstream from the Thunderbird Creek confluence (ADFG 2020). One adult stream resident Dolly Varden was captured upstream from the pinch point indicating suitable fish habitat may exist above the barrier throughout the year. During ADFG surveys completed in September 2020, juvenile Coho Salmon were collected and observed upstream of Thunderbird Creek and approximately half a mile upstream of the lower dam site. Additionally, adult Coho Salmon were observed in the Eklutna River upstream of the Thunderbird Creek confluence (personal communication Ron Benkert, September 25, 2020). Both observations extended the upper extent of anadromy for adult and juvenile Coho Salmon life stages in the Eklutna River and indicate that anadromous fish could migrate upstream past the lower dam site.

Adult Escapement

Previous data on run timing and strength of adult anadromous salmon in the Eklutna River is based on two years of escapement surveys conducted by NVE in 2002 and 2003 (NVE unpublished data), and an adult salmon index survey completed by the USACE in 2007 (USACE 2007). Based on these data, Chum Salmon appeared to be most abundant, followed by Coho Salmon, Chinook Salmon, Pink Salmon, and Sockeye Salmon. Pink Salmon abundance oscillates between even and odd years as has been elsewhere observed in Knik Arm drainages. Sockeye Salmon, reported to have been abundant historically, now occur only incidentally in the Eklutna River (USACE 2011).

Adult salmon spawning has been observed in the lower Eklutna River from the upper limit of tidal influence to the reach between the confluence of the river with Thunderbird Creek and the lower dam site, including Thunderbird Creek itself (NVE, unpublished data) where Coho Salmon and Chinook Salmon spawning has been documented (USACE 2011).

Juvenile Rearing

Juvenile rearing and out migration from fresh water varies across salmon species. Chum, Pink and Sockeye salmon spend little time in freshwater as compared to Chinook and Coho salmon. In this section we briefly summarize this live history period for these fishes as it relates to their expected presence and habitat use in the Eklutna River.

After emergence, juvenile Chum Salmon rear in freshwater for a period of less than one day to several weeks before migrating downstream toward estuarine waters (Grette and Salo 1986). Unimpeded downstream passage is important to the survival of these salmon fry, and it has been suggested that the braided section of the Eklutna River upstream from the railroad bridge poses risk of fry stranding and predation associated with fluctuating flows and the presence of several small rivulets that dead end in thick vegetation or a dewatered channel (USACE 2011).

Juvenile Coho and Chinook salmon generally reside in river systems for 1 to 2 years before they migrate to the ocean. Some portion of Chinook Salmon juveniles may also leave natal streams as sub-yearlings and overwinter in larger water bodies downstream. Data from past fish sampling in the lower Eklutna River indicate that Coho Salmon are the predominate species collected with fewer Chinook Salmon juveniles captured compared to Coho Salmon.

Rearing habitat for both juvenile Chinook and Coho salmon in both summer and winter is limited in the lower Eklutna River. During winter conditions, juvenile fish may be forced to migrate to suitable habitats such as deep pools or beaver ponds in order to survive. In freshwater, juveniles of these species require complex habitats for rearing, such as main channel habitats with instream structure, cover, and pool sub-units as well as off-channel and/or side channel habitats with structure, cover, and reduced velocities. Habitat composition downstream of the spawning areas is predominantly a single channel with low habitat complexity, based on in-stream shelter values that ranged from 4 to 22% (NVE 2020). Downstream of the New Glenn Highway bridges to the railroad bridge is a braided reach of the river containing a flooded forest at higher flows. Observations of fish sampling teams have raised concern about the potential for salmon stranding or trapping in this reach due to the high number of shallow and perched channels/depressions present (G. George personal communication, July 2021).

Anadromous Three-spine Stickleback are also present in the lower river. They are thought to move into the lower river ponds in early spring to spend the summer. Ward (2010) documented large numbers of Three-spine Stickleback in the Eklutna off-channel ponds in May through July, with catch per unit effort up to seven times higher than that calculated for juvenile Coho Salmon.

In-River Habitat

An NVE habitat assessment on the mainstem Eklutna River delineated channel types and inventoried habitat units (NVE 2020). This study characterized the river as having primarily a single channel system, with some braiding present in the lower river due to flooding by beaver dams and historical gravel mining, rather than geomorphological features. The river up to Eklutna Lake was estimated at 11.6 mi. long, with only the lower approximately one-half of the river receiving sufficient inflows to have continuous year-round flow. Average channel width ranged from 6 to 79 feet and average water depth ranged from 6 to 21 inches.

The Fish Species Composition and Distribution Study on the Eklutna River was initiated in 2021 in accordance with Section 3.3 of the May 2021 Final Study Plans (FSP) (McMillen Jacobs Associates [MJA] 2021). As noted in the FSP, based on early outreach efforts, the main goal of the agencies and interested parties relative to the fisheries study is to find a new balance amongst the uses of water in the Eklutna River basin, including power production, potable water supply, and fish habitat. Potential fisheries related PME measures involve providing a flow regime into the Eklutna River that would accomplish habitat restoration and increase the anadromous fish assemblage of the river. The FSP provides additional background information and context for the fish species composition and distribution study.

This Study Report describes the data collected during the 2021 and 2022 field seasons and analysis on the distribution of juvenile and adult fish species in the Eklutna River between the upper extent of tidal influence and the Eklutna Dam. Characteristics of instream habitat for rearing juvenile salmonids in the Eklutna River, as well as use of that habitat by fishes, are presented. Additionally, two years of data on the distribution of adult spawning fish in the Eklutna River downstream of the lower Anchorage Water and Wastewater Utility (AWWU) road, as well as Thunderbird Creek, are presented. While this study investigated available habitat and its use by fishes during spring, summer, and fall, it is also important to consider whether observed conditions may be suitable for overwintering of juvenile salmonids that spend multiple years rearing in freshwater, such as Coho and Chinook salmon. Habitat requirements for these species change during winter conditions, so suitable habitat during this period should be a consideration for management of fish resources in the Eklutna River Watershed. This topic is also addressed in the Year 2 Instream Flow Report (Reiser et al. 2023).

1.1. Coordination with Native Village of Eklutna

The NVE has conducted various habitat, fish utilization, and spawning surveys in habitats in Eklutna River in 2021 and 2022. These studies provide important complimentary data to those data presented in this report. We intend to reference data from NVE in this report when it becomes available in 2023 to supplement and support data collected during the Fish Species Compositions and Distribution Study. Specific data that we hope to provide with consent and collaboration from NVE in the final version of this report include:

- 2022 Spawning surveys of Pacific Salmon. NVE has provided their initial fish counts, but not spatial data. We would like to combine two years of spatial spawning data to generate a complete survey of fish spawning activity distribution, periodicity of adult salmon use of the Eklutna River, and identification of any habitats that are especially important for target species that should be considered with greater weight than others.
- Juvenile fish use of Beaver Pond habitat downstream of Fish Study Reach 1 (Fish Study reaches are delineated the same as Instream Flow or Geomorphology Reaches).

1.2. Study Objectives

The goal of this study was to characterize the current composition and distribution of fish species using the freshwater portions of the Eklutna River including both adult and juvenile life stages of Pacific salmon and resident fish species.

- Task 1: Eklutna River Fish Community. The objective was to describe the seasonal composition, distribution, and habitat use for juvenile anadromous salmonids, non-salmonid anadromous fishes, and resident fishes in both in-river habitats (2021) and the off-channel beaver ponds near the confluence with salt water (2022).
- Task 2: Adult Salmon Spawning Surveys 2021 and 2022. The objectives were to:
    - 2.1 Index temporal abundance of spawners; and
    - 2.2 Determine the spawning distribution.

1.3. Study Area

The study area for Task 1, Eklutna River Fish Community, included approximately 11.3 miles of the Eklutna River beginning with the beaver complex at the extent of tidal influence (RM 0.35) and reaching to the Eklutna Lake Dam spillway plunge pool (RM 11.6) (Figure 1.1-1).

The study area for Task 2, Adult Salmon Spawning Surveys, included approximately 4.4 miles of the Eklutna River starting just upstream of the beaver complex and extent of tidal influence and extending up to the downstream end of the AWWU access road, approximately 1.4 miles above the lower dam site. Adult salmon surveys also took place in Thunderbird Creek from the confluence with the Eklutna River upstream to Thunderbird Falls, a documented anadromous fish barrier (ADFG 2019; Geifer and Blossom 2020) (Figure 1.1-2).

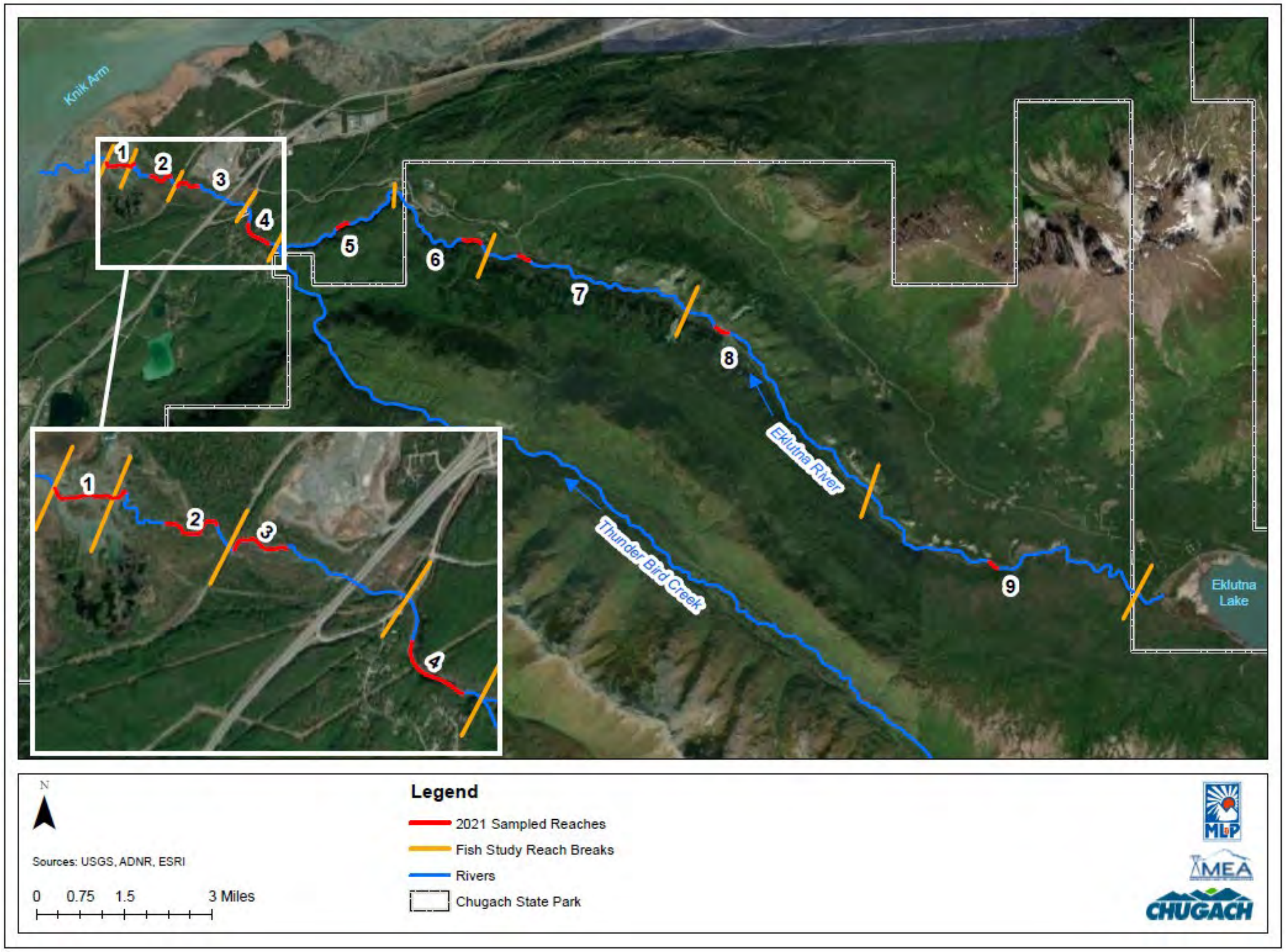

Figure 1.1-1. Task 1 Eklutna River Fish Study (2021-2022) study area including reach breaks (1-9), sub-reaches that were investigated for fish presence and assessed for habitat characteristics.

Figure 1.1-2. Task 2 Eklutna River Spawning Survey Area 2021 study area including reach breaks (1-5) indicated by black and white bars, and the anadromous catalog anadromous extent (2020) shown in blue dotted lines.

2 METHODS

The methodology used for all sampling efforts for the Eklutna River Fish Study in 2021 and 2022 was consistent with those outlined in the May 2021 FSP. Some methods for capture (gill nets, seines) proposed in the study plan were not implemented because other methods proved to be very effective for capturing fish in sampled habitats.

2.1. Task 1: Eklutna River Fish Community

To document resident and juvenile anadromous fish community composition and species distributions, seasonal sampling of reaches measuring 40 times the wetted channel width (minimum of 325 ft., maximum of 1,312 ft.) was conducted. The starting location or habitat unit for sampling within each reach was randomly selected prior to the first survey using a random number table. River fish sampling took place over three sample periods in 2021: Spring (May 25-29); Summer (July 27-August 3); and Fall (October 7-15).

This collection window allowed surveys to cover most of the time that anadromous fish were expected to be migrating through, or residing in, the Eklutna River. Sampling was stratified among nine defined geomorphic reaches including:

1) single channel reach and side channels near the upstream extent of tidal influence;
2) multi-channel reach up to the railroad bridge;
3) railroad bridge to the Old Glenn Highway;
4) Old Glenn Highway to Thunderbird Creek confluence;
5) Thunderbird Creek confluence to the old dam site;
6) old dam site to the downstream end of the AWWU access road;
7) Canyon upstream of the end of the AWWU access road;
8) Lower AWWU Road Reach with sediment sources; and
9) Upper AWWU Road Reach with sediment sources.

Sub-reaches and habitat units selected for sampling are displayed in Figure 1.1-2 (above). Representative images of each sampled sub-reach are presented in Figure 2.1-1. In 2022, the extensive beaver complex located near tidal influence was added as a sample site (Figure 2.1-2).

Study reaches 1-9 were identified during study planning and collaboratively agreed to with the Aquatics Technical Working Group (TWG) in early 2021. Habitat units within each reach to be sampled were selected based on the first habitat break identified at each reach when surveyed from downstream to upstream. Each initial habitat unit was identified by habitat type, and the wetted width of the unit was measured. Total target reach length was determined based on a calculation of 40 times the initial wetted width measurement (or until the next habitat break) at habitat unit #1 in each reach. During 2021 study flow releases, changes to the connectivity of the beaver complex in the lower river justified addition of the habitat in 2022 sampling as a potentially important rearing and overwintering habitat for juvenile salmonids. Only fish sampling occurred in the beaver ponds.

Figure 2.1-1. Representative photos of the nine sub-reaches sampled for Resident and Juvenile Fish Species and Distribution in 2021.

Figure 2.1-2. Beaver complex located on river left near the Eklutna River estuary. The areas within the complex closest to the beaver dams where water was actively flowing were the most used by fish.

Each reach was sampled using single-pass backpack electrofishing and baited minnow traps. Use of electrofishing as a fish capture technique is regulated by ADFG. Consistent with recommendations, electrofishing was not conducted when adult anadromous salmon were present. ADFG-recommended target voltage settings for juvenile salmonid sampling in cold water were used as a reference at the onset of sampling (Bales and Geifer 2015), as well and the Quick-Setup feature of the LR-24 Smith-Root Backpack Electrofishing unit, which calculates recommended voltage settings based on ambient conductivity and water temperature. All backpack electrofishing activities followed NMFS (2000) Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act.

A Smith-Root LR-24 backpack electrofishing unit was operated by a trained field crew leader who was assisted by two people with dipnets. Each backpack unit was fitted with a standard Smith-Root cathode and a single anode pole with a steel ring. Single-pass electrofishing surveys were conducted through the selected study reach moving in an upstream direction. All stunned fish were captured with dipnets away from the electric field and held in buckets for later processing. Backpack electrofisher settings were determined in the field based on water quality conditions, professional judgment, and the overall goal of minimizing impacts to fish health (Temple and Pearsons 2007). Prior to electrofishing, ambient water chemistry was recorded including conductivity (µS), turbidity (nephelometric turbidity unit [NTU]), and surface water temperature (°C) with a digital meter at the downstream end of the sampling site to help determine initial backpack electrofishing unit settings. In all cases, the electrofishing unit was operated and configured with settings consistent with guidelines established by the manufacturer (Smith-Root 2009), ADFG (Bales and Geifer 2015), and NMFS (2000). Personnel operating electrofishing units were trained and certified per ADFG permit requirements. The location of each habitat unit electrofished was mapped using handheld Global Positioning System (GPS) units and marked on high-resolution aerial photographs. Start and stop times and total effort (in seconds) was recoded to quantify and standardize effort between seasonal surveys.

Gee-type minnow traps (17.5 in. x 9 in. with ~1 in. openings and ¼ in. mesh) were baited with sterilized, commercially preserved salmon eggs (or disinfected with a 10-minute soak in a 1/100 Betadine) and soaked overnight at a density of 1 trap/ 69 ft. sample length. Distances between traps depended on available habitat, reach length, water depth, and complexity, and traps were set more densely in complex habitats with appropriate depth (Bryant 2000). Minnow traps were set in habitats with slow water and/or cover to maximize catch and left overnight for a period ranging from sixteen to twenty-four hours. The number of traps deployed, and their locations were recorded to maximize trap recovery. Trap retrieval lines were tethered to streamside vegetation or staked and marked with fluorescent flagging that included a trap identification number and required ADFG permit information.

Fish collected within each mesohabitat unit were counted and processed separately and to the extent possible, fish capture methods were repeated with a similar level of effort between seasonal surveys. Fish were identified to species, measured for fork length (mm), and released alive near the point of capture. The resources “Fish Identification of Coastal Juvenile Salmonids” by Pollard et al. (1997) and “Juvenile Salmonid and Small Fish Identification Guide” by Weiss (2003) were used for field verification of juvenile salmonid species in addition to the ADFG guide. Sculpin were recorded as “*Cottus* sp.”. A dip net was used when catching fish to be measured. Hands, dip nets, and measuring boards were wetted before touching fish. Length measurements were taken on a clean, smooth, wet PVC cradle with easy-to-read gradations in millimeters. Ancillary data including fish condition, sex (if determined), presence of spawning colors, and any injuries or mortalities was recorded on field forms. Analysis of length data to determine age classes and assessment of Catch Per Unit Effort (CPUE) by habitat type to analyze seasonal preferences were completed using R (R-Core Team 2022) based on (Benaglia et al. 2009).

A standard suite of physical habitat data and descriptive information was collected where fish sampling occurred within each geomorphic reach. These parameters were taken from the U.S. Forest Service (USFS) Aquatic Habitat Tier One survey (USFS 2001, Chapter 20). Channel morphology characteristics for each survey reach were documented at one single channel riffle, or where no significant side channels were present, and included:

- channel type
- channel pattern
- average bankfull width (m/ft.)
- bankfull maximum depth (m/ft.)
- water surface gradient (%)
- riparian vegetation
- location/type/area of off-channel habitats width and status of side channels

Habitat units that fell within survey reaches were delineated. Habitat types were classified as follows: backwater pool (PL-bw), scour pool (PL-sc), beaver pond (BP), glide (GL), riffle (RF), boulder riffle (BR), rapid (RP), chute (CH), cascade (CS), falls (FS), dry channel (DC), and puddled (PD) (Appendix 1). Photographs of representative habitat as well as any special habitat features were taken at each survey reach. For each habitat unit the following data were collected:

- unit type and number
- unit length (m/ft.)
- location of the downstream and upstream endpoints using a GPS receiver (latitude/longitude in decimal degrees in the WGS84 datum)
- average wetted width (m/ft.) based on three measures
- average wetted depth (m/ft.) based on three measures
- maximum pool depth (m/ft.) if applicable
- modified Wentworth substrate composition (%)

2.2. Task 2: Adult Salmon Spawning Surveys

Adult salmon spawning and carcass surveys were conducted weekly from early July to the end of October in collaboration with NVE who also surveyed staging and spawning activity of Pacific salmon weekly. No adult salmon were observed near the downstream end of the AWWU access road, so surveys were not continued beyond this location in 2021.

To support comparison with previous years' survey efforts (NVE 2002, 2003; USACE 2007), count data were summarized by the following survey reaches (Task 2 study area Figure 1.1-2):

1) Eklutna River upstream of the beaver pond complex and zone of tidal influence to the railroad bridge (~0.7 mi.)
2) Eklutna River from the railroad bridge to the Old Glenn Highway bridge (~0.7 mi.)
3) Eklutna River from Old Glenn Highway bridge to the confluence with Thunderbird Creek (~0.5 mi.)
4) Eklutna River above the confluence with Thunderbird Creek to the downstream end of the AWWU access road approximately 1.4 mi. upstream of the lower dam site (~2.5 mi.)
5) Thunderbird Creek from the confluence with the Eklutna River to Thunderbird Falls (~0.5 mi.).

Pedestrian surveys were conducted from a downstream to upstream direction to enumerate live adult salmon by species in each survey reach. Where multiple stream channels were present in Reaches 1 and 2, each channel was surveyed and adult salmon counts were separated into right side braids, left side braids, and single channel. In the field, data were entered on prepared forms. GPS locations of observed salmon spawning and established redds were collected using a GPS receiver (latitude/longitude in decimal degrees in the WGS84 datum). The species and number of fish in spawning areas was described on field forms. Information collected for each survey included total salmon count by species and reach, location and number of redds by species, and opportunistic photographs of spawning areas, redds, and adult fish.

Water temperature (°C) and turbidity (NTU) were collected during each survey at established locations in the Eklutna River downstream of the Old Glenn Highway bridge, and in both the river and Thunderbird Creek upstream of their confluence. Water visibility was estimated with a survey rod to measure the visible depth to the stream substrate. Eklutna River stream stage (feet) near the Old Glenn Highway bridge at RM 2.3 and RM 2.5, and above Thunderbird Creek at RM 2.9 was recorded for each survey. When possible, surveys were initiated mid-morning to minimize shadow effects on visibility. Polarized glasses were worn by observers and any survey conditions that affected visibility and salmon counts including water color/ turbidity, weather, and cloud cover were recorded. In 2021, two carcass samples (heads) were collected from dead Chinook and Coho salmon by MJA and delivered to ADFG for otolith and stock identification. Additional carcasses were delivered to ADFG by NVE in 2022.

2.3. Data Management and QA/QC

The goals of data management were to establish a data quality assurance/quality control (QA/QC) protocol to be applied at logical stages of data collection and processing, and to ultimately create a database of all QC'd fish composition and distribution data collected for the Eklutna Project. Five levels of QC (QC1 to QC5) are underway to govern data collection efforts and ensure a rigorous and high-quality product. Each QC level is tracked either within tabular datasets (Excel and database tables), or within file path names (as for raw field data files). This allows for quick determination of the QC status of all data. A data dictionary describing the database entities and attributes was compiled to accompany the database and to provide an understanding of data elements and their use by anyone querying or analyzing the database deliverable to be provided in 2023 following completion of all data collection and analysis. All original field data will be preserved during the QA/QC process as well as complete documentation of any adjustments (e.g., conversion of units) or qualifiers as to the appropriate use of data for analysis.

The five QC documentation steps are as follows:

- **QC1 Field Review**: Review of field forms before leaving the field, or the QC level of raw data collected via field equipment such as cameras, GPS units, etc. The goal of QC1 was to identify errors and omissions and correct them under similar field conditions prior to leaving the field. Review was done on 100% of data and included completeness, legibility, codes, and logic on all information recorded. This was typically completed in the field daily. Paper and electronic field forms were backed up nightly in the field by scanning and downloading to a storage unit.
- **QC2 Data Entry**: Data from paper forms was entered into an electronic format and verified by a second party against the field forms. The goal of QC2 was to verify correct, complete, and consistent data entry. Verification was done on 100% of data entered and included extrapolation of shorthand codes that were used in the field into longhand or standard codes during data entry.
- **QC3 Senior Review:** Final review by a senior professional before submitting field data, or the QC level of raw data cleaned up for delivery. Data was reviewed by a senior professional on the consultant team, checking for logic, soundness, and adding qualifiers to results if warranted. Calculated results were also be added at this time.

- **QC4 Database Validation**: Tabular data files were verified to meet project database standards. Data was verified for completeness, project standards (codes, field name conventions, date formats, units, etc.), calculated and derived fields, QC fields, etc. The data files were incorporated into the project database schema, splitting into normalized tables as necessary, and all primary and foreign keys checked.
- **QC5 Technical Review**: Data revision or qualification by senior professionals when analyzing data for reports. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

3 RESULTS

3.1. Task 1: Fish Habitat Use

3.1.1. Reach Habitat Characteristics

Total reach lengths sampled for fish ranged from 475 ft. to 1,312 ft. with the longer reaches occurring in the lower portion of the Eklutna River (Reaches 1-4) where the channel morphology is less constrained as compared to the canyon reaches. Documented wetted habitat units were generally wider in these longer, lower river reaches (Table 3.1-1). Riffle and glide habitat were the most commonly observed habitat type by length with limited occurrence of backwater, side channel, or pool habitat upstream of the Old Glenn Highway bridge. Habitat complexity was highest in Reaches 1 and 2 where scour pools, backwaters, and side channels were present.

Table 3.1-1. Physical habitat characteristics of habitat units within Reaches 1- 9 sampled for fish species abundance and distribution between May and October of 2021. Physical habitat data are presented for the dominant habitat type in the reach and averaged between habitat surveys completed in May and October (no surveys were completed in the summer).

Reach Habitat Characteristics	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R- 9
Unit Length (ft)	1,312	1,312	1,000	1,312	475	702	541	597	475
Avg. Bankfull Depth (ft)	--[1]	2.95	1.6	2.29	1.64	3.6	4.26	3.28	1.64
Avg. Bankfull Width (ft)	45.9	39.0	31.8	49.5	28.5	32.4	40.4	27.9	36.1
Avg. Wetted Width (ft)	45.9	27.9	20.7	30.5	10.5	14.4	13.1	15.1	28.5
Water Gradient (%)	0.3	1.5	3.4	2.3	2.6	3.4	2.0	2.0	2.0
Channel Type	Simple	Complex	Split	Single	Single	Single	Single	Single	Single
Dominant Habitat Type (by length)	Glide (61%)	Riffle (38.3%)	Riffle (79%)	Riffle (100%)	Riffle (100%)	Riffle (52%)	Glide (70%)	Riffle (83%)	Pocket (68%)

Notes:
1 No average presented for R1 Bankfull depth because depth was highly variable across the transect.

3.1.2. Water Quality

Water quality parameters, including temperature and turbidity, varied across the seasons. Water temperature ranged from 2.1-4.9 ℃ in spring with colder water in lower reaches (1 and 2). In summer, temperatures ranged from 5.4-11℃ with colder water in the middle canyon reaches where there is little sun penetration (Table 3.1-2). Turbidity varied from less than 7 NTU to a level outside the range of measurement with our water quality meter (>300 NTU). These very high turbidity measurements occurred in Reach 6 following study flow releases when sediment was actively being recruited from the muddy banks and Reach 8 where the beaver pond influenced the turbidity of the sampled water (Table 3.1-2). Water quality parameters were not sampled during study flow releases.

Table 3.1-2. Water quality measurements for Turbidity and Water Temperature at Reaches 1-9 during spring, summer, and fall sampling.

		Turbidity (NTU)		Water Temperature ºC		
Reach	**Samples**	**Min**	**Max**	**Min**	**Mean**	**Max**
1	9	<7	47	2.1	7.6	10
2	3	<7	45	1.6	6.9	9.8
3	3	<7	33	3.8	5.5	6.9
4	3	<7	15	3.36	5.1	6.9
5	3	<7	90	3.1	6.0	7.6
6	3	10	>300	4.1	5.2	6.1
7	3	<7	130	4.61	5.1	5.4
8	3	18	>300	4.9	6.6	9.9
9	3	13	45	4.8	8.7	11

3.1.3. Fish Community

Relative abundance and distribution of fish species were surveyed in all established reaches (1-9) and all habitat sub-units (i.e., riffle, glide, cascade) within those reaches. Presence of fish species in the beaver pond complex was surveyed in the late summer of 2022 using electrofishing to complement a 2022 NVE sampling event that used minnow trapping methodology.

Electrofishing and deployment of gee-type minnow traps were both effective methods for capture of juvenile fish in the Eklutna River. A total of eleven fish species were identified, which ranged from ubiquitous (Dolly Varden) to rare (Alaska blackfish and Eulachon, single exemplars captured). Species richness decreased with distance upstream under the flow conditions present in 2021. Species richness was greatest in Reach 1 and the beaver pond, was representative of the number of anadromous salmonid species in Reaches 2-5, and was limited to Dolly Varden in reaches upstream of the lower dam site (Reaches 6-9) (Table 3.1-3). Reference photographs of commonly encountered species and life history stages are presented in Figure 3.1-1.

Table 3.1-3. Juvenile anadromous and resident fish species distribution as observed at Reaches 1-9 during electrofishing and minnow trapping efforts in May, July/August, and October 2021, and at the beaver complex (BP) in August of 2022 (BP).

Juvenile/ Resident Fish Species Present by Reach	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-8	R-9	BP
Chinook Salmon	X	X	X	X	X						X
Coho Salmon	X	X	X	X	X						X
Chum Salmon	X	X	X	X							X
Pink Salmon	X										
Sockeye Salmon	X										X
Kokanee										X[1]	
Dolly Varden	X	X	X	X	X	X	X	X	X	X	
Sculpin	X	X	X	X	X						
3 Spine Stickleback	X										X
9 Spine Stickleback	X										X
Alaska Blackfish	X										
Eulachon	X										

Notes:
1 Adult kokanee that were washed into the upper Eklutna River above the upstream-most beaver dam during the study flow releases in 2021 and were captured at Reach 9 in mid-October.

Relative abundance of fish species in the Eklutna River reaches changed longitudinally from the lower to upper river. Chinook and Coho salmon juveniles accounted for 80% of fish captured (73 total) in the beaver ponds in 2022 with incidental occurrence of Sockeye (2), Chum (1) and stickleback (8). In 2021, Coho Salmon and both 3- and 9-spine stickleback accounted for over 75% of the total fish sampled in Reach 1. From Reach 2 to Reach 5, the proportion of Coho Salmon and Chinook Salmon decreased from more than 50% (Reach 2) to less than 25% of the total sample (Reach 5), while the proportion of Dolly Varden captured increased proportionally. In Reaches 6–9, the sampled fish population in all seasons included only Dolly Varden (Figure 3.1-2).

Figure 3.1-1. Representative photographs of fish species encountered during 2021 electrofishing and minnow trap sampling at Eklutna River reaches 1-9 during May-October.

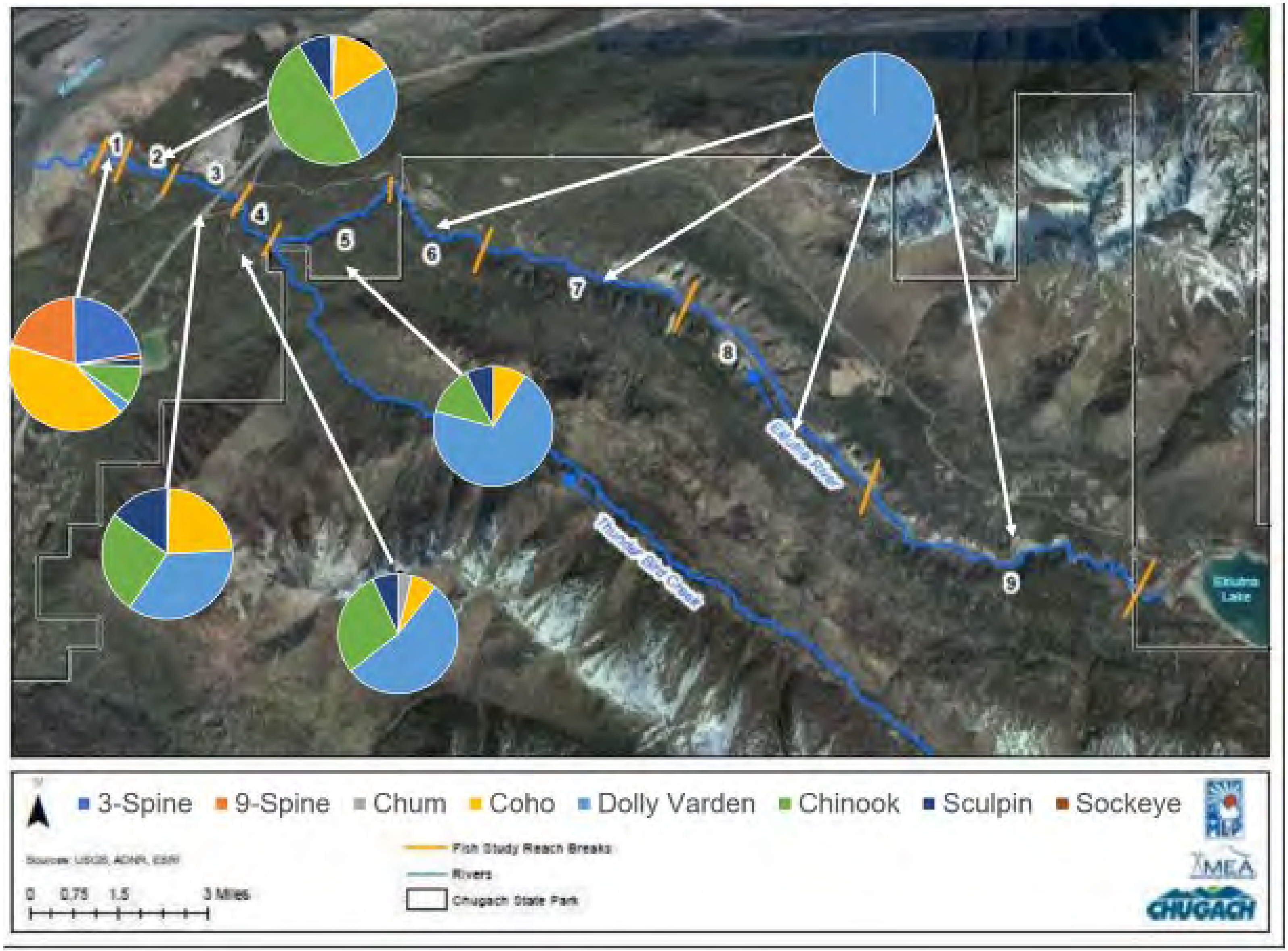

Figure 3.1-2. Relative abundance of juvenile fish species encountered during all seasons by Eklutna River Reach.

Electrofishing and minnow trap sampling in Eklutna River Reaches 1-5 resulted in capture of both juvenile Chinook and Coho salmon, and Dolly Varden that included representatives of multiple age classes ranging from emerging young-of-year to smolts to mature adults (Dolly Varden). The changing size distribution of Chinook and Coho juveniles observed from May to July/August to October may be indicative of factors including within-basin redistribution, smolt out-migration, and growth (Figure 3.1-3).

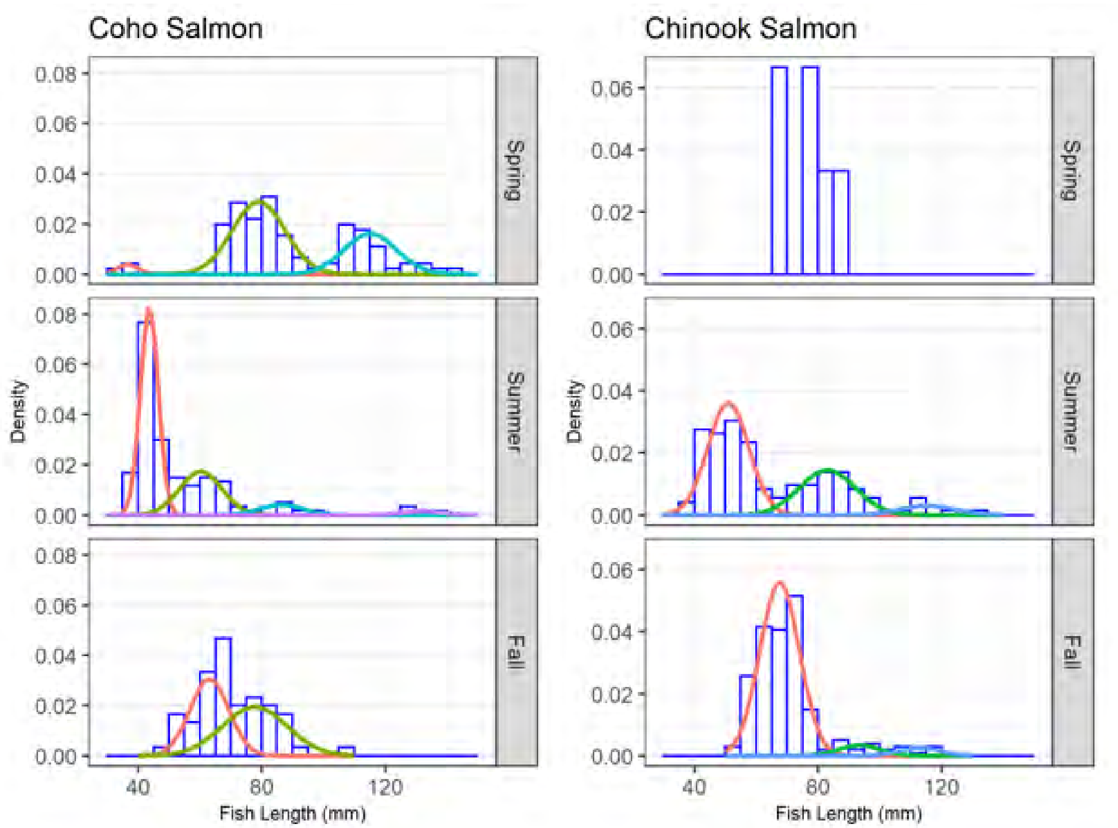

Figure 3.1-3. Length Frequency histograms for spring (upper panel), summer (middle panel), and fall (lower panel) for Coho Salmon (left column) and Chinook Salmon (right column). The x-axis indicates Fork Length in mm and the Y-axis is density. The presence of multiple peaks suggests age stratification among captured fish. Data compiled from electrofishing sampling, Eklutna River Reaches 1-5. Minnow trap data not included because it is a more size-selective fishing method.

3.1.4. Fish Habitat Use

Within reaches, each habitat unit was individually sampled using minnow trapping and electrofishing for presence of juvenile fish to determine habitat preferences by species and age class. The greatest habitat diversity was observed in Reaches 1-3 (see Figure 1.1-2) and fish sampling indicates that fish occupied available habitats, though distribution of species among habitat varied. For salmonid species including Chum Salmon, Coho Salmon, Chinook Salmon, and Sockeye Salmon, occurrence in Reach 1 was greatest in riffle habitats and side channels where cover such as vegetation or overhanding banks was available. These species were also concentrated along the downstream margins of the many beaver dams where cover and structure are available. In Reaches 2 and 3, Coho Salmon, Chinook Salmon, and Dolly Varden were present in all habitat types while incidental Chum Salmon and Sockeye Salmon were present only in riffle and pool habitat, respectively. In Reaches 4 and 5 where predominantly riffle habitat is available, all fish were documented in a single habitat type. Table 3.1-4 shows relative abundance of salmonid juveniles captured in dominant habitat types by reach, including total capture number by species for all seasons sampled in 2021.

Table 3.1-4. Relative abundance of salmonid juveniles captured in dominant habitat types by reach, and total capture number ("Total N," electrofishing and minnow trapping) by species for each reach. Habitat Type category "other" includes scour pool, pool, and backwater habitats. Data for Reaches 6-9 where only Dolly Varden were present are not shown. Data are compiled from all seasons.

Eklutna River Reach (1-5)	Habitat Type	Chum	Coho	Chinook	Sockeye	Dolly Varden
1	*Glide (61.3%)*	33.3	56.7	19.1	10.0	50.0
1	*S. Channel (38.7%)*	66.7	43.3	80.9	90.0	50.0
Total N		3	584	89	10	22
2	*Glide (20.3%)*	0.0	19.7	22.9	--	34.5
2	*Riffle (38.3%)*	100.0	37.9	22.4	--	45.5
2	*S. Channel (22.4%)*	0.0	6.1	30.8	--	7.3
2	*Other (19.0%)*	--	36.4	23.8	100.0	12.7
Total N		3	66	208	1	121
3	*Glide (6.4%)*	--	--	--	--	1.8
3	*Riffle (79.0%)*	--	54.1	94.9	--	75.4
3	*S. Channel (5.5%)*	--	5.4	--	--	12.3
3	*Other (9.1%)*	100.0	40.5	5.1	--	12.3
Total N		1	37	39	0	57
4	*Riffle (100%)*	100.0	100.0	100.0	--	100.0
Total N		6	11	46	--	86
5	*Riffle (100%)*	--	100.0	100.0	--	100.0
Total N		--	6	9	--	47
Beaver Pond	*Pool (88%)*	0	0	0	0	0
Beaver Pond	*Beaver Dam (12%)*	100.0	100.0	100.0	4	0
Total N		0	14	44	4	0

3.1.5. Seasonal Fish Habitat Use

Juvenile fish use of habitats varied by season for target species Coho and Chinook salmon. Since the amount of each habitat type varied among seasons, in part because of study flow releases, it was important to normalize the fish count by habitat type to the electrofishing effort expended in each habitat. We compared CPUE, which is fish counts per minute of electrofishing time. No juvenile salmonids were captured in the upper reaches (6-9) in any season. Therefore, we did not include consideration of the sampled habitats in these reaches with zero counts, which might bias the habitat association results.

The seconds of sampling effort were not recorded for a backwater habitat in Reach 2 in the fall (no juvenile salmonids were captured), nor for one side channel in Reach 1 in the summer (29 juvenile Coho Salmon captured). These habitat units are not included in the analysis below.

In the spring, most habitat sampled and available was riffle habitat, with only a small amount of glide habitat in Reach 2. Fewer juvenile Chinook Salmon were captured, and all were in riffles in Reaches 2 and 4. Almost all Coho Salmon juveniles were captured in Reach 1. In Reach 2, densities were higher in glides than in riffles.

In the summer, habitats were more diverse and included some alcove, pond, and side channel habitat. Juvenile Chinook Salmon were found in the highest densities in side channel habitat in Reach 1, followed by scour pools in Reaches 1 and 2, and glides and riffles in Reach 2. They were also found in Reach 4 (all riffle habitat). As in spring, juvenile Coho Salmon were found in the highest densities in the downstream reaches, with a very high density in Reach 1 side channel habitat. They were also found in moderate densities in scour pools in Reaches 1 and 2, and in alcove and pond habitats in Reach 3 (Table 3.1-4).

In the fall, fewer Coho Salmon juveniles were captured, and most of them were found in side channel habitat in Reach 1, with some also in side channels and glides in Reach 2. Chinook Salmon were mostly found in Reaches 2 and 3, with a very high density in Reach 2 side channel habitat. Chinook Salmon were also using scour pools and glides in Reach 2 and mainly riffle habitat in Reach 3 (Table 3.1-4).

Table 3.1-4. Sampling effort, count, and count per minute effort for Coho and Chinook salmon in Reaches 1-5 (combined) in three seasons by habitat type.

Season	**Habitat**	**Effort** (minutes)	**Coho Salmon**		**Chinook Salmon**	
			Count	CPUE	Count	CPUE
Spring	*Glide*	4.5	5	1.1	0	0
	Riffle	93	153	1.6	6	0.065
Summer	*Alcove/Pond*	4.3	15	3.5	0	0
	Glide	25	19	0.8	20	0.8
	Riffle	46	31	0.7	71	1.5
	Scour Pool	20	80	3.9	59	2.9
	Side Channel	4.1	35	8.5	19	4.6
Fall	*Glide*	17	10	0.58	32	1.9
	Riffle	42	2	0.047	63	1.5
	Scour Pool	8.1	0	0	36	4.5
	Side Channel	17	50	3	65	3.9

3.2. Task 2: Adult Salmon Spawning Surveys

3.2.1. 2021 Spawning Surveys

Spawning surveys occurred approximately weekly from July 9, 2021 to October 28, 2021. Surveys in mainstem spawning reaches (1-4) were not completed on September 18 or 23 during the 150 cubic feet per second (cfs) flow releases (September 13-29) because extreme turbidity associated with released sediment and dangerous flow conditions precluded safe execution of the survey. Thunderbird Creek (Spawning Reach 5) continued to be surveyed during the study flow releases. Spawning surveys were completed on Thursday or Friday of each week to the extent possible, though survey dates varied due to weather, schedule conflicts, and coordination with NVE who also completed weekly spawning surveys during the same period. NVE completed spawning surveys on Tuesdays and used identical methods so that data sets could be comparable. The NVE and MJA weekly surveys were staggered to ensure that no staging and spawning activity of Pacific salmon would be missed. 2021 MJA Survey dates were as follows:

- July 09, 16, 22, 31
- August 06, 11, 20, 26
- September 03, 11, 18 (Thunderbird only), 23 (Thunderbird only), 29
- October 05, 14, 22, 28

No spawning salmon or Dolly Varden were observed during our first survey on July 9 nor on the last survey on October 28.

Spawning activity of anadromous salmon observed included presence of adult fish, active digging or guarding of redds, constructed or partially constructed redds, and presence of post-spawned carcasses. Characteristic photographs were taken when water clarity allowed to document spawning activity, as shown in Figure 3.2-1 for a Chinook Salmon redd.

The period during which adult fish of each species were observed in the Eklutna River in and Thunderbird Creek in 2021 were as follows and are presented in Figure 3.2-2

- Chinook Salmon: July 16-August 6, 2021
- Pink Salmon: July 31-September 09, 2021
- Chum Salmon: August 20-September 03, 2021.
- Coho Salmon: September 03-October 14, 2021
- Dolly Varden (resident): September 23-October 22, 2021

Figure 3.2-1. Example of Chinook Salmon redd photographed upstream of the New Glenn Highway bridges on July 16, 2021.

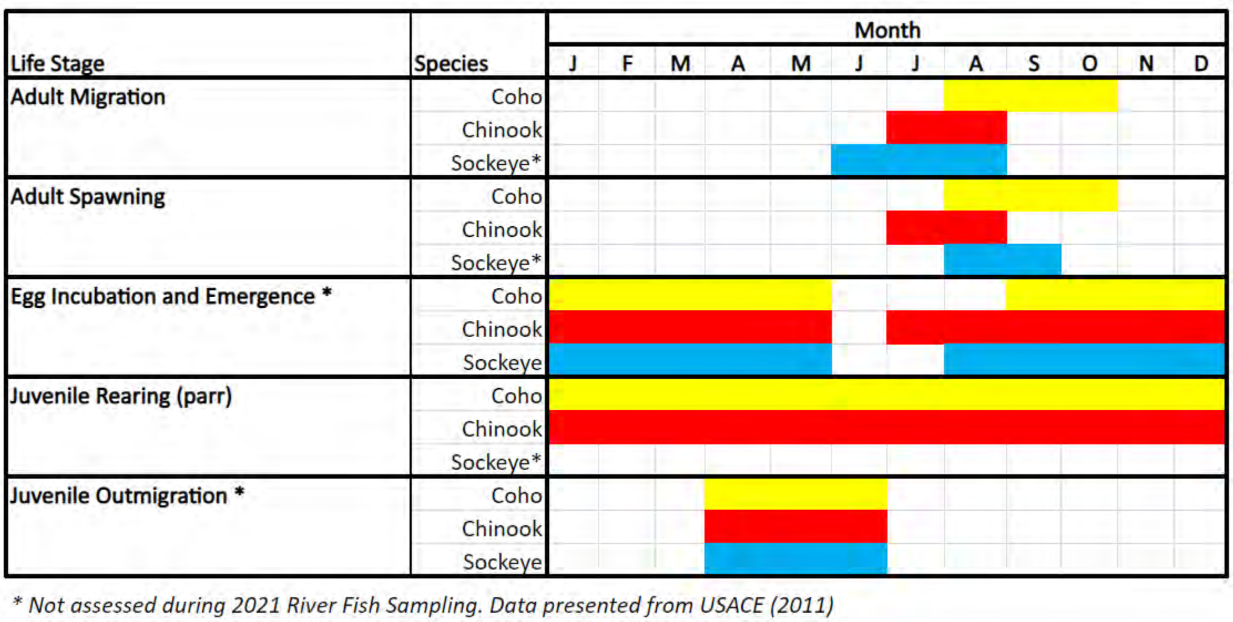

Figure 3.2-2. Pacific salmon life stage periodicity observed in Eklutna River 2021 and 2022.

Pink Salmon were the most abundant anadromous species with a range of 20-120 individuals observed per spawning survey from July 3-September 9, 2021, and a total of 98 Pink Salmon redds observed over the same period. Chinook and Coho salmon were equally scarce with 1-2 individuals observed per spawning survey from July 16-August 6, 2021. Two Chinook Salmon and one Coho Salmon redd were observed in the mainstem Eklutna, while a further one Chinook and six Coho redds were documented in Thunderbird Creek. The distribution of observed spawning activity indicates the preference of Chum and Pink salmon for habitats in the downstream reaches, while Chinook and Coho were observed using habitat in further upstream reaches 4 and 5 including the clearwater Thunderbird Creek. Figure 3.2-3 indicates the GPS position of all anadromous salmon redds documented in 2021, most of which were identified to species by presence of adult fish.

Analysis of carcass heads returned to ADFG in 2021 identified that the origin of Chinook salmon carcasses in the Eklutna River was likely the ADFG Eklutna Powerhouse Tailrace Fishery.

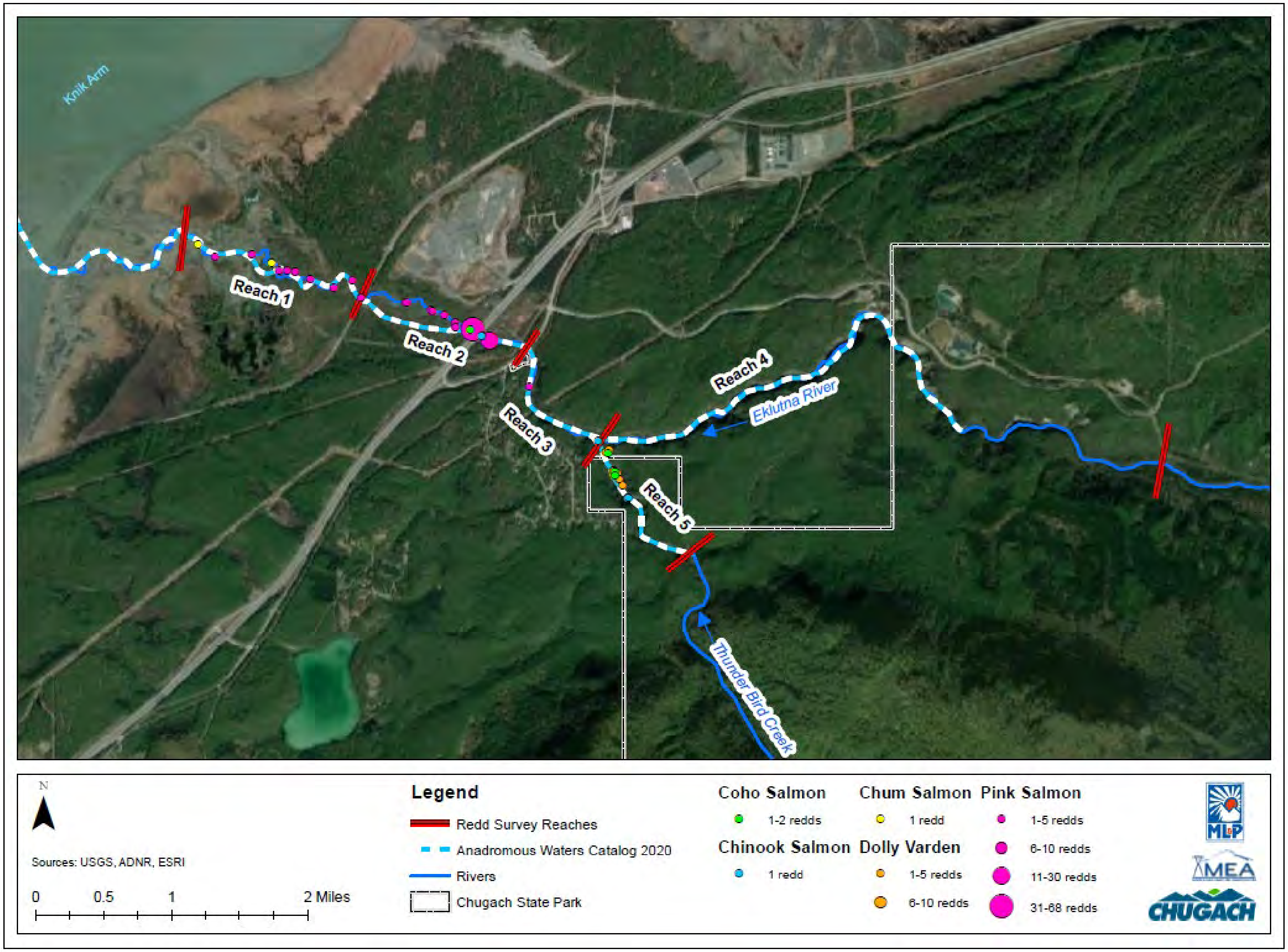

Figure 3.2-3. Distribution of observed redds by species in Spawning Survey Reaches 1-5 in 2022. Relative size of markers indicates relative abundance of redds at that GPS location.

3.2.2. 2022 Spawning Surveys

Spawning surveys occurred approximately weekly from July 8, 2022 to October 24, 2022. In 2022, south-central Alaska experienced more rain than in the past 25 years with over 20 inches falling by mid-October (Weather.com). These persistent rains resulted in higher summer flows and higher turbidity during spawning surveys than was observed in 2021 making salmon observations challenging. Several spawning surveys had to be canceled due to safety concerns from flood water. Many surveys during the months of August and September were also challenging because visibility was less than one foot, making fish observations difficult, and redds often impossible. Higher velocity flows also tend to flatten redds quickly which allows a shorter window of opportunity to observe them. Surveys were not completed on August 8, September 19, and October 11 due to flooding.

Thunderbird Creek (Spawning Reach 5) continued to be surveyed during flooding conditions when feasible, though high flows in the lower half of Thunderbird made it unsafe to wade on some survey days. Spawning surveys were completed on Monday of each week to the extent possible, though survey dates varied due to weather, schedule conflicts, and coordination with NVE who also completed weekly spawning surveys during the same period. NVE completed spawning surveys on Thursdays and used identical methods so that data sets could be comparable. The NVE and MJA weekly surveys were staggered to ensure that no staging and spawning activity of Pacific salmon would be missed. 2022 MJA Survey dates were as follows:

- July 08, 16, 25
- August 01, 08 (no survey), 15, 22, 29
- September 06, 13, 19 (no survey), 26
- October 05, 14, 22, 28

One unknown fish was observed during the first spawning survey on July 8; it was not possible to identify because the water was too turbid for positive identification. No spawning salmon or Dolly Varden were observed during our last survey on October 24 and there was ice and snow obscuring visibility beyond the increased turbidity.

Spawning activity of anadromous salmon observed included presence of adult fish, active digging or guarding of redds, constructed or partially constructed redds, and presence of post-spawned carcasses. Characteristic photographs were taken when water clarity allowed to document spawning activity, as shown in Figure 3.2-4 for a post-spawned Coho Salmon holding near an ice-encrusted bank.

Figure 3.2-4. Example post-spawning Coho Salmon photographed between the railroad Bridge and the New Glenn Highway Bridge at N61.45172, W-149.37891 on October 24, 2022.

The period during which adult fish of each species were observed in the Eklutna River in and Thunderbird Creek in 2022 is shown below. Coho were observed later into October than in 2021 but the periodicity of life stage activity by month is similar to 2021 (see Figure 3.2-4 above).

- Chinook Salmon: July 16-August 22, 2022
- Pink Salmon: August 1-August 22, 2022
- Chum Salmon: September 9-September 13, 2022
- Coho Salmon: August 22-October 24, 2022
- Dolly Varden (resident): September 23-October 24, 2022

The total number of observed adult Pacific salmon and salmon redds was much lower than observed in 2021 (Table 3.2-1). As noted above, low visibility, higher water level, and heavy rain influenced the visibility of fish in the river and reduced the surface characteristics of redds (e.g., relief, coloration) that make them visible from one week to the next. Pink Salmon were the most abundant anadromous species with a range of 2-18 individuals observed per spawning survey from August 1-August 22, 2022, and a total of only 40 Pink Salmon redds observed over the same period. Chinook and Coho salmon were equally scarce with 1-2 individuals observed per spawning survey from July 16-September 13, 2022. The distribution of observed spawning activity indicates the preference of Chum and Pink salmon for habitats in the downstream reaches, while Chinook and Coho were observed using habitat in further upstream reaches near Thunderbird Creek and downstream as observed in 2021. Figure 3.2-5 indicates the GPS position of all anadromous salmon redds documented in 2022, most of which were identified to species by presence of adult fish rather than completed redds or carcasses.

Table 3.2-1. Summary table of adult spawning salmon observed during 2021 and 2022 spawner surveys on the Eklutna River. While the relative proportion of species were observed with similar periodicity between 2021 and 2022, significantly fewer fish were observed in 2022 due to poor visibility.

2021					2022				
Date	Chinook	Coho	Chum	Pink	Date	Chinook	Coho	Chum	Pink
7/9/2021	0	0	0	0	7/8/2022	0	0	0	0
7/16/2021	0	0	0	0	7/16/2022	1	0	0	0
7/22/2021	7	0	0	0	7/25/2022	0	0	0	0
7/31/2021	9	0	0	17	8/1/2022	0	0	0	27
8/6/2021	2	0	0	61	8/8/2022	0	0	0	0
8/11/2021	0	0	0	65	8/15/2022	1	0	0	19
8/20/2021	0	0	3	120	8/22/2022	4	2	0	16
8/26/2021	0	0	1	13	8/29/2022[B]		-	-	-
9/3/2021	1	3	1	1	9/6/2022	0	4	4	0
9/11/2021	0	4	0	-	9/13/2022	0	3	2	0
9/18/2021[A]	0	3	0	-	9/19/2022[B]	-	-	-	-
9/23/2021[A]	0	0	0	0	9/26/2022	0	1	0	0
9/29/2021	0	2	0	0	10/3/2022	0	0	0	0
10/5/2021	0	0	0	0	10/11/2022[B]	-	-	-	-
10/14/2021	0	2	0	0	10/17/2022	0	6	0	0
10/22/2028	0	0	0	0	10/24/2022	0	2	0	0
Total Fish	19	14	5	277	Total Fish	6	18	6	62

Notes: A) Only Thunderbird surveyed due to study flow releases; B) Dangerous conditions due to rainfall/ flooding

3.3. COMPARATIVE ANALYSIS WITH NVE DATA

NVE also collected spawning data for ocean run Pacific Salmon in 2022. We hope to provide a combination of the data provided by both groups and then complete an additional analysis to compare 2021 and 2022 data with available historic data and earlier studies on the periodicity of spawning by species. This analysis could also include a comparison of periodicity within the Eklutna as observed in 2021/ 2022 with that of other nearby watersheds. We anticipate that NVE will be providing their data in spring of 2023.

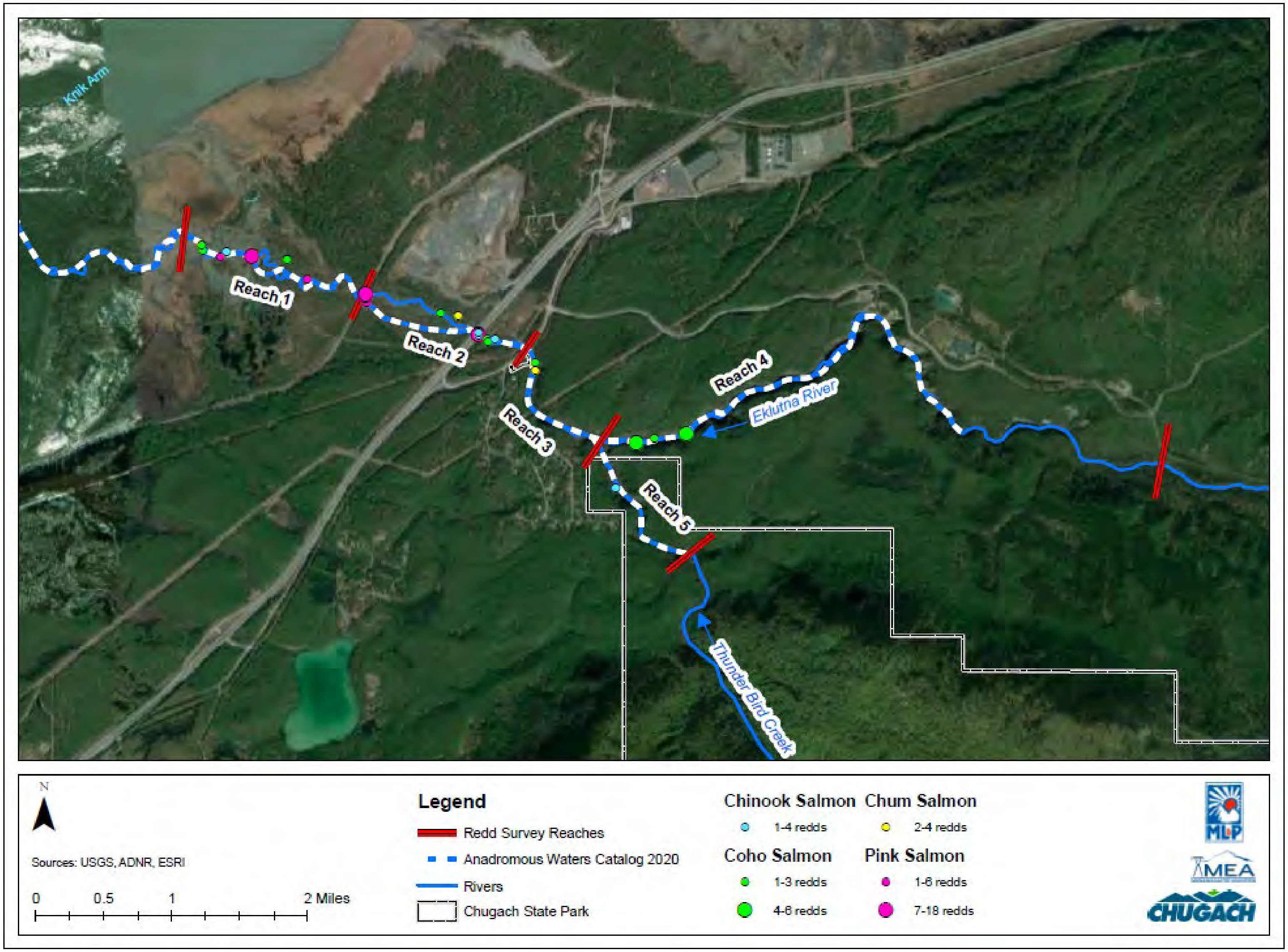

Figure 3.2-5. Distribution of observed redds by species in Spawning Survey Reaches 1-5 in 2022. Relative size of markers indicates relative abundance of redds at that GPS location.

4 CONCLUSIONS

The results and conclusions from this study will be utilized during alternatives analysis to evaluate any potential impacts to fish species composition and distribution that may result from future water management changes.

4.1. Habitat Use

Juvenile salmonids seek out low velocity areas with cover and predictable food supply. In turbid systems, turbidity may also play a role in either providing cover for some species while driving others into more clear water areas (Dugan et al. 1984). Although juvenile Chum Salmon and Sockeye Salmon were captured in similar habitat types as other salmon species, their use of riverine habitat for rearing is limited as they outmigrate relatively quickly. In contrast, both juvenile Coho Salmon and Chinook Salmon display extended riverine rearing periods. When given an option, juvenile Coho Salmon and Chinook Salmon in the Eklutna River appear to exhibit a preference for low velocity (<1.0 ft/sec), shallow water depth (<3.0 ft) areas within the downstream portion of most reaches. These preferences for shallow water habitat were evident during summer sampling when river temperatures ranged from 7.2 -11.4^{o}C. During fall sampling when water temperatures were much colder 1.7-4.9^{o} C, CPUE for Chinook and Coho was highest in pools, along undercut banks, and within structures like beaver dams. The presence of these habitat types (i.e., pools, undercut banks, and beaver dams) during winter months may play an important role in the seasonal distribution of target species and merit consideration of this habitat type to supplement an instream flow program.

4.2. Winter Habitat Use

Within northern latitude riverine ecosystems, nearly all fish species exhibit physiological and/or behavioral responses to the seasonal change in habitat from summer to winter (Reynolds 1997), such as reduced metabolic rate (Brown et al. 2011), swimming ability (Beamish 1978), movement to off-channel and low-velocity habitats (Peterson 1982; Jakober et al. 1998), shifts in diel activity patterns (Roni and Fayram 2000; Heggenes et al. 1993), and decreased territorial aggression (Reynolds 1997). In stream systems like the Eklutna River, the complex interaction between winter water temperature, low stream flow, ice formation, habitat accessibility, and suitability for stream-dwelling fish species all play a role in successful egg incubation and juvenile rearing (Huusko et al. 2013; Linderschmidt et al. 2018; Prowse 2001a, b).

During fall, many fish will migrate to winter habitats that provide refuge from extreme flow events, freezing temperatures, and predators. This allows fish to minimize energy expenditure while providing a stable environment that is protected from environmental extremes (Brown et al. 2011; Gutsch 2012). These conditions can be met in habitats such as: deep pools with cover, off-channel areas such as sloughs, beaver ponds, and side channels with low water velocity that are often influenced by groundwater and/or hyporheic flow. The connectivity of beaver ponds in the Eklutna River downstream of the railroad crossing may represent important overwintering habitats for Pacific salmon species with life history strategies that spend multiple years in freshwater habitats.

Comparison of salmonid abundance among macrohabitats in interior rivers located in British Columbia during winter indicated that utilization of side channel and off-channel habitats was greater than main channel areas (Swales et al. 1986). Off-channel habitats, such as side sloughs and beaver ponds, were of particular importance for juvenile Coho Salmon providing refuge from extreme winter conditions (Bustard and Narver 1975; Peterson 1982; Swales et al. 1986).

Similar findings were reported from winter studies conducted during the 1980s and 2012-2014 on the nearby Susitna River with juvenile Coho Salmon utilizing groundwater-fed side sloughs and upland sloughs for winter habitat, while primary winter habitats for juvenile Chinook Salmon consisted of side slough and side channel areas with groundwater upwelling (Delaney et al. 1981; Stratton 1986; R2 2014). While some reaches of the Eklutna were found to be gaining in terms of total discharge during study flow releases in 2021 (Dube 2023), the role that groundwater may play in the maintenance of winter habitat for rearing juvenile salmonids in the Eklutna River is unknown.

For the Eklutna River, a combination of winter instream flows as well as physical manipulation may be considered to ensure overwintering habitat suitable for rearing Chinook and Coho salmon is present in the Eklutna River. The presence and connectivity of beaver pond habitats in both the upper Eklutna River near the AWWU Portal Valve (Reach 8/9) and in the lower river downstream of the railroad bridge may also be considered to ensure that these habitats are accessible to juvenile fish during pre-winter redistribution.

4.3. Adult Salmon Use

The total number of adult Pacific salmon observed spawning in the Eklutna River in 2022 was much lower for all species than was observed in 2021. This is most likely because the heavy rains that predominated the weather pattern in the summer and early fall of 2022 resulted in low visibility conditions on required survey dates. Higher flow and swifter flows also likely impacted how long redds were visible before being flattened out and likely biased redd counts low. Despite the decreased total number of fish observed, the periodicity of adult Pacific migrations remained similar as observed in 2021, and the relative proportion of fish species was also similar between years.

We look forward to improving this section with the addition of data from NVE. Since conditions were unfavorable for spawning surveys during much of the rainy summer, it might be possible to pool spatial data on GPS position of spawning fish and redds to generate a more complete assessment of spawner activity in 2022 than would be possible with either data set alone. We expect this dataset to be available in spring of 2023.

5 VARIANCES FROM FINAL STUDY PLAN AND PROPOSED MODIFICATIONS

In 2021, we collaborated with NVE on spawning surveys to corroborate findings and coordinate schedules. Further, some of the sampling methods approved in the 2021 Study Plans for capturing fish including hand seining were not required to complete study objectives in 2021 field work. No other variances from the final approved study plan were required during execution of 2021 or 2022 field work.

6 REFERENCES

Alaska Department of Fish and Game (ADFG). 2001. Anadromous Water Catalog Nomination 01-305. Observations made by E. Weiss. Available online: https://www.adfg.alaska.gov/FDDDOCS/NOM_PDFs/SCN/01-305.PDF.

Alaska Department of Fish and Game (ADFG). 2020. Eklutna River Aquatic Habitat Monitoring, 2019. Technical Report no. 19-13. January 2020.

Bales, J. and J. Geifer. 2015. Anadromous Cataloging and Fish Inventory in Select Cook Inlet-Shelikof Straight and Bristol Bay drainages. Alaska Department of Fish and Game. Regional Operation Plan SF. 4A 2015.03.

Beamish, F.W.H.: Swimming capacity. In: Fish physiology, Vol. 7, pp 101–187. Ed. by W.S. Hoar and D.J. Randall, New York: Academic Press 1978.

Benaglia, T., D. Chauveau, D.R. Hunter, D. Young (2009). mixtools: An R Package for Analyzing Finite Mixture Models. Journal of Statistical Software, 32(6), 1-29. URL http://www.jstatsoft.org/v32/i06/.

Brown, R.S., W.A. Hubert, and S.F. Daly. 2011. A primer on Winter, Ice, and Fish: What Fisheries Biologist Should Know about Winter Ice Processes and Stream-dwelling Fish. Fisheries 36: 8-26.

Bustard, D.R. and D.W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead (*Salmo gairneri*). Journal of Fisheries Research Board of Canada 32:667-680.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K. Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P. Suchanek, R. Sundet, and M. Stratton. 1981. Juvenile anadromous fish study on the Lower Susitna River. Phase I Final Draft Report, Alaska Department of Fish and Game Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, Alaska. 200 pp. APA Document No. 1310.

Dube, K.V. Watershed GeoDynamics. 2023. Eklutna Hydroelectric Project Geomorphology and Sediment Transport Year 2 Report, Draft. Prepared for Municipality of Anchorage, Chugach Electric Association, Inc., and Matanuska Electric Association.

Geifer, J. and B. Blossom. 2020. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southcentral Region, effective June 1, 2020. Alaska Department of Fish and Game, Special Publication No. 20-03, Anchorage.

Gutsch K.M. 2012. Identification and Characterization of Juvenile Coho Salmon Overwintering Habitats and Early Spring Outmigration in the Anchor River Watershed, Alaska. Master’s Thesis, University of Alaska Fairbanks, School of Fisheries.

Heggenes J., O.M.W. Grog, O.R. Lindås, J.G. Dokk, and J.D. Armstrong. 1993. Homeostatic behavioural responses in changing environment: brown trout (Salmo trutta) become nocturnal at night. Journal of Animal Ecology 62:295–308.

Huusko, A., T. Vehanen, and M. Stickler. 2013. Salmonid habitats in riverine winter conditions with ice. In: Maddock, I., Harby, A., Kemp, P., Wood, P., eds. Ecohydraulics: An Integrated Approach. Chichester: John Wiley & Sons, pp 177–192.

Jakober, M.J., T.E. McMahon, R.F. Thurow, and C.G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society 127:223-235.

Kammerer, J.C. 1990. Water fact sheet: largest rivers in the United States. U.S. Geological Survey, Open-File Report 87-242, Reston, Virginia.

Lindenschmidt, K.E., H. Baulch, and E. Cavaliere. 2018. River and Lake Ice Processes – Impacts of Freshwater Ice on Aquatic Ecosystems in a Changing Globe. Water 10(11):1586.

McMillen Jacobs Associates. 2021. Eklutna Hydroelectric Project 1991 Fish & Wildlife Agreement Implementation. Final Study Plans. Prepared for Municipality of Anchorage, Chugach Electric Association, Inc., and Matanuska Electric Association.

National Marine Fisheries Service (NMFS). 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act.

Native Village of Eklutna (NVE). 2002. 2002 Eklutna River fish Study. Unpublished Study Plan by Marc Lamoreaux, Land and Environment Director, 5 pp.

Native Village of Eklutna (NVE). 2003. Eklutna River Fish Counts. Unpublished Report by Marc Lamoreaux, Land and Environment Director. 3 pp.

Peterson, N.P. 1982. Immigration of juvenile coho salmon (Oncorhynchus kisutch) into riverine ponds. Canadian Journal of Fisheries and Aquatic Sciences 39:1308-1310.

Pollard, W.R., G.F. Hartman, C. Groot, and P. Edgell. 1997. Fish Identification of Coastal Juvenile Salmonids. Harbor Publishing, Madeira Park, BC Canada. 32 pp.

Prowse, T.D. 2001a. River-Ice Ecology. I: Hydrologic, geomorphic, and water-quality aspects, Journal of Cold Regions Engineering 15(1-16).

Prowse, T.D. 2001b. River-Ice Ecology. II: Biological Aspects, Journal of Cold Regions Engineering 15(17-33).

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Reiser, D., B. Carey, C. Huang, S. Beck, M. Gagner, and C. Yoder. Kleinschmidt Associates. 2023. Eklutna Hydroelectric Project Eklutna River Instream Flows Year 2 Study Report, Draft. Prepared for Municipality of Anchorage, Chugach Electric Association, Inc., and Matanuska Electric Association.

Reynolds, J.B. 1997. Ecology of overwintering fishes in Alaskan freshwaters. Pages 281-302 in A.M. Milner and M.W. Oswood, eds. Freshwaters of Alaska: ecological syntheses. Springer-Verlag, New York.

R2 Resource Consultants, Inc. 2014. Fish and aquatics instream flow study (Study 8.5), 2013-2014 instream flow winter studies, technical memorandum, Susitna-Watana Hydroelectric Project. Prepared for Alaska Power Authority, Anchorage, Alaska.

Roni, P. and A. Fayram. 2000. Estimating winter salmonid abundance in small western Washington streams: a comparison of three techniques. North American Journal of Fisheries Management 20:683-692.

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

Swales, S., R.B. Lauzier, and C.D. Levings. 1986. Winter habitat preferences of juvenile salmonids in two interior rivers in British Columbia. Canadian Journal of Zoology 64:1506-1514.

U.S. Army Corps of Engineers (USACE). 2011. Eklutna River Aquatic Ecosystem Technical Report. USACE Alaska District. November 2011.

Weiss, E. 2003. Juvenile and Small Fish Identification Aid. Alaska Department of Fish and Game Habitat and Restoration Division.

7 APPENDICES

Appendix 1: Stream Habitat-Type Classifications

This appendix contains the following tables:

Table A.1-1 Meso habitat unit types for fish composition and distribution studies.

Macro-scale Habitat Type	Meso-scale Habitat types	Description
Slow Water	Backwater Pool (PL-BW)	Found along channel margins, created by eddies around obstructions such as boulders, root wads, or woody debris. Alcoves included
	Scour Pool (PL-SC)	Formed by flow impinging against a stream bank, partial obstruction (logs, root wad, or bedrock), or substrate. Includes both lateral and mid-channel scour pools.
	Beaver Pond (BP)	Water impounded by the creation of a beaver dam
Fast Water	Glide (GL)	An area with generally uniform depth and flow with no surface turbulence. Glides may have some scour areas but are distinguished from pools by their overall homogeneity and lack of structure.
	Riffle (RF)	Fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates.
	Boulder Riffle (BR)	Same flow and gradient as Riffle, but with numerous boulders than can create sub-unit sized pools or pocket water created by scour.
	Rapid (RP)	Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0 -4.0 percent slope, occasionally 7.0-8.0 percent.
	Chute (CH)	An area where most of the flow in constricted to a channel much narrower than the average channel width. Laterally concentrated flow in generally created by a channel impingement or a laterally asymmetric bathymetric profile. Flow is fast and turbulent.
	Cascade (CS)	Fast water habitat with turbulent flow; many hydraulic jumps, strong chutes, and eddies and between 30-80 percent white water. High gradient; usually greater than 4.0 percent slope. Much of the exposed substrate composed of boulders organized into clusters, partial bars, or steep-pool sequences.
	Falls (FS)	Steep near vertical drop in water surface elevation greater than approximately 5 feet over a permanent feature, generally bedrock.
Special Case Units	Dry Channel (DC)	Section of the stream channel that is completely dry at the time of survey.
	Puddled (PD)	Nearly dry channel but with sequence of small isolated sour pools less than one channel width in length or width.